Crooked Lake

Comprehensive Lake Management Plan
2014-2018

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1.0 Scope of Plan

To protect and enhance the long term health of Crooked Lake, Coon Creek Watershed District (CCWD) has advocated for long range comprehensive planning. The first step in this process was the development of the 2008 Crooked Lake Comprehensive Lake Management Plant. The two main goals this plan was to understand the water quality condition of Crooked Lake and to also develop strategies for the protection and enhancement of water quality.

Successful lake management requires a strong commitment to adaptive management. This management strategy is critical because lake conditions are not static and often times, problems threatening lake health are not completely understood. To best facilitate the adaptive management strategy, a thorough assessment of lake health trends, implications, and management needs is periodically conducted. This document serves as an update to the original plan and will focus on current issues facing Crooked Lake and the management strategies from 2014-2018.

Two primary goals of this Plan are:
1. Identify and evaluate lake health trends
2. Develop strategies for the protection and enhancement of Crooked Lake

2.0 Identification

Crooked Lake is located in the south central portion of Anoka County, split between the Cities of Andover to the north and Coon Rapids to the south (Figure 1). It is wholly contained within the Coon Creek Watershed District and designated as Public Water 02-84P by the Minnesota Department of Natural Resources.

Crooked Lake is a small 118 lake, elongated on a north-south orientation. It is relatively shallow with an average depth of 9 feet with littoral zone comprising 73% of the total lake area. The watershed of the lake is situated in a largely residential area where land use is dominated by single family homes. Detailed characterizations of the Crooked Lake watershed and the lake itself were completed in 2008 as part of the initial comprehensive lake management plan and can be found in Appendix C.

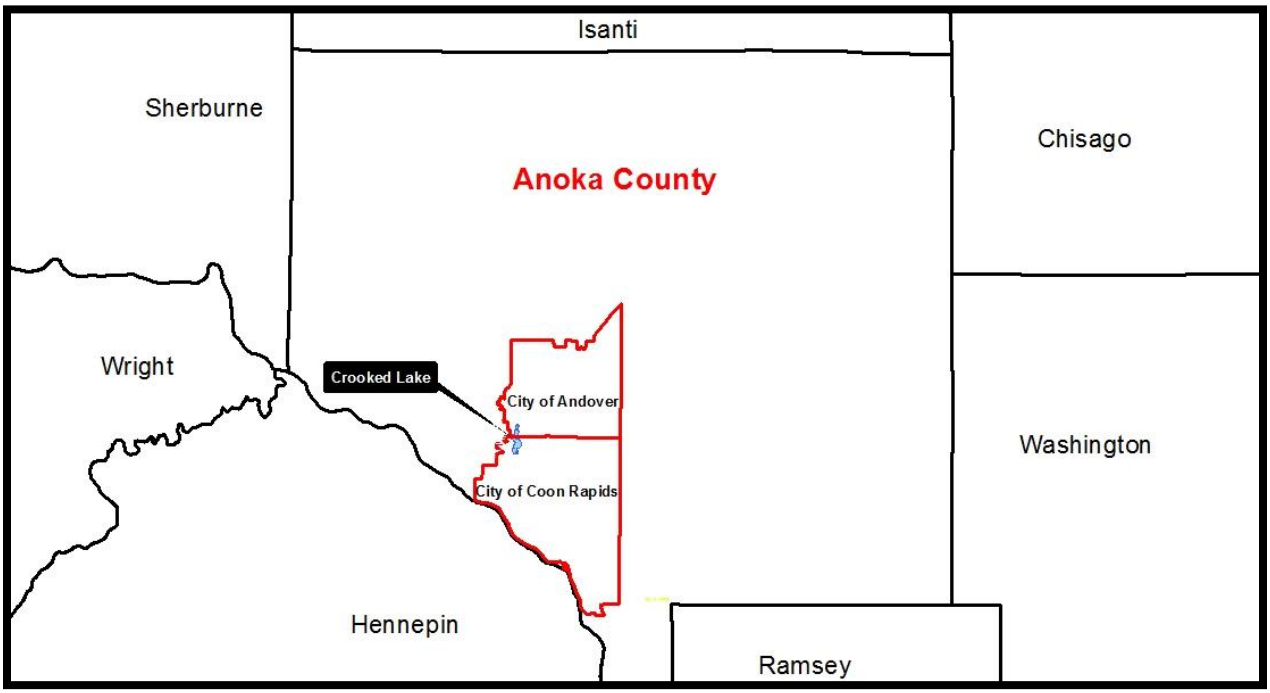


Figure 1. Location Map

3.0 Lake Trends and Implications

3.1 Aquatic Invasive Species (AIS)

Background

Eurasian Watermilfoil and Curly-leaf Pondweed have been managed in Crooked Lake for over two decades. Control of these species has proven to be time and cost intensive. The number of AIS threatening Crooked Lake continues to increase with identification of two new species in 2013. Water Lettuce (*Pistia stratiotes*) and Water Hyacinth (*Eichhornia crassipes*) were both discovered at the Crooked Lake boat landing during post treatment lake vegetation surveys. These plants were likely introduced via dumping of an aquarium or private aquaculture pond. These species are not expected to survive "typical" northern climates but propagules have shown the ability persist through mild Minnesota winters.

In 2013, a variance was granted by MNDNR to increase the treatment area to 40% of the littoral zone for control of Eurasian Watermilfoil (EWM). This variance nearly tripled the allowed treatment area moving up from 12.6 acres to 34 acres.

Trends

1. The number of species (plant and animal) with a high risk for introduction to Crooked Lake is increasing.
2. The occurrence of EWM has declined since 2011 (Figure 2).
3. The occurrence of CLP has declined since 2004 (Figure 2).

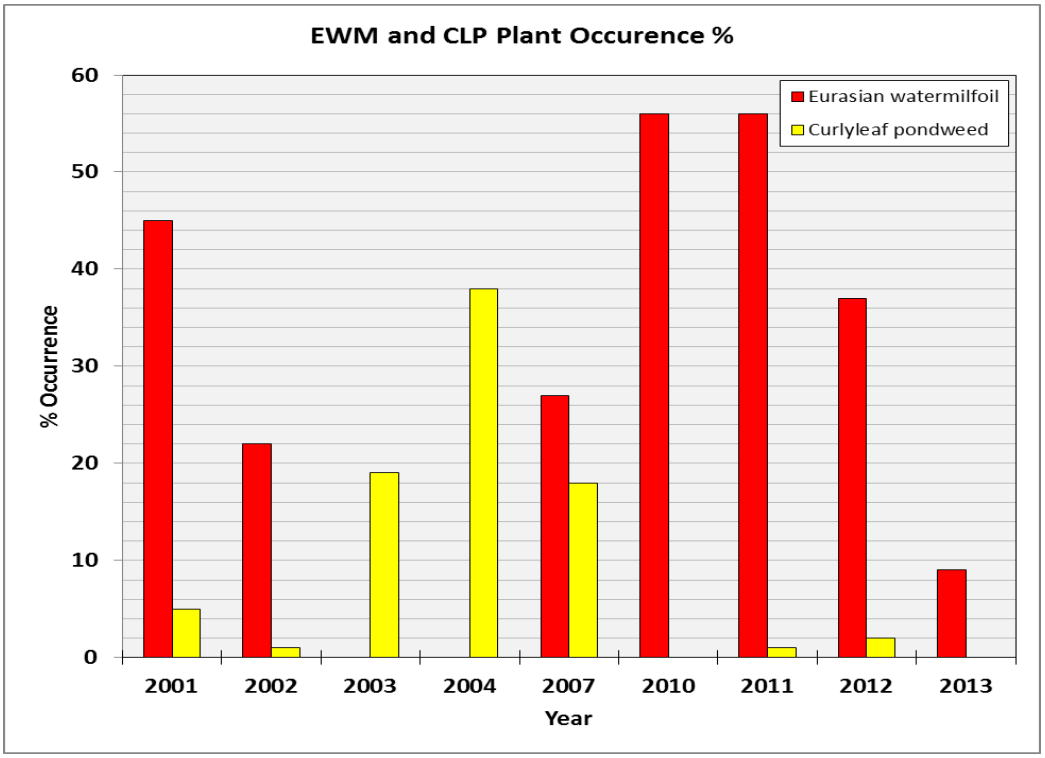


Figure 2. Aquatic Plant Trends for Crooked Lake.

Implications

If EWM/CLP trends continue;

1. Abundance of native lake vegetation should increase as plants re-establish areas devoid of EWM/CLP.
2. Near shore recreational opportunities should increase as EWM and CLP drop below nuisance levels.
3. Regular large scale treatments may not be needed on an annual basis.

If AIS infestation trends continue;

1. The associated cost of AIS control and prevention may increase for all stakeholders.
2. Laws regulating AIS control may increase in both number and severity.
3. Threats to diversity and abundance of native plant species will increase.
4. Fish populations may undergo a shift in species and abundance.
5. Recreational activity on Crooked Lake may decrease as a result of increased regulation on AIS transport.
6. Property values may decline as AIS infestations increase.

Needs

1. Increased public awareness of species with a high risk of introduction.
2. Increased efforts to prevent new infestations.
3. Develop a district wide AIS plan focused on early detection and rapid response new infestations.

3.2 Lake Vegetation

Background

Aquatic plants play a critical role in the ecology of shallow water lakes. Plant life provides protection against sediment re-suspension, protection from wind and wave forces, increased water oxygenation, and habitat diversity. The abundance, types, and general health of plants directly affect nutrient cycling, water clarity, and food web interactions of the lake. Fish are highly dependent on plant diversity for reproduction, survival, and growth.

Careless plant control activities, degraded water clarity, and invasion of non-native species are all threats to the health of aquatic plant communities. The depletion of a healthy plant community can have grave effects on lake ecology as detailed above. For this reason, it is prudent to find the balance between control of nuisance plants and the protection of native plant communities.

Trends

1. The total number of native plant species has declined in recent years (Table 1).
2. Coontail and Chara spp. (Muskgrass) have increased in occurrence becoming the two most dominant species.

Table 1. Number of native plant species surveyed in Crooked Lake (PLM surveys).

Year	# of Native Plant Species
2010	12
2011	12
2012	6
2013	8

Implications

If current trends continue;

1. Coontail and Muskgrass may continue to increase; these species are quick to re-establish areas once dominated by EWM and CLP.
2. Native plant diversity may decrease upsetting the natural ecology of the lake and potentially returning the lake to a turbid state.
3. Fish and macroinvertebrate diversity and abundance may decrease.

Needs

1. Continue annual post-treatment lake vegetation survey to monitor potential lake vegetation changes.
2. Follow future DNR fisheries surveys to assess health of the fish community.
3. Continue annual water quality monitoring for water clarity, total phosphorus, and chlorophyll-a concentrations.

3.3 Fisheries

Background

There have been a total of 12 DNR fish surveys on Crooked Lake dating back to 1951. The MN DNR is scheduled to survey the lake again in 2015. Survey results dating back to 1951 are limited and for that reason, only survey data since 1994 was analyzed.

Data was separated by trophic guild as this is often a better measure of community health rather than analyzing individual fish species. Species within the same trophic group serve the same ecological process in the lake (i.e., panfish species feed on zooplankton and invertebrates and serve as prey for top predators), and for this reason should be evaluated as one trophic guild rather than separate species. Trophic group summaries of abundance and biomass are presented in Figure 3 and Figure 4, respectively.

Survey data from 2004 and 2009 were analyzed for this plan for the most accurate depiction of recent fisheries trends. Fish abundance increased over this period while fish biomass decreased. In order for these observations to occur, a decrease in average fish size is needed; a pattern commonly referred to as "stunting".

Stunting often occurs in bluegill populations when the representation of large male bluegills is reduced due to either natural or human causes. In urban, shallow water lakes, the most common anthropogenic cause of reduced bluegills is over harvest by anglers. The lack of large male bluegills increases the abundance of small fish because these large, dominant males suppress the breeding success of younger fish. They do so by aggressively defending spawning beds limiting the reproductive success of smaller fish. As a result, smaller fish are forced to place more energy into growth rather than allocating finite energy sources into sexual maturation. In the absence of large males, small bluegills experience increased breeding success at younger ages resulting in an over-abundance of small bluegills. Approximately 70% of all bluegills sampled in 2009 were between 0 and 5 inches in length.

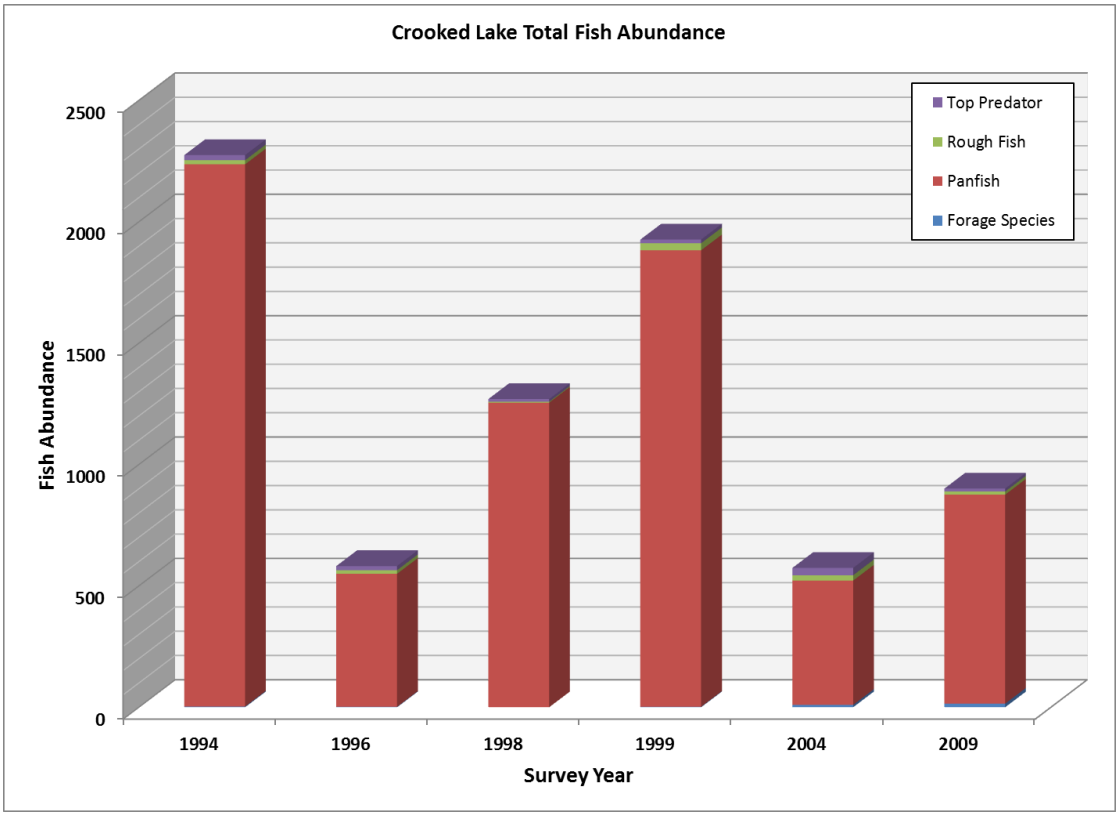


Figure 3. Fish Trophic Group Abundance for Crooked Lake

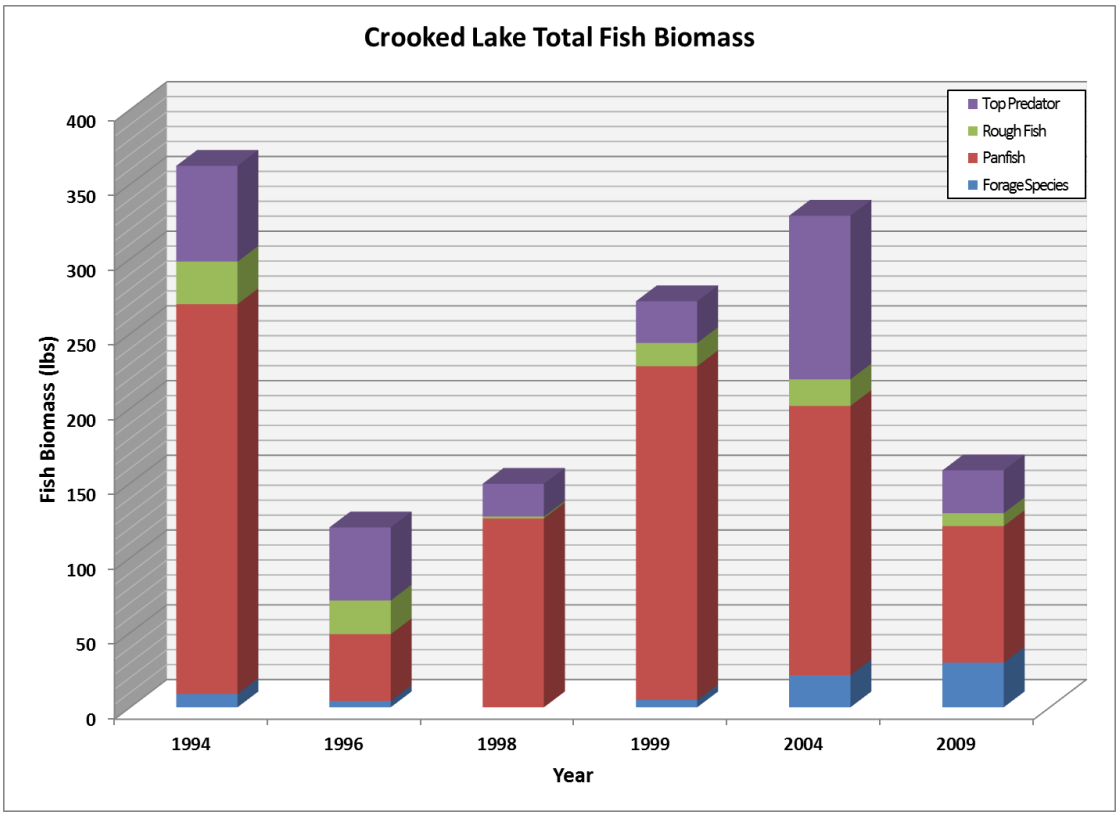


Figure 4. Fish Trophic Group Biomass for Crooked Lake

Trends

1. Fish abundance increased from 2004 to 2009 and near 15 year average (1994-2009).
2. Fish biomass decreased from 2004 to 2009 and near 15 year average (1994-2009).
3. Bluegills remain the most abundant fish species in Crooked Lake.

Implications

If current trends continue;

1. The abundance of below average size bluegills may continue.
2. Top predators may increase in size and number due to the abundance of prey species (bluegills).
3. Competition for food amongst "panfish" trophic guild may increase.
4. Competition amongst fish for preferred habitat may increase.

Needs

1. Analyze future fish survey data collected by MN DNR to assess health of fish community.
2. Increase the number of larger sized predators, especially of Largemouth Bass as bluegills are there preferred food source.

3.4 Water Level

Background

Crooked Lake saw a 2.5 foot fluctuation in lake levels from 2009-2013. This fluctuation is approximately 1 foot greater than fluctuation observed from the previous five year period, 2004-2008. The increase in lake fluctuations appeared to be largely driven by both the timing and amount of precipitation. Water level lows occurred in 2009, an exceptionally dry year. Water level highs were observed in 2011 when nearly 12 inches of rain fell during the spring groundwater recharge period of April and early May.

Whenever water levels are discussed, it is important to include groundwater in the conversation. Groundwater and surface water are often managed as separate entities, however; they are in fact, one hydrologic system. This means a depletion of groundwater aquifers can cause a decline in surface waters and vice versa.

Analysis of regional groundwater flow suggests groundwater enters Crooked Lake from the northeast quadrant before eventually existing along the western side of the lake. Because of this, the northeast quadrant of Crooked Lake is referred to as the "supply side".

Groundwater flow is susceptible to alteration from groundwater pumping by municipal and private wells. This is especially true in urban areas where drinking water demand is high and wells are congregated. If pumping rates surpass recharge rates, groundwater levels decline eventually draining surface water features.

Approximately 480 private wells and two municipal wells are located within 1 mile of Crooked Lake (Figure 5). Roughly half of these wells are located on the "supply side" of the lake. Inside the lakeshed, 129 private wells exist with 52 of them situated on the "supply side".

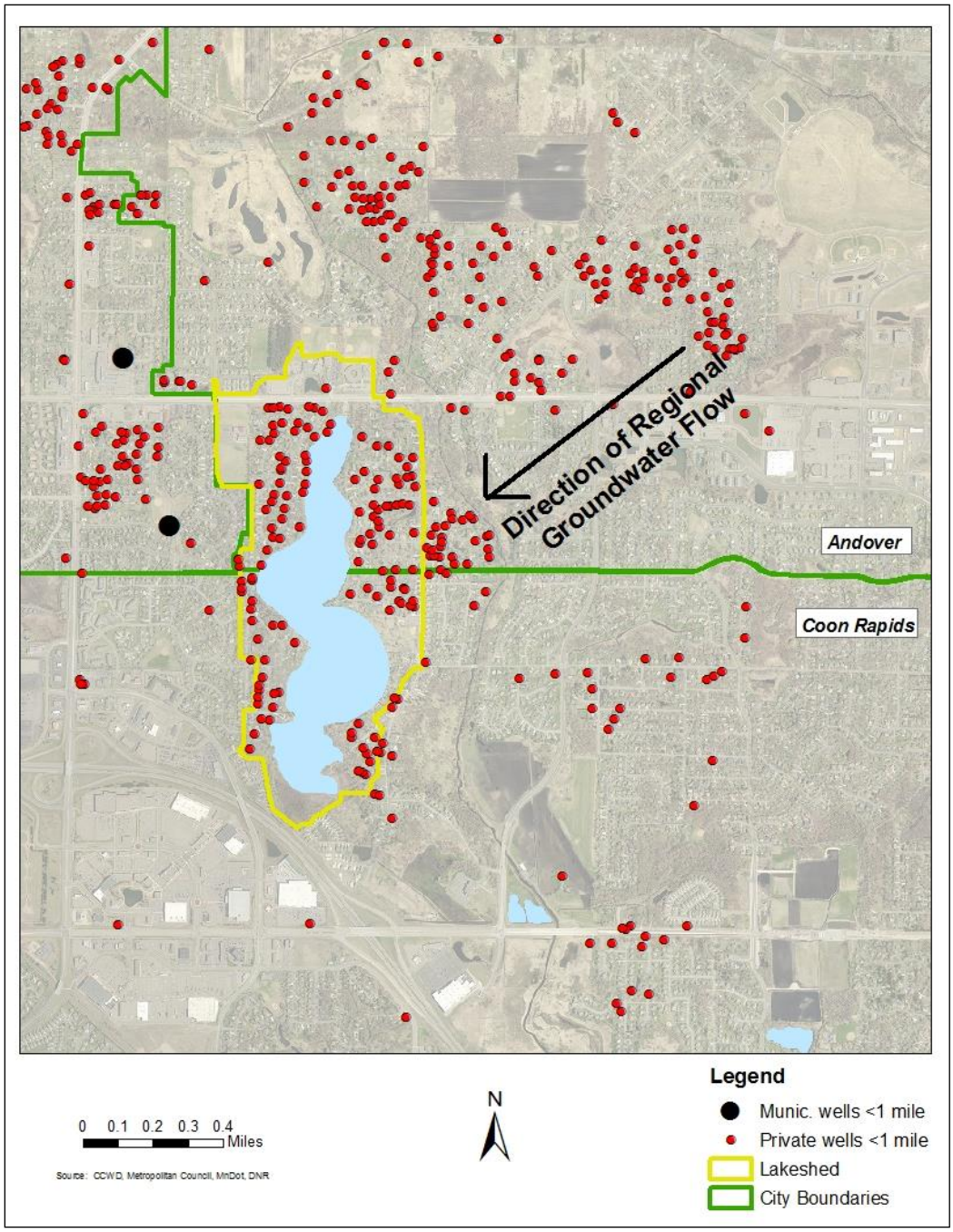


Figure 5. Well distribution within 1 mile of Crooked Lake.

Trends

1. Annual lake level fluctuation is increasing (Figure 6).
2. Crooked Lake water levels are declining (Figure 7).

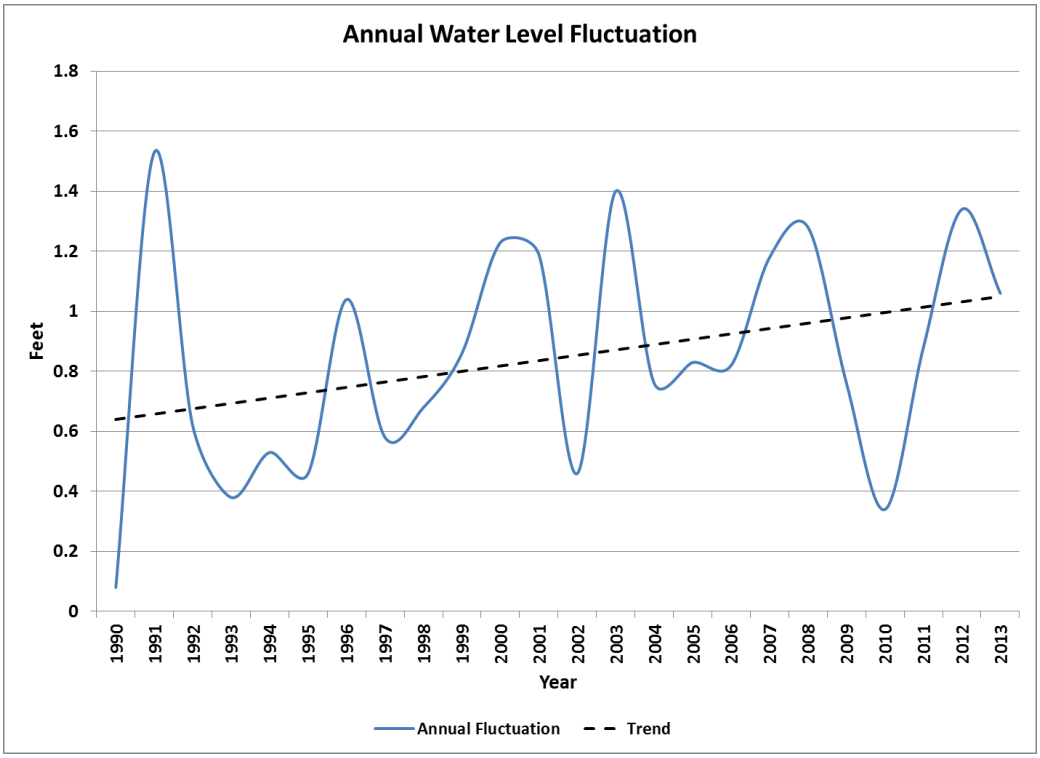


Figure 6. Annual Lake Level Fluctuation.

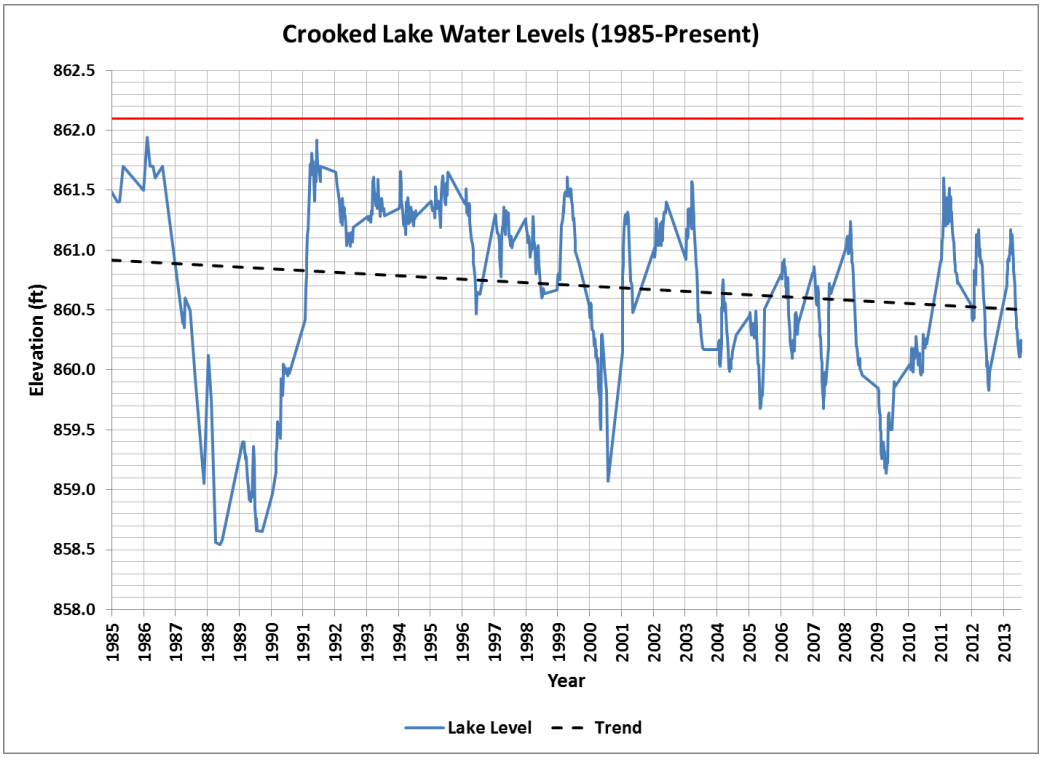


Figure 7. Crooked Lake Historical Water Level Trend

Implications

If lake levels continue to decline;

1. Fish populations may become more concentrated increasing the risk for winter die-off as well as potential for disease transmission.
2. The percentage of the lake bottom receiving sunlight could increase, resulting in increased lake vegetation growth.
3. Eurasian Watermilfoil and Curly-leaf pondweed may take root in depths where it previously could not grow.
4. Lake access could become problematic due to shallowing of the public access boat ramp.
5. Erosion and destabilization of shorelines could increase as water "pulls" away from the shoreline.

Needs

1. Gain a better understanding of the lake hydrology, specifically the effects of climate change and groundwater decline.
2. Conduct a groundwater/surface water study to determine the impact of groundwater pumping on Crooked Lake.
3. Continue work with the MN NDR toward the creation of the Anoka County Hydrogeologic Atlas.
4. Continue to follow the North and East Groundwater Management Area efforts and related studies.

3.5 Total Phosphorus

Background

Total phosphorus measures both the dissolved and particulate forms of phosphorus to determine the availability of nutrients for uptake by plant and algal growth. Over the past 5 years, annual average TP concentrations dropped to 27.85 µg/L. This is roughly half the annual concentration observed during the 1980's (50 µg/L). Phosphorus concentrations have decreased from the beginning of Crooked Lake water quality monitoring in 1983 (Figure 8). During the 1980s the annual average phosphorus concentration was 50 µg/L. From 2004 to 2008 the annual average phosphorus concentration was 32.0 µg/L, a 18 µg/L reduction since the 1980's. In 2012, average annual TP concentrations dropped to 22 µg/L; the lowest recorded observation in Crooked Lake.

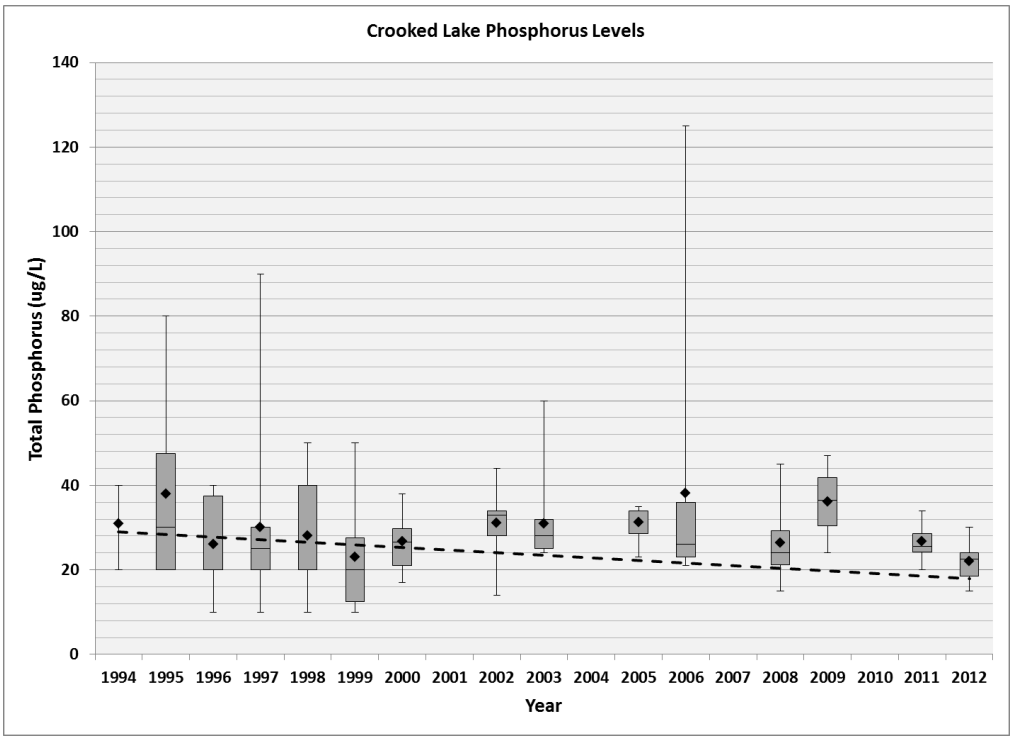


Figure 8. Crooked Lake Phosphorus Concentrations. Box plots show median (middle line), 25th and 75th percentile (boxes) and min/max observations (vertical lines).

Trends

1. Total phosphorus concentrations in Crooked Lake are declining.

Implications

If Phosphorus concentrations continue to decline;

1. Algal growth may decline.
2. Water clarity may increase.
3. Public perception of water quality may increase.
4. Contact recreational use (i.e., swimming, wading, boating) could increase.

Needs

1. Maintain the current water quality condition and nutrient level (phosphorus) in Crooked Lake.
2. Continue annual water quality monitoring two times monthly from May through September.
3. Inspect and maintain current stormwater infrastructure minimizing stormwater runoff and resultant nutrient inputs to Crooked Lake.
4. Continue to educate lakeshore owners of best management practices for their property aimed at reducing nutrient inputs to the lake (i.e., lawn clippings, fertilizers, wastewater).

3.6 Chlorophyll-a

Background

Direct measures of algal biomass can be determined through cell by cell counts and volumes but this process is time intensive and expensive. Chlorophyll-a concentrations are widely accepted as a good surrogate for determining algal biomass for a given waterbody. More specifically, chlorophyll-a is a measure of active chlorophyll in a sample, or the portion still undergoing photosynthesis. High chlorophyll-a concentrations indicate a high level of nutrient loading is occurring.

Chlorophyll-a concentrations have improved since the early 1980s. The annual average chlorophyll-a concentration for the 1980s was 24 µg/L. The annual average from 2002-2007 was 10.95µg/L, less than half the concentration found during the 80's. Since CLMP conception in 2008, chlorophyll-a concentrations have continued to drop to the lowest recorded observation of 4.93µg/L in 2012 (Figure 9).

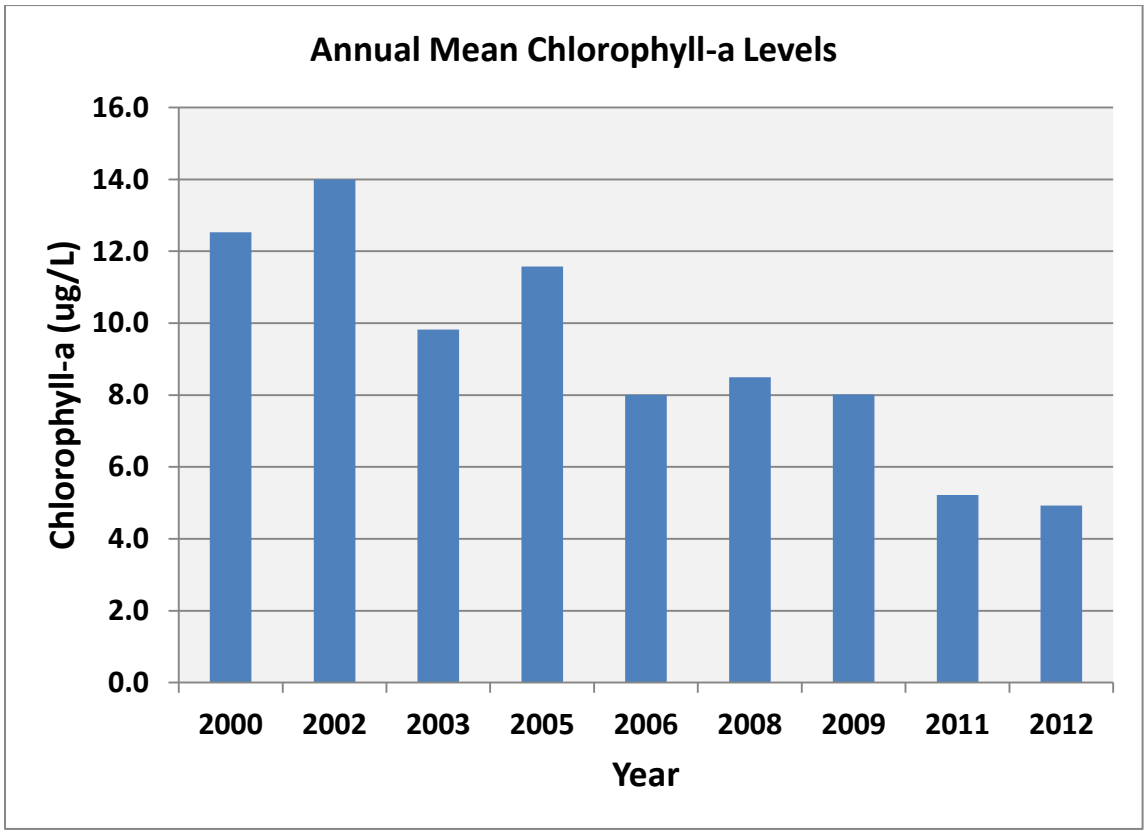


Figure 9. Mean Chlorophyll-a Concentrations for 2000-2012

Trends

1. Chlorophyll-a concentrations in Crooked Lake are declining.

Implications

If Chlorophyll-a concentrations continue to decline;

1. Algal growth may decline.

2. Water clarity may increase.
3. Public perception of water quality may increase.
4. Contact recreational use (i.e., swimming, wading, boating) may increase.

Needs

1. Maintain the current water quality condition in Crooked Lake.
2. Continue to monitor Crooked Lake water quality two times monthly from May through September.
3. Inspect and maintain current stormwater infrastructure minimizing stormwater runoff and resultant nutrient inputs to Crooked Lake.
4. Continue to educate lakeshore owners of best management practices for their property aimed at reducing nutrient inputs to the lake (i.e., lawn clippings, fertilizers, wastewater).

3.7 **Water Clarity**

Background

Water clarity/transparency is affected by algae, soil particles, and other materials suspended in the water. The Clarity/ Transparency of the water is measured using a Secchi disk. A Secchi disk is a small disk that is lowered into the water until it cannot be seen. The depth at which it disappears when it is lowered, and reappears when it is raised are recorded and averaged as a measure of clarity/transparency.

Secchi readings are not a direct measure of water quality. However, transparency is often indicative of lake overall water quality, especially the amount of algae present. It is also a measure of light penetration and therefore plant composition and growth.

The annual average secchi depth for the 1980s was 3.78 feet. The annual average from 2000-2008 is 6.45 feet, a 2.67 foot increase compared to the 1980's. Since 2008, annual average transparency has reached 8.97 feet equating to a 2.52 foot increase from the previous five years (Figure 10).

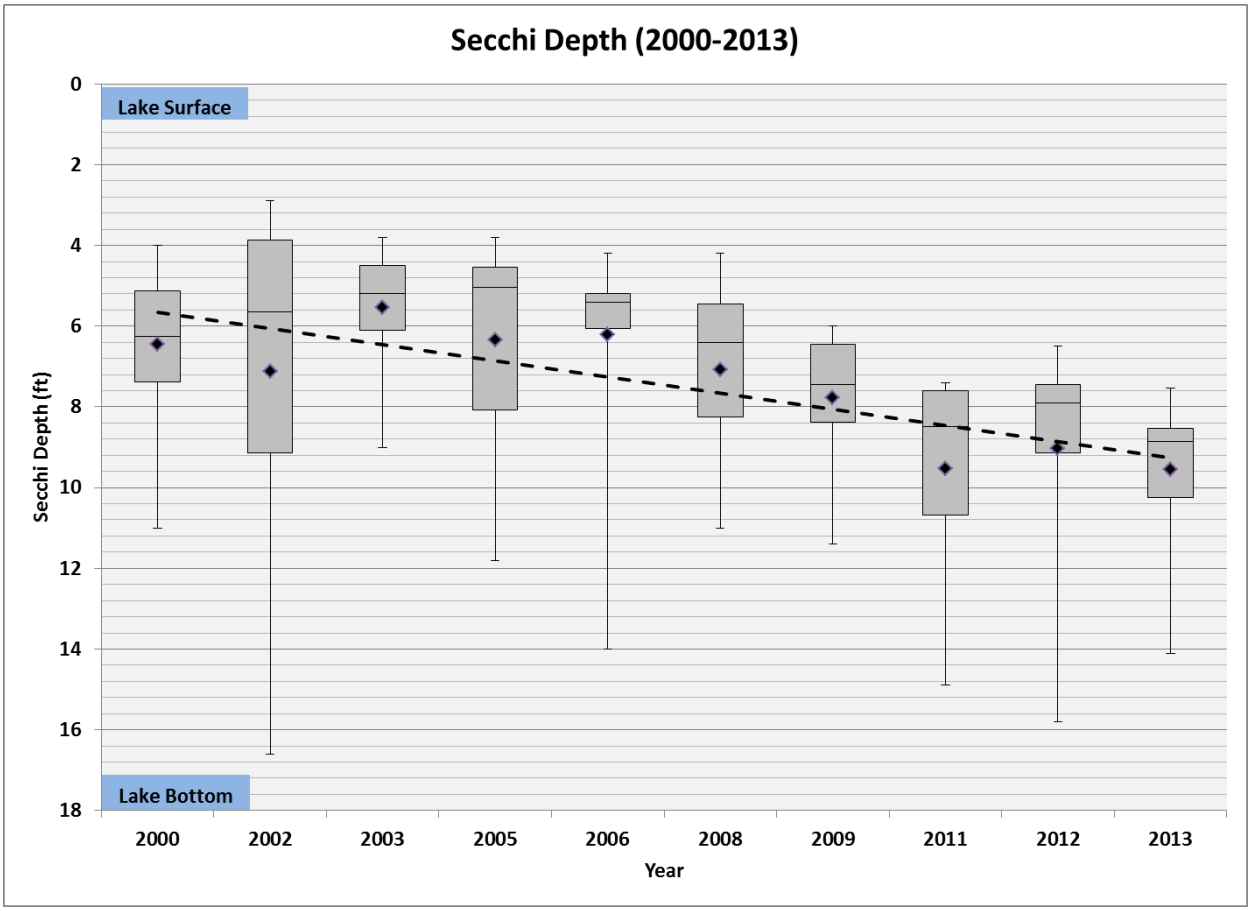


Figure 10. Secchi depth readings for Crooked Lake.

Trends

1. Crooked Lake water clarity is increasing.

Implications

If water clarity continues to increase;

1. Lake vegetation could increase due to increased sunlight penetration.
2. Recreational use (i.e., swimming, wading, boating) may increase.

Needs

1. Inspect and maintain current stormwater infrastructure minimizing stormwater runoff and resultant nutrient inputs to Crooked Lake.
2. Continue to educate lakeshore owners of best management practices for their property aimed at reducing nutrient inputs to the lake (i.e., lawn clippings, fertilizers, wastewater).

3.8 Designated Use Impairments

Background

The State of Minnesota is required under the federal Clean Water Act to adopt water quality standards to protect its waters from pollution. Numerical standards define how much of a pollutant can be in the water and still meet its designated uses, such as aquatic life, drinking water, fishing, and swimming. A water body is listed as "impaired" if it does not meet water quality standards and consequently listed on the Clean Water Act, 303(d) List of Impaired Waters.

In 2008, Crooked Lake was listed as impaired for aquatic consumption. Crooked Lake is impaired for aquatic consumption due to high mercury levels in fish tissues. Across Minnesota, roughly 1,270 lakes and streams are considered impaired due to excess mercury. 99.5% of mercury detected in fish is attributed to atmospheric deposition. Management of this issue is a state, national and international effort since approximately 90% of the mercury entering Minnesota waters come from outside the state.

The U.S. Environmental Protection Agency approved Minnesota's Statewide Mercury Total Maximum Daily Load study in March 2007. Since that time, the Minnesota Pollution Control Agency (MPCA) has worked with stakeholders to reduce mercury input to Minnesota waters.

Trends

1. Minnesota has reduced mercury emissions by more than 70% from 1990 to present.
2. Fish tissue samples indicate a slight decline in mercury levels statewide but concentrations are still above Minnesota Department of Health (MDH) standards.

Implications

1. Fish consumption guidelines for Crooked Lake suggest one meal per week of Bullhead and/or Northern Pike due to excess mercury. Consumption guidelines list all other species in Crooked Lake as "unrestricted" for the general population.

Needs

1. Continue to follow Minnesota's Statewide Mercury TMDL study.
2. Adhere to MDH fish consumption guidelines.

3.9 Water Quality Summary

The Trophic State Index (TSI) is a number summarizing overall nutrient richness of a given waterbody. Nutrient richness ranges from clear lakes, low in nutrients (oligotrophic), to green lakes, with very high nutrient levels (hypereutrophic). Figure 11 below shows the overall TSI rating for Crooked Lake (top bar), followed by TSI ratings for the individual parameters that contribute to nutrient richness. These TSI calculations are based on data collected between June and September 2003 to 2012. Figure 12 gives a general portrayal of expected water clarity for each trophic state.

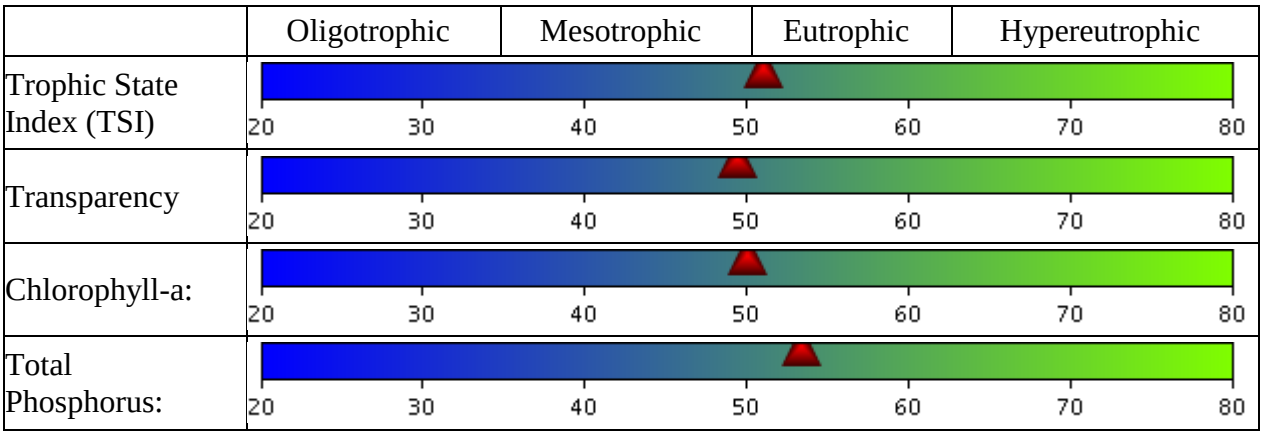


Figure 11. Trophic State Index for Crooked Lake

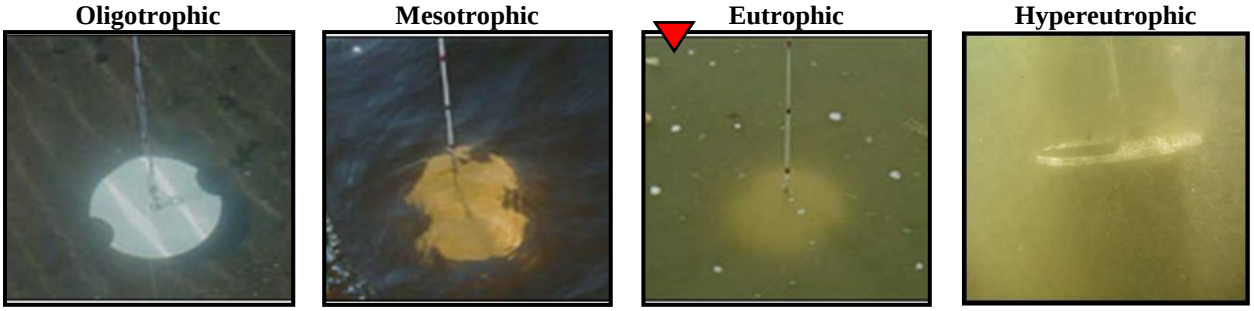


Figure 12. General depictions of water clarity for trophic state. Red triangle represents Crooked Lake.

4.0 Current Lake Management Priorities

On May 30th, 2013, a public workshop was held at the Crooked Lake Elementary School. Workshop attendees were asked to identify their single top concern facing Crooked Lake. A similar public workshop was held in 2008, however, attendees were asked to identify their top three concerns at that gathering. Identifying a single top concern in 2013 resulted in a more succinct and focused list of concerns. Input was received from 23 individuals.

Four main concerns facing Crooked Lake were identified by the public and are present below in order of percentage of "votes."

1. AIS/Milfoil (82.6%)
2. Trash & Garbage (8.7%)
3. Nonpoint Source Pollution (4.3%)
4. Weeds (4.3%)

Management of Eurasian Water Milfoil/Aquatic Invasive Species (AIS) remained the top concern in 2013. Trash and non-point source pollution (runoff) were less important issues than in 2008 validated both by public vote and current water quality data. In addition to the four issues identified above, Crooked Lake Stakeholders also identified water levels as a concern.

For specific lake management issues identified in 2008, a progress summary can be found in Appendix B.

5.0 Areas of Management Focus

This section of the plan addresses specific areas of management focus for Crooked Lake as identified by stakeholders. The management strategies discussed in following pages center on water resource issues with potential for medium to high impact on Crooked Lake. Issues are presented in order of potential impact and importance (Table 2).

Table 2. Impact/Importance Matrix for Lake Management

Impact	Low	Medium	High
High		Non-point Pollution	AIS/Milfoil Lake Levels
Medium		Weeds (Lake Vegetation)	
Low	Trash & Garbage		

Importance

5.1 Aquatic Invasive Species/Milfoil

Demands and Preferences

Needs	The presence of invasive species is seen as the single biggest liability to the use and enjoyment of Crooked Lake and, in some instances, to individual home and property value and enjoyment. What is desired is a lake where invasive species are either below nuisance levels (not readily seen or interfering with boating or swimming) or eliminated from the lake.
Problem Statement	The presence of Eurasian watermilfoil was the most-often cited problem in 2013. In addition to EWM, Curly-leaf Pondweed, Water Hyacinth and Water Lettuce have been discovered in Crooked Lake. All of these species have potential to interfere with recreational and aesthetic use as well as the ecology of the lake.

Watershed & Lake Characteristics

Extensive Littoral Zone	The littoral zone of Crooked Lake encompasses 73% of the lake surface. This means that 83 of the 114-acre surface is prime habitat for invasive species.
Invasive Species Habitat	The aggressive nature of invasive plants combined with the extensive availability of prime habitat (73% of the lake) allows these plants to outcompete native species in most instances and creates a nuisance for boaters and swimmers.
Lake Sediments	The bottom of Crooked Lake is composed primarily of fine sandy muck, a preferred substrate and growth medium for EWM and CLP.
Prevalence Of Seed Source And Propagules	The prevalence of both EWM and CLP and their reproduction and growth characteristics ensure a source of plant reproduction, making eradication nearly impossible. Focus should be placed on management rather than eradication.
Increased Insolation (Sunlight penetration and transmission)	The combination of decreasing lake levels and increasing water clarity is creating more suitable habitat for EWM and CLP. Sunlight is readily available to a depth of approximately 9 feet in Crooked Lake. This light reaches approximately 58% of the lake bottom.
History of Both Turbid and Clearwater States	In recent history, Crooked Lake has gone through a turbid state (a period of high algal productivity and low aquatic plant productivity (1970s). The lake has also had periods where it exists in a clear water state (low algal productivity, large aquatic plant community). The drivers that led to the switch from a relatively clear water state in the 1940s, 50s and 60s to a more

turbid state in the 1970s are well understood. The switch back to a relatively clear water state by the 1990s is not well understood nut appears to coincide with the discovery of Eurasian water milfoil in the lake. The concern about over treating for aquatic macrophytes has to do, in part, with the potential for the lake to switch to a turbid water state as a result of the release of nutrients and the decline in dissolved oxygen as the plants decompose.

Management Programs and Policies

Aquatic Plant Management	Pesticide control of aquatic macrophytes on all public waters and watercourses, treatment is limited to: The lesser of 15 percent of the littoral area or a maximum of 100 feet of shoreline per site belonging to an individual riparian property owner may be treated for control of submerged vegetation. Applications for large area or baywide treatment must include Lake Vegetation Management Plan (LVMP) and a variance from the DNR.
Aquatic plants growing in public waters are the property of the state	Because of their value to the lake ecosystem, they may not be destroyed or transplanted unless authorized by the Department of Natural Resources.
Prohibited Plant Control Methods	Excavating the lake bottom for aquatic plant control Use of hydraulic jets Destroying or preventing the growth of aquatic plants by using lake bottom or benthic barriers Removing aquatic vegetation within posted fish-spawning areas Removing aquatic plants from an undeveloped shoreline Removing aquatic plants where they do not interfere with swimming, boating, or other recreation
Prevention	Boat Inspection: The Crooked Lake Area Association and the MDNR have periodically instituted inspection programs in an attempt to eliminate any further introduction of invasive species into the lake. MR 6116 states that individuals may not transport watercraft or related equipment containing prohibited invasive species on public roads.
Treatment & Control	Chemical Control: Eurasian water milfoil was first discovered in 1990. Whole lake treatments to control Eurasian watermilfoil have occurred in 1992 and 2002. Partial treatments (15% of the littoral zone) were conducted by the Crooked Lake Area Association from 2003 through 2012. A summary of treatment activity is tabled below:

Year	Target	Scope	Acres	Sponsor	Cost	$/Ac

2009	EWM/CLP	15%	12.6	CLAA	$4,853	$385
2010	EWM/CLP	15%	12.6	CLAA	$7,410	$588
2011	EWM	15%	12.6	CLAA	$3,913	$310
2012	EWM	15%	12.6	CLAA	$3,178	$252
2013	EWM	40%	34.0	CLAA	$5,746	$169

*Cost for 2010 and 2011 include cost of DNR permit fee of $750 and $735 respectively

Fisheries

The lake is currently managed for walleye, channel catfish, and largemouth bass. The lake naturally supports a large population of Centrarchids i.e., bluegills, pumpkinseeds and largemouth bass. Dense cover is vitally important to these species.

Current Situation

Treatments conducted in 2013 proved highly effective in controlling EWM. Similar treatment area is being pursued by CLAA again in 2014 pending approval by the MN DNR. Based on lake vegetation surveys conducted post treatment, native species of submergent vegetation appear to be increasing as a result of the reduced occurrence of EWM. The continued growth of native species is critical to prevent returning the lake to a turbid state.

Reduction of invasive species within Crooked Lake must be done in a manner that does not
Drive the lake into a turbid water state
Remove or eliminate plant cover to the point where the removal adversely affects the fishery.

To achieve this:
The reduction of invasives must be accompanied by replacement by native submergent species.
The rate of replacement must remain below the level that could drive the lake to switch from a clear to a turbid water state.

Assessment

Management Goal(s)

Reduce Eurasian water milfoil (EWM) to below nuisance levels:
Plants rarely reach the surface
Navigation and recreational activities are not generally hindered
Stem density is 0-160 stems/m^2
Biomass is 0-50 g dry wt/ m^2
Estimated Total Phosphorus load is <1.7 lbs/acre
Increase abundance and diversity of native submersed aquatic plants

Measures

Decrease in occurrence of Eurasian water milfoil and curly leaf pondweed.

Milestones

Annual spring treatment of Eurasian water milfoil
Annual monitoring of lake vegetation
Annual water quality for at least

Clarity
Phosphorus
Chlorophyll-a

Recommended Strategies to Achieve these Goals

Annual Plant Survey	Includes Pre-treatment delineation survey of EWM and CLP and annual post-treatment survey of aquatic macrophytes: distribution, diversity and frequency of aquatic plants.
Water Quality Monitoring	Continue water quality monitoring. The existing water quality monitoring effort should be continued.
Prevention	Continued boat inspection. Inspecting boats at the public access should be continued. The presence should: Occur during high-use periods Provide an enforcement presence Emphasize invasive species awareness and general public education on the nature of the lake.
Annual Chemical Treatment	Continue chemical control. Annual chemical treatments should be continued to allow for recreational use and aesthetic enjoyment.
Early Detection Efforts	Conduct observational lake surveys 2 times annually for aquatic invasive species at high risk for introduction to Crooked Lake.
District AIS Plan	Develop a district-wide plan aimed at early detection and rapid response to invading aquatic invasive species.
Educational Outreach	Increase Aquatic Invasive Species awareness through educational materials (i.e. brochures, fact sheets, public service announcements, digital media)

Implementation Schedule/Responsibilities

Method	Unit Cost	ACD	CLAA	CCWD	Andover	CR	DNR
Annual Plant Surveys	$850/Pre-treatment $700/Post-treatment	Tech Assist	Finance				Tech Assist
Annual Chemical Treatment	$169/Acre		Lead		Finance	Finance	Regulatory Oversight
Watercraft Inspections	--		Lead				Tech Assist
Water Quality Monitoring	$160/Sample	Lead		Finance			
Early Detection Surveys	$583	Lead		Finance			
AIS Plan	--			Lead			
Educational Outreach	$650/effort			Lead			

Table 3. Aquatic Invasive Species Implementation Schedule/Responsibilities.

Costs

Agency	Activity	2014	2015	2016	2017	2018	Total
Andover	Chemical Treatment (40% of Littoral Zone)	$2,873	$2,916	$2,959	$3,002	$3,045	$14,795
CCWD	Water Quality Monitoring	$1,600	$1,624		$1,672	$1,696	$6,592
	Early Detection Surveys	$583	$591		$609	$618	$2,401
	Educational Outreach		$670				$670
Coon Rapids	Chemical Treatment (40% of Littoral Zone)	$2,873	$2,916	$2,959	$3,002	$3,045	$14,795
Crooked Lake Area Association	Annual Plant Survey (Pre-treatment delineation)	$850	$862	$875	$888	$902	$5,295
	Annual Plant Survey (Post-treatment)	$700	$710	$721	$731	$742	$3,604
Totals		$8,539	$9,427	$6,639	$9,016	$9,146	$42,857

Table 4. Cost Estimate for Implementation Plan.

5.2 Lake Levels

Demands and Preferences

Needs Water levels are critical to the long term health of Crooked Lake as well as numerous recreational uses on the lake. Water level was identified as a concern at the 2008 public input meeting but not identified in 2013. A rebound in lake levels is important for the long term health of the lake. For that reason, water levels were identified by local stakeholders as an important issue due to the potentially high impact on Crooked Lake.

Problem Statement Crooked Lake water levels are on a declining long term trend. Continued decline in lake levels can create issues with lake access as well an increase in weed growth. A 2009 Metropolitan Council study projected a decline in Crooked Lake of up to 5 feet by 2030.

Watershed & Lake Characteristics

Lake Level On October 27, 2013, Crooked Lake water elevation was at 860.15 FASL. This elevation is 0.31 feet below the 10 year average and 0.53 feet below the period of record (1974-2013).

Declining Precipitation Over the past decade, annual precipitation has been on a slight decline. If current trends continue, Crooked Lake will experience 5% (1.5 inches) less annual precipitation by 2020.

Less Effective Precipitation Increased frequency of larger storms (>1") is resulting in more runoff and less infiltration. Reduced effective precipitation can impact the amount of recharge occurring in surficial aquifers; a key component of Crooked Lake water levels.

Management Programs and Policies

Lake Level Monitoring The elevation of Crooked Lake water levels have been monitored for roughly 40 years.

Earthen Dam at South End of Lake An earthen dam constructed by the State of Minnesota around 1940 has an outlet control structure with an elevation of 862.3. Infrequent discharges do exist on occasion but water levels are often well below this elevation.

Annual Inspections CCWD annually inspects the Crooked Lake Dam as a preventative measure to ensure the earthen dam and outlet are in proper repair.

Current Situation There are several unknowns about the behavior of water levels on Crooked Lake. In particular, the connection between groundwater and surface water levels in not completely understood. Crooked Lake water levels are on a declining trend and may potentially impact recreational uses and lake ecology in the future. It is important to support efforts

aimed to better understand surface water and groundwater interactions.

Assessment

Management Goal(s)	To develop a better understanding of the water budget, particularly the water supply of Crooked Lake. A better understanding will allow stakeholders to develop practices best suited to sustain the water level of Crooked Lake.
Outcome Measures	Annual lake level monitoring Groundwater elevations
Milestones	Annual inspection report of Crooked Lake cam Report of groundwater and surface water interactions Annual Anoka County Water Almanac

Recommended Strategies to Achieve these Goals

Lake Level Monitoring	Continue citizen lake level monitoring program. This provides an accurate record of both short and long term lake level trends. Unfortunately, this strategy alone cannot determine the causes for lake level fluctuations.
Annual Dam Inspection	Continue inspection of earthen dam and outlet structure on south end of Crooked Lake. Although lake discharge is uncommon with current water levels, should they rebound, this structure is critically important to Crooked Lake water levels.
Groundwater Monitoring	Record elevations of surficial aquifer in the vicinity of Crooked Lake.
Conduct Groundwater/ Surface water Study	This study aims provide better understanding of surficial groundwater resources and impacts to surface waters. Study will analyze lake levels, geology, observation well data, and Part B (Hydrogeology) of the Anoka County Geologic Atlas for interactions with one another.

Implementation Schedule/Responsibilities

Method	Unit Cost	ACD	CLAA	CCWD	Andover	CR	DNR
Lake Level Monitoring	$250	Lead		Finance			
Annual Dam Inspection	$56			Lead			
Groundwater Monitoring	$525	Lead		Finance			
Conduct Groundwater/ Surface water review	--			Lead			Tech Assist

Table 5. Lake Level Implementation Schedule/Responsibilities.

Costs

Agency	Activity	2014	2015	2016	2017	2018	Total
CCWD	Lake Level Monitoring	$250	$254	$258	$262	$268	$1,292
	Annual Dam Inspection	$56	$57	$58	$59	$60	$290
	Groundwater Monitoring	$1,575	$533	$541	$549	$557	$2,705
Totals		$1,881	$844	$857	$870	$885	$4,287

Table 6. Cost Estimate for Implementation Plan.

5.3 Nonpoint Source Pollution

Demands and Preferences

Needs Minimizing nonpoint source pollution in Crooked Lake reduces nutrient loading and improves water clarity. Protecting the current water quality of Crooked Lake is important for the long term health of the lake.

Problem Statement Nonpoint source pollution was the fourth most often cited problem facing Crooked Lake and tied second for the aspect of Crooked Lake people would like to see addressed.

Watershed & Lake Characteristics

Land Use Loadings 76% of the contributing drainage area into Crooked Lake is residential. It is the largest single land use affecting Crooked Lake. Residential land uses contribute approximately 89% of the suspended solids to the lake and approximately 90% of the total phosphorus.
Other contributors are vehicle traffic, lawn care practices, pets, eroded sediment and vegetative litter.

Phosphorus Levels Over the past 5 years, annual average TP concentrations continued to decrease to an annual average of 27.85 µg/L; a 13% reduction from 2004-2008.

Chlorophyll-a Levels Over the past 5 years, annual average chlorophyll-a concentrations have declined to an average of 6.05; a 35% reduction from 2004-2008.

Water Clarity Water clarity over the past 5 years has showed in improving trend. Water clarity improved nearly 2.5 feet compared to the average from 2004-2008.

Management Programs and Policies

Meadow Creek Church Pond In 1999 Bunker Lake Blvd was reconstructed. At that time, Stormwater from the roadway was routed to the pond at Meadow Creek Church securing treatment of all of drainage area 7.

Coon Creek Aquaduct The aquaduct from Coon Creek to Crooked Lake is the outlet for subwatershed 10. The old channel and the wetland remaining adjacent wetland areas provide sufficient storage for a long enough period of time to gain non-point treatment for subwatershed 10

Storm Water Pollution Prevention Planning (SWPPP) The cities of Andover, Coon Rapids, and the Coon Creek Watershed District are MS4s under the NPDES program administered by the MPCA. All three units of government are required to develop plans and programs for the protection and improvement of water quality within their jurisdictions, to the maximum extent practicable.

Current Situation Non-point pollution is pollution that occurs when rainfall, snowmelt, or irrigation runs over land or through the ground, picks up or dissolves pollutants, and deposits them into rivers, lakes, and other waters or

introduces them into ground water.

Urban surfaces are subject to the deposit of various contaminants which are then subject to wash-off by rainfall or snowmelt. Typical contributors to pollutants in runoff include vehicular traffic, industry, power production, lawn care, pets, eroded sediment and vegetative litter.

The major nonpoint-source pollutants include sediment, nutrients, oxygen-demanding substances, toxic chemicals, chloride, bacteria and viruses and temperature changes.

Water quality indicators such as chlorophyll-a, total phosphorus, and water clarity provide a good measure of non-point pollution impacts on the lake. Generally speaking, these indicators have showed significant improvement over the lake monitoring period and continued this improvement over the last 5 years. Sustaining the current water quality condition of Crooked Lake is important to its long term health.

Assessment

Management Goal(s)

Provide for the non-degradation of current water quality in Crooked Lake.

Measures

Phosphorus, Total	40 mg/L
Chlorophyll-a	<15 mg/L
Secchi disk transparency	>1.2 meters
Oxygen, dissolved	>5 mg/L daily average
	>4 mg/L daily minimum

Milestones

Production of educational products (i.e. brochures, pamphlets, PSA's)
Annual inspection report of stormwater infrastructure.

Recommended Strategies to Achieve these Goals

Education Outreach

Increase Best Management Practice awareness for lakeshore owners; topics may include proper fertilizer use, pet waste, lawn clippings.

Inspection and Maintenance of Stormwater Infrastructure

Continue inspections of stormwater best management practices including the public ditch system, on a regular basis to ensure proper installation and maintenance.

Implementation Schedule/Responsibilities

Method	Unit Cost	ACD	CLAA	CCWD	Andover	CR	DNR
Education Outreach	$660		Lead	Finance & Lead			
Inspection/Maintenance of Stormwater Infrastructure	--			Lead	Lead	Lead	

Table 7. Non Point Source Pollution Implementation Schedule/Responsibilities.

Costs

Agency	Activity	2014	2015	2016	2017	2018	Total
CCWD	Education Outreach	$660					$1,330

Table 8. Cost Estimate for Implementation Plan.

5.4 Lake Vegetation

Demands and Preferences

Needs

"Weeds" were identified as a concern in 2013 but ranked low in overall public importance receiving only one submission. However, the composition of the native plant community is important to the ecology of Crooked Lake and vital to the long term health of the lake. Sustaining a diverse plant community increases lake resiliency and helps to protect the lake from outside threats.

Problem Statement

The number of native plant species in Crooked Lake has declined since 2011. Occurrence rates of Coontail, Muskgrass, and Illinois Pondweed are increasing in Crooked Lake. The dominance of these three species is likely a response to the sudden reduction of EWM in response to 2013 treatment. Native species, especially in eutrophic lakes, have the ability to reach nuisance levels affecting recreational use in near shore areas.

Watershed & Lake Characteristics

Extensive Littoral Zone

The littoral zone, the preferred habitat of a majority of native aquatic plants, encompasses 73% of the lake. This means 86 of the 118 surface acres is good habitat for native plant establishment.

Lake sediments

The lake bed of Crooked Lake is primarily composed of muck, a nutrient rich substrate and preferred growth medium for many native plant species.

Native Seed Source

The lake bed of Crooked Lake possesses a rich seed bank of native species based on the recovery of the plant community after the decimation from fluridone treatment in the 1990's and the increased occurrence of natives in 2013 in response to reduced EWM.

Increased Insolation (Sunlight penetration and transmission)

Water clarity over the past 5 years has increased by nearly 2.5 feet. In addition, long term lake levels are declining which increases the amount of sunlight reaching lake sediments ultimately creating conditions favorable for increased vegetation growth.

Management Programs and Policies

Aquatic plants growing in public waters are the property of the state.

Because of their value to the lake ecosystem, aquatic plants may not be destroyed or transplanted unless authorized by the Department of Natural Resources as stipulated in the Aquatic Plant Management Rules.

Prohibited Plant Control Methods

The following plant control methods are prohibited in Minnesota;

1. Excavating the lake bottom for aquatic plant control
2. Use of hydraulic jets
3. Destroying or preventing the growth of aquatic plants by using lake bottom or benthic barriers

4. Removing aquatic vegetation within posted fish-spawning areas
5. Removing aquatic plants from an undeveloped shoreline
6. Removing aquatic plants where they do not interfere with swimming, boating, or other recreation

Control methods requiring DNR permit

The following control methods require DNR permitting;

1. Destruction of ANY emergent vegetation (i.e. cattails, bulrushes)
2. Cutting or pulling by hand, or by mechanical means, submerged vegetation in an area larger than 2,500 square feet.
3. Applying herbicides or algaecide.
4. Moving or removing a bog of any size that is free-floating or lodged in any area other than its place of origin in public waters.
5. Transplanting aquatic plants into public waters.
6. Use of automated aquatic plant control devices (such as the Crary WeedRoller).
7. Physical removal of floating-leaf vegetation from an area larger than a channel 15 feet wide extending to open water.

Control methods NOT requiring a DNR permit

If a lakeshore property owner wishes to create or maintain a swimming or boating dock area, they may cut or pull submerged vegetation without permit as long as;

1. Total area to be cleared must be no larger than 2500 square feet, and;
2. Cleared area must not extend more than 50 feet along the shoreline or one-half the length of your shoreline, whichever is less.

A channel up to 15 feet wide, and as long as necessary to reach open water, may also be cleared through submergent vegetation. The cutting or pulling may be done by hand or powered equipment that does not significantly alter the course, current, or cross section of the lake bottom. Such control cannot be done with draglines, bulldozers, hydraulic jets, suction dredges, automated aquatic plant control devices, or other powered earth-moving equipment. After you have cut or pulled aquatic plants, you must dispose of them on land to prevent them from drifting onto your neighbor's property or washing back into the lake. In addition, a channel 15 feet wide through floating-leaf vegetation extending to open water may be maintained by mechanical means without a permit. Any other destruction of floating-leaf vegetation requires a permit (MN DNR).

Fisheries

The lake is currently managed for walleye, channel catfish, and largemouth bass. The lake naturally supports a large population of Centrarchids i.e., bluegills, pumpkinseeds and largemouth bass. Dense vegetative cover is

vitally important to these species.

Current Situation With effective EWM management, the prevalence of Coontail and Muskgrass has increased in near shore areas and could reach nuisance levels limiting recreational activities. Control options for native vegetation are rather limited relative to invasive plants. Measures such as cutting, pulling, or using herbicides can control aquatic plants from season to season. But in the long run, the best way to combat excessive growth of aquatic plants is prevention--reducing the nutrient load delivered to the lake via point and nonpoint source pollution.

Assessment

Management Goal(s)

1. Protect diversity of native plant species.
2. Provide for the non-degradation of current water quality in Crooked Lake.

Measures

Phosphorus, Total	40 mg/L
Chlorophyll-a	<15 mg/L
Secchi disk transparency	>1.2 meters (about 4 ft)
Oxygen, dissolved	>5 mg/L daily average
	>4 mg/L daily minimum

No further loss of native plant diversity.
No new introductions of aquatic invasive species.

Milestones Annual plant survey results
Production of educational products (i.e., brochures, PSAs)

Recommended Strategies to Achieve these Goals

Annual Plant Survey Continue annual plant surveys to assess shifts in the native plant community of Crooked Lake.

Implementation Schedule/Responsibilities

Method	Unit Cost	ACD	CLAA	CCWD	Andover	CR	DNR
Annual Plant Survey	$700		Finance				

Table 9. Lake Vegetation Implementation Schedule/Responsiblities.

Costs

Agency	Activity	2014	2015	2016	2017	2018	Total
CLAA	Annual Plant Survey	$700	$710	$721	$731	$742	$3,604

Table 10. Cost Estimate for Implementation Plan.

6.0 Management Activities

This section of the plan addresses recommended management activities for Crooked Lake over the next five years. These activities are proposed to address the management needs of Crooked Lake in the near future. The discussion of each issue will be organized as follows:

Management Activity is the activity title
Description provides a brief explanation of the activity
Goal(s) gives objective(s) of management activity
Specific Components & Notes includes details of activity methods
Measures are quantitative actions to be taken to achieve goal
Milestones are actions as results of the Measures
Implementation Timeline
Responsible Person for this Activity provides contact information
Educational Component Related to this Activity is broken down into:
Audience Involved, Educational Goals, Activities Used, and Responsible Party

The Management Activities are:
6.1 Annual Plant Survey
6.2 Water Quality Monitoring
6.3 Boat Inspections
6.4 Annual Chemical Treatment
6.5 Early Detection Surveys
6.6 Develop AIS Plan
6.7 Educational Outreach
6.8 Lake Level Monitoring
6.9 Ground Water Monitoring
6.10 Annual Dam Inspection
6.11 Inspection of Stormwater Infrastructure
6.12 Groundwater/Surface Water Review

Management Activity	**6.1 Annual Plant Survey**
Description	A survey of aquatic macrophyte species distribution, diversity, and frequency in Crooked Lake.
Goal	The primary goals of surveying aquatic macrophytes are 1) Comparing year-to-year data within a lake, 2) Comparing data among lakes.
Specific Components & Notes:	The formal quantitative survey is conducted at pre-determined sampling locations distributed evenly over the lake surface (point-intercept method). This method, when combined with a boat survey to gather additional information on areas not sampled directly, will best characterize the lake plant community. The baseline sampling should be conducted between early July and mid-August. Although changes (such as biomass) in the plant community through this long sampling window might complicate data interpretation, we are mostly interested in species diversity and frequency, variables that should be fairly constant through the growing season.
Measures	Surveys completed Surveys budgeted Surveys planned
Milestones	Publication/posting of past survey data Mapping of past survey data Budgeting and planning for survey
Implementation Timeline	September – Budget adoption & preliminary work plan January – Annual work plan June (weather dependent) – Conduct pre-treatment delineation survey August – Conduct post treatment point intercept survey
Responsible Person for this Activity	Agency: Crooked Lake Area Association Title: President Phone: 763.422.0682

Educational Component Related to this Activity

Audience	**Goals**	**Activities**	**Resp. Party**
Lakeshore Owners, City Councils (Andover & Coon Rapids)	Communicate that not all "weeds" are invasive.	Winter meeting presentation	CCWD
	Increase awareness regarding benefits of a diverse aquatic plant community	Post lake management plan on Web	CCWD

Management Activity	**6.2 Water Quality Monitoring**
Description	Monitor water quality twice monthly from May-September
Goal	Lake water quality evaluation.
Specific Components & Notes:	Monitoring is done on the following parameters: Chlorophyll-a Conductivity Dissolved Oxygen (DO) pH Salinity Secchi transparency Temperature Total phosphorus (TP) Turbidity Detailed data provided annually in the Anoka Water Almanac including summaries of historical conditions and trend analysis.
Measures	Standard for each parameter: Parameter – Measure Chlorophyll-a – Milligrams per liter Conductivity – mS/cm Dissolved oxygen – Milligrams per liter & % pH Salinity – Percent Secchi transparency – Feet & Meters Temperature – F^o & C^o Total phosphorus – Milligrams per liter Turbidity – FNRU (a standard for measurement)
Milestones	Work plan for ACD and CCWD. Publishing of Anoka County Water Almanac.
Implementation Timeline	January – Work plan for ACD and CCWD May - Monitoring begins September - Monitoring ends Mid-February following year – draft Water Almanac published
Responsible Person for this Activity	Agency: Anoka Conservation District Title: Water Quality Specialist Phone: 763.434.2030

Educational Component Related to this Activity

Audience	**Goals**	**Activities**	**Resp. Party**
Lakeshore Owners	Increase public awareness on the current water quality condition of Crooked Lake.	Annually publish Anoka Water Almanac	ACD

Management Activity	**6.3 Watercraft Inspection Program**
Description	Monitor the public access and watch for boats, trailers, or other equipment that may contain plant fragments or other material that can be viably introduced to the lake.
Goal	To intercept all boats leaving from or coming to Crooked Lake which carry invasive species, and oversee the disposal of those species so that they do not enter the lake.
Specific Components & Notes:	The presence of inspectors should: 1. Occur during high use periods 2. Provide an enforcement presence by photographing and documenting equipment containing plant fragments 3. Emphasize invasive species and general public education on the nature of the lake by providing individual with Crooked Lake and Invasive Species Brochure
Measures	Number of inspections Number of brochures distributed
Milestones	Annual training by MDNR Annual volunteer schedule
Implementation Timeline	Annually April: Train boat inspection volunteers May: Begin inspections
Responsible Person for this Activity	Agency: Crooked Lake Area Association Title: President Phone: 763.422.0682

Educational Component Related to this Activity:

Audience	**Goals**	**Activities**	**Resp. Party**
Inspection Volunteers	1. How to approach a lake user	Training	DNR
	2. How to inspect watercraft	Training	DNR
	3. How to identify invasive species	Training	DNR
	4. How to properly dispose of invasive species	Training	DNR
Boaters/Lake Users	1. How to inspect watercraft	Signage	DNR
	2. How to identify invasive species	Signage	DNR
	3. How to properly dispose of invasive species	Signage	DNR

Management Activity	**6.4 Annual Chemical Treatment**
Description	Involves application of liquid or pelletized herbicides applied to target area or to plants directly. Treatment areas are determined by pre-treatment delineation surveys.
Goal	Reduce Eurasian watermilfoil and Curly leaf pondweed to below nuisance levels: Plants rarely reach the surface Navigation and recreational activities not generally hindered Stem density is 0-160 stems/m^2 Biomass is 0-50 g dry wt/ m^2 Estimated Total Phosphorus (TP) load is <1.7 lbs/acre
Specific Components & Notes:	Aquatic plants growing in public waters are owned by the state and can interfere with riparian property owners' access to lakes. The use of herbicides in lakes to control submerged vegetation, or the destruction of emergent vegetation by any means, require DNR permits. Overall program coordination within DNR is managed by staff in Ecological Services. Permit applications require the following items: 1. <u>Applicant information</u>: a. Crooked Lake Area Association 13415 Heather St NW Coon Rapids, MN 55433 b. (763) 422-0682 c. Permit Number 2. <u>Lake information</u>: Crooked Lake, Anoka County Inventory Number: 02-0084-00 3. Treatment information: Justification Fee information Enclosures
Measures	1. Plants rarely reach the surface 2. Navigation and recreational activities not generally hindered 3. Stem density is 0-160 stems/m^2 4. Biomass is 0-50 g dry wt/ m^2 5. Estimated Total Phosphorus (TP) load is <1.7 lbs/acre
Milestones	Completion of Treatment Treatment Report

Implementation Timeline	Winter: Submit Lake Vegetation Management Plan to DNR and apply for Permit Early Spring: Conduct Pretreatment delineation of EWM & CLP Late Spring: Apply herbicide Fall: Conduct lake vegetation survey
Responsible Person for this Activity	Agency: Crooked Lake Area Association Title: President Phone: (763) 422-0682

Educational Component Related to this Activity

Audience	**Goals**	**Activities**	**Resp. Party**
Lakeshore Owners	Inform residents of contracted treatment areas.	Newsletter Web posting	CLAA CLAA
City Council Members	Inform stakeholders of treatment effectiveness.	Annual Report	CLAA

Management Activity	**6.5 Early Detection Surveys**
Description	Involves biannual inspection of habitats on the lake with high susceptibility to invasive species infestation.
Goal	To identify any newly invading species before they reach nuisance levels.
Specific Components & Notes:	Early detection and early response is critical for effective control of invasive species. Contract ACD to perform a general survey of the littoral zone on a biannual basis for any new invasive species. Conducting a spring and mid-summer survey will provide an adequate effort to detect recently introduced species.
Measures	Surveys completed
Milestones	Survey Report
Implementation Timeline	Spring and Mid-summer, 2014-2018
Responsible Person for this Activity	Agency: Anoka Conservation District Title: Water Quality Specialist Phone: 763.434.2030

Educational Component Related to this Activity:

Audience	**Goals**	**Activities**	**Resp. Party**
Lake Shore Owners	Provide information on species with high risk for introduction	Newsletter AIS Factsheets AIS Plan	CLAA CCWD CCWD
Lake Users	Provide information at landings of what lake users can do if they spot AIS.	Signage	DNR

Management Activity	**6.6 Develop AIS Plan**
Description	Develop an AIS plan that focuses on early detection and rapid response to species posing threats to the water resources within the Coon Creek Watershed District.
Goal	Efficiently and effectively manage AIS through increased education, awareness, prevention, and to coordinate efforts with local partners to protect the ecological integrity of water resources with the Coon Creek Watershed District.
Specific Components & Notes:	The District AIS plan will cover; 1. Background, Issues and Problem Definition 2. Impacts of Aquatic Invasive Species in Coon Creek Watershed 3. Management Priorities 4. Goals 5. Existing Authorities and Programs 6. Aquatic Invasive Species Management Strategy 7. Priorities for Action 8. Implementation Table 9. Program Monitoring and Evaluation
Measures	Mapping existing AIS infestations Number of new infestations
Milestones	Completion of AIS Plan
Implementation Timeline	2014
Responsible Person for this Activity	Agency: Coon Creek Watershed District Title: Invasive Species Specialist Phone: 763.755.0975

Educational Component Related to this Activity:

Audience	**Goals**	**Activities**	**Resp. Party**
General Public, Lakeshore Owners, Lake users	Increase AIS Awareness	Public Service Announcements	DNR
	Educate on actions that can be taken to prevent AIS transport.	AIS signage at public access	DNR
		Partner with Wildlife Forever "Stop Aquatic Hitchhiker Campaign!"	CLAA CCWD
		Promote "Clean, Drain, Dry" campaign	CLAA CCWD

Management Activity	**6.7 Educational Outreach**
Description	Educate Crooked Lake stakeholders on water resource related issues affecting the lake.
Goals	Increase knowledge and awareness of lakeshore BMP's. Increase knowledge and awareness of AIS. Increase knowledge and awareness of lake "health".
Specific Components & Notes:	Provide educational information to Crooked Lake Association, lake users, and other stakeholders through brochures, pamphlets, web links, public service announcements, etc.
Measures	Brochures, pamphlets, web links, public service announcements.
Milestones	Number of annual outreach efforts
Implementation Timeline	2014-2018
Responsible Person for this Activity	Agency: Coon Creek Watershed District Title: Information and Education Coordinator Phone: 763.755.0975

Educational Component Related to this Activity:

Audience	**Goals**	**Activities**	**Resp. Party**
General Public, Lakeshore Owners, Lake users	Increase knowledge and awareness of lakeshore BMP's.	Newsletter Brochures Digital media	CLAA CCWD
	Increase knowledge and awareness of AIS.	Public Service Announcements	DNR
	Increase knowledge and awareness of lake "health".	Newsletter Provide notification of educational opportunities	CLAA CCWD

Management Activity	**6.8 Lake Level Monitoring**
Description	Understanding lake hydrology including impact of climate or other water budget changes. These data are useful for regulatory, building development, and lake management decisions such as resolving water level disputes, determining flood elevations, ground water to surface water recharge relationships, surficial ground water fluctuations, flows and trends, and local zoning (floodplain, shoreland).
Goal	Lake water levels will be recorded weekly by volunteers during ice-out conditions.
Specific Components & Notes:	• Install and survey lake gauge • Coordinate volunteers; for example, provide equipment and datasheets • Troubleshoot problems such as moving gauges in low or high water conditions • Receive data, check its quality, and submit to state databases.
Measures	Lake elevation in feet above mean sea level
Milestones	Data periodically submitted to the DNR for inclusion in their "Lakefinder" database. Final report in the Anoka Water Almanac
Implementation Timeline	Spring ice-out: install and survey Open water season: volunteers take weekly readings. Late October: remove gauges from lakes in locations where they could be a danger to snowmobiles or others. Feb. 15 following year: rough draft of Anoka Water Almanac report. March 31 following year: final draft of Anoka Water Almanac report.
Responsible Person for this Activity	Agency: Anoka Conservation District Title: Water Quality Specialist Phone: 763-434-2030

Educational Component Related to this Activity:

Audience	**Goals**	**Activities**	**Resp. Party**
Lakeshore Owners, CLAA, City of Andover, City of Coon Rapids, DNR	Provide annual average lake level information for incorporation into long term trend analysis.	Web posting for public viewing	ACD, DNR
		Publish Anoka Water Almanac	ACD

Management Activity	**6.9 Ground Water Monitoring**
Description	This activity involves monitoring the elevations of the surficial aquifer up and down gradient from Crooked Lake.
Goal	To protect ground water supplies and determine water inputs and outputs to Crooked Lake.
Specific Components & Notes:	Collect and analyze well logs in the hydrogeologic vicinity of Crooked Lake. Develop a Hydrogeologic atlas and picture of the groundwater supply and loss to and from Crooked Lake. Establish transects, wells, and peizometers to monitor the surficial aquifer.
Measures	Surficial groundwater elevations
Milestones	Hydrogeologic atlas Calculation of 1, 5, and 10 year times of travel
Implementation Timeline	2015
Responsible Person for this Activity	Agency: Coon Creek Watershed District Title: District Administrator Phone: 763-755-0975

Educational Component Related to this Activity:

Audience	**Goals**	**Activities**	**Resp. Party**
Lakeshore Owners, CLAA, DNR, City of Andover, City of Coon Rapids, and groundwater users	Establish understanding of groundwater/surface water interactions	GIS Maps/Animations	CCWD

Management Activity	**6.10 Annual Dam Inspection**
Description	Ensure that the earthen dam and outlet of Crooked Lake is in proper repair
Goal	Detect and repair potential issues threatening the integrity of the dam.
Specific Components & Notes:	The Crooked Lake dam is inspected annually. Inspection in 2013 showed no leakage or signs of recent discharge.
Measures	Inspection completed annually
Milestones	Annual Inspection Report Annual county water atlas
Implementation Timeline	Annually, 2014-2018
Responsible Person for this Activity	Agency: Coon Creek Watershed District Title: Operations and Maintenance Coordinator Phone: 763-755-0975

Educational Component Related to this Activity:

Audience	**Goals**	**Activities**	**Resp. Party**
Lakeshore Owners, City of Coon Rapids	Assure stakeholders of dam integrity	CLAA Newsletter	CLAA

Management Activity	**6.11 Inspection/Maintenance of Stormwater Infrastructure**
Description	The Watershed District will inspect best management practices (BMPs) on a regular basis to ensure proper installation and maintenance. Involves inspection of the public ditch system and adherence to preventive maintenance strategy and practices.
Goal	Annually inspect 20% of stormwater infrastructure.
Specific Components & Notes:	The inspection will take specific note of any object or condition affecting the course, current, cross section, or quality of the public ditch, drainage way, or conveyance. The District will conduct an annual inspection of the Crooked Lake dam and outlet, weirs, ponds, etc. The District Inspector will continue to perform a spring flood inspection program at critical points within the hydrologic system. Inspections will occur; 1. During or immediately following installation of BMPs 2. Following severe storms/critical events 3. Prior to seeding deadlines, particularly in the fall 4. Prior to return of escrows 5. On report of issue
Measures	Annual Inspection
Milestones	Annual Inspection report Annual SWPPP report
Implementation Timeline	January – Annual public review and discussion of SWPPP June – Annual report due to NPDES
Responsible Person for this Activity	Agency: Coon Creek Watershed District Title: Operations and Maintenance Coordinator Phone: 763.755.0975

Educational Component Related to this Activity:

Audience	**Goals**	**Activities**	**Resp. Party**
CLAA, Lakeshore Owners,	Educate residents on condition of stormwater infrastructure	Inspection Report	CCWD City of Andover City of Coon Rapids

Management Activity	**6.12 Groundwater/Surface Water Review**
Description	Conduct review of groundwater/surface water interactions.
Goal	To gain better understanding of groundwater levels and the effect it has on surface waters. To better understand the groundwater supply and loss to and from Crooked Lake.
Specific Components & Notes:	Collect and analyze well logs from observation well networks. Collect and analyze geologic information provided through MN DNR geologic atlas. Analyze Anoka County Hydrogelogic Atlas upon its release.
Measures	Groundwater levels Geologic setting
Milestones	Release of Anoka County Hydrogeolgic Atlas
Implementation Timeline	2014-2018
Responsible Person for this Activity	Agency: Coon Creek Watershed District Title: District Administrator Phone: 763.755.0975

Educational Component Related to this Activity:

Audience	**Goals**	**Activities**	**Resp. Party**
Lakeshore Owners, CLAA, DNR, City of Andover, City of Coon Rapids, and groundwater users	Educate on the potential impacts declining groundwater can have on surface waters.	GIS Maps/Animations	CCWD
		Informational material (i.e., webpages, articles) on connectedness of groundwater and surface water	CCWD, CLAA, DNR

7.0 Implementation Plans

This section contains the implementation plans for each of the six organizations involved in management activities for Crooked Lake. These organizations were identified because each has programs and/or policies in place with direct impact on Crooked Lake. Detail for each organization can be found in Appendix C (Page 138).

7.1 Anoka Conservation District

The Anoka Conservation District will be involved with the following issues:

- Aquatic Invasive Species/ Milfoil
- Lake Levels
- Nonpoint Source Pollution
- Native Aquatic Vegetation

Goals

The Anoka Conservation District will pursue the following goals:

1. Identify strategies to restore or enhance lakeshore habitat
2. Reduce nonpoint pollution to Crooked Lake
3. Increase diversity of native submersed aquatic plants
4. Better understanding of groundwater/surface water interactions
5. No new invasive species infestations in Crooked Lake

Role	Routine Activity	2014	2015	2016	2017	2018
Lead	Water Quality Monitoring	X	X	--	X	X
Tech Assist	Annual Plant Survey	X	X	X	X	X
Tech Assist	Annual Plant Survey Map	X	X	X	X	X
Lead	Early Detection surveys	X	X	--	X	X
Tech Assist	Ground Water Monitoring	X	X	X	X	X
Tech Assist	Lake Level Monitoring	X	X	X	X	X

7.2 Crooked Lake Area Association

The Crooked Lake Area Association will be involved with the following issues:

- Aquatic Invasive Species/ Milfoil
- Nonpoint Source Pollution
- Native Aquatic Vegetation

Goals

The Crooked Lake Area Association will pursue the following goals:

1. Identify strategies to restore or enhance lakeshore habitat
2. Increase diversity of native submersed aquatic plants
3. Reduce interference with recreational use of Crooked Lake caused by Eurasian water milfoil
4. Reduce nonpoint pollution to Crooked Lake
5. Keep Crooked Lake Clean
6. No new invasive species infestations in Crooked Lake

Role	Routine Activity	2014	2015	2016	2017	2018
Finance	Annual Plant Surveys	X	X	X	X	X
Lead	Annual Chemical Treat.	X	X	X	X	X
Role	**Non- Routine Activity**	**2014**	**2015**	**2016**	**2017**	**2018**
Lead	Boat Inspection	X	X	X	X	X
Lead	Education Outreach	X	X	--	--	--

Costs

Routine Activity	Unit Cost	2014	2015	2016	2017	2018	Total
Annual Plant Survey (pre-treatment)	$850	$850	$862	$875	$888	$902	$5,295
Annual Plant Survey (post-treatment)	$700	$700	$710	$721	$731	$742	$3,604

7.3 Coon Creek Watershed District

The Coon Creek Watershed District will be involved with the following issues:

- Aquatic Invasive Species/ Milfoil
- Lake Levels
- Nonpoint Source Pollution
- Native Aquatic Vegetation

Goals

The Coon Creek Watershed District will pursue the following goals:

1. Identify strategies to restore or enhance lakeshore habitat
2. Reduce nonpoint pollution to Crooked Lake
3. Reduce interference with recreational use of Crooked Lake caused by Eurasian water milfoil
4. Increase diversity of native submersed aquatic plants
5. Better understanding of groundwater/surface water interactions
6. No new invasive species infestations in Crooked Lake

Role	Routine Activity	2014	2015	2016	2017	2018
Finance	Lake Water Quality Monitoring	X	X	--	X	X
Finance	Lake Level Monitoring	X	X	X	X	X
Finance & Lead	Annual Dam Inspection	X	X	X	X	X
Finance	Early Detection Surveys	X	X	--	X	X
Lead	Inspection/Maintenance of Stormwater Infrastructure	X	X	X	X	X
Finance	Groundwater Monitoring	X	X	X	X	X
Role	**Non-Routine Activity**	**2014**	**2015**	**2016**	**2017**	**2018**
Lead	AIS Plan	X	--	--	--	--
Finance	Educational Outreach	X	X	--	--	--
Lead	Groundwater/surface water review	X	X	--	--	--

Costs

Routine Activity	Unit Cost	2014	2015	2016	2017	2018	Total
Lake Water Quality Monitoring	$160/sample	$1,600	$1,624	--	$1,672	$1,696	$6,592
Early Detection Surveys	$583	$583	$591	--	$609	$618	$2,401
Lake Level Monitoring	$250	$250	$254	$258	$262	$268	$1,292
Groundwater Monitoring	$525/well	$1,575	$1,599	$1,623	$1,647	$1,671	$8,115
Annual Dam Inspection	$56	$56	$57	$58	$59	$60	$290
Non-Routine Activity	**Unit Cost**	**2014**	**2015**	**2016**	**2017**	**2018**	**Total**
Educational Outreach	$650	$650	$660	--	--	--	$1,310
Totals	--	$4,714	$4,785	$1,939	$4,249	$4,313	$20,000

7.4 City of Andover

The City of Andover will be involved with the following issues:

- Aquatic Invasive Species/ Milfoil
- Nonpoint Source Pollution

Goals

The City of Andover will pursue the following goals:

1. Reduce interference with recreational use of Crooked Lake caused by Eurasian water milfoil (EWM) and curly leaf pondweed
2. Keep Crooked Lake Clean
3. Reduce nonpoint pollution to Crooked Lake
4. No new invasive species infestations in Crooked Lake

Role	Routine Activity	Unit Cost	2014	2015	2016	2017	2018
Finance	Annual Chemical Treatment	$169/acre	X	X	X	X	X
Lead	Inspection/Maintenance of Stormwater Infrastructure	--	X	X	X	X	X

Costs

Routine Activity	Unit Cost	2014	2015	2016	2017	2018	Total
Annual Chemical Treatment	$169/acre	$2,873	$2,916	$2,959	$3,002	$3,045	$14,795

Summary

Plan Assumes that the city of Andover will:

1. Continue to contribute money to the annual treatment of EWM in the lake, including treatment of up to 40% of lake littoral zone per DNR variance.
2. Inspect Meadow Creek Pond & the Aqueduct & Maintain to specs (NURP Stds.)

7.5 City of Coon Rapids

The City of Coon Rapids will be involved with the following issues:

- Aquatic Invasive Species/ Milfoil
- Nonpoint Source Pollution

Goals

The City of Andover will pursue the following goals:

1. Reduce interference with recreational use of Crooked Lake caused by Eurasian water milfoil (EWM) and curly leaf pondweed
2. Keep Crooked Lake Clean
3. Reduce nonpoint pollution to Crooked Lake
4. No new invasive species infestations in Crooked Lake

Role	Routine Activity	Unit Cost	2014	2015	2016	2017	2018
Finance	Annual Chemical Treatment	$169/acre	X	X	X	X	X
Lead	Inspection/Maintenance of Stormwater Infrastructure	--	X	X	X	X	X

Costs

Routine Activity	Unit Cost	2014	2015	2016	2017	2018	Total
Annual Chemical Treatment	$169/acre	$2,873	$2,916	$2,959	$3,002	$3,045	$14,795

Summary

Plan Assumes that the city of Coon Rapids will:

1. Continue to contribute money to the annual treatment of EWM in the lake, including treatment of up to 40% of lake littoral zone per DNR variance.

7.6 Minnesota DNR

The Minnesota Department of Natural Resources (MDNR) will be involved with the following issues:

- Invasive Species
- Lake Levels

Goals

The DNR will pursue the following goals:

1. Reduce interference with recreational use of Crooked Lake caused by Eurasian water milfoil (EWM)
2. Increase diversity of native submersed aquatic plants
3. No new invasive species infestations in Crooked Lake

Role	**Routine Activity**	**Unit Cost**	**2014**	**2015**	**2016**	**2017**	**2018**
Tech Assist	Annual Plant Survey	--	X	X	X	X	X
Regulatory Oversight	Annual Chemical Treatment	--	X	X	X	X	X
Role	**Non-Routine Activity**	**Unit Cost**	**2014**	**2015**	**2016**	**2017**	**2018**
Tech Assist	Groundwater/surface water review	--	X	X	--	--	--
Tech Assist	Watercraft Inspection	--	X	X	X	X	X

Appendix A

Rules, Regulations, and Standards Affecting Lake Management

In-Lake Requirements, Regulations, & Standards

Topic	Minnesota Rule	Synopsis of Regulation or Standard
Transport of Invasive Species	6216.0000	Individuals may not transport watercraft or related equipment containing prohibited invasive species on public roads.
Aquatic Plant Management	6280.0350	**Pesticide control of aquatic macrophytes** On all public waters and watercourses treatment is limited to: The lesser of 15 percent of the littoral area or A maximum of 100 feet of shoreline per site belonging to an individual riparian property owner may be treated for control of submerged vegetation.
		Riparian property owners' associations Applications for large area or baywide treatment must include a written statement of the plan and a map showing areas proposed to be treated. The Commissioner may reduce the amount of littoral area which the applicant proposes to control.
Excavation Of Public Waters	6115.0200	**Standard**: Limit the excavation of materials from the beds of public waters in order to: A. preserve the natural character of public waters and their shorelands B. regulate the nature, degree, and purpose of excavations so that excavations will be compatible with the capability of the waters to assimilate the excavation; Prohibited excavation Excavation is prohibited in the following cases: A. Where it is intended to gain access to navigable water depths when such access can be reasonably attained by alternative means which would result in less environmental impact; C. When the proposed excavation will be detrimental to significant fish and wildlife habitat and there are no feasible, practical, or ecologically acceptable means to mitigate the effects;

Topic	Minnesota Rule	Synopsis of Regulation or Standard
Water Quality Standards	7050.0222	Classifies Crooked Lake as a 2C lake with the following standards: **Parameter** — **Standard** Phosphorus, Total — 40 mg/L Chlorophyll-a — <14 µg/L Secchi disk transparency — >1.4 meters Oxygen, dissolved — >5 mg/L daily average; >4 mg/L daily min.

Watershed Requirements, Regulations, & Standards

Groundwater		
	Rule	CCWD Rule 9.3
	Policy	1. To implement the purpose and intent of the water quality provisions of the District's Comprehensive Management Plan as they may relate to ground water. 2. To maintain the present and natural rate of recharge to the surficial aquifer, and when possible, enhance the rate of recharge. 3. To ensure a dependable water supply and ensure the integrity of natural drainage patterns. 4. To protect fresh water supplies from the dangers of drought, overdraft, pollution, or mismanagement. 5. To define the roles and responsibilities of governmental units in implementing land use controls for the protection of groundwater quality 6. To prevent property damage, and the losses and risks associated with flood conditions that may arise from high water tables.
	Regulation	A person must submit a permit application and obtain a permit from the District for appropriation or disposal of groundwater. The withdrawal of ground and surface water and the location of the place of discharge thereof shall conform to the standards of the Minnesota Pollution Control Agency and the Department of Natural Resources Consider alternative measures to conserve, allocate and use ground water, versus removing the water from the area and watershed. Demonstrate that at a minimum, recharge from the one inch storm from impervious surfaces will be infiltrated. Infiltration shall not be allowed within a one year travel zone of a public well as determined by the municipal well-head protection plan
	Standards Standards	1. The quality of water infiltrated to the water table or surficial aquifer shall remain unchanged or improved by the land disturbance activity. 2. Low floors must be at least 2 feet above high water table elevation or mottled soils, whichever is higher, unless the applicant can show that the potential for property damage, and the losses and risks associated

Groundwater		
		with high water table conditions are nonexistent or acceptably remote or as required by local ordinance 3. Ground water may not be discharged in a manner that causes erosion or flooding of the site or receiving channels or a wetland. 4. Water pumped from a project site shall be treated by temporary sedimentation basins, grit chambers, sand filters or other appropriate controls designed and used to remove particles of 100 microns or greater for the highest pumping rate. 5. The withdrawal from the Surficial Aquifer and the location of the place of discharge thereof shall conform to the standards of the Minnesota Pollution Control Agency and the Department of Natural Resources.

Stormwater		
	Rule	CCWD Rule 9.5
	Policy	1. To promote, preserve and enhance the water and related land resources of the Coon Creek Watershed. 2. To implement the nondegradation requirements of the NPDES program using 1988 as the baseline year and load allocation reductions or management practices noted in a District adopted Total Maximum Daily Loads (TMDLs) implementation plan 3. To protect water and related land resources of the Coon Creek Watershed from the adverse effects resulting from poor or incompatible land use activities. 4. To implement applicable TMDLs 5. To encourage compatibility between land use activities upstream and downstream and natural resource capacity. 6. To regulate land-disturbing activities affecting the course, current or cross section of ditches and water courses. 7. Regulate improvements by riparian property owners of the bed, banks, and shores of lakes, streams, and wetlands for preservation and beneficial use.
	Regulation	A person must submit a permit application and obtain a permit from the District incorporating a stormwater plan before commencing an activity described in the scope and applicability section above. Unless determined by the District to be exempt or granted a

Stormwater		
	Regulation	waiver, the following shall be addressed for stormwater management at all sites: 1. All site designs shall establish stormwater management practices to control the peak flow rates of stormwater discharge associated with the 1, 10, 25, and 100 year design storms and reduce the generation of stormwater. 2. All stormwater management practices will be designed so that the specific storm frequency storage volumes (e.g. recharge, water quality, channel protection, 10 year and 100 year) as identified in the current Minnesota Pollution Control Agency Stormwater Design Manual are met, unless the District grants the applicant a waiver or the applicant is exempt from such requirements. 3. Stormwater volume management practices shall be the equivalent of infiltrating the first inch of precipitation 4. These practices should seek to utilize pervious areas for stormwater treatment and to infiltrate stormwater runoff from driveways, sidewalks, rooftops, parking lots and landscaped areas to the maximum extent practical to provide treatment for both water quantity and quality. 5. In addition, if regulatory, hydrologic, topographic or landscape conditions (e.g. drainage sensitive uses, TMDL or nondegradation requirements) warrant greater control than that provided by the minimum control requirements, the District reserves the right to impose additional requirements deemed necessary to control the volume, timing and rate of runoff. 6. Applicants shall consult the Minnesota Pollution Control Agency Stormwater Design Manual for guidance on the factors that determine site design feasibility when selecting a stormwater management practice. Stormwater management practices for a site shall be chosen based on the physical conditions of the site. Among the factors that should be considered: • Topography • Maximum Drainage Area • Depth to Water Table • Soils • Slopes • Terrain • Head Location in relation to environmentally sensitive features or urban areas.
	Standards	1. Stormwater leaving the site must be routed to a public

Stormwater		
		drainage system 2. Drainage sensitive uses downstream from the proposed site must be accounted for and their ability to discharge in a timely manner must be assured. 3. Stormwater plans must ensure that discharge rates from the proposal are controlled such that within Drainage-Sensitive Uses Areas the post-development 100-year peak flow rate shall not exceed predevelopment 25-year peak flow rate (by subwatershed) 4. In Non-Drainage Sensitive Uses Areas the post-development 100-year peak flow rate shall not exceed predevelopment 100-year peak flow rate (by subwatershed) 5. The proposal must infiltrate the first one inch of precipitation

Water Quality		
	Rule	CCWD Rule 9.6
	Policy	1. To control and minimize pollution caused by erosion and sedimentation. 2. To reduce siltation to, and the pollution of water bodies and streams. 3. To preserve and improve the quality of the lakes and wetlands within the watershed 4. Improve the quality of the surface and subsurface discharges to the lakes and wetlands within the watershed by limiting nutrients and other contaminants 5. To pursue non-degradation of the waters of the District
	Regulation Regulation	A person must submit a permit application and obtain a permit from the District incorporating a stormwater plan before commencing an activity described in the scope and applicability section above. Unless determined by the District to be exempt or granted a waiver, the following shall be addressed for water quality management at all sites: All discharges into wetlands and waterbodies must be pretreated by an appropriate best management practice. The proposal shall not cause extreme fluctuations of water levels or temperature changes in wetlands or streams. The proposal shall not detrimentally affect the existing water quality of the receiving water. All stormwater management practices shall be designed to convey stormwater to allow for the maximum removal

Water Quality		
	Regulation	of pollutants and reduction of flow velocities. These shall include, but not be limited to: a. Maximizing of flowpaths, where appropriate, from inflow points to outflow points b. Protection of inlet and outfall structures c. Elimination of erosive flow velocities d. Providing of underdrain systems, where applicable For new development, structural stormwater treatment practices shall be designed to remove 80% of the average annual post development total suspended solids (TSS) unless otherwise specified by a TMDL or nondegradation requirement. All stormwater treatment practices shall have an acceptable form of water quality pretreatment, in accordance with the pretreatment requirements found in the current stormwater design manual. All stormwater runoff generated from new development shall not discharge untreated stormwater directly into jurisdictional wetlands or local water bodies without adequate treatment. Where such discharges are proposed, the impact proposed on wetland function shall be assessed using a method acceptable to the District. In no case shall the impact on wetland function or value be allowed to degrade the current function as identified in the District's Comprehensive Water Management Plan. Stormwater discharges to critical areas with sensitive resources or where a TMDL is in place may be subject to additional performance standards, or may need to utilize or restrict certain stormwater management practices. Stormwater discharges from land uses or activities with higher potential pollutant loadings, may require the use of specific structural STPs and pollution prevention practices.
	Standards	It is presumed that a Stormwater Treatment Practices (STP) complies with this performance standard if it is: 1. Sized to capture the prescribed water quality volume 2. Designed in accordance with specific design standards outline in an approved stormwater design manual 3. Constructed properly 4. Maintained properly

Fish and Wildlife		
	Rule	CCWD Rule 9.8
	Policy	It is the policy of the District to

Fish and Wildlife		
		1. To prevent loss of wildlife and vegetation and the habitats on which they depend. 2. To protect, preserve and manage unique resource areas and unique and/or endangered species of plants and animals that populate these areas from adverse impacts associated with land use change.
	Regulation	No person shall impact an endangered species, threatened species, special concern species <u>or elements</u>, or communities, without first obtaining a permit from the District.
	Standards	Applicant must: 1. Establish the presence of endangered, threatened or special concern species or communities on-site and the source of that information. 2. Assess the potential effect on wildlife and vegetation and the habitats on which they depend. 3. The District may require applicant to provide a habitat management plan when the District determines applicant cannot avoid direct or indirect impacts on the habitat in question.
	Standards	Assessment of significant adverse impacts should be based on the following factors: 1. The amount of vegetation/habitat removal and/or alteration within the development site 2. The amount of habitat of similar type and quality within the development site that remains contiguous 3. The existing and proposed amount of lot coverage 4. The existence of contiguous habitat of similar type and quality on adjoining land 5. Mitigation efforts that directly address the negative effects of the proposed land use on wildlife habitat.

Appendix B

1.0 2008 Lake Management Priorities

1.1 Introduction

On March 25th, 2008, a public workshop on issues facing Crooked Lake was held at Crooked Lake Elementary School. Coon Creek Watershed District (CCWD) sponsored the workshop with promotional help from the Crooked Lake Area Association (CLAA). Several workshop members had attended a presentation on Shallow Lake Ecology by CCWD staff (Joe Bischoff, Wenck) at the CLAA winter membership meeting held one month earlier on February 28, 2008.

Seven questions were asked of the group at the public input workshop. The first two were posed to the group publicly. The next five questions were answered privately with individual responses on 3x5 cards with each question on a different color card and placed under categories determined by issues in Question 3. The questions posed were:

1. Why is Crooked Lake special (or not special)? *to live,*to play, *to be near
2. What aspects of Crooked Lake would you like to see improved?
3. What do you believe are the three major issues facing Crooked Lake?
4. What is causing these issues?
5. What factors contribute to these causes?
6. What actions do you think are needed to address each of these factors?
7. Who should take the lead in addressing each of these actions?

1.2 Perceived Lake Management Priorities

As part of the 2008 CLMP, management activities were proposed to best manage five issues identified at the public workshop: Eurasian Water Milfoil, Water Clarity, Muck, Nonpoint Pollution, Trash/Garbage, and Water Levels. The following pages provide summaries of each identified issues. Summaries include issue identification, management needs, and 2014 progress assessments.

Issue: Invasive Species (EWM & CLP)

Issue Identification

Problem Statement	In the eyes of the public, the presence of Eurasian watermilfoil and curly leaf pond weed were the most often cited problem needing to be addressed. Both species interfere with recreational and aesthetic use of the lake.
Demands and Preferences	The presence of invasive species is seen as the single biggest liability to the use and enjoyment of Crooked Lake, and is some instances, to individual home and property values. What is desired is a lake where invasive species are either below nuisance levels (not readily seen or interfering with boating or swimming) or eliminated from the lake

Management Needs

Annual Plant Surveys	Annual survey of aquatic macrophyte species, distribution, diversity, and frequency in Cooked Lake.
Annual Chemical Treatment	Involves application of liquid or pelletized herbicides applied to target area or to plants directly.
Apply for Treatment of 20% Littoral Zone	Involves application of liquid or pelletized herbicides applied to target area or to plants directly over 20% of the littoral zone.
Boat Inspection	Monitor the public access and watch for boats, trailers, or other equipment that may contain plant fragments or other materials that can be viably introduced to the lake.
Plant Restoration	Approaches to the re-establishment of submerged macrophytes in shallow lakes can be broken down in two basic strategies: Internal and External. <u>Internal strategies</u> rely on plant regeneration "internal" to the lake by relying on natural development of submerged macrophytes or volunteerism. This strategy relies on the ability of submerged vegetation to develop naturally from: 1. The existing bank of propagules 2. The remaining macrophyte stands 3. Naturally introduced propagation units. The presence, density, and composition of a seed bank can influence the rate and extent of vegetation establishment. Unsuitable conditions for germination and herbivory by fish and waterfowl may delay recolonization. <u>External strategies</u> rely on artificial support of macrophyte

	development. The more expensive and maintenance intensive artificial support by planting or seeding of submerged plants may be appropriate if: 1. If viable propagation units of desired macrophytes are insufficient or not viable 2. The lake was to become more turbid and establishment and immediate stabilization by submerged macrophytes was needed to salvage a clear-water state. 3. The promotion of specific low growth macrophytes in particular areas of the lake is required to enable recreational use.
Water Quality Monitoring	Monitor lake water quality twice monthly from May-September

Progress Assessment

Measures	Decrease in dominance of Eurasian water milfoil and curly leaf pondweed.
Outcome	Occurrence of EWM has dropped 46% since the 2010 survey. 2013 vegetation surveys show EWM as having the 4th highest occurrence rate behind native species such as Coontail, Muskgrass, and Illinois Pondweed. The increased abundance of these native species was forecasted in the 2012 vegetation plot study done by Freshwater Scientific. EWM occurrence from 2012 to 2013 suggests the increased treatment area was more effective than previous years. CLP had a low occurrence rate across all years. CLP was not detected at any sampling points in 2013.

Issue: Water Clarity

Issue Identification

Problem Statement	Water clarity/transparency is affected by algae, soil particles, and other materials suspended in the water. The clarity/transparency of the water is measured using a Secchi disk. A Secchi disk is a small disk that is lowered into the water until it cannot be seen. The depth at which it disappears when lowered, and reappears when raised are recorded and averaged as a measure of clarity/transparency. Secchi readings are not a direct measure of water quality. However, transparency is often indicative of overall lake water quality, especially in the amount of algae present. It is also a measure of light penetration and therefore plant composition and growth.
Demands and Preferences	Poor water clarity was publicly identified as one of the three most important issues facing Crooked Lake.

Management Needs

Lake Water Quality Monitoring	Monitor water quality twice monthly from May-September.
Pond Inspection	The Watershed District will inspect best management practices (BMP's) on a regular basis to ensure proper installation and maintenance.

Progress Assessment

Measures	Total Phosphorus concentration. Chlorophyll-a concentration.
Outcome	Since 2009, annual average TP concentrations in Crooked Lake have declined to their lowest observed reading in 2012 of 22 µg/L. Chlorophyll-a concentrations have followed the same trend dropping to their lowest recorded observation of 4.93µg/L in 2012. The improvement of both these water quality parameters is observed in Secchi disk observations as well. Secchi depth has increased roughly 2 feet since 2008 when it was identified as a top three concern.

Issue: Muck

Issue Identification

Problem Statement	Muck was the third most-often cited issued facing Crooked Lake in 2008 yet was listed 6th in the aspects of Crooked Lake that people would like to see improved.
Demands and Preferences	Discussions with Lakeshore owners and lake users focused on the north bay of the lake in the vicinity of the boat access. Concerns appeared to address: 1. Weed growth 2. The potential contribution of "muck" from a. Stormsewer outlets b. Carp and turtles stirring up the bottom c. Detritus from previous years plant growth

Management Needs

Dredge Boat Channel for Public Access	IF: 1. Water levels continue to drop, or 2. Sufficient borings of the lake bottom on the north end are taken to define an area where siltation has occurred, Then it may be prudent to pursue a DNR permit for "Works in the bed of public waters" to dredge a channel from the boat access to the main body of the lake.

Progress Assessment

Measures	3-D map of lake substrate and extent of sedimentation.
Outcome	The boat landing was dredged in August 2007 as part of the City of Andover-Crooked Lake Boat Landing project. A total of 218 cubic yards of material was removed from the landing allowing a water depth of 2.5 feet to be maintained approximately 40 linear feet from the end of concrete ramp. Outside of this activity, there is little that can be done to alleviate lake sedimentation since it is a naturally occurring process and conflicts fisheries management objectives.

Problem Title: Nonpoint Source Pollution

Issue Identification

Problem Statement	Nonpoint source pollution was the fourth most-often cited problem facing Crooked Lake.
Demands and Preferences	Nonpoint source pollution tied for second for aspects of Crooked Lake people would like to see addressed

Management Needs

Buffer Strips: Subwatershed 8/Lakeshore	Buffer strips are a vegetated area bordering a lake or stream that exist or are established to: 1. Protect water quality 2. Stabilize shoreline 3. Provide aquatic and terrestrial habitat For water quality, buffer strips work by intercepting sheet flow of surface water before it reaches the water body. By slowing the water and forcing it to flow through the buffer vegetation, increased settling occurs as well as filtration. In addition, the plants take up and utilize the nutrients deposited in the buffer.
Curb Cut Rain Gardens Subwatershed 6, 5, & 3	A rain garden is a planted depression that is designed to absorb rainwater runoff from impervious urban areas like roofs, driveways, walkways, and compacted lawn areas. This reduces rain runoff by allowing stormwater to soak into the ground (as opposed to flowing into storm drains and surface waters which causes erosion, water pollution, flooding, and diminished groundwater). Rain gardens can cut down on the amount of pollution reaching creeks and streams by up to 30%. Native plants are recommended for rain gardens because they generally don't require fertilizer and are more tolerant of local climate, soil, and water conditions. The plants — a selection of wetland edge vegetation, such as wildflowers, sedges, rushes, ferns, shrubs and small trees — take up excess water flowing into the rain garden. Water filters through soil layers before entering the groundwater system. Root systems enhance infiltration, moisture redistribution, and diverse microbial populations involved in biofiltration. Also, through the process of transpiration rain garden plants return water vapor into the atmosphere. A more wide-ranging definition covers all the possible elements that can be used to capture, channel, divert, and make the most of the natural rain and snow that falls on a property

Progress Assessment

Measures	Total Phosphorus	<40 mg/L
	Chlorophyll-a	<15 mg/L
	Secchi disk transparency	>1.2 meters
	Dissolved Oxygen	>5 mg/L daily average
		>4 mg/L daily minimum
Outcome	Since 2009, annual average TP concentrations in Crooked Lake have declined to their lowest observed reading in 2012 of 22 µg/L. Chlorophyll-a concentrations have followed the same trend dropping to their lowest recorded observation of 4.93µg/L in 2012. The improvement of both these water quality parameters is observed in Secchi disk observations as well. Secchi depth has increased roughly 2 feet since 2008 when it was identified as a top three concern. Dissolved Oxygen concentrations maintain >5 mg/L daily average outside of winter months when lows are experienced in depths below 12-15 ft.	

Problem Title: Trash

Issue Identification

Problem Statement	Trash/garbage was the fifth most cited issue facing Crooked Lake and the third most cited issue that citizens noted as wanting to be addressed Attendees to the workshop spoke adamantly about the amount of trash being left at the public access in summer and winter as well as garbage dumping occurring at the public access. Concern was also raised about the amount of trash left on the ice by ice fishermen and others using the lake in the winter.
Demands and Preferences	Citizens on the lake have indicated that they would like increased enforcement presence on the lake from the Cities, Anoka County, and the DNR.

Management Needs

Install Garbage Cans and Signage	Install appropriate number and size of garbage containers that ensures "extra refuse, debris, and material can be disposed of, and the public landing maintains an ordered and policed appearance."
Increased Frequency of Garbage Pick up	This activity involves an aggressive program of garbage and litter pick up at the Crooked Lake public access and park in an effort to present a facility where it is not okay to dump or leave debris.
Enforcement Blitz/Campaign	A two-year effort of aggressive police patrol and enforcement to reduce or eliminate illegal dumping and uses occurring on the Lake.

Progress Assessment

Measures	Number of garbage pick-ups per year. Number of litter pick-ups per year.
Outcome	The city of Andover increased the number of garbage cans at the public boat landing. The city of Andover conducted bi-weekly garbage pick-ups during the summer months. A joint effort between the City of Andover and CLAA resulted in the placement of an ADA porta-potty at the public access in Andover. The City of Coon Rapids increased garbage pickup to four times per week. Twelve new garbage receptacles were added to the park in Coon Rapids.

Problem Title: Water Levels

Issue Identification

Problem Statement	Water levels were the sixth most-cited issue facing Crooked Lake, and the fourth most-cited aspect that citizens wanted to see addressed. It is an issue for boating and lake access at the north and south ends of the lake. The bottom slopes of the lake are very gradual and small variations in the surface elevation of the lake can render both ends unnavigable as well as more conducive to emergent plants. The water level in Crooked Lake is the oldest issue on the lake, dating back to at least 1934. Prior to 1934, Crooked Lake was at an elevation of approximately 860.0 feet. At that time, the public sought to raise the average lake elevation approximately 1 foot. Between 1934 and 1940 several earthen dams were constructed at the sound end of the lake to raise the lake level. The first two dams had leakage problems so were replaced or repaired. The dam raised the normal water level of Crooked Lake over one foot.
Demands and Preferences	Water levels were the sixth most-cited issue facing Crooked Lake, and the fourth most-cited aspect that citizens wanted to see addressed. It is an issue for boating and lake access at the north and south ends of the lake.

Management Needs

Inspect Dam	Ensure that the earthen dam and outlet structure of Crooked Lake is in proper repair through annual inspections.
Lake Level Monitoring	Understanding lake hydrology including impact of climate or other water budget changes. These data are useful for regulatory, building/development, and lake management decisions such as resolving water level disputes, determining flood elevations, ground water to surface water recharge relationships, surficial ground water fluctuations, flows and trends, and local zoning (floodplain, shoreland).
Ground Water Monitoring	This activity involves monitoring the elevations of the surficial aquifer up and down gradient from Crooked Lake.

Progress Assessment

Measures	Inspection report of dam every 5 years. Annual Anoka County water atlas.
Outcome	The Crooked Lake dam has been inspected annually. The dam has a culvert serving as the main outlet structure for Crooked Lake. A

	metal weir welded on the lakeside end of the culvert has an elevation of 861.4 feet which is 0.7 feet below the ordinary high water level of 862.1 feet. Animal burrows in the dam were reported in the 2013 inspection report but are not of concern since they are minimal and at elevations at or above the control elevation. Recommendation to continue monitoring efforts for future repairs. Lake level monitoring since 1985 indicates that Crooked Lake water levels are on a downward trend. This trend is largely driven by periods of low lake levels in the late 80's, 2000, and 2009. Since CLMP development in 2008, Crooked Lake water levels have rebounded slightly mostly due to an exceptionally wet year in 2011, including the wettest July on record. It is probable the recent upswing in lake levels is only a short term deviation from the long term declining trend.

Appendix C

Crooked Lake

2008 Comprehensive Lake Management Plan

2. Introduction

For over 70 years Crooked Lake has been managed, like many lakes, in reaction to issues that have likely reached critical stages. Several agencies and users have jurisdiction or impact on the health of the lake. Yet, there has been no overarching plan or set of goals for the lake except perhaps for the game fishery.

To protect and enhance the health of the lake in the long term, Coon Creek Watershed District (CCWD) has advocated for long range comprehensive planning with the cooperation of the most vital stewards of the lake, the lakeshore residents. Development of this Crooked Lake Comprehensive Lake Management Plan started in the winter of 2007 when CCWD encouraged the Crooked Lake Area Association (CLAA) to consider lake issues comprehensively, and based on scientific information. The CLAA Board supported the development of a comprehensive plan as part of the CCWD 2008 Work Plan. The scope and purpose of the plan was presented to the CLAA membership at their winter meeting in February. In March a public input workshop was held to gain public perspectives and priorities. The workshop was attended in large part by CLAA members. Drafts of the Plan were reviewed by the CLAA Board and a Technical Advisory Committee. The completed plan will be presented to the CLAA membership winter 2009, and posted at the Coon Creek Watershed District website for the public.

2.1 Scope and Purpose of the Plan

The purpose for the Plan is to provide a comprehensive "picture" of the lake based on scientific and historical information. Therefore, this Plan addresses previous research and management actions, long-term goals, ways to achieve those goals, and ecological and economic consequences of those goals. To do this, the scope of the plan includes review and analysis of watershed hydrology, lake water quality, nutrient budgets, aquatic communities and ecology, and specific management and control of the invasive species: Eurasian water milfoil & curly leaf pondweed.

Two primary goals of this Plan are:

3. Understanding the water quality condition of Crooked Lake
4. Developing strategies for the protection and enhancement of water quality

2.2 Identification

Crooked Lake is located in the south central portion of Anoka County, straddling the border between the Cities of Andover to the north and Coon Rapids to the south. It is wholly contained within the Coon Creek Watershed District and designated as Public Water 02-84P by the Minnesota Department of Natural Resources (DNR).

Crooked Lake is a small lake (114 acres), elongated in the north-south direction. It is relatively shallow with an average depth of 9 feet and a large littoral zone comprising 73% of the total lake area. It contains one small (0.5-acre) island in the southwest bay of the lake.

Crooked Lake is sustained by a combination of ground water inputs and surface water runoff from a 260-acre watershed. The watershed includes inputs from the municipal storm sewer systems of both Andover and Coon Rapids. The lake has no natural surface water inlets and one outlet located at the southern end of the lake. The outlet is controlled by a culvert through an earthen dam built in 1935.

Crooked Lake is situated in a residential area where land use is mainly single-family homes. There is a public access to the lake via a DNR boat launch on the north shore in Andover and a city park on the east shore in Coon Rapids.

Figure 2.2.1 Location Map

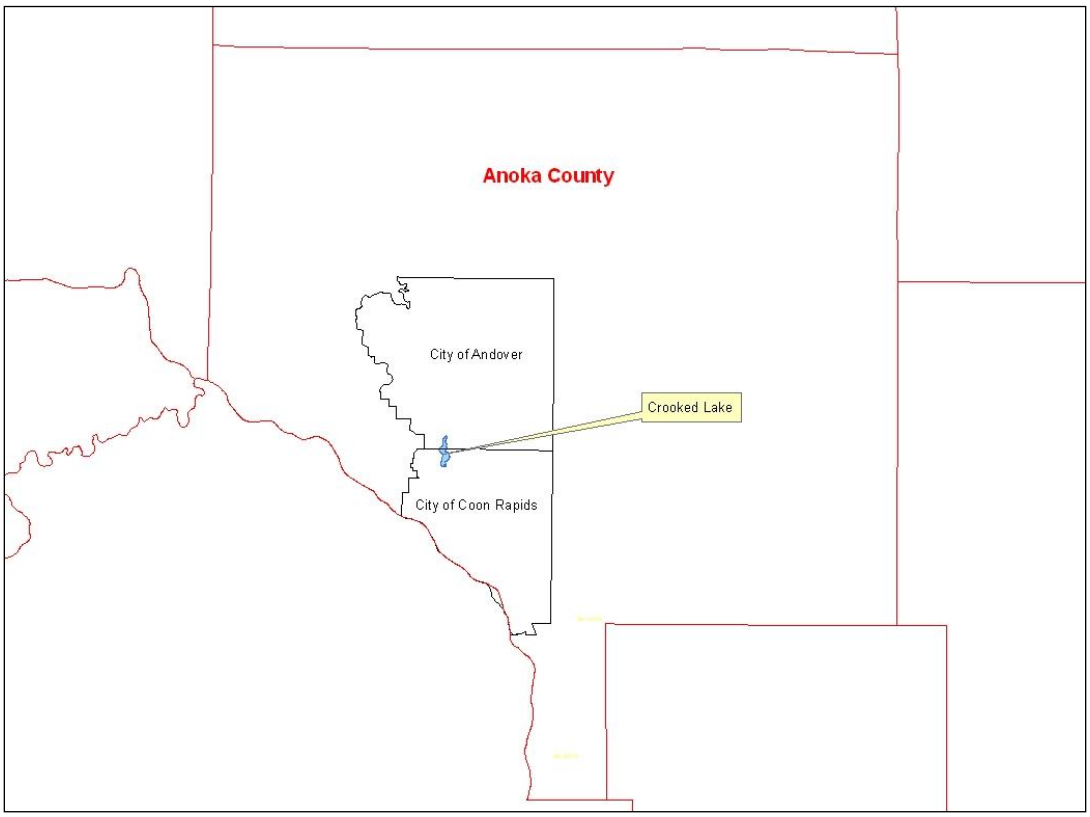
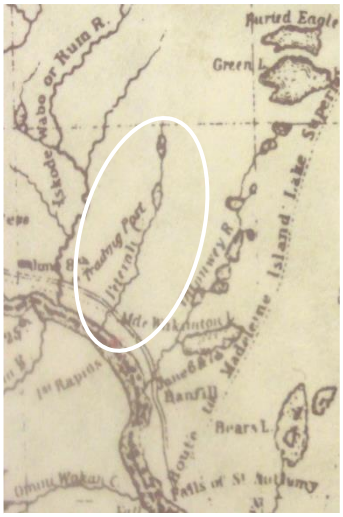


Figure 2.2.2 Crooked Lake Watershed

2.3 History of Use & Management

Crooked Lake has been "on the map" for a long time. It may have been one of two lakes shown connected to a stream on an early map by noted explorer Joseph Nicollet from his 1836-7 exploration of the Mississippi River region. This map shows the Dakotah name, "Peterah," ('burning coals' – burning peats) for Coon Creek. Peterah leads north where it connects with two lakes. Crooked Lake is probably one of those lakes. (source:oral history project, Coon Rapids Historical Commission & Anoka Ramsey Community College).



1843 Map by J. Nicollet based on explorations in 1836-37. Source: Anoka County Historical Society

The creek actually flows about 1/3 mile east of the lake. Before it was ditched in the late 1800s it meandered greatly. Nicollet could possibly have mischarted or misunderstood the creek as flowing to the lake.

Anoka County, 1874. source: www.MNHS.org/True North project

By 1857 Anoka County was legally established and getting settled by Europeans. An 1874 map of Anoka County clearly shows the lake with the surrounding landscape, shown as timbered probably with oak. Nearby roads are also shown that became: Main Street which turns north, currently as Crooked Lake Boulevard, shown stopped at the Section line (current boundary between Coon Rapids and Andover), and Bunker Lake Boulevard just north of the lake.


Annual Farm Bureau Picnic at Crooked Lake, 1921. An estimated 2,500 people attended the event.[39] *Photo: Anoka County Extension Service*

Crooked Lake was being used for community gatherings by the early 1900s. For example, annual picnics were held by Farmers clubs for social and educational purposes. Three sites were rotated annually: Crooked Lake, Lake George, and Camp Salie. In 1921, the Annual Farm Bureau-Farmers Club Picnic was held at Crooked Lake and drew an estimated 2,500 farmers and town folk. The location was probably at Swick's Resort which had a pavilion, store, and 10 cottages for rent. By 1927, there was an adjacent resort with a dancehall and cottages rented for the season, setting the stage for community activities by regularly-attending families from Minneapolis, 20 miles away. The dancehall later burned down.

The Crooked Lake Farmers Club was an active one. Farmers' Clubs had about one-third of all farmers as members, with 19 clubs in Anoka County. Crooked Lake residents were welcomed to join the local club, going to the old schoolhouse for sponsored oyster-stew suppers or to dances at the dancehall with live music. By 1929, though, the numbers dropped and several clubs shut down and by 1935, the Crooked Lake Farmers Club was one of only 5 or 6 clubs left (History of Agriculture: 1900-45, p. 57, Anoka County Historical Society).

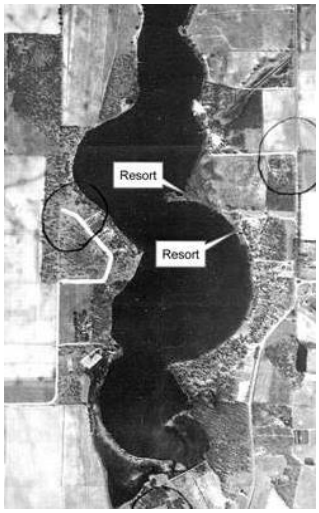
1930s

By the 1930s, Crooked Lake was also used as a 4-H camp site for children. The lake provided the backdrop for teaching agricultural skills, and a place for an early dip and afternoon swimming. During this decade, the southeast shore was split into cabin lots by the Cole/Sewell family, annual resorters who bought the 'dancehall' resort and sold the lots not needed by the family.

Anoka County Agricultural Extension Agent, John L. Currell, gives a demonstration in fitting and blocking sheep during the 4-H Club Camp at Crooked Lake, 1937.[60] *Photo: Anoka County Extension Service*

Crooked Lake FERA project (circled), 1938

The drought of the1930s resulted in very low water levels for the shallow lake. As a result, in 1934 the first recorded management action occurred. The "Crooked Lake Restoration Project" was funded by the Federal Emergency Relief Administration (FERA) to control lake levels. This project consisted of an earthen dyke built at the outlet at the southern tip of the lake and a diversion project in the northeastern quadrant to bring in water from Coon Creek. The work was to be done by the State Emergency Relief Administration which coordinated unemployed workers for public projects, usually funded by the FERA. Due to complications in management and funding, the project ran from 1934-1941 by Works Progress Administration.



Crooked Lake, 1947 aerial, City of Coon Rapids.

1940s

In the 1940s the Crooked Lake community grew, mainly on the east side near the deepest part of the lake where it was more clear and less weedy. The southern resort in this photo was Swick's Resort, and just south of it was "Ted's" barbershop and gas pump with small store run by Ted & Millie Buzzelli once Ted's father died. This legacy lives on;

Millie still runs the store (she died February 2009). The second resort may be mismarked on the photo according to local history, and would have been south of Swick's Resort. The Cole-Sewell family community expanded with new lakefront lots and owners in this area. Gatherings were more family-oriented than for the public communities of the earlier 1900's. Cabins were still rented out and primary access to the lake was through private, not public, property.

Ted's store, 2008, CCWD

1950s

The 1950s brought change to the Crooked Lake landscape. The first report of fish surveys by the MN Department of Conservation began probably because of a noted fish kill during the winter of 1950-51. Post-World War II prosperity resulted in development in the village of Coon Rapids southeast of the lake. Then in 1959 Coon Rapids incorporated as a city with its northern boundary at the Section line so that approximately 60% of the lake is within the city boundary. This part of Coon Rapids developed slower than the area closer to Minneapolis, so use of the lake as a summer retreat continued. The community of cabin owners pooled resources to hire summer swimming instructors.

1960s

Then Coon Rapids grew into a Minneapolis suburb during the 1960s. The number of homes built in the Crooked Lake watershed more than doubled compared to the 1950s. In 1965 the city proposed an eight-acre park with swimming beach in the location of Swick's resort. In response, the community of cabin owners reorganized into the Crooked Lake Civic Association (CLCA) and formally opposed the Beach Park; concerns were voiced for the additional "water pollution from possibly hundreds of swimmers." Other concerns were low lake levels, weeds, and swimmers itch.


Crooked Lake Beach Park, recent aerial photo, City of Coon Rapids.

By 1966, the city of Coon Rapids established Crooked Lake Beach Park. The City also offered "free access" to the lake that same year. After voting down the access since neither the east nor west sides wanted the public access, the CLCA tabled the discussion until they knew what type of access was being considered. As a result, the lake association decided to forego fish stocking, including CLCA requests for walleye; the lake was now considered private and, therefore, not under DNR jurisdiction.

Meanwhile, in the previous fall of 1965 the DNR "reclaimed" the lake by poisoning out the rough fish and then in spring of 1966 stocking walleyes, followed by northern pike. None of the walleye was believed to survive, explained as possibly because "some

toxicity from fall treatment remained when they were stocked the following spring" (DNR letter, 11/21/69).

1970s

By the early 1970s water pollution was confirmed in Crooked Lake. The biological and water quality conditions of the lake were degrading according to a 1971"Final Report on Crooked Lake Water Quality Investigation" by Norman Wenck of Hickok & Associates. A benthic survey showed a predominance of pollution-tolerant organisms, Oligochaeta and Chironimidae, giving the lake a "semi-degraded" rating. And, phosphorus concentrations were sufficient to support "abundant algae and weed growth."

The report noted water quality degrading not only in Crooked Lake, but in Coon Creek and the area shallow domestic wells. "The sources of contamination appear to be individual septic systems, both local and upstream along Coon Creek and agricultural runoff to Coon Creek." A subsequent water quality survey of Coon Creek was done by the MN Pollution Control Agency (MPCA) for by CCWD. Results revealed high concentrations of fecal coliform bacteria and nutrients throughout the creek. The results also showed, however, that agricultural runoff had lower concentrations than the creek at the test station of a tributary at a Ham Lake sod farm.

The Hickok report also looked at the effect of lake level augmentation using the Coon Creek pump. The report concluded that the lake level is "mainly dependent on the elevation of the ground water table in the area," and that "augmentation can be helpful in replacing the evaporation losses during the summer but cannot economically be used to substantially change the lake elevation." If augmentation were to happen, "ground water in the deeper aquifers appears to be acceptable for the lake augmentation." Water from Coon Creek, used before for augmentation, was no longer a viable source for lake level augmentation because of its water quality (non-swimmable).

The first Report recommendation was the installation of a municipal sanitary sewer system to prevent further degradation. A municipal water system was also recommended, as was augmenting the lake levels "from a deep groundwater aquifer" and the inclusion of stormwater recharge basins into any planned storm sewer design. Lake residents were also recommended to prevent organic deposits from entering the lake and to maintain septic systems in good working order. By July 1972, enforcement of new shoreland zoning ordinances regulating septic tanks, land use, shoreline alterations, and structure placement in accordance with the MN Shoreland Management Act of 1969.

The City of Coon Rapids then hired Hickok & Associates for a "Crooked Lake-Coon Creek Groundwater Investigation" into the feasibility of raising the groundwater table in the Crooked Lake area. The May 1972 report recommended moving the Coon Creek control structure to south of Crooked Lake at Main Street, thereby raising the level of the Creek to provide a corresponding rise in groundwater level. The structure could help maintain a stable water level, establish a "ground water contour at 861.0 in the vicinity of Crooked Lake" causing seasonal overflows that could release nutrients. The resulting 100-acre reservoir could also be an open space, recreational, and wildlife resource. In

1973 the City applied to the U.S. EPA for a grant. No known action was taken. In 1974 the CLCA wrote to Anoka County Commissioner, Ed Fields, for the preservation of the Coon Creek-Crooked Lake ditch for future lake level augmentation once the Creek was not polluted. The dam project was not implemented though it was discussed five years later at a CLCA meeting.

The 1970s was also the decade of the largest build-out of residential homes in the lake watershed, primarily from the development of the Peterson farm in the northwest quadrant. Cabins started getting remodeled or torn down for year-round homes. In 1974, the city of Andover was incorporated from Grow Township. By 1975 city sewer was going in from Coon Rapids (planned since 1969), and in 1976 Andover was making Master Storm Sewer plans. Water quality improved in Crooked Lake.

1980s

By the 1980s the build-out slowed down with few lots left in the watershed. Privacy of the lake changed when in 1981 a joint agreement was signed between the City of Andover and the DNR for a public boat ramp with trailer parking located on the north tip of the lake, on Bunker Lake Boulevard. The site was originally the Pearson home that had burnt down, was bought by Grow Township in 1972, and then used as lake access but parking was across the road at Crooked Lake elementary school (built in 1968). By providing boat access, the lake changed to a public resource and so under the jurisdiction of the DNR again and eligible for fish management.

Winterkill of fish, and muck concerns mostly on the west side of the lake, prompted the CLCA to "re-activate" in 1984 and pursue lake aeration, possibly using a multiple inversion system proposed to also reduce muck. Dredging had already been researched in 1979, but considered expensive and problematic. In 1987, a "Diagnostic & Feasibility Study" by Wenck & Associates recommended winter aeration, and vegetation management only in selected areas since the presence of the existing well-balanced predator-prey fishery would be disrupted with extensive aquatic plant eradication. Winter aeration continued as a priority for the CLCA with the Minneapolis Star Tribune reporting a $41,000 cost-share between the DNR, Coon Rapids and Andover, plus $500 by the CLCA with maintenance by the Anoka County Parks. The aeration proved successful at eliminating fish winterkill, and the fishery was managed throughout the decade until Crooked Lake became known regionally for its bass fishing (a permanent aeration system was installed in 1997).

Meanwhile, other issues existed on the lake. By 1985 the public beach had become a magnet for teen delinquency so the city of Coon Rapids put up a fence and charged a $1 user fee. This caused enough neighborhood controversy that it was reported in the Minneapolis Star-Tribune newspaper. The CLCA renamed itself its current name, the Crooked Lake Area Association (CLAA) in 1986 and boating issues surfaced with

increased recreational use. In1990, the popular swimming beach was closed. The City cited public safety concerns from turbid water.

1990s

Though weed control had been ongoing since at least the 1960s and done primarily by individual lakeshore owners, the1990s brought an "about face" to vegetation management by all stakeholders. Eurasian water milfoil (EWM), an invasive plant that thrives in waters with minimal native plant communities, appeared in the lake and quickly became overabundant. Within one year of discovery of EWM the Coon Rapids Herald newspaper reported fear of the lake "strangling to death." Though bass could use the thick plant growth of EWM for ambush habitat, its impedance to boats and recreational activities plus rapid spread across the state resulted in a call for alarm. In 1992 an experimental whole-lake treatment cost nearly $13,000. Approximately $22,000 was raised: 64 property owners donated $12, 526, CCWD - $5000, Coon Rapids-$2500, Andover -$2000. The money was held in a fiduciary fund at CCWD until the CLAA formed into a non-profit corporation (2008).

2000s

As experience and research grew, both on Crooked Lake and across the state, so did the realization that management of invasive aquatic plants needed to shift from elimination to control. By 2002, the DNR made this EWM management revision statewide. In the meantime, another exotic species, curly leaf pondweed (CLP), started showing up in DNR aquatic plant surveys on Crooked Lake (2001-2005). It is currently being managed in conjunction with Eurasian water milfoil.

Meanwhile, the water quality in shallow, urban Crooked Lake is considered good. The management focus now turns to protection and improvement of water quality. In 2007, the boat landing was re-designed to divert stormwater runoff to pervious pavers and a rain garden. This Comprehensive Plan was initiated. And, the CLAA became a non-profit corporation for fundraising options primarily for ongoing EWM and CLP treatments.

Table 2.3 Summary of Management Activity

Known management of Crooked Lake dates back to 1934 with the construction of both the earthen dam at the south end of the lake and the diversion from Coon Creek for lake level augmentation. Since then eight issues have repeatedly surfaced for Crooked Lake:

Issue	First addressed	Last addressed
Lake Water levels	1934	2000
Fishery, winter kill	1951	2004
Swimming Beach	1966	1990
Water quality	1971	1999
Public Access	1981	2007
Curly Leaf Pondweed – Invasive Species	1982	2008
Water Clarity and Turbidity	1987	2003
Eurasian Water Milfoil – Invasive Species	1990	2008

2.4 Population and Economic Characteristics

Currently 133 parcels are characterized as lakefront property. The majority is single family residential homes but also includes the City of Andover boat launch area at the north of the lake, the Coon Rapids city park in the east, and a townhome complex in the southwest. In addition, 291 parcels are within the contributing lakeshed of Crooked Lake but have no direct lakeshore access.

Median family income in the lakeshed of Crooked Lake is in the $70,001-$200,000 range according to 1999 Census data available through the Minnesota Land Management Information Center (www.lmic.state.mn.us).

Table 2.4 Single family residential summary statistics (Anoka County, 2005)

Average lot size	0.62 acres
Average house size	1,373 sf
	3 bedrooms, 2 baths
Average lake frontage	ft
Average House Age	39 years (built in 1968)
Median House Age	35 years (built in1973)
Oldest house	Built in 1893
Newest house	Built in 2005
Average home cost	$239,817
Average land worth	$106,430

Figure 2.4 Crooked Lake Watershed Development Patterns

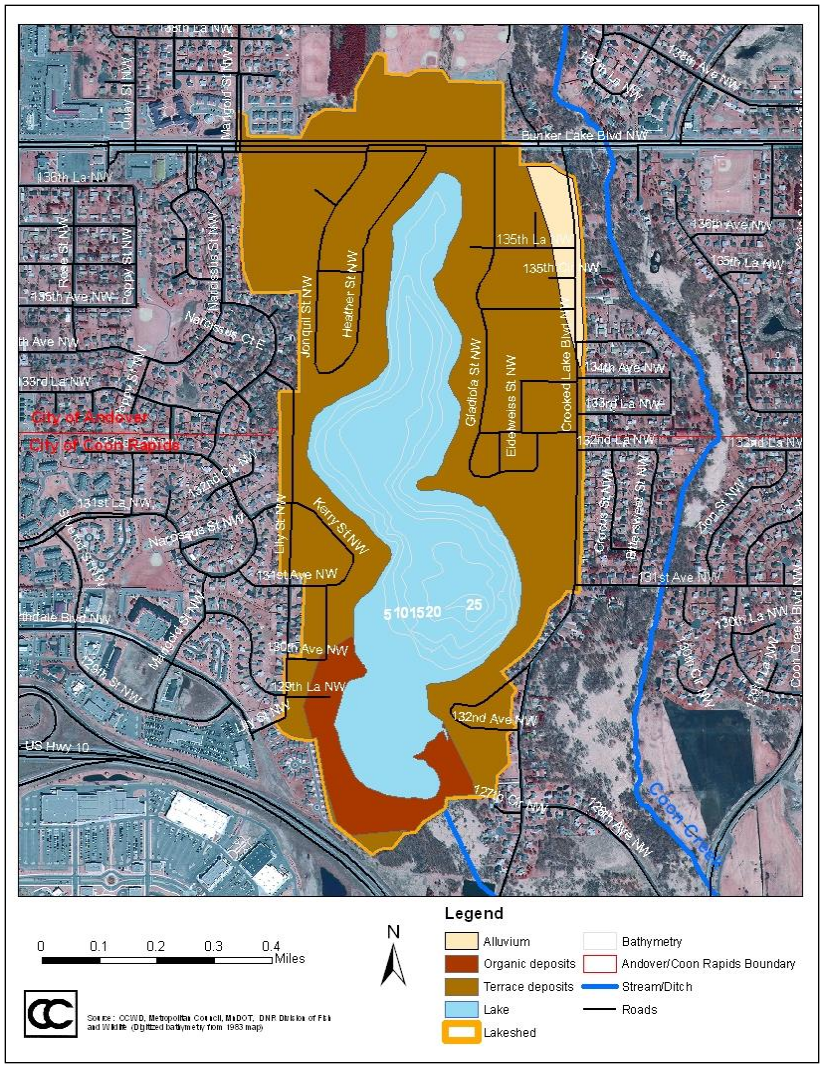
3. Watershed and Hydrologic Characteristics of Crooked Lake

3.1 Geologic Setting and Hydrogeology

Crooked Lake is located in the Mississippi Sand Plain portion of the Anoka Sandplain. This geologic feature is an undulating outwash plain characterized by flat topography, sandy soils, and a shallow water table.

Surficial geology in the area is composed of postglacial deposits formed from the retreat of the Superior Lobe of the Grantsburg sublobe of the Lake Wisconsin glaciers. The majority of the watershed is composed of terrace deposits with the exceptions of the area in the south of the lake which is composed of organic deposits and a small area in the northeast adjacent to Coon Creek which is composed of alluvial deposits.

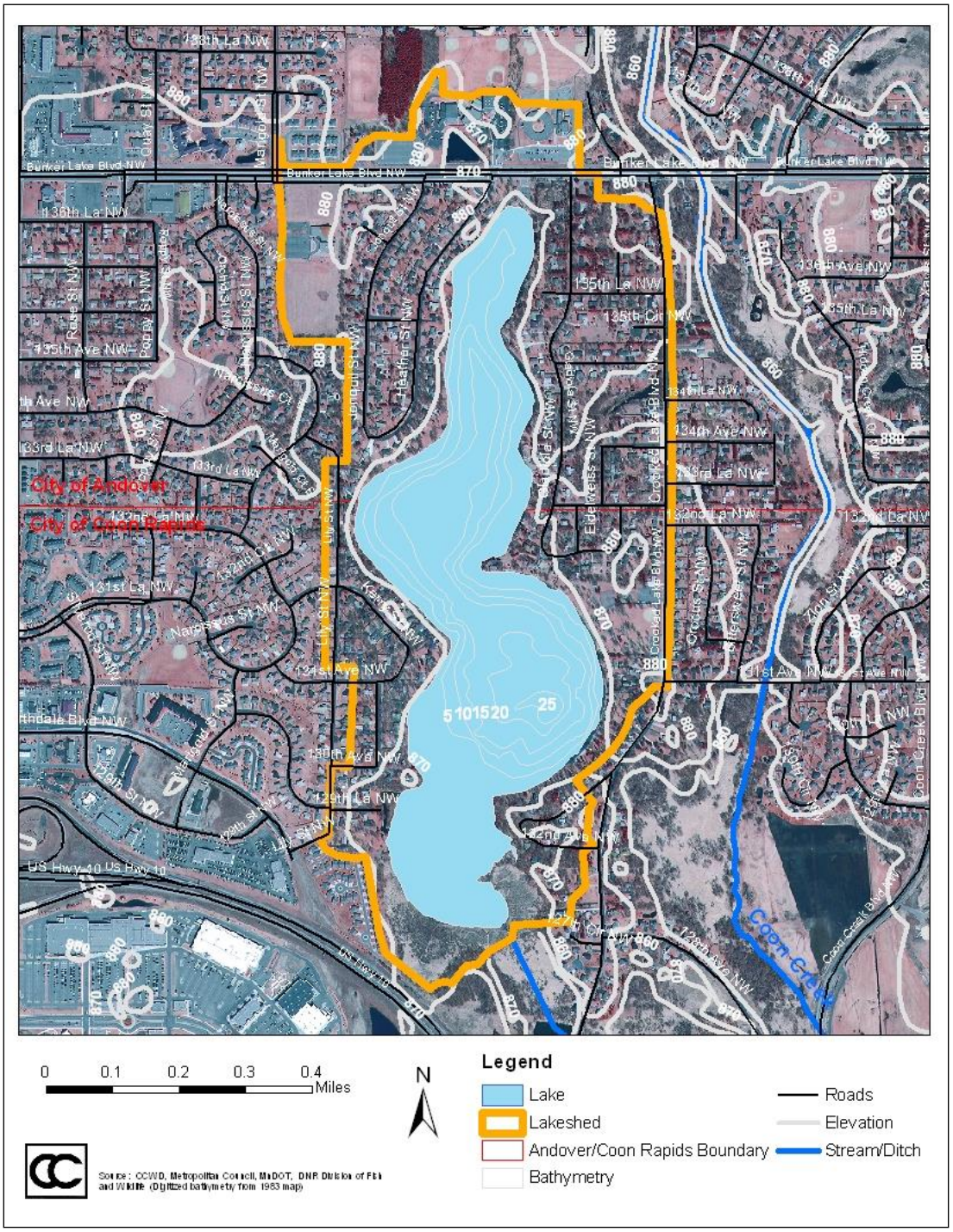
Figure 3.1 Crooked Lake Surficial Geology



3.2 Topography

The watershed of Crooked Lake is typified by gently rolling topography generally ranging between 860-880 feet in elevation above sea level. The lake bottom has an average slope of 0.02%. Elevations are more varied to the east and north of the lake and flatten out to the west.

Figure 3.2 Crooked Lake Topography



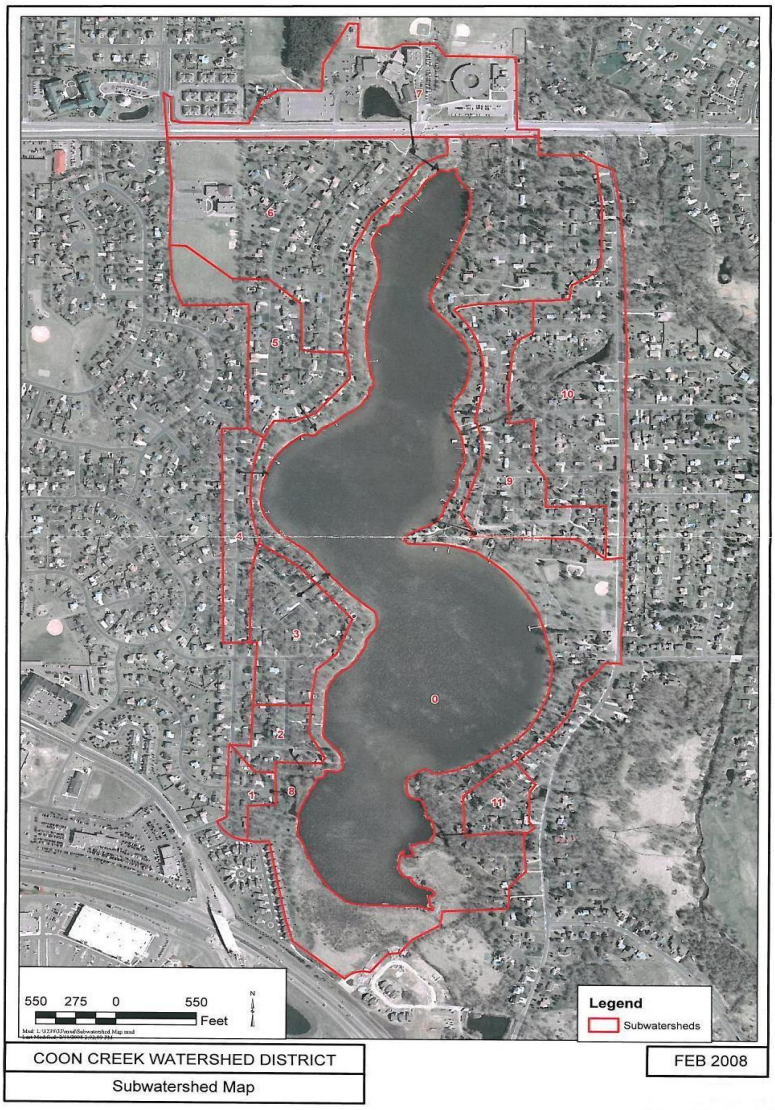
3.3 Subwatersheds & Watershed Ratio

The Crooked Lake watershed is approximately 236 acres in size. The ratio of the size of the drainage are to the size of the lake is approximately 2:1

The watershed is comprised of 11 Subwatersheds (Sub WS):

Sub WS	Area (ac)		Sub WS	Area (ac)
1	3.3		7	24.7
2	4.8		8	75.9
3	13.0		9	17.7
4	7.8		10	29.5
5	15.4		11	4.6
6	39.8		**Total Area**	**236**

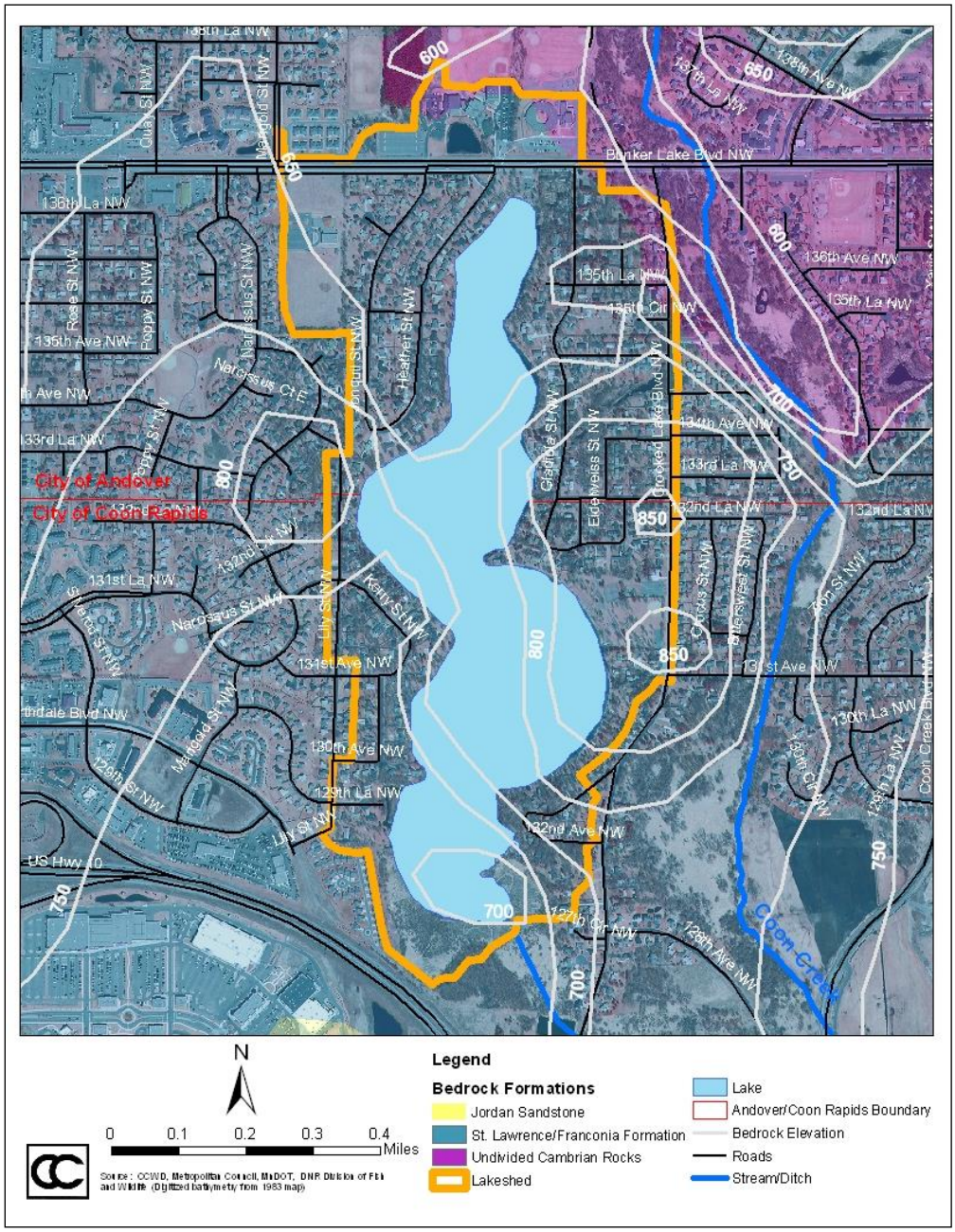
Figure 3.3 Subwatersheds of Crooked Lake



3.4 Bedrock Geology

Bedrock geology of Crooked Lake consists mainly of St. Lawrence and Franconia formations, with a small portion at the northern end of the watershed characterized as undivided Cambrian rock. Crooked Lake lies in an upthrust area between two faults to the northwest and southeast. Bedrock elevation ranges between 650-850 feet above sea level. It is shallowest beneath the surface in the eastern portion of the watershed and deepest in the northern portion of the watershed. (Bedrock Geologic Map and Bedrock Topographic Map of the Seven-County Twin Cities Metropolitan Area, Minnesota Geologic Survey, 1986).

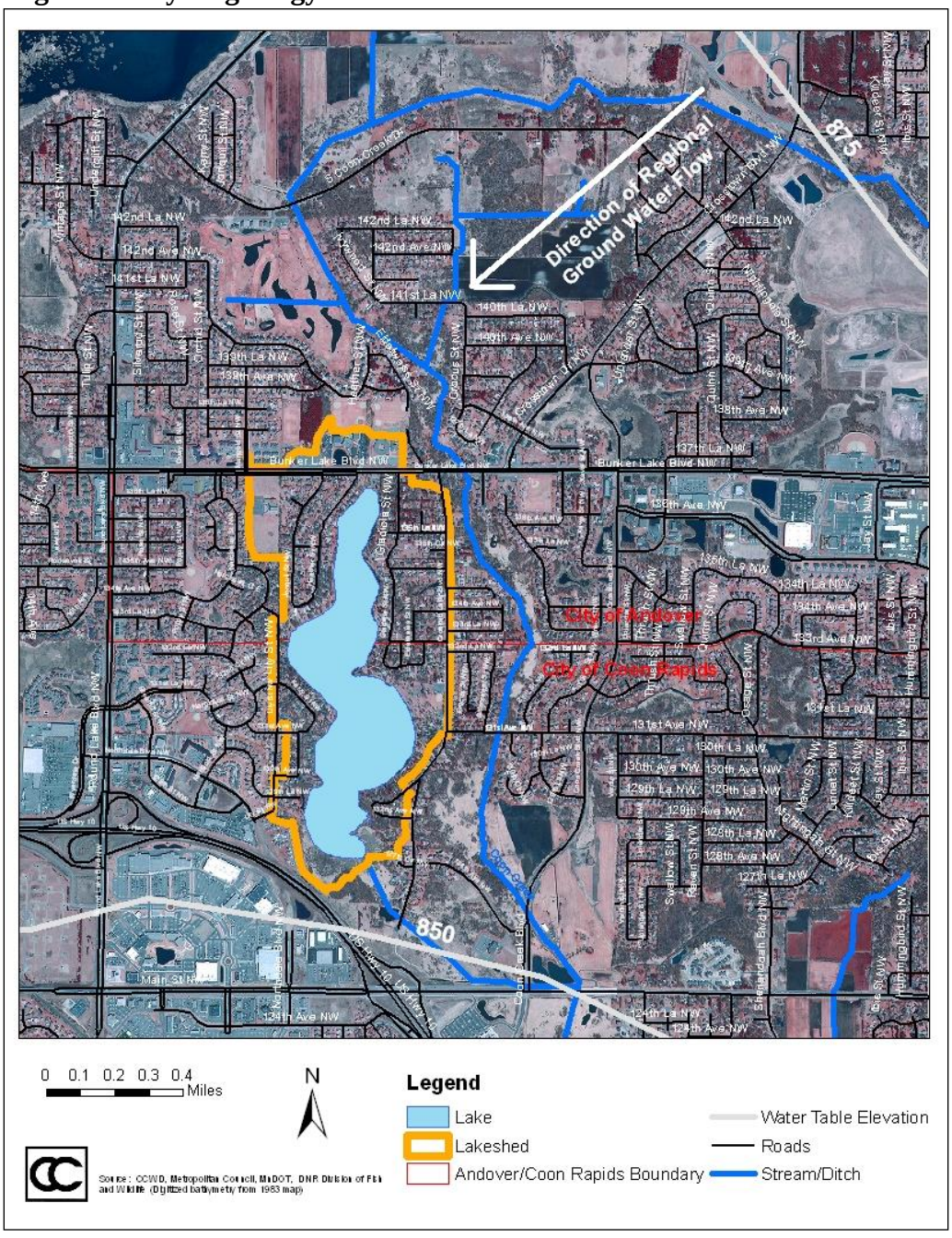
Figure 3.4 Bedrock Geology of Crooked Lake



3.5 Ground Water Levels

Ground water elevations in the Crooked Lake watershed range from approximately 850 to 860 feet above sea level going, respectively, from the extreme southern portion of the watershed in the northeastern portion of the watershed. Ground water generally flows from the northeast to the southwest towards the Mississippi River. Ground water susceptibility to pollution is ranked as very high, with water-borne contaminants at the land's surface taking hours to months to reach the uppermost aquifer. (Anoka Sandplain Regional Hydrogeologic Assessment, MN Department of Natural Resources, 1993).

Figure 3.5 Hydrogeology of the Crooked Lake Area



3.6. Land Use

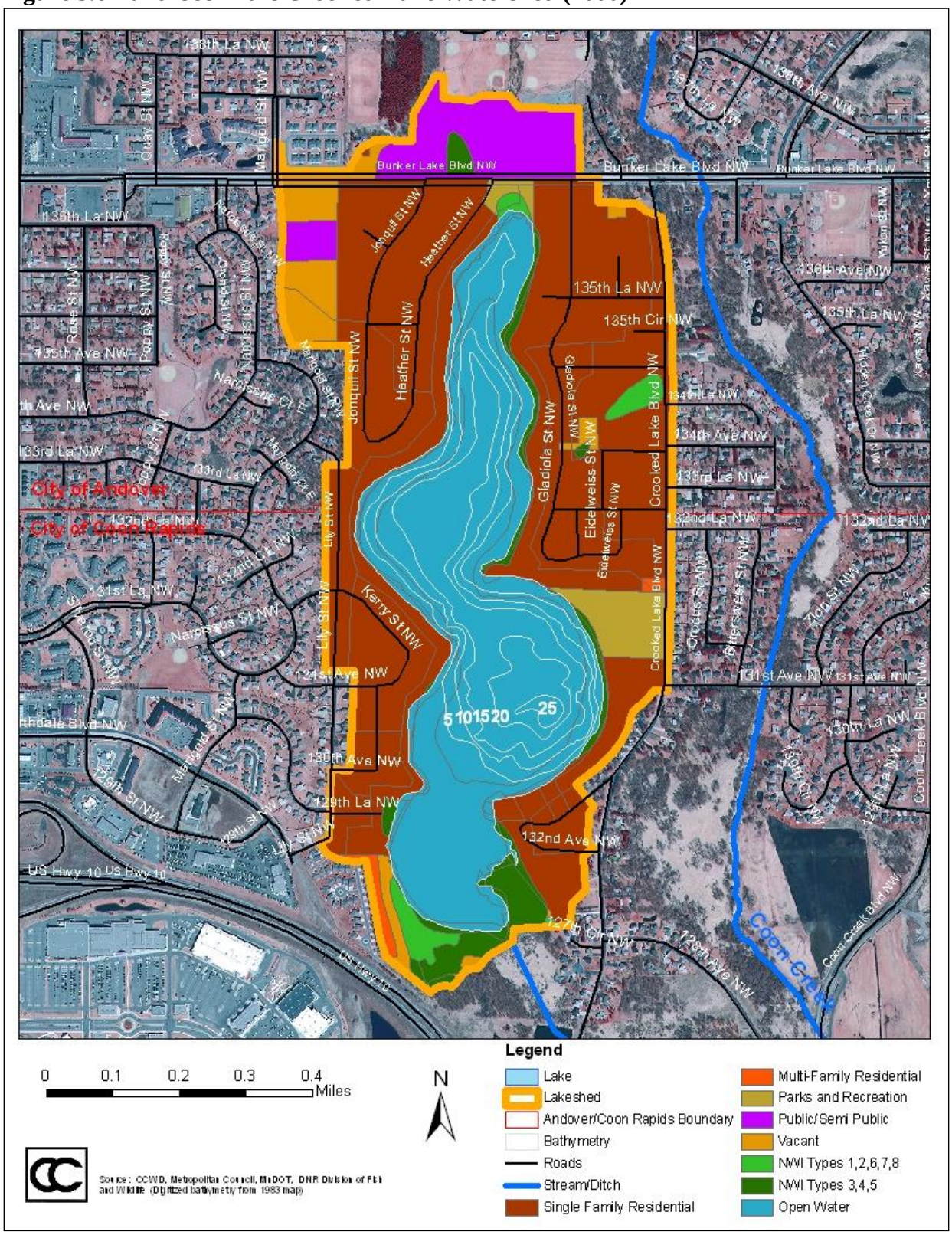
Land use in the Crooked Lake watershed falls into one of eight categories as outlined in Table 3.6 below. The majority of land use (78%) in the watershed is single family residential; mostly detached housing units with the exception of a townhome complex in the southwest part of the lake. Multi-family housing is located north of the Crooked Lake city park; it composes a very small percentage of land use in the watershed.

There are two park areas located in the watershed: the boat landing on the northern shore in Andover, and a city park on the east shore in Coon Rapids. Public/semi-public use include two churches, both in the north in Andover: Riverdale Assembly of God in the northwest area and Meadow Creek church/school complex north of Bunker Lake Boulevard. Parcels of vacant land exist adjacent to Riverdale church in the northwest, adjacent to the townhome development in the southwest, and in the northeast of the watershed near the southern end of the abandoned aqueduct. The remainder of the watershed is composed of wetlands and about one-third is open water (30.1%).

Table 3.6 Land Use in the Crooked Lake watershed (2005)

Land Use	Area (Acres)	Percentage of Total	Land Use Impervious Percentage %	Pervious Curve Number (CN)
Single Family	184.8	78.3%	25	74
Multi-family	2.6	1.1%	70	74
Parks and Recreation	9.6	4.0%	5	60
Public/Semi-public	22.4	9.5%	50	74
Vacant	16.6	7.0%	5	60
	236			

Figure 3.6 Land Use in the Crooked Lake Watershed (2000)



3.7 Hydrologic Characteristics of Crooked Lake

Crooked Lake is sustained by a combination of surface water runoff and ground water inputs. The term "hydrologic cycle" denotes the general circulation of water in various physical states (liquid, solid, gas) from surface water to the atmosphere, from the atmosphere over and through the ground, and back to surface water again. Quantification of the hydrologic cycle is accomplished by developing a drainage basin budget. The parameters of the hydrologic cycle (precipitation, evaporation, transpiration, infiltration, and runoff) are balanced until all of the water entering and leaving the watershed is accounted for.

The budget of any drainage basin may be represented by the equation:

$$P = ET + R + \Delta SMS + \Delta GMS + \Delta DS + GWF$$

$$\text{Lake Level} = R + GWF - P - ET - \Delta SMS - \Delta DS - \Delta GMS$$

where

P = Total precipitation input
ET = Total evapotranspiration loss
R = Total Runoff
ΔSMS = Change in soil moisture storage
ΔGMS = Change in ground water storage
ΔDS = Change in depression storage
GWF = Ground water flux (ground water flow into or out of the drainage basin).

Precipitation

Precipitation in its various forms is the source of all water coming into the watershed. Significant variation in precipitation amounts can occur within the watershed from individual storm events. Precipitation is also highly variable on an annual and monthly basis.

The average annual precipitation in the watershed is 30.6 inches with a normal variation of 28.3 to 34.1 inches. About 70 percent of the annual precipitation, approximately 22 inches, falls between April and September. About 6 inches of precipitation occur on average during the spring ground water recharge period of April and early May. Measurable precipitation of 0.01 inches occurs on about 110 days per year, 4 of which have 1 inch or more.

Annual amounts of precipitation have ranged from a low of 15.56 inches in 1976 to a high of 43.03 inches in 1991 (UM, 1999). The most precipitation occurring in any month was 9.35 inches in June 1975.

Table 3.7.1 Hydrologic condition as a function of annual precipitation

Year	Annual Precipitation	Acre Feet	Hydrologic Condition
2000	27.3	850.9	Dry
2002	36.1	1,125.1	Wet
2003	21.7	676.3	Dry
2005	31.5	981.8	Normal
2006	26.7	832.2	Dry

2007 was 2.53 inches below normal.

Evapotranspiration Loss

Evapotranspiration includes evaporation from all water, soil, ice, vegetative and other surfaces, and transpiration from plants. Evapotranspiration losses can be grouped into three categories:

1. Interception losses
2. Evaporation from undrained basins
3. Evapotranspiration from soil and ground water.

Since no method exists for directly measuring evapotranspiration, it is the most difficult component of the water budget to account for.

Potential Evapotranspiration (PET), the amount of water that would be lost to the atmosphere if water were not limiting, can be estimated using a number of methods. The Thornthwaite equation uses mean temperature and latitude to determine monthly potential evapotranspiration (Thornthwaite, 1955). The estimated annual PET for Crooked Lake is 24.9 inches per year.

Table 3.7.2 Effective Precipitation (Annual Precipitation minus PET)

Year	Precipitation	Effective Precipitation	Acre Feet
2000	27.3	2.4	74.8
2002	36.1	11.2	1,125.2
2003	21.7	-3.2	-99.7
2005	31.5	6.6	205.7
2006	26.7	1.8	56.1
2007	28.8	3.9	121.5

Surface Water Flows into Lake

The drainage area of Crooked Lake is 260 acres in 11 subwatersheds. 75.9 acres flow directly to the lake via overland flow. The remaining 184 acres drains through storm sewer pipes. The 75.9 acres (subwatershed number 8) includes all of the lakeshore property including Crooked Lake Beach Park and the north-northeast neighborhood in the vicinity of 135th Avenue NE. The table below shows the size, pervious curve number, percent impervious and discharge method for each subwatershed:

Table 3.7.3 Subwatershed (Sub WS) Runoff Character

Sub WS	Area (ac)	Pervious CN	Percent Impervious	Discharge type
1	3.3	74	0.26	Pipe
2	4.8	74	0.25	Pipe
3	13.0	74	0.25	Pipe
4	7.8	74	0.25	Pipe
5	15.4	71	0.21	Pipe
6	39.8	71	0.22	Pipe
7	24.7	72	0.26	Pipe
8	75.9	71	0.22	Direct Inflow
9	17.7	74	0.25	Pipe
10	29.5	72	0.23	Pipe
11	4.6	74	0.25	Pipe
Total Area	236			

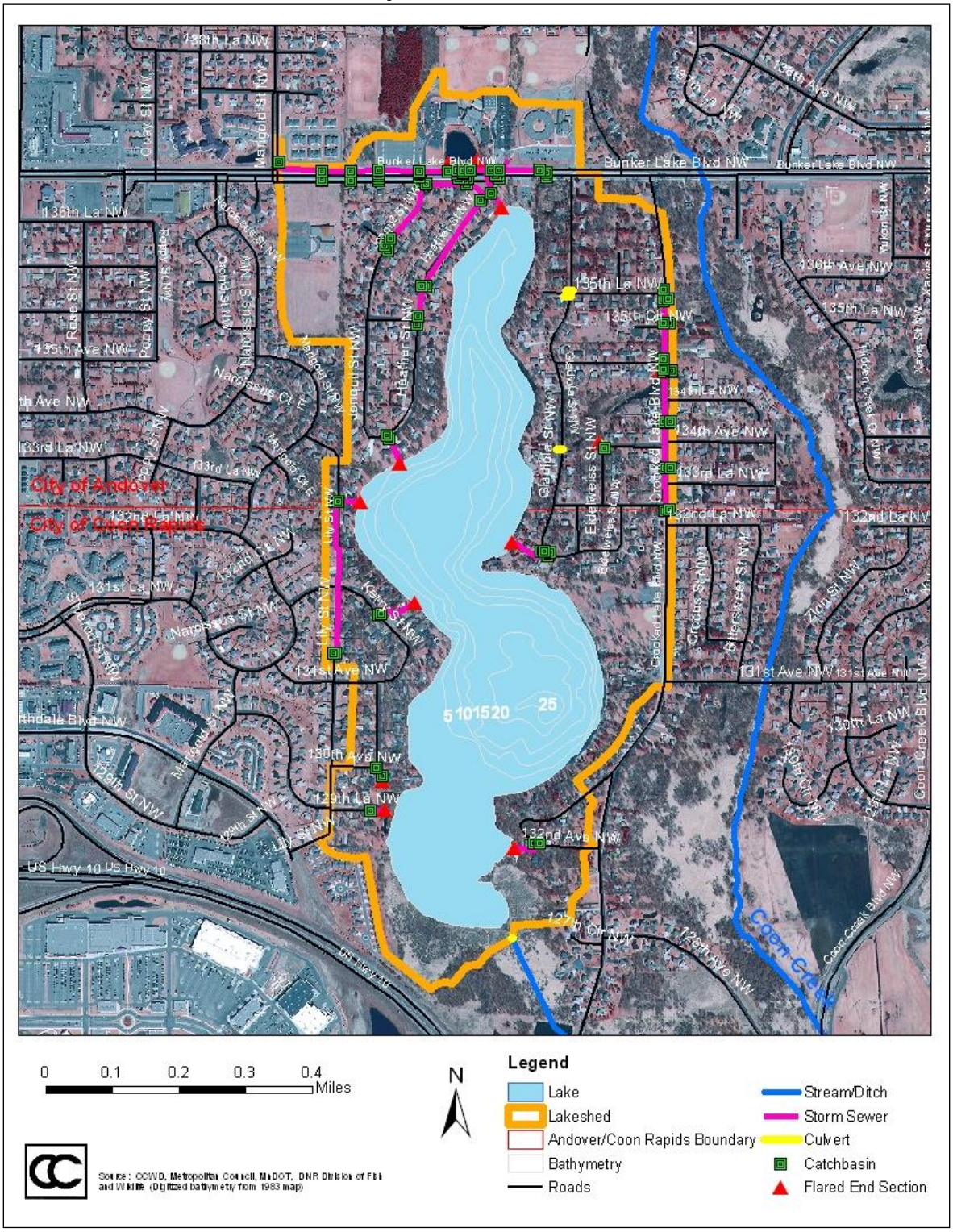
Tributaries and Pipes: Crooked Lake has no natural surface water tributaries. However, there are 2.06-miles of storm sewer from both the City of Andover and Coon Rapids that convey water into the lake.

Eighty-four catch basins (71 in Andover and 13 in Coon Rapids) direct street runoff into the storm sewer system. Eight stormwater outfalls are located at various locations around the lake (three in Andover and five in Coon Rapids). In addition, remnants of an historic aqueduct are still discernable in a neighborhood in the northeast portion of the watershed. The aqueduct was once used to direct water from Coon Creek to Crooked Lake for augmenting lake levels but was disconnected due to poor water quality in Coon Creek. Storm water still enters the lake in this area via overland flow through a culvert under Crooked Lake Boulevard. There is one surface water outlet to the lake via a culvert in an earthen dam in the southern end of the lake.

3.7.4 Annual Inflow to Crooked Lake

Year	Annual Inflow (ac-ft)		Year	Annual Inflow (ac-ft)
2000	131		2005	154
2002	202		2006	154
2003	102			

3.7.1 Crooked Lake Storm Sewer System



Soil Moisture Storage

Soils in the watershed of Crooked Lake are mainly of the Hubbard-Nymore association. These soils are formed in outwash sands and are characterized by nearly level to gently sloping, excessively drained soils that are sandy throughout. Organic content is typically low and water table at a depth of more than 6 feet. Due to this low water capacity, soils are prone to doughtiness and wind erosion. Soils in this association are within the C or D hydrologic group and are found mainly along the shores of Crooked Lake or adjacent to the marshy areas in the southern part of the watershed. Soils in the A and B hydrologic group are found higher up in the watershed.

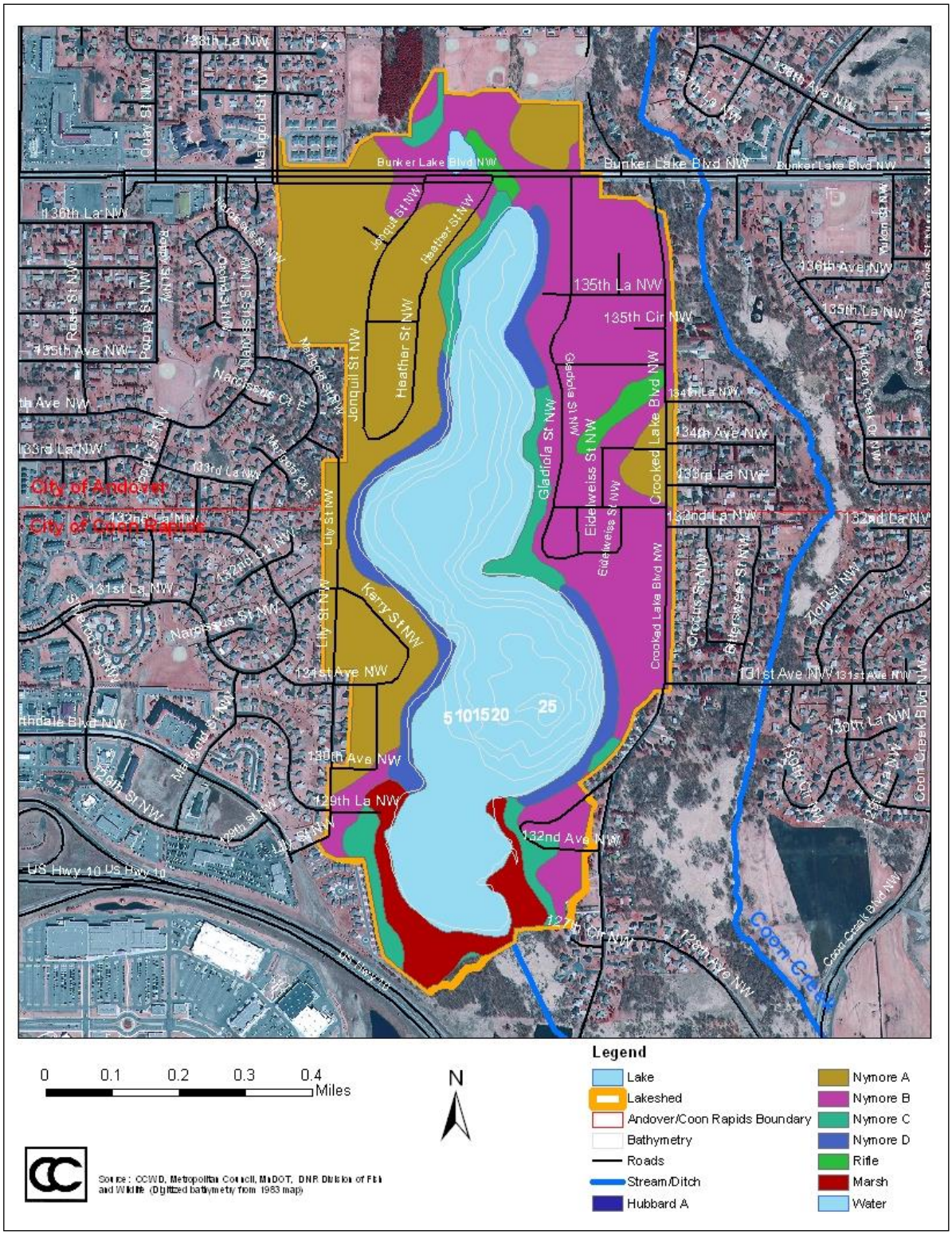
There are two areas of Rifle soils in the watershed, one is in the area of the abandoned aqueduct and the other straddles Bunker Lake Blvd. between the lake and a stormwater pond to the north. It is characterized by level, very poorly drained soils formed in organic material. It has a very high available water capacity and organic content, and the water table is very close to the surface.

Seventy-five percent (194 acres) of the soils surrounding Crooked Lake are excessively well drained (Hydrologic Groups A & B). However, because the area is fully developed and soils are fully compacted, runoff is much higher than on undeveloped A and B soils.

Table 3.7.5 Soils of Crooked Lake

Soil Name	Hydrologic Group	Soil Type	Slope	Size (Acres)
Hubbard	A	coarse sand	0-2%	<0.1
Nymore	A	loamy sand	0-2%	91.06
	B	loamy sand	2-6%	103.0
	C	loamy sand	6-12%	29.1
	D	loamy, coarse sand	12-25%	19.5
Rifle	D	mucky peat	0-1%	5.1
Marsh	unclassified	unclassified	0-1%	14.5
Open Water	unclassified	unclassified	unclassified	120.4

3.7.2 Crooked Lake Soils



Ponding and Depression Storage

Depression storage includes ponds and wetlands in addition to small depressions that fill with and hold water during and after rainstorms. The Crooked Lake watershed includes two ponds:

Church Pond is approximately 2.5 acres in size when full. This pond collects all runoff from Subwatershed 7 which is basically Bunker Lake Boulevard and the properties north. The pond contains 4.5 acre feet of live storage.

Aqueduct Wetland areas, adjacent to the aqueduct in the north east quadrant of the lake, provide some storage.

A 14.5-acre marsh is mapped at the southern end of the lake. Marshes are characterized as level shallow ponds or lakes where water is 1-3 feet deep for most of the year.

The remainder of the area is the open water of Crooked Lake itself. The soils are not characterized in this area.

Ground Water Storage

Best available information indicates that historical ground water levels in the immediate vicinity of Crooked Lake were probably at an elevation of approximately 859; they are now at approximately 850. This elevation is approximately 10 feet below much of the shoreline and 11 feet below the lake outlet. Ground water generally flows from the northeast to the southwest towards the Mississippi River (Anoka Sandplain Regional Hydrogeologic Assessment, Minnesota Department of Natural Resources, 1993).

It should be noted that ground water levels may fluctuate three to five feet per year and are the most significant determinant of the influence and effluence of ground water on surface water (Moering, 1993). These fluctuations are believed to be largely the result of plant, particularly tree, transpiration, but also have long-term climatic and anthropogenic dimensions as well.

Ground Water Flux

Observed values for the permeability of natural soils is approximately 230 feet /day for sands. Thus, the Anoka Sandplain Surficial aquifer possesses high flow-rates within the context of ground water. Flow rates will decrease when ground water encounters either surficial water bodies or other materials in the substrata. They will also decrease as ground water levels decrease because of the decrease in back pressure or head.

3.8 Lake Levels

The level of Crooked Lake is ultimately controlled by an earthen structure at the south end of the lake. The structure, built in the late 1930s, contains a 36-inch corrugated metal pipe set at an elevation of 860.3. The pipe has a board placed in front of it with a top elevation of 862.3. The top of the dam is at 863.4 (CCWD, 2008).

A 1972 study indicated that Crooked Lake is in fact an extension of the shallow ground water table (Hickok & Associates, 1972). This appears to be a reasonable conclusion given the lake substrata, and it explains, in part, the annual fluctuation in lake levels. Average lake levels appear to have fallen approximately one foot in the last five years. This appears to correspond with decreases in surficial aquifer levels throughout most of the Anoka Sand Plain.

Table 3.8 Annual Crooked Lake Levels

	Average	Min	Max	Range (Ft)
2003	860.98	860.17	861.57	1.40
2004	860.27	859.99	860.75	0.76
2005	860.23	859.68	860.51	0.83
2006	860.54	860.10	860.92	0.82
2007	860.35	859.68	860.86	1.18
2008	860.75	859.96	861.24	1.28

Highest recorded: 861.94 ft (05/16/1986)
Lowest recorded: 858.54 ft (08/29/1988)
Recorded range: 3.4 ft
Average water level: 860.76 ft
Last reading: 861.02 ft (4/29/2008)
Ordinary High Water (OHW) elevation: 862.1 ft

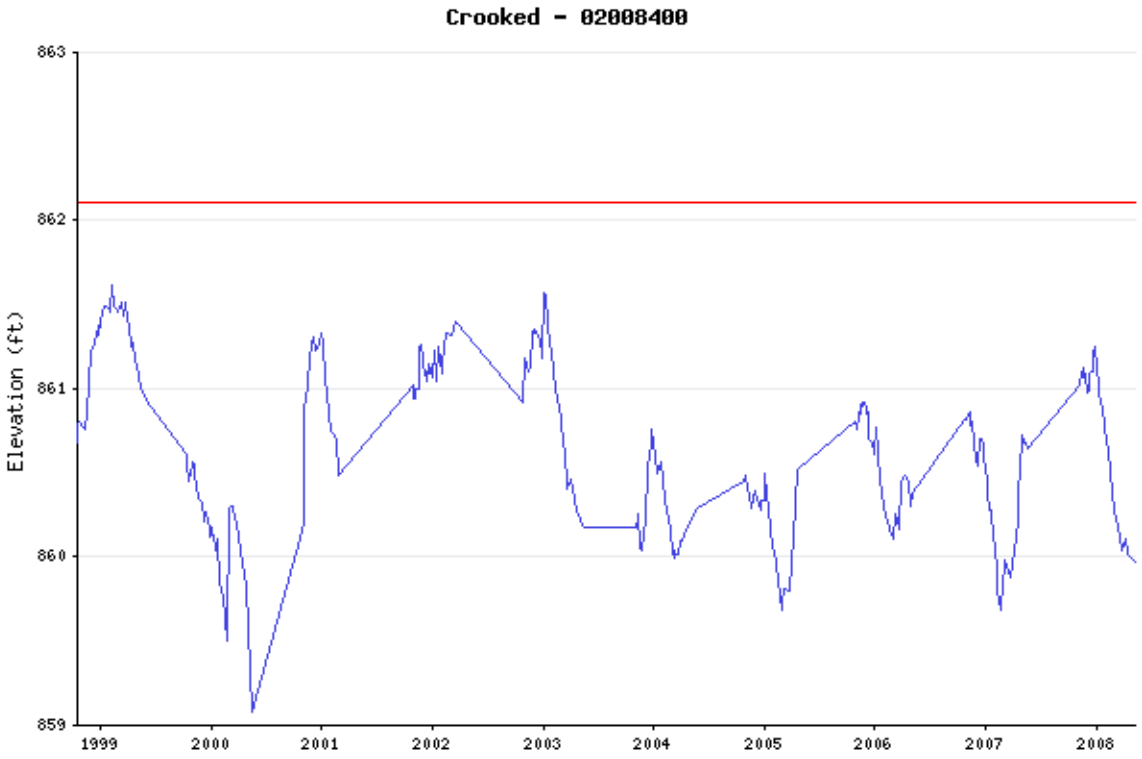


Figure 3.8 Crooked Lake Levels

4. Lake Characteristics

The Origin and Nature of Crooked Lake

Crooked Lake is the result of the partial filling of a glacial drainage way left by the Superior lobe of the Wisconsin glaciation. Channels such as the one occupied by Crooked Lake are conspicuous by the general alignment to the north and northeast of most of the lakes in Anoka County.

4.1 Morphology and Bathymetry

Crooked Lake is approximately 114 acres in size with a mean depth of 9 feet. It is elongated in the north-south direction and is almost four times long as wide. Crooked Lake is a shallow lake with 73 percent of the lake classified as littoral zone (<15 feet). The deepest area has been measured at 26 feet in the central southeast portion of the lake. It has a meandered shoreline length of 2.9 miles and one small ½-acre island in the southwest which is separated from the shore by a narrow channel.

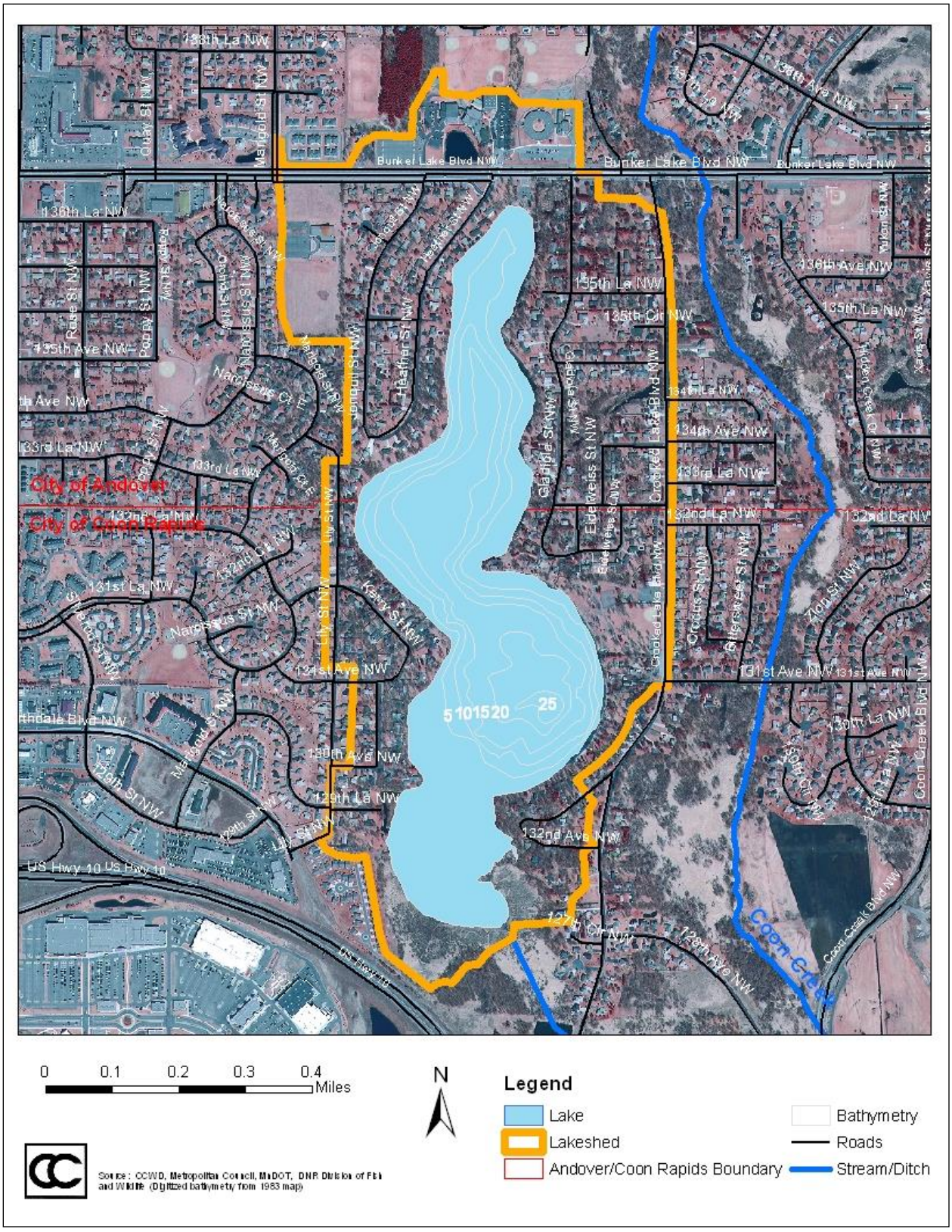
Table 4.1.1 Crooked Lake Morphology

Lake Feature	Measurement
Lake Surface Area	114 acres
Watershed Area	236 acres
Littoral Zone Area (depth <15 feet)	83 acres
Percent Littoral Area	73%
Maximum Depth	26 feet
Mean Depth	9.0 feet
Relative Depth	1.0%
Average Slope	0.02%
Maximum Lake Length	1.08 miles
Maximum Lake Width	0.29 miles
Length to Width Ratio	3.7
Maximum Fetch Distance	1.07 miles
Lake Perimeter (Shoreline Length)	2.9 miles

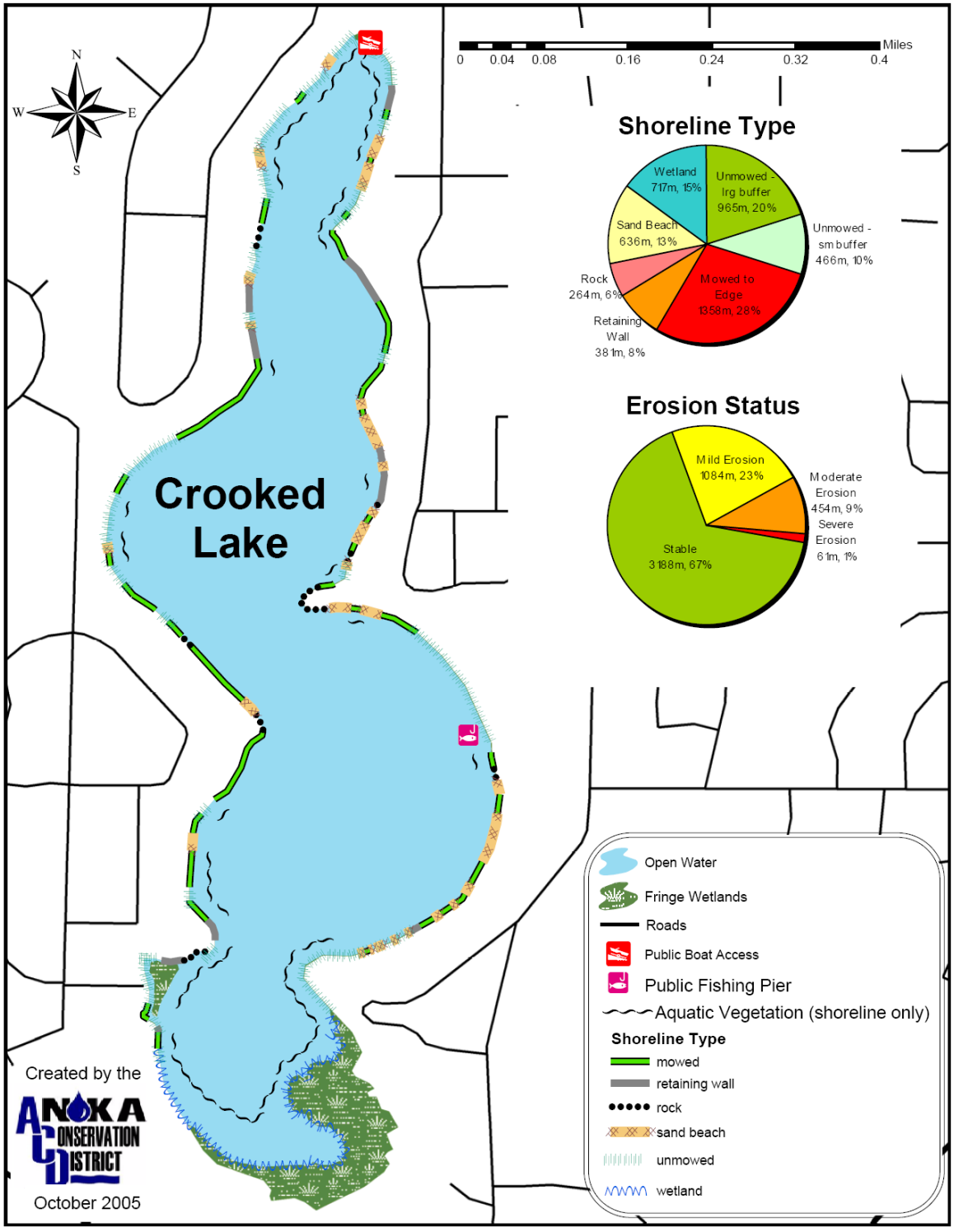
Table 4.1.2 Crooked Lake Bathymetry

Depth [ft]	Area (acres)	Volume (ac-ft)	Bottom Area	% Lake Area
surface	114	1,021		100.0
5	65	441	49.0	43.0
10	47	278	17.8	15.7
15	31	192	16.5	14.5
20	8	90	22.8	20.0
25	1	20	6.7	5.9

Figure 4.1 Crooked Lake Morphology and Bathymetry



4.2 Crooked Lake Shoreline

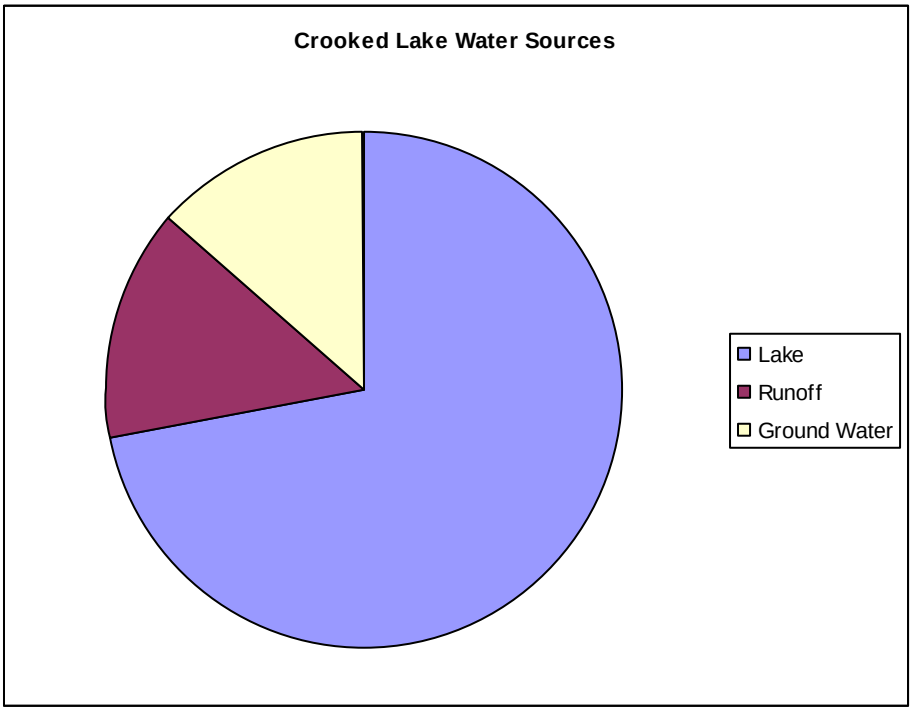


4.3 Water

Crooked Lake has no natural inlets and is supported by ground water and a relatively small watershed area of approximately 236 acres. Consequently only 29% of the water in the lake comes from the watershed (15%) and groundwater (14%).

There is a culvert outlet through an earthen dam at the southern end of the lake where water can flow to a channel (County Ditch 54-1) to confluence with Coon Creek to the southeast. Inspection of the dam and outlet in fall, 2008 showed that the lake has not discharged in a very long time.

Lake Feature	Measurement
Lake Volume (acre-feet)	1,021 acre-feet



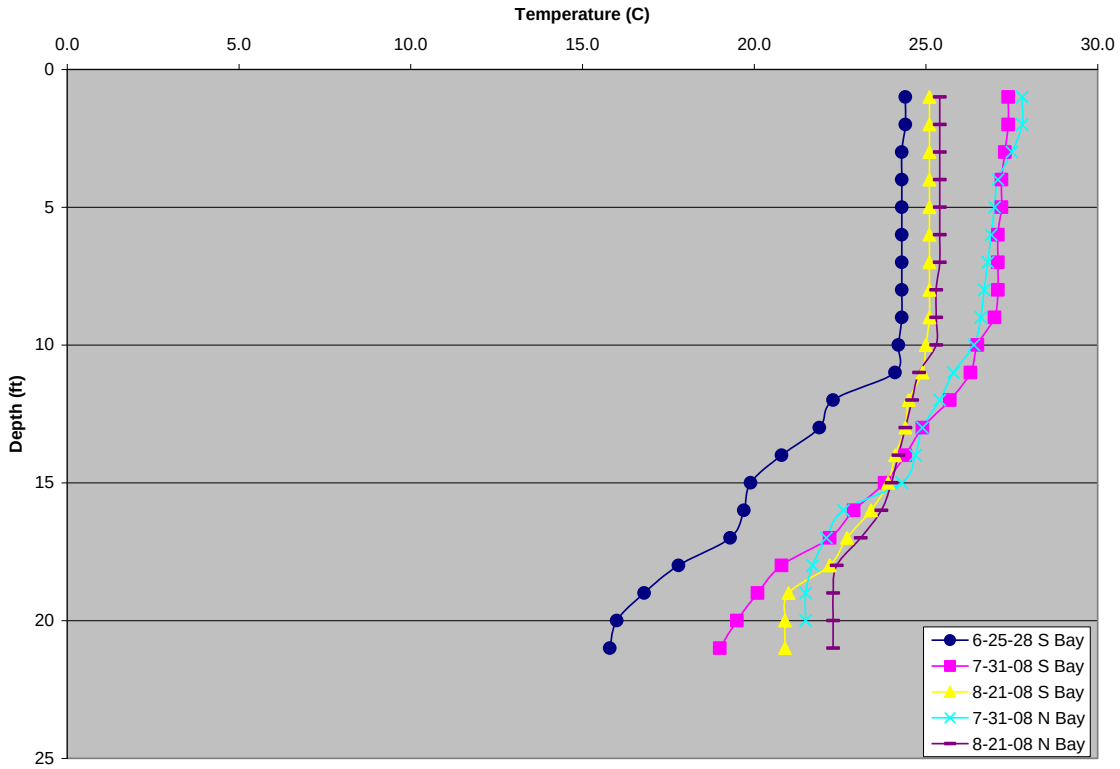
Hydraulic Residence

It is estimated that Crooked Lake requires 7.4 years to renew the lake water volume. The residence time is a function of the volume of water entering or leaving the lake relative to the volume of the lake and is a determinant in how a lake responds to various inputs. The length of time for Crooked Lake is a function of its relatively small watershed.

4.4 Mixing and Temperature

Lake mixing and thermal stratification play important roles in lake ecology including nutrient recycling. Water stratifies based upon temperature differences, unless mixing by wind occurs to the bottom. The extent of mixing is observed by taking measurements of dissolved oxygen and temperature at various depths

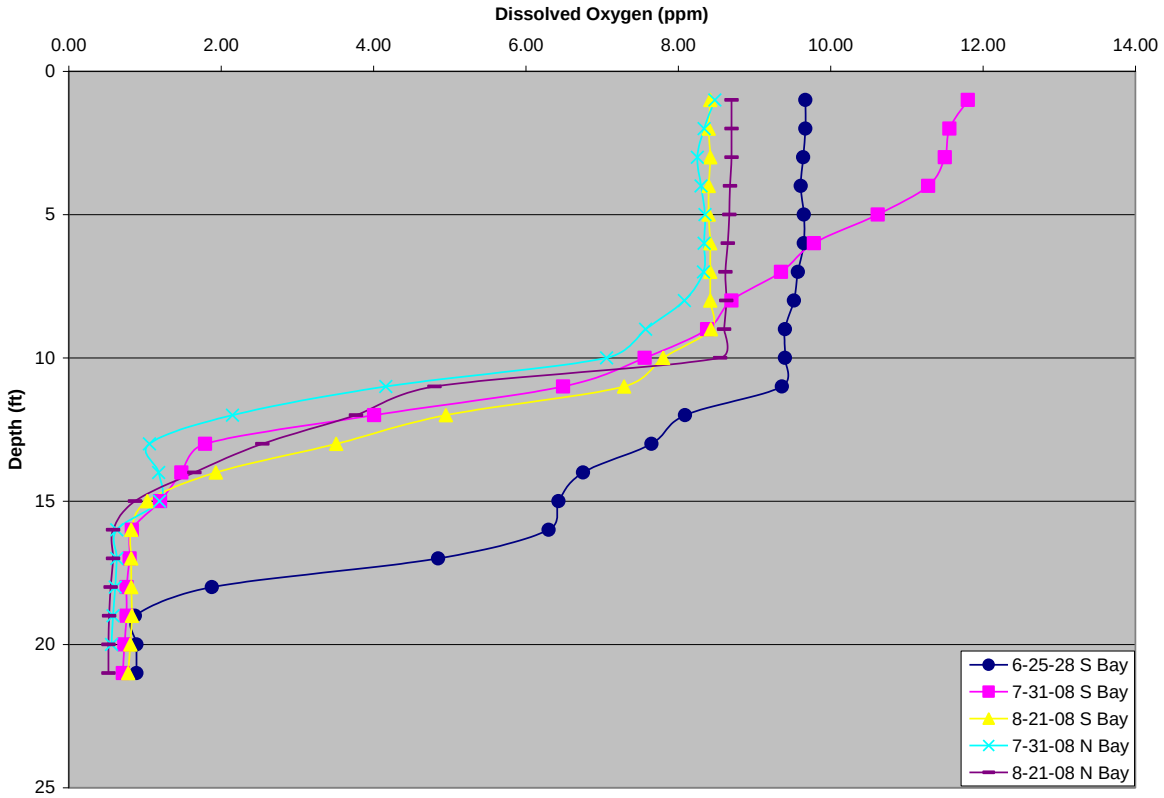
Crooked Lake is polymictic, meaning it is nearly continuously mixed to the bottom by wind and wave action. The relative lack of stratification compared to many lakes is due to a somewhat shallow basin and broad north-south expanse over which wind can create turbulence by wave action. Relatively homogenous water column temperatures are indicated by the vertical isotherm graph to a depth of approximately 10 feet (15.7% of lake area). Approximately 15% of Crooked Lake thermally stratifies during the summer months, restricted to areas of the lake deeper than 12 feet.



4.5 Dissolved Oxygen for Crooked Lake

The minimum amount of dissolved oxygen (D.O.) needed for most fish to survive and grow is 5 mg/L. In Crooked Lake, summertime (May-Sep) dissolved oxygen amounts are almost always above this level, averaging 8.5 mg/L (readings at 1 m depth, 2000-2008). The only time low summertime dissolved oxygen levels have been recorded was a single reading of 4.23 mg/L in August 2000. Lower oxygen levels are commonly found at depths greater than 12 feet due to decomposition on the lake bottom and lack of wind mixing.

Wintertime dissolved oxygen has been more problematic because ice eliminates wind mixing and plant photosynthesis is reduced. Fish kills have occurred in the winters of 1950-51, 1955-56, 1964-65, 1969-70 and 1978-79. A winter aeration system, first installed in 1988, has eliminated winterkills.

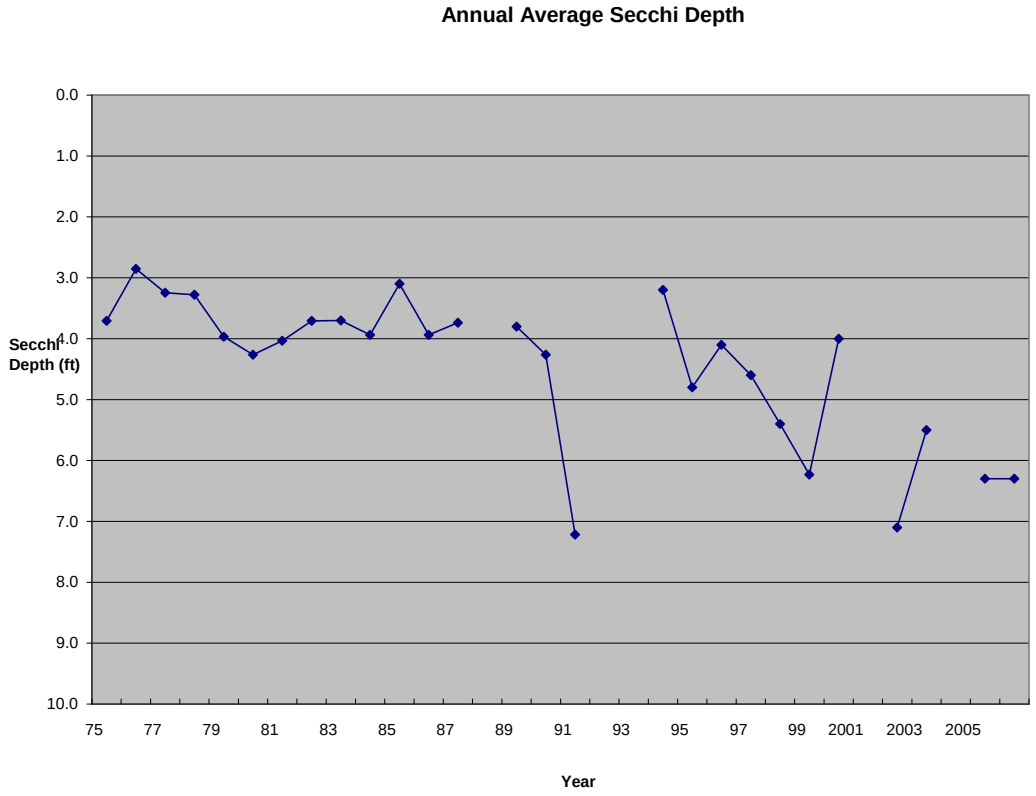


4.6 The pH of Crooked Lake

The data indicate daily fluctuations in pH primarily due to variations in the amount of primary productivity occurring in the lake. The pH ranges from 7.68 to 9.42 and the average pH is 8.6.

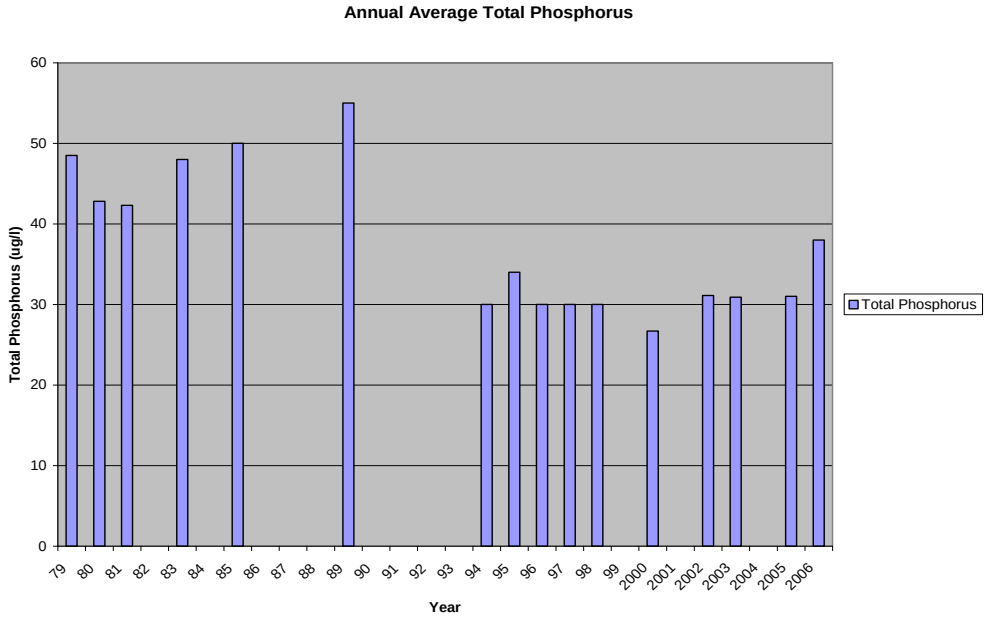
4.7 Transparency in Crooked Lake

Water clarity has improved since the 1980s. The annual average secchi depth for the 1980s is 3.78 feet. The annual average from 1990-2006 is 5.3 feet.



4.8 Total Phosphorus in Crooked Lake

Phosphorus concentrations have significantly decreased from 1983 to 2006. During the 1980s the annual average phosphorus concentration was 50 µg/L. From 1995 until the present the annual average phosphorus concentration is 30 µg/L.



4.9 Current Phosphorus Budget Components

The phosphorus budget for Crooked Lake includes atmospheric load, internal load from lake sediments, and watershed loads from stormwater runoff.

Atmospheric Load

Atmospheric loads were estimated using published literature values for aerial loading rates in Minnesota (14.91 kg/km^2-yr for an average precipitation year; Barr Engineering, 2004). Aerial loading rates were multiplied by lake surface area to determine the annual loading rate (kg/yr) for atmospheric deposition.

Internal Load

Internal loading for Crooked Lake was calculated by Equation 1:

Equation 1: (Lake Area) * (Anoxic Factor) * (Internal Total Phosphorus Release Rate)

The predicted anoxic factor was estimated based on research of shallow lakes conducted by Nürnberg (2005). Multiple regression analysis of multi-year Total Phosphorus (TP) data sets were used to develop an equation to predict the anoxic factor (AF_{pred}) for shallow lakes and is given by Equation 2:

Equation 2: AF_{pred} (days) = -35.4 + 44.2 log (TP) + 0.95 $z/A^{0.5}$ (Nürnberg 2005)

Where TP is the average measured water column TP (µg/L) of the lake, z is the mean depth in meters, and A is the lake surface area in hectares. The release rate (mg/m^2-day) was estimated from literature values.

Watershed Loads

Pollutant load generation and delivery to Crooked Lake were estimated using the P8 computer model (Walker 2007, Version 3.2). P8 inputs include devices (detention ponds and pipes) and watershed information (area, percent impervious and pervious curve number.)

Using 2-foot contours and storm sewer information obtained from the Cities of Andover and Coon Rapids along with construction plans from Coon Creek Watershed District permits, the Crooked Lake watershed was divided into 11 subwatersheds. Ten of these subwatersheds are point source discharges that enter the lake through stormsewer pipes, and the 11^{th} subwatershed has overland flow direct drainage.

Two subwatersheds, approximately 25% of the Crooked Lake watershed, contain water quality treatment. One is located north of Crooked Lake: a stormwater pond treating 25 acres of roadway and public/semi-public buildings. The other is on the east side of the lake: an old ditch currently acting as a stormwater pond for 29 acres. Both of these detention basins have been incorporated into the P8 model.

Table 4.9.1

Subwatershed ID	Avg. Runoff Volume (ac. ft./yr)	Avg. TP Load (lbs./yr)
1	2.3	1.1
2	3.2	1.6
3	8.8	4.2
4	5.3	2.5
5	8.8	4.2
6	23.3	11.0
7	17.0	3.2
8	44.3	21.0
9	12.0	5.7
10	18.0	3.3
11	3.1	1.5

The percent impervious and pervious curve numbers were estimated by current land use. Based on literature values and LANDSAT imagery, an impervious percent was assessed to each land use type. All pervious undeveloped areas were assigned a curve number of 60. All pervious developed areas were assigned a curve number of 74 (Wenck 2007).

Table 4.9.2 summarizes the land uses, total areas, impervious fractions, and curve numbers used:

Table 4.9.2

Land Use	Area (ac)	Impervious fractions	Pervious Curve Number
Single Family Residential	181	0.25	74
Multi-Family Residential	3	0.40	74
Parks and Recreation	9	0.05	60
Public/Semi-Public	22	0.30	74
Vacant	16	0.05	60
NWI Types 1,2,6,7,8	6	0.00	60
Totals (weighted average*)	236	0.23*	72*

Water quality data collected in 2000, 2002, 2003, 2005 and 2006 were used to verify the P8 model simulation of pollutant load generation and delivery (water quality data was not available for years 2001 and 2004). The P8 model was calibrated so that the BATHTUB model equations approximately matched the in-lake monitored phosphorus concentrations. The calibration was conducted by modifying the scale factor for particle loads in the P8 model.

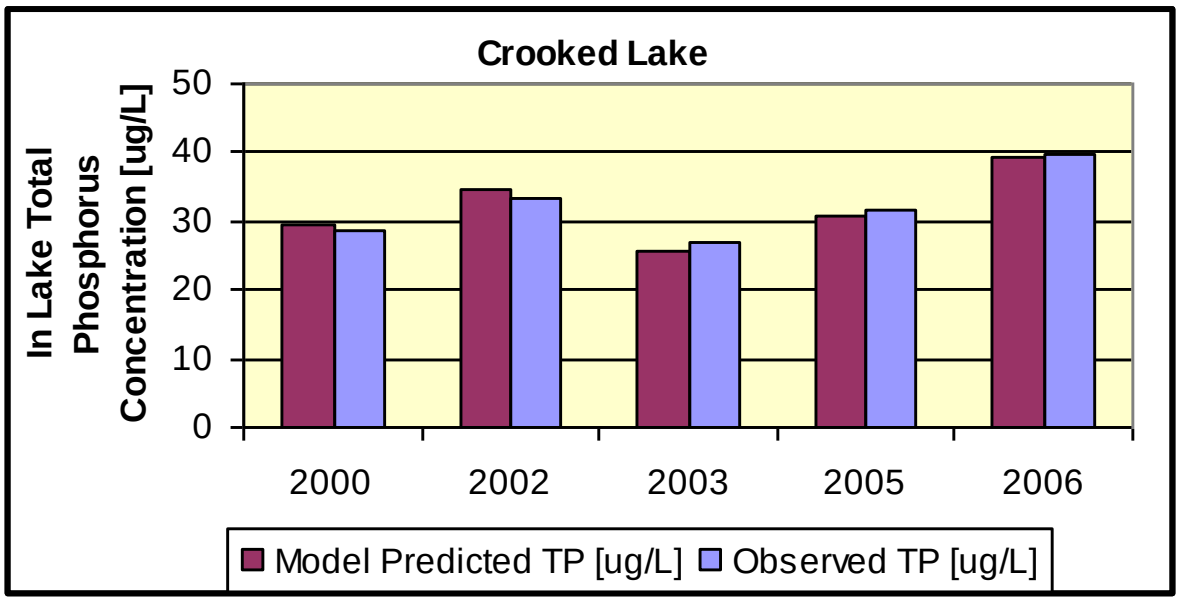
4.10 Water Quality Response Modeling

Model equations from BATHTUB were used to estimate the in-lake response to hydraulic and pollutant loads in 2000, 2002, 2003, 2005 and 2006 in Crooked Lake. Several models are available within the BATHTUB model. The Canfield-Bachmann model for natural lakes was used to estimate lake response for phosphorus.

BATHTUB was used to estimate chlorophyll-a concentrations as a function of phosphorus, light, and flushing rate. BATHTUB was also used to estimate Secchi depth as a function of chlorophyll-a and non-algal turbidity. The coefficient for chlorophyll-a concentration was modified from 0.025 to 0.015 to represent shallow lakes more accurately (Steve Heiskary, pers. comm.).

Model Validation: The results from the in-lake phosphorus response model are compared to measured in-lake phosphorus concentrations (TP) as shown in Figure 4.10. This model performed well for the modeled years and is considered a reasonable representation of the nutrient dynamics in the lake and watershed.

Figure 4.10



4.11 Current Phosphorus Budget

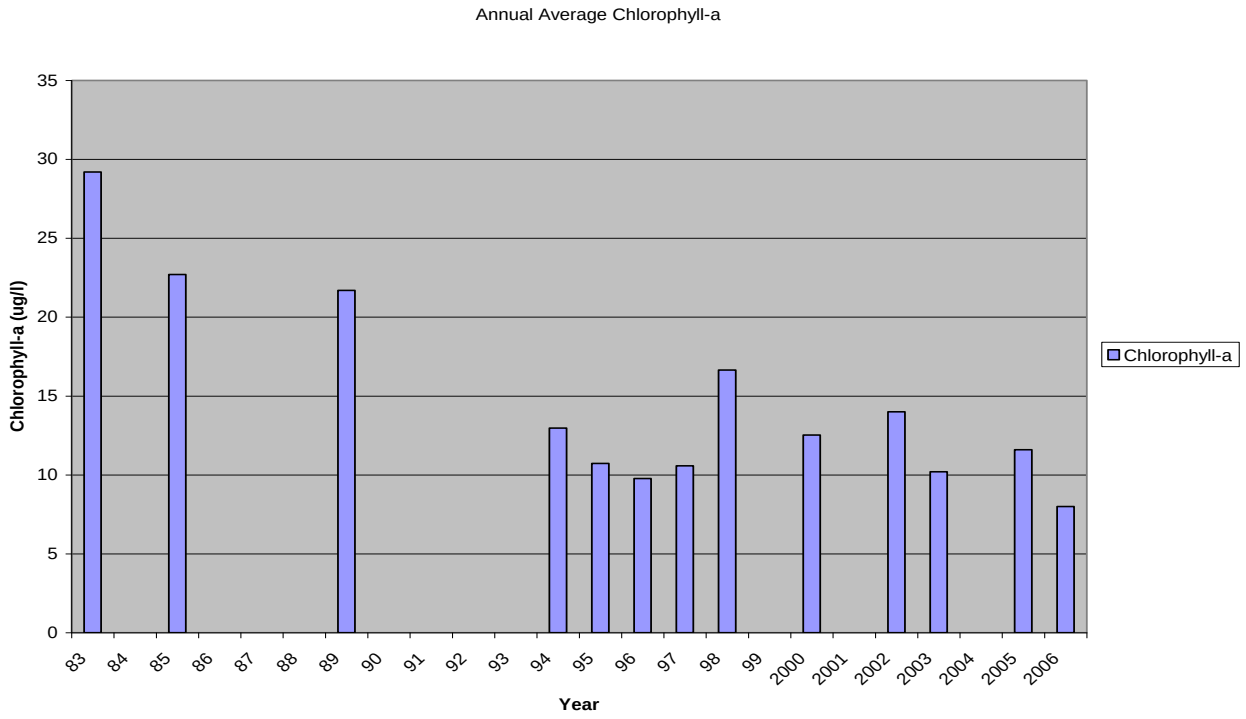
Modeled and monitored data from 2000, 2002, 2003, 2005, and 2006 were used to estimate the current sources of phosphorus to Crooked Lake. It is assumed that 100% of the hydraulic loading for Crooked Lake is contributed by its watershed. For the years considered in this study the phosphorus loading is distributed on average as follows: 6% from atmospheric deposition, 18% from internal loading, and 76% from the watershed. The hydrologic and phosphorus budget for Crooked Lake is presented in Table 4.11:

Table 4.11

	2000	2002	2003	2005	2006
Annual Total Phosphorus Load [lb]					
Watershed	48	82	35	55	90
Atmosphere	5	5	4	5	5
Internal (1 mg/m^2-day)	15	12	12	16	18
TOTAL	68	99	51	76	113

4.12 Chlorophyll-a in Crooked Lake

Chlorophyll-a concentrations have significantly improved since the early 1980s. The annual average chlorophyll-a concentration for the 1980s was 24 µg/L. The annual average from 1995-2006 was 11.6 µg/L.



4.13 Aquatic Macrophyte Plants

Crooked Lake has a diverse aquatic plant community that is comprised of numerous native species plus two invasive species, Eurasian watermilfoil and Curly leaf pondweed. In some areas plants grow densely and to the surface, both native and invasive species. Given the water clarity and diverse plant community, dense plant numbers are expected especially in shallow areas; this is not unhealthy. A map of nuisance vegetation conditions and invasive species has not been created for the lake yet; it is scheduled into this Plan. In recent years staff from the Anoka Conservation District have noted that dense vegetation at or near the surface occurs in limited areas, mostly in shallow areas near shore, with a few exceptions. Lake managers generally strive for healthy, diverse aquatic plant communities with invasive species below nuisance levels (if present at all).

Invasive Species

Crooked Lake contains two invasive plant species which have reached nuisance conditions on the lake:

Genus	Species	Common Name
Myriophyllum	spicatum	Eurasian watermilfoil
Potamogeton	crispus	Curly leaf pondweed

Eurasian watermilfoil: Eurasian watermilfoil was first discovered in 1990 and whole-lake treatments have occurred in 1992 and 2002 to control Eurasian watermilfoil. Eurasian watermilfoil is an extremely adaptable plant that is able to tolerate and thrive in a variety of environmental conditions. It grows in water depths from one to 10 meters (three to 33 feet). Eurasian watermilfoil grows best on fine textured, inorganic sediments, and relatively poorly on highly organic sediments. Eurasian watermilfoil requires high light, has a high photosynthetic rate, and can grow over a broad temperature range. Eurasian watermilfoil exhibits an annual pattern of growth. In the spring, shoots begin to grow rapidly as water temperatures approach 59 degrees Fahrenheit. Shoots branch profusely when near the surface, forming a dense canopy. Below one meter in depth, leaves senesce in response to self-shading. Typically, plants flower upon reaching the surface (usually mid to late July). During fall, plants die back to the root crowns, which sprout again in the spring.

Curly leaf pondweed: Curly leaf pondweed, another highly productive aquatic macrophyte, has a life cycle that can significantly impact summertime phytoplankton productivity. Curly leaf pondweed reproduces by forming vegetative propagules called turions. Turions will remain dormant in the summer and then most will germinate in the fall and continue to grow slowly through the winter. These young plants will grow rapidly in the spring and by early summer the entire crop senesces. The density of growth and the timing of senescence for Curly leaf pondweed can have significant impacts on productivity because the release of phosphorus occurs at a time when growth conditions are ideal for phytoplankton. A heavy nuisance level of Curly leaf pondweed biomass (~400 stems/m^2) can potentially contribute 6.7 pounds phosphorus per acre.

Management of Invasive Plants: In 1992 Crooked Lake was subjected to a whole lake treatment with 15 ppb fluridone. The treatment reduced the milfoil population to below

detectable levels for four years but also caused unacceptable damage to the native aquatic plant community (Crowell 2002). By 1998 Eurasian watermilfoil was back to nuisance levels. In 2002 Crooked Lake was chosen along with two other Minnesota lakes to determine if a lower concentration of fluridone (4-5 ppb) would effectively control Eurasian watermilfoil without causing unacceptable harm to native vegetation. The fluridone treatment reduced the frequency of Eurasian watermilfoil to zero. The treatment also reduced the total number of native plant taxa in the lake. By 2003 the number of taxa had rebounded to pretreatment levels.

Native Plant Species

Approximately 34 aquatic plant species occur in Crooked Lake. The following species were found during DNR aquatic plant inventories of 2001 to 2005, and are classified by physical similarity.

Table 4.13

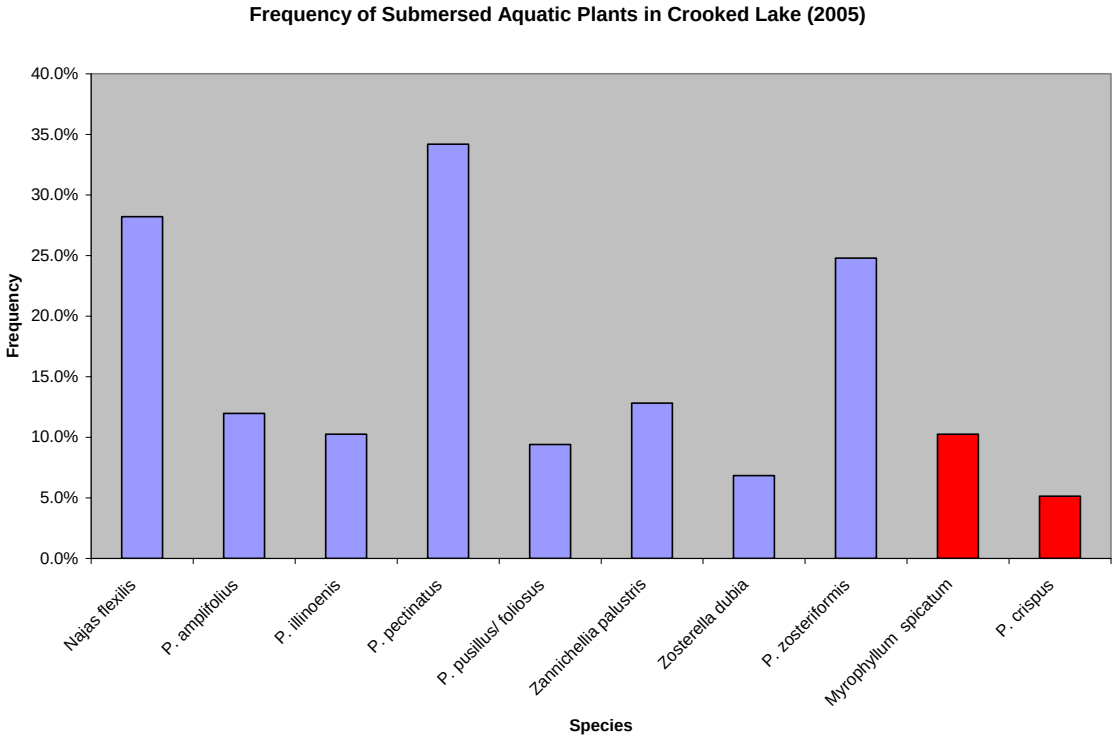
Plant Group	**Genus**	**Species**	**Common Name**
Trees	Populus	sp.	Poplar/Cottonwood
	Salix	sp.	Willow
Emergent			
Cattail	Typha	sp.	Cattail
	Eleocharis	sp.	Hairgrass
Rush	Juncus	sp.	Rush
	Scirpus	americanus	American bulrush
	Scirpus	validus	soft-stem bulrush
Lily & Lotus	Nuphar	sp	Water-lily
	Nymphaea	sp.	Water-lily
	Cicuta	maculata	Spotted water hemlock
	Rumex	crispus	Curled dock
	Sagittaria	sagittifolia	Arrowhead
Free Floating			
	Lemna	minor	Common Duckweed
	Ricciocarpus	natans	Purple-fringed riccia
	Spirodella	polyrhiza	Common Duckweed
	Wolffia	sp	Watermeal

Table 4.13
Continued

Plant Group	Genus	Species	Common Name
Submergent			
Broadleaf	Potamogetan	amplifolius	Largeleaf pondweed
	Potamogetan	illinoensis	Illinois pondweed
	Potamogetan	natans	Broad-leaved pondweed
Curled Pondweed	Potamogeton	crispus	Curly leaf pondweed
Fine-leaf	Certaophyllum	demersum	Coontail
	Myriophyllum	spicatum	Eurasian watermilfoil
	Myriophylum	sibiricum	Northern watermilfoil
	Najas	sp.	Bushy pondweed
Low Growth	Chara	spp.	Stonewart / muskgrass
	Utriculalria	vulgaris	Common bladderwort
	Vallisneria	americana	Wild celery
	Zannichellia	palustris	Horned pondweed
	Zosterella	dubia	water stargrass
Narrowleaf	Potamogeton	pectinatus	Sago pondweed
	Potamogeton	pusillus	Small pondweed
	Potamogeton	foliosus	Leafy pondweed
	Potamogeton	zosteriformis	flat-stem or eelgrass pondweed

Aquatic Plant Frequency Distribution – 2005

The most recent DNR aquatic plant survey in 2005 found 10 species that were widespread enough to be present in >5% of the samples. Eurasian watermilfoil was present in <10% of locations sampled and curly leaf pondweed in <15%. The density of these plants at each location is not known. Sago pondweed, bushy pondweed, and flat-stem pondweed were the most frequently encountered, all at >25% of locations sampled. The figure below summarizes the frequency of the remaining five species:



4.14 Fish Community Structure and Health

The fish community of Crooked Lake is in a stable, healthy state.

The first fish survey for Crooked Lake was conducted in 1951. There have been 11 total fish surveys conducted on Crooked Lake with the most recent fisheries survey conducted in 2004. The next scheduled survey is in 2009.

Table 4.14.1 Prominent species found in Crooked Lake

Trophic Guild	Common name	Genus	species
Forage Species	White Sucker	Catostomus	commersonii
	Channel Catfish	Ictalurus	punctatus
Pan Fish	Bluegill	Lepomis	macrochirus
	Smallmouth Bass	Microterus	dolomieui
	Yellow Perch	Perca	flavescens
	Black Crappie	Pomoxis	annularis
Rough Fish	Common Carp	Cyprinus	carpio
	Yellow Bullhead	Ameiurus	natalis
Top Predator	Northern Pike	Esox	lucius
	Largemouth Bass	Microterus	salmoides
	Walleye	Sander	vitreus

Based on the DNR surveys bluegills are the most abundant fish in Crooked Lake, comprising the largest percentage of total fish collected in each of the 11 surveys. Additional species that comprised a significant portion of the total catch include black crappie, black bullhead, northern pike, and yellow perch.

Fish community data was summarized by trophic groups for Crooked Lake. Species within the same trophic group serve the same ecological process in the lake (i.e., panfish species feed on zooplankton and invertebrates; may serve as prey for predators). Analyzing all the species as a group is often a more accurate summary of the fish community. Trophic group summaries of abundance and biomass are presented in Figures 4.14.1 and 4.14.2, respectively.

Based on trophic group analysis, panfish are the dominant group in Crooked Lake in terms of both abundance and biomass. The rough fish and top predator groups make up a relatively small percentage of the total fish abundance in Crooked Lake during most survey years. However, in terms of abundance the top predator group comprises a significant portion of the total lake biomass during most surveys. Additionally, large mouth bass are known to be present in the lake in moderate to large numbers. Largemouth bass are not well represented in DNR surveys.

Combining this information of the top predator biomass with the known occurrence of largemouth bass indicates that three is a good mechanism for top-down control in the fish community.

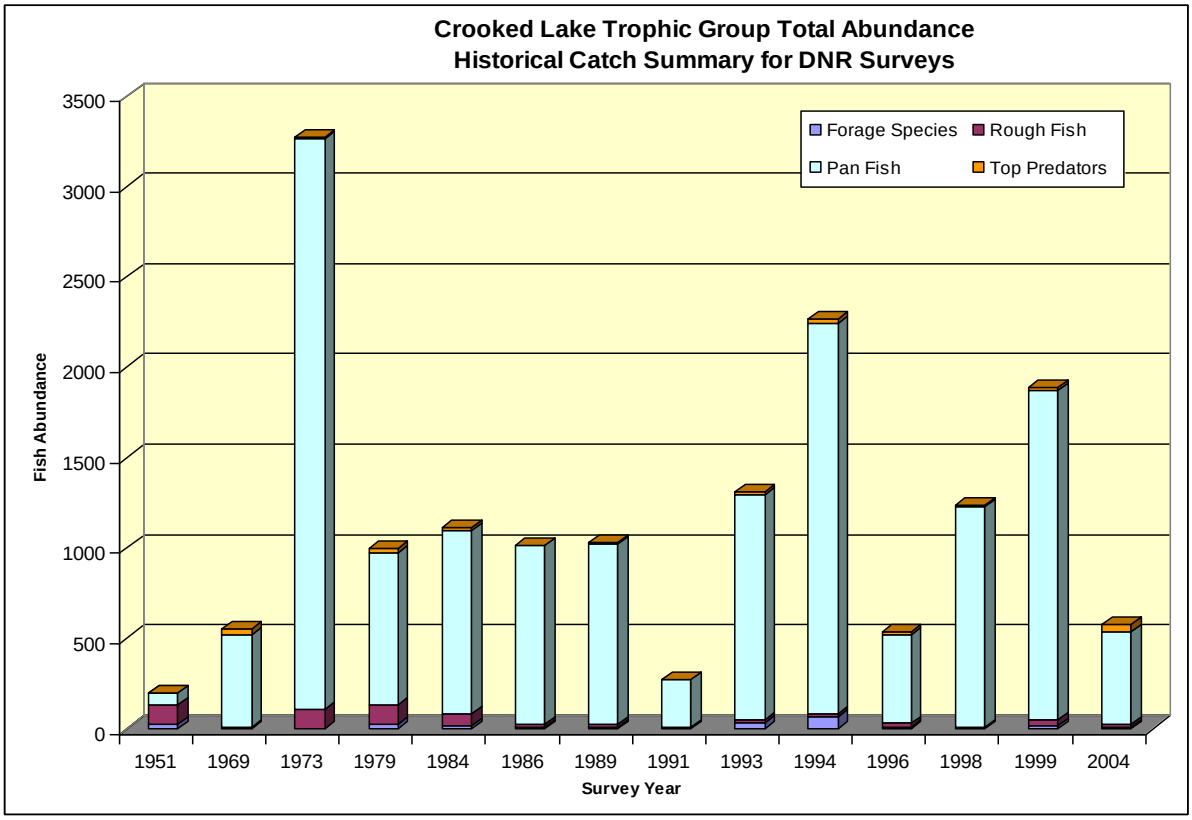


Figure 4.14.1: Fish trophic group abundance based on historical DNR surveys for Crooked Lake

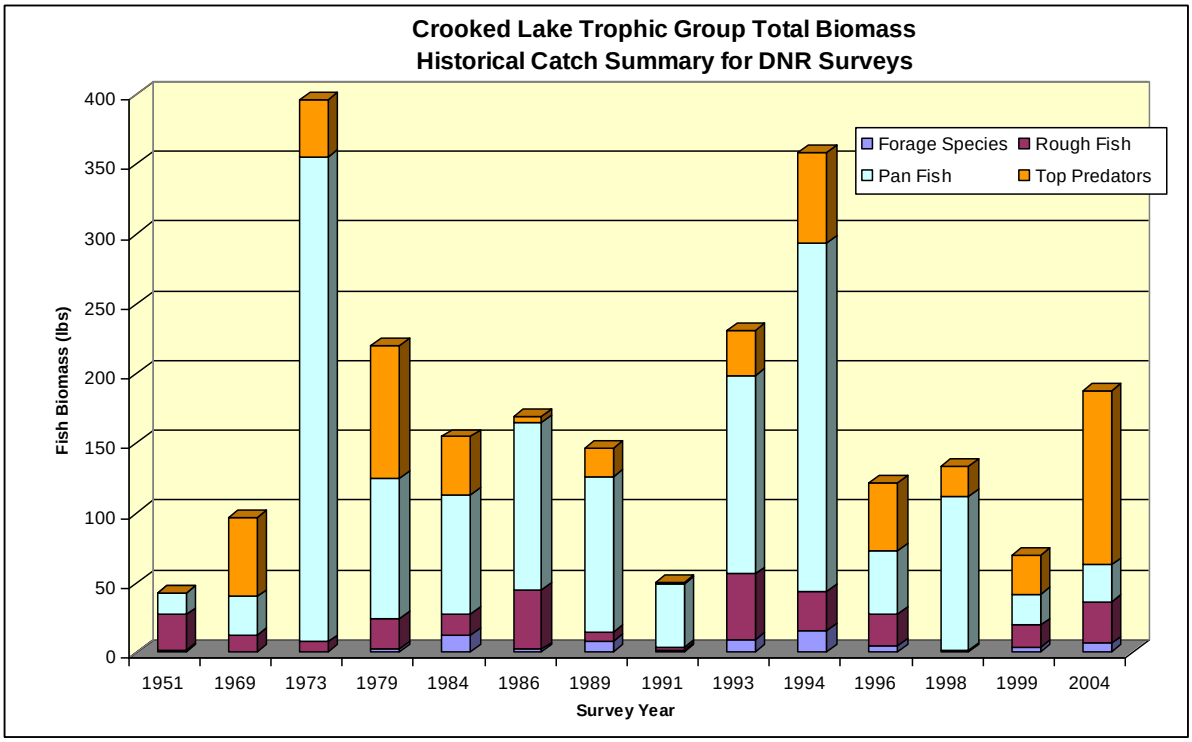


Figure 4.14.2: Fish trophic group biomass based on historical DNR surveys for Crooked Lake

Current Fish Management Emphasis

A variety of historical fish survey data are available. The lake management plan developed by the Fisheries Division of the DNR identifies:

Primary management species

- Walleye
- Channel catfish

Secondary management species

- Largemouth bass

The selection of walleye and channel catfish as primary management species is an interesting choice as neither species is naturally abundant in the lake and their populations are being maintained through supplemental stocking.

Problem Species

While rough fish are present in the lake, including black bullhead and common carp, they are not dominating the fish community and do not appear to be creating water quality nor fish community problems. Although carp are not abundant in the lake, the management of the carp population will be critical in maintaining healthy conditions in Crooked Lake. If the carp population were to get out of control, the lake could switch to a turbid water state. Limiting the size of the carp population will be important in protecting Crooked Lake.

5.0 Public Participation and Perceptions

5.1 Introduction

On March 25th, 2008, a public workshop on issues facing Crooked Lake was held at Crooked Lake Elementary School. Coon Creek Watershed District (CCWD) sponsored the workshop with promotional help from the Crooked Lake Area Association (CLAA). Several workshop members had attended a presentation on Shallow Lake Ecology by CCWD staff (Joe Bischoff, Wenck) at the CLAA winter membership meeting held one month earlier on February 28, 2008.

Seven questions were asked of the group at the public input workshop. The first two were posed to the group publicly. The next five questions were answered privately with individual responses on 3x5 cards with each question on a different color card and placed under categories determined by issues in Question 3. The questions posed were:

8. Why is Crooked Lake special (or not special)? *to live,*to play, *to be near
9. What aspects of Crooked Lake would you like to see improved?
10. What do you believe are the three major issues facing Crooked Lake?
11. What is causing these issues?
12. What factors contribute to these causes?
13. What actions do you think are needed to address each of these factors?
14. Who should take the lead in addressing each of these actions?

5.2 The Lake as a Special Element in the Community

The community surrounding Crooked Lake indicated a very strong attraction to the lake because of its physical character and recreational opportunities. People repeatedly indicated that the view of the lake and its discouragement of large boats because of lake size contributed to making Crooked Lake a wonderful area in which to live. In addition, numerous people spoke about being drawn to the lake by the number of recreational opportunities available: swimming, boating, fishing, floating, and wildlife viewing were all mentioned numerous times.

The fact that the lake and nearby neighborhoods were not busy or congested was cited as a quality that helped facilitate a “community feel” which changes or evolves with time but is still very present. Economic value was also cited, but far less than the lake itself and its recreational value.

Crooked Lake is clearly the focal point of the immediate community. It is an active element of the landscape—changing and responding to climate, season, and management in very dynamic ways. Residents are watchful of the lake and are very connected to its condition. Visual changes are watched in great detail including invasive species (EWM), water clarity, water level fluctuations, and lake use.

The lake is perceived as having shifted from being a ‘public’ lake in the past, when it hosted large summer gatherings of farmers and other Anoka County residents, to being more ‘private’ today. Although public accesses and lands are available for use, local residents sense a change in

lake availability for those other than shoreline property owners. Fewer open, unbuilt areas of shoreline may have contributed to this perception.

Residents value both their internal and external attachments to the lake. A combination of these values guides decision-making about changes in the community and the lake edge. External attachments sometimes override the quieter, more personally held internal attachments. The following examples illustrate the difficulty in balancing the two:

- Fewer lots and areas left undeveloped in the watershed
- The sense that access to the lake is restricted for those not living on it
- Emergent vegetation is removed for aesthetic reasons and boat access, even though residents realize it is important for fish habitat.

5.3 Desired Improvements to the Lake

The public identified 15 aspects of Crooked Lake they would like to see improved. The list below is presented in priority based on responses and relevance to lake management:

1	Milfoil, weeds, invasive species
2	Water quality, Non-point pollution, Stormwater runoff, smell
3	Garbage & Trash, dog droppings
4	Water Clarity
5	Old Beach
6	Water Level & depth
7	Mucky bottom
8	Boats: too much wave action; slower & fewer
9	Noise: US 10 - Noise S End
10	Geese
11	Public Access
12	Public Beach - re-open
13	Car Dealership Lights
14	South Marsh
15	Fish

5.4 Perceived Lake Management Priorities

Of the 15 issues identified above, only eleven were identified when the group was asked to identify three priorities. Of the eleven, three issues clearly stood out above the rest:

1. Eurasian Water Milfoil control/management
2. Water quality (including water clarity and non-point pollution)
3. Muck

Trash and lake water levels were also identified. The tables on the following pages provide details on these top five issues.

Eurasian Water Milfoil, Weeds, and Invasive Species

Background	The presence of Eurasian Watermilfoil (EWM) and Curly leaf Pondweed (CLP) was the single biggest issue raised at the March 2008 workshop. It is seen as the single biggest liability to use and enjoyment of Crooked Lake, and in some instances to individual home and property values.
Perceived Causes	The majority of people believed that irresponsible people not cleaning their boats was the primary reason for the introduction and spread of EWM. A second group (22%) believed that the spread of EWM was due to the DNR policy limiting the treatment of EWM. Others indicated EWM presence was from wildlife, or low water levels.
Perceived Contributing Factors	The factors contributing to the above conditions were primarily viewed as a lack of concern, typically by boaters. A significant number of other people felt that there was a lack of political will at the state level and a lack of education concerning EWM. Another group felt a lack of enforcement, or ability to stop "dirty" boats from entering the lake. Others believed that the contributing factor to EWM was the lack of funds for EWM control. One individual noted that shallowness of the lake was the primary contributing factor.
Perceived Remedies	<u>Chemical Treatment</u>: Almost half of the people in attendance supported chemical treatment of the lake to control EWM. Portions of that group spoke specifically to annual treatments while two individuals supported a whole lake treatment. One individual proposed increasing the size/percentage of the annual treatment area. <u>Education</u>: The next largest group supported education primarily of boaters about the nature of EWM. <u>Other approaches</u> included research, increased enforcement, harvesting, and closing the public access.
Implementation Leadership Responsibilities	The Minnesota DNR was seen as the obvious lead in addressing EWM, followed by the Crooked Lake Area Association, and the Coon Creek Watershed District.

Water Quality Perceptions

Background	The term "water quality" is used in many contexts. In this section, public perceptions of water quality were determined from data gathered at the public workshop in March 2008. Water quality is an important issue of concern to the community, ranking second behind, and sometimes considered impacted by, Eurasian watermilfoil (EWM). Water quality was defined as a combination of water clarity and non-point pollution, the latter phrase familiar to the audience. In fact, stormwater runoff and lawn fertilizer runoff, caused primarily from unconcerned and, secondly, uneducated homeowners, had the highest number of responses.
Perceived Causes	The majority of people who indicated that water quality was one of the three major issues facing Crooked Lake indicated that fertilizer and stormwater runoff were the major contributors or threats to poor water quality in Crooked Lake.
Perceived Contributing Factors	The majority of people indicated that the principal causes for water quality problems in Crooked Lake were lack of education/understanding concerning lawn care, management of lawn clippings, and the use of fertilizer. A second group identified infrastructure problems and people not caring or being aware of the impacts of letting some things drain to the lake. Still others indicated that water quality issues derived from a range of sources such as too many people, a lack of respect for the environment, geese, poor management of stormwater runoff, and lack of long term vision for the lake.
Perceived Remedies	Education: The vast majority of people who spoke to this issue believed that an education program targeting fertilizer and lawn and lake care was the best remedy. Other remedies included intergovernmental coordination, regulation of fertilizers, enforcement, monitoring, street sweeping, and value prioritization.
Implementation Leadership Responsibilities	The vast majority of people who spoke to this issue believed that individual homeowners should take the lead, followed by the Crooked Lake Association, Coon Creek Watershed District and the MDNR. The cities and Anoka County were also mentioned.

Muck

Background	Muck, particularly on the north end of the lake, was the third most cited issue facing Crooked Lake. The muck is described as approximately 4 feet deep and is churned up by boaters, carp, and turtles.
Perceived Causes	The majority of people commenting on this issue believed that the muck present in the northern part of the lake was from the accumulation and decomposition of organic stormwater runoff. The remainder of the individuals attributed the source of the organic matter to vegetation growing in the lake.
Perceived Contributing Factors	People addressing the contributing factors to muck focused on the stormsewer system in the northern part of the lake.
Perceived Remedies	Dredge: The most popular remedy for muck was to dredge the northern bay, although education was also a popular remedy. Other remedies involved rerouting stormsewer, elimination of weeds contributing to muck formation, and research.
Implementation Leadership Responsibilities	The MN DNR was seen as providing the most leadership. The cities, county, watershed district, and lake association were viewed to have about the same level of involvement.

Trash

Background	Trash was the fourth most cited issue facing Crooked Lake, and the third most cited issue that citizens wanted addressed.
Perceived Causes	Sources and causes cited for trash were boaters, ice fisherman, and users of the fishing pier.
Perceived Contributing Factors	The underlying reason for littering was people who are apathetic, irresponsible, or simply unaware of the consequences of their action.
Perceived Remedies	The number one suggested remedy for trash and littering was enforcement. Secondary remedies education, increased City pick up, and closing both the fishing pier and the public access.
Implementation Leadership Responsibilities	The Cities of Andover and Coon Rapids were seen as the primary parties responsible for addressing this issue followed by the Crooked Lake Area Association and Anoka County.

Water Levels

Background	Water level in the lake was the fifth most cited aspect that people would like to see improved and the sixth most cited challenge facing the lake.
Perceived Causes	Only three individuals offered potential causes to the concern a lake levels. Two individuals cited "mother nature" and drought, and one individual cited potential construction but could not cite where.
Perceived Contributing Factors	The individuals who spoke to this concern cited a poor understanding of the hydrodynamics of the lake and a lack of a long-term perspective on the cumulative effects of construction as factors affecting water levels.
Perceived Remedies	The only suggestion in addressing this concern was education of developers, county, and cities of the possible causes of water level fluctuations.
Implementation Leadership Responsibilities	The Minnesota DNR was seen as the only agency who might address this concern.

6.0 Organizations, Roles, & Goals

Seven local and state organizations play direct roles in the management of Crooked Lake. Other agencies, such as the Metropolitan Council, conduct research and are involved in monitoring the condition of lakes within the seven county Metropolitan area.

This Plan discussed those agencies that have programs or policies which have a direct impact on the management of Crooked Lake.

The seven agencies are:

Local Agencies & Organizations

1. Crooked Lake Area Association
2. City of Andover
3. City of Coon Rapids
4. Anoka Conservation District
5. Coon Creek Watershed District

State Agencies

6. Minnesota Department of Natural Resources
7. Minnesota Pollution Control Agency

Local Agencies & Organizations

6.1 Crooked Lake Area Association

www.cooncreekwd.org>News & Information>Get Involved!>Crooked Lake Area Association
c/o 13415 NW Heather Street
Andover, MN 55304

The Crooked Lake Area Association is a non-profit organization dedicated to the conservation of Crooked Lake. The Association is organized to encourage wise use, management, and preservation of Crooked Lake in order to maintain the delicate ecological balance which must be kept between the lake and the adjacent watershed. Further, the Association considers, recommends, and endeavors through comprehensive management planning and responsible means, to bring about appropriate action by agencies of government and private individuals to effectively manage and preserve Crooked Lake, its watershed.

The purpose of the Association is to preserve and protect Crooked Lake and its surrounding watershed, and to enhance the water quality, fishery, boating safety, and aesthetic values of Crooked Lake, as a public recreational facility for today and for future generations.

The Association operates eight programs either independently or in cooperation with other agencies to fulfill this purpose:

Table 6.1.1

Organization	Mission	Program	Description
Crooked Lake Area Association	To preserve and protect Crooked Lake and its surrounding watershed	Adopt-A-Park: Boat Landing	Policing the park and landing once-a-week and picking up and disposing of litter and garbage
		Boat Inspections	In cooperation with the DNR, inspect boats entering and leaving the lake for invasive species.
	To Enhance the water quality, fishery, boating safety and aesthetic values of the lake	Invasive Plant Treatment	Annually coordinate the application and treatment of the lake for Eurasian Watermilfoil and Curly leaf Pondweed
Crooked Lake Area Association		Lake Level Monitoring	Record lake water levels weekly during ice-out. Program

Organization	Mission	Program	Description
			coordinated by the Anoka Conservation District (ACD)
		Communication: Newsletter	Prepare and distribute a news letter to members 2-3 times per year
	To prepare, maintain, and support the Comprehensive Plan for Crooked Lake	Planning	Be actively involved in the development and maintenance of this Comprehensive Plan and other planning processes and reports that may affect the lake
		Governmental Relations: Watch Dog	To monitor the activities of Boards, Councils, and Commissions when financial and policy decisions influence the lake and its watershed.
		Winter & Summer Meetings	Hold a winter meeting focused on the business of the Association and issues regarding the lake. Hold a summer meeting focused on building and maintaining the Crooked Lake community.

Cities within the District

Crooked Lake is located within two cities: Andover and Coon Rapids.

6.2 City of Andover

www.ci.andover.mn.us

1685 Crosstown Boulevard NW
Andover, MN 55304

The City of Andover is a city of the second class with a population exceeding 30,000. The city operates 6 programs that directly affect Crooked Lake:

Table 6.1.2

Department	Mission	Program	Description
Council/Administration	Responsible for all activities and operation conducted by the City	Budgeting	The Andover City Council has made funds available to the Crooked Lake Area Association for the treatment of invasive species in the lake.
Engineering	Responsible for virtually all City public improvement projects	Storm Sewer	Projects include all publicly owned facilities
Parks and Recreation	Provide information about various programs and offer literature on various natural resource subjects	Natural Resources	There are several different natural resource and environmental quality issues in Andover: Water quality, tree preservation, tree insect, and invasive vegetation are some examples
Public Works	Responsible for the care and maintenance and some construction of City improvements.	Parks Maintenance	Maintains city parks and trail system. Maintenance tasks related to Crooked Lake include: buildings and shelters, landscaping, trees and plantings, blacktop repair,

Department	Mission	Program	Description
	There are six main departments within the Public Works Division: 1. Parks Maint 2. Street Maint. 3. Sewer Maint		trash and litter control, and various construction projects.
Andover Public Works		Sewer Maintenance	Maintains all storm sewers, catch basins, manholes, and sediment ponds consistent with the City comprehensive storm water management plan.
		Street Maintenance	Maintains all City streets to minimize deterioration. Maintenance includes seal coating, crack sealing, pothole patching, sweeping, gravel road maintenance, and wash and seal bridges.

6.3 City of Coon Rapids

www.ci.coon-rapids.mn.us

11155 Robinson Drive
Coon Rapids, MN 55433

Coon Rapids is the fifth largest city in the Metropolitan area and ninth largest city in the state with a population over 61,500. The City operates four programs that directly affect Crooked Lake and its watershed:

Table 6.1.3

Division	Mission	Program	Description
Council/Administration	Responsible for all activities and operation conducted by the City	Budgeting	The Coon Rapids City Council has made funds available to the Crooked Lake Area Association for the treatment of invasive species.
Public Works	Ensures City water is safe, streets are plowed, patched and swept, parks are maintained, and the City fleet of equipment and vehicles is in good condition.	Engineering	New streets, sidewalks, water mains, sanitary sewers and storm drain infrastructure are designed and construction supervised by the Engineering Division.
		Parks	Responsible for construction, operation, and maintenance of Coon Rapids park facilities. The department installs and removes park equipment, makes repairs, mows grass, trims around fences, and picks up garbage & litter.
		Utilities	Operates the storm sewer systems; based on the City comprehensive storm water management plan.

6.4 Anoka Conservation District

www.anokanaturalresources.com
16015 Central Ave, Suite 103
Ham Lake, MN 55304

The Anoka Conservation District (ACD) is a non-regulatory district by Minnesota State statute. The mission of the Anoka Conservation District is to:

- inform and assist county residents and landowners in natural resource management
- conduct research and monitoring for soil and water conservation
- promote practices for soil and water conservation
- serve as a guide to local units of government in land use planning.

The ACD operates four programs in cooperation with individuals or other agencies which directly pertain to Crooked Lake:

Table 6.1.4

Division	Mission	Program	Description
Water Resources	Conduct research and monitoring of water resources and promote water quality improvement projects	Lake Level Monitoring	Coordinate weekly lake water levels readings by volunteers
		Water Quality Monitoring	Collect water quality samples every two weeks during the period of May through September for a total of 10 samples. Monitoring is done 2 of every 3 years.
		Precipitation Monitoring	Collect and analyze precipitation data
	Inform and assist county residents in natural resource management. Promote practices for soil and water conservation.	Shoreland Erosion Education	Work with individual property owners to address erosion problems and concerns
		Water Atlas	Annual report of basic statistics on condition, trend and hydrologic features affecting the lake.

6.5 Coon Creek Watershed District

www.cooncreekwd.org

12301 Central Avenue NE, Suite 100
Blaine, MN 55434

The Coon Creek Watershed District (District) is a regulatory district by Minnesota State statute. The District is charged with managing water resources within the 94-square mile watershed of Coon Creek in Anoka County, Minnesota.

The Coon Creek Watershed District mission is to manage the groundwater and surface water drainage systems within the watershed to prevent property damage, maintain hydrologic balance, and protect water quality for the safety & enjoyment of citizens and the preservation & enhancement of wildlife habitat.

The District currently operates four programs that directly relate to Crooked Lake:

Table 6.1.5

Program	Mission	Activity	Description
Development Regulation	To evaluate, permit, and monitor plans and programs affecting water and related land resources of the District in an orderly and informed fashion.	Issues & Complaints	Investigates and responds to unanticipated and unplanned circumstances, events, or conditions that may affect Crooked Lake and its related land resources.
		Permit Inspection and Enforcement	Ensures compliance with permit requirements and the goals, objectives, and rules of the District.
		Permit Review	Involves reviewing, monitoring, evaluating, and permitting plans and programs affecting the water and related land resources of the District.
		Permits	Regulates land-disturbing activities affecting the quality, course, current, or cross-section of Crooked Lake.
Planning Programming and Budgeting	To coordinate the planning, prioritizing, and financing of programs & activities	Annual Reporting	Includes basic statistics on trend condition and trend of Crooked Lake

Program	Mission	Activity	Description
Planning Programming and Budgeting		Annual Budget	The Board of Managers has funded special studies, on-going data collection, and special services for Crooked Lake.
		Comprehensive Planning and SWPPP	Guiding documents for program and capital facilities management, and provides context and purpose to near-term choices and assesses the future consequences of those choices.
Public & Governmental Relations	To ensure that the continuing planning and management of the Crooked Lake is responsive to the needs and concerns of an informed public;	Education	To increase public awareness on the nature of issues and conflicts that arise when managing water resources
	and to coordinate policies and programs of local, state, and federal government agencies to achieve consistency with the Comprehensive Plan.	Information	To disseminate and discuss the issues, decisions to be made, and the consequences of proposed actions and inactions.
		Involvement	To provide for active involvement of the public and related units of government in developing and implementing water management plans and activities.
Research	Provide integrated resource information used in planning, evaluating, and decision making	Monitoring	To collaborate with Anoka Conservation District to monitor and track qualitative and quantitative aspects of watershed hydrology to calibrate models and assess for signs of potential impairment of water resources.

State Agencies

Because of the broad range of state planning and regulatory responsibilities, it is essential that the District take an aggressive role in ensuring that the actions of various agencies are consistent with the objectives of the Comprehensive Management Plan. Some state agencies, in particular the Department of Natural Resources (DNR), have far-reaching powers in terms of both public and private land-use decisions.

This section touches upon the major roles state agencies currently play in the management of Crooked Lake.

6.6 Minnesota Department of Natural Resources

www.dnr.state.mn.us

500 Lafayette Road
St. Paul, MN 55155-4040

The Department of Natural Resources (DNR) is the agency of the state of Minnesota charged with conserving and managing state natural resources. The agency maintains areas such as state parks, state forests, recreational trails, and recreation areas as well as managing minerals, wildlife, and forestry. The agency is currently divided into eight sections: Ecological Resources, Enforcement, Fish & Wildlife, Forestry, Lands and Minerals, Trails and Waterways, Parks and Recreation, and Waters.

Five Divisions and 10 programs have the most involvement with the management of Crooked Lake:

Table 6.2.1

Division	Mission	Program	Description
Ecological Resources	To protect the ecological health of Minnesota resources by restoring ecosystems and addressing threats such as invasive species	Designating and identifying infested waters (Crooked Lake is listed).	Water bodies are designated infested if they contain invasive species that could spread to other waters if activities are not regulated, and where the risk of spread to an uninfested waterbody is high.
		Inspecting boats at public water accesses	The program hires a crew of seasonal watercraft inspectors each year to educate boaters about aquatic invasive species.
		Prohibited Invasive Species (EWM & CLP are “Prohibited Invasive Species)	It is a misdemeanor to possess, import, purchase, transport, or introduce these species except under a permit.

Division	Mission	Program	Description
Ecological Resources		Aquatic Plant Control Permits	Any removal of emergent vegetation in a Public Water requires a permit.
Enforcement	Focuses on the enforcement of Minnesota natural resource laws and public safety	Conservation Officers	Includes state laws and regulations related to laws dealing with the alteration of lake beds, streams, and wetlands
Fish & Wildlife	To manage, protect and regulate state fish and wildlife resources	Fisheries	Management of the diverse fishery in Crooked Lake.
Trails & Waterways	To provide opportunities to enjoy recreational activities in public resources, without causing damage to the wildlife.	Fishing Piers	Installs/constructs fishing piers in select lakes in MN
		Public Access	Constructs public boat landings to Public Waters
Waters	Accountable for all lakes, rivers and streams, wetlands, and ground water within the state	Public Waters Permits	Regulates all activities that affect the course, current, or cross-section of public waters and wetlands. Crooked Lake is a Public Water.
		Shoreland Regulations	Requires cities to adopt regulations governing land use within Shoreland areas. Shoreland is all land within 1,000 feet of the Ordinary High Watermark of Crooked Lake or the landward extent of the floodplain, whichever is greater.

6.7 Minnesota Pollution Control Agency

www.pca.state.mn.us
520 Lafayette Road
St. Paul, MN 55155-4194

The Minnesota Pollution Control Agency (MPCA) is the agency of the State of Minnesota that monitors environmental quality, offers technical and financial assistance, and enforces environmental regulations. The MPCA finds and cleans up spills or leaks that can affect our health and environment. Staff develop statewide policy, and support environmental education

Four programs have direct interaction or influence on the management of Crooked Lake:

Table 6.2.2

Division	Mission	Program	Description
Municipal	Works with cities and towns to ensure proper management of wastewater, stormwater, and solid waste to help protect the environment and citizens. Work includes technical assistance, development of rules and policy, permitting, and compliance and enforcement	Stormwater	To better manage stormwater across the state, the MPCA administers the requirements of the federal Clean Water Act in addition to its own State Disposal System requirements. The Stormwater Program includes three general stormwater permits: 1. Municipal Separate Storm Sewer System (MS4) 2. Construction Stormwater 3. Industrial Stormwater Each program administers a general permit (and in some cases, individual permits) that incorporates federal and state requirements for stormwater management.
Environ-	To monitor and evaluate the	Biological	Tracks the health of

Division	Mission	Program	Description
mental Analysis and Outcomes	physical, chemical, and biological conditions of the environment in Minnesota.	Monitoring	biological systems: measuring and evaluating the condition of biological systems, and the consequences of human activities for those systems. The aim is to distinguish between naturally occurring variation and changes caused by human activities. The MPCA currently conducts biological monitoring to assess the health of riverine and wetland environments utilizing fish, macroinvertebrate, or plant communities.
		Citizen Lake Monitoring Program	Volunteers collect water transparency data using an 8-inch, circular, all-white metal plate attached to a calibrated rope. This tool is called a Secchi disk.
		Lake Water Quality Assessment Program	Provides lake water quality criteria which can improve how lake resources are managed and how current conditions are measured: this provides a knowledge base that can be used to protect and restore lakes.

7.0 Management Activities

This section of the plan addresses specific issues pertaining to Crooked Lake. The issues discussed are in the order identified at the public participation workshop of major issues facing Crooked Lake held on March 25, 2008.

Problem Title Invasive Species

Eurasian water milfoil & curly leaf pondweed

Problem Statement	In the eyes of the public, the presence of Eurasian watermilfoil and curly leaf pondweed was the most-often cited problem needing to be addressed. Both species interfere with recreational and aesthetic use of the lake.

Watershed & Lake Characteristics

Extensive Littoral Zone and Available Eurasian Water Milfoil Habitat	The littoral zone of Crooked Lake encompasses 73% of the lake surface. This means that 83 of the 114-acre surface is prime habitat for these invasive species. Eurasian water milfoil (EWM) and curly leaf pondweed make up a combined 15.4% of the aquatic macrophyte species in the lake. However, the growth characteristics of the plants combined with the extensive availability of habitat (73% of the lake) makes these plants extremely prevalent and a nuisance for boaters and swimmers.
Lake Sediments	The bottom of Crooked Lake is composed primarily of fine sandy muck, a preferred substrate and growth medium for EWM.
Prevalence Of Seed Source And Propagules	The prevalence of both EWM and CLP and their reproduction and growth characteristics ensure a source of plant reproduction, making eradication nearly impossible.
Increased	Sunlight is readily available to a depth of approximately 6 feet over

Problem Title Invasive Species

Insolation (Sunlight penetration and transmission)	57% of the lake bottom.
History of Both Turbid and Clearwater States	In recent history, Crooked Lake has gone through a turbid state (a period of high algal productivity and low aquatic plant productivity (1970s). The lake has also had periods where it exists in a clear water state (low algal productivity, large aquatic plant community). The drivers that led to the switch from a relatively clear water state in the 1940s, 50s and 60s to a more turbid state in the 1970s is well understood. The switch back to a relatively clear water state by the 1990s is not well understood and appears to coincide with the discovery of Eurasian water milfoil in the lake. The concern about over treating for aquatic macrophytes has to do, in part, with the potential for the lake to switch to a turbid water state as a result of the release of nutrients and the decline in dissolved oxygen as the plants decompose.

Current Management Programs and Policies

Aquatic Plant Management	Pesticide control of aquatic macrophytes on all public waters and watercourses, treatment is limited to: The lesser of 15 percent of the littoral area or a maximum of 100 feet of shoreline per site belonging to an individual riparian property owner may be treated for control of submerged vegetation. Applications for large area or baywide treatment must include a written statement of the plan and a map showing areas proposed to be treated.
Aquatic plants growing in public waters are the property of the state	Because of their value to the lake ecosystem, they may not be destroyed or transplanted unless authorized by the Department of Natural Resources.
Prohibited Plant Control Methods	1. Excavating the lake bottom for aquatic plant control 2. Use of hydraulic jets 3. Destroying or preventing the growth of aquatic plants by using lake bottom or benthic barriers 4. Removing aquatic vegetation within posted fish-spawning areas 5. Removing aquatic plants from an undeveloped shoreline 6. Removing aquatic plants where they do not interfere with swimming, boating, or other recreation

Problem Title Invasive Species

Prevention

Boat Inspection: The Crooked Lake Area Association and the MDNR have periodically instituted inspection programs in an attempt to eliminate any further introduction of invasive species into the lake.

MR 6116 states that individuals may not transport watercraft or related equipment containing prohibited invasive species on public roads.

Treatment & Control

Chemical Control: Eurasian water milfoil was first discovered in 1990. Whole lake treatments to control Eurasian watermilfoil have occurred in 1992 and 2002. Partial treatments (15% of the littoral zone) were conducted by the Crooked Lake Area Association in the years:

Year	Target	Scope	Acres	Sponsor	Cost	$/Ac
1982	CLP		12.5	DNR		
1987	CLP		12.5	DNR		
1990	EWM	15%	12.5	CLAA		
1991	EWM	15%	12.5	CLAA		
1992	EWM	100%	83.0	DNR		
1997	EWM	15%	12.5	CLAA	$3,496	$275
1999	EWM	11%	12.5	CLAA	$3,680	$296
2000	EWM	15%	12.5	CLAA	$5,852	$289
2001	EWM	15%	12.5	CLAA		
2002	EWM	100%	83.0	DNR		
2003	EWM	15%	12.5	CLAA		
2004	EWM	15%	12.5	CLAA		
2008	EWM	15%	9.5	CLAA	$4,350	$458

Fisheries

The lake is currently managed for walleye, channel catfish, and largemouth bass. The lake naturally supports a large population of panfish (Centrarchids and smallmouth bass). Dense cover is vitally important to these species.

Demands and Preferences

Demands and Preferences

The presence of invasive species is seen as the single biggest liability to the use and enjoyment of Crooked Lake and, in some instances, to individual home and property value and enjoyment.

What is desired is a lake where invasive species are either below nuisance levels (not readily seen or interfering with boating or swimming) or eliminated from the lake.

Problem Title Invasive Species

Management

Current Situation

Reduction of invasive species within Crooked Lake must be done in a manner that does not

1. Drive the lake into a turbid water state
2. Remove or eliminate plant cover to the point where the removal adversely affects the fishery.

To achieve this:

1. The reduction of invasives must be accompanied by replacement by native submergent species.
2. The rate of replacement must remain below the level that could drive the lake to switch from a clear to a turbid water state.

Management Goal(s)

1. Reduce Eurasian water milfoil (EWM) and curly leaf pondweed (CLP) to below nuisance levels:
   Plants rarely reach the surface
   Navigation and recreational activities are not generally hindered
   Stem density is 0-160 stems/m^2
   Biomass is 0-50 g dry wt/ m^2
   Estimated Total Phosphorus load is <1.7 lbs/acre

2. Increase abundance of native submersed aquatic plants

Strategies to Achieve these Goals

Plant Survey

Annual Survey of Aquatic Macrophytes: distribution, diversity and frequency of aquatic plants.

Monitoring

Continue Water Quality Monitoring. The existing water quality monitoring effort should be continued.

Prevention

Continued Boat Inspection. Inspecting boats at the public access should be continued. The presence should:

1. Occur during high-use periods
2. Provide an enforcement presence
3. Emphasize invasive species and general public education on the nature of the lake.

Chemical Controls

Continue Chemical Control. Annual chemical treatments should be continued to allow for recreational use and aesthetic enjoyment.

Restoration

Begin plant community restoration within the lake. The lake should be evaluated for its potential in restoring native macrophyte communities to restore native fishery habitat and replace EWM & CLP.

Problem Title Invasive Species

Apply for Treatment of 20% of Littoral Zone	Apply for a permit to apply pesticides to submerged vegetation in 20% of the littoral zone (M.R. 6280.0350, Subp 4, A). Limiting chemical treatment to 15% of the littoral zone is a standard and attempts to allow a reasonable but not excessive portion of the lake to be treated. By limiting treatment areas, the 15% rule also forces treatment to occur in the highest priority areas. However, limiting treatment to 20% of the littoral zone achieves the same ends.

Implementation

		Means					
Method	**Unit Cost**	**ACD**	**CLAA**	**CCWD**	**Andover**	**CR**	**DNR**
Annual Plant Survey	$5,000	Tech Assist	Finance				Lead
Annual Plant Survey Map	$3,000	Tech Assist		Lead & Finance			
Annual Chemical Treatment	$4,500		Lead		Finance	Finance	Regulatory Oversight
Apply For Treatment of 20% of Littoral Zone	$6,000		Lead & Finance				Regulatory Oversight
Boat Inspection	-		Lead				Tech Assist
Plant Restoration	$10,000	Tech Assist	Finance	Tech Assist			Finance
Water Quality Monitoring	$587	Lead		Finance			

Costs

Agency	Activity	2009	2010	2011	2012	2013	Total
Andover	Annual Chemical Treatment	2,250	2,318				$ 4,568
	Treatment of 20% of Littoral Zone			3,000	3,090	3,183	$ 9,273
CCWD	Annual Plant Survey & Map		3,000	3,090	3,183	3,278	$ 12,551
	Water Quality Monitoring	587	605		641	661	$ 3,116

Problem Title Invasive Species

Coon Rapids	Annual Chemical Treatment	2,250	2,318				$ 4,568
	Apply For Treatment of 20% of Littoral Zone			3,000	3,090	3,183	$ 9,273
Crooked Lake Area Association	Plant Restoration	10,000	10,000	10,000	10,000	10,000	$ 50,000
DNR	Annual Plant Survey		5,000	5,150	5,305	5,464	$ 20,918

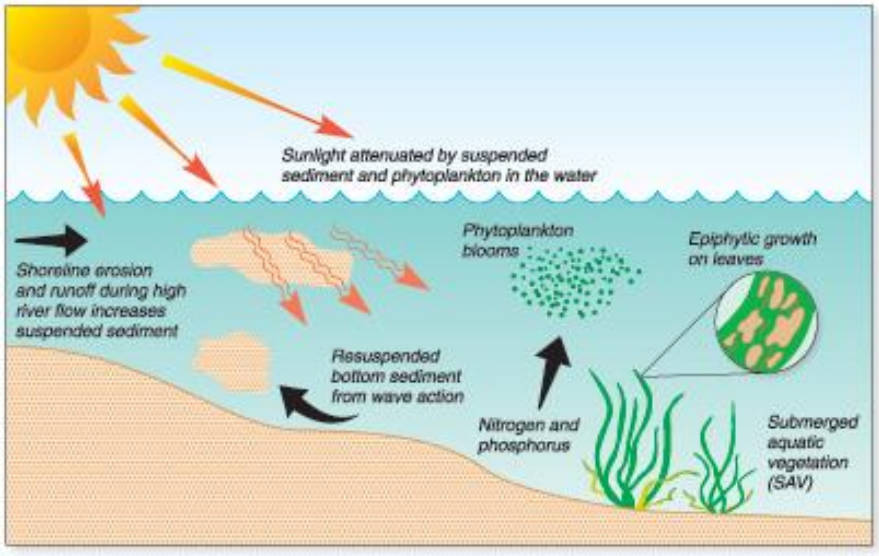
Outcome Measures Decrease in dominance of Eurasian water milfoil and curly leaf pondweed

Milestones

Annual spring treatment for Eurasian water milfoil
Annual monitoring of vegetation
Annual water quality monitoring for at least

1. Clarity
2. Phosphorus
3. Chlorophyll-a

Problem Title Water Clarity



Problem Statement

Water clarity/transparency is affected by algae, soil particles, and other materials suspended in the water. The Clarity/ Transparency of the water is measured using a Secchi disk. A Secchi disk is a small disk that is lowered into the water until it cannot be seen. The depth at which it disappears when it is lowered, and reappears when it is raised are recorded and averaged as a measure of clarity/transparency.

Secchi readings are not a direct measure of water quality. However, transparency is often indicative of lake overall water quality, especially the amount of algae present. It is also a measure of light penetration and therefore plant composition and growth.

Watershed & Lake Characteristics

Lower Phosphorous Levels	Phosphorus concentrations have decreased 40% from 1983 to 2006 to an annual average of 30 ug/l. With lower phosphorus levels there is a corresponding decrease in blue green algae, a major detriment to water clarity.
Lower Chlorophyll-a Levels	Chlorophyll-a in the water column is a direct measure of free floating plant growth (usually algae) in the water column. Chlorophyll-a concentrations in Crooked Lake have decreased by almost 52% since 1980 to an annual average in 2006 of 11.6 ug/l.
Prolonged Residence Time	Crooked Lake is a shallow, closed lake basin with an extended residence time (7.4 years).

Problem Title **Water Clarity**

Current Management Programs and Policies

Research: Water Quality Monitoring

Data on water clarity/transparency began to be collected for Crooked Lake in 1975, and has continued two of every three years since that time. Over that period the lake has exhibited a typical transparency depth of between 3.3 and 5.9 feet, with a 32-year average of 4.7 feet.

The worst years for clarity were 1976 and 1988 when transparency was 3.0 feet. The 'clearest' year was 1992 when clarity averaged 7.5 feet. 1992 was also the year of the whole basin treatment for Eurasian water milfoil which was judged by DNR to have a detrimental affect on the lake and its fishery because of the significant loss and decrease of macrophytic plants.

Water clarity has improved considerably since the late 1970s.

Decade	70s	80s	90s	00s
Avg Secchi Depth (Ft)	3.4	3.6	5.3	6.2

Circulation and Destratification

Aerators have been used on Crooked Lake to prevent or discourage winter kills of the fishery. Aerators keep water moving and are intended to break up stratification within the lake.

Ponding Requirements

Since 1994 Coon Creek Watershed District requires new development or redevelopment of greater than 1 acre that discharges into a lake to pre-treat stormwater to remove 50% to 80% phosphorus.

The 1999 reconstruction of Bunker Lake Blvd routed all storm water to Meadow Creek Church water quality pond for treatment prior to discharge into Crooked Lake. The pond was designed to meet the 50%-80% phosphorus removal efficiency standard.

Phosphorus Free Fertilizer

In 2005, the non-phosphorus fertilizer law went into effect limiting or prohibiting the inclusion and sale of fertilizer containing phosphorus.

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In-Lake Control: Herbicide Applications

Beginning in 1992 Crooked Lake has seen several herbicide treatments. The 1992 whole lake treatment was conducted on the entire lake. Since then there have also been several private and Crooked Lake Area Association-sponsored treatments limited to 15% of the littoral zone.

It would appear that a decrease in concentrations of both

Problem Title Water Clarity

phosphorus and Chlorophyll-a have occurred since that time. However, no monitoring for these factors was conducted within 2 years before or after the 1992 treatment, so caution should be exercised in too closely drawing a correlation with the increase in water clarity.

Demands and Preferences

First addressed in 1987, water clarity was the fourth most-cited aspect of Crooked Lake that people wanted to see improved. Water clarity 'improvement' however was listed second and was cited as one of the three most important issues facing Crooked Lake.

Current Situation Assessed on an annual basis, water clarity has continued to improve over the past 40 years

Management Goal(s)	Secchi depth of 6 ft.
Strategies to Achieve these goals	Maintaining this goal will require a four prong strategy 1. Monitoring: continue lake water quality monitoring 2. Use aerators when needed 3. Inspect Meadow Creek Pond and repair if needed 4. Inspect aqueduct pond and repair if needed

Recommended Management Activities

Lake Water Quality Monitoring	The existing water quality monitoring efforts which include taking secchi disk depth measurements needs to continue.
Pond Inspection	Inspection of Meadow Creek and Aqueduct ponds as part of the NPDES inspection schedule is essential.
Repair Infrastructure as needed	The Meadow Creek and aqueduct ponds are intended to remove 40 %-60% of phosphorus from runoff. Periodic maintenance of these ponds through dredging is essential.

Implementation

		Means					
Method	**Unit Cost**	**ACD**	**CLAA**	**CCWD**	**Andover**	**CR**	**DNR**
Monitoring	$240	Lead		Finance			
Regular Pond Inspection	$250			Tech Assist	Lead		

Problem Title Water Clarity

Pond Maintenance as Needed	$2,500	Finance

Costs

Agency	Activity	2009	2010	2011	2012	2013	Total
CCWD	Monitoring	$240	$247		$262	$270	$1,019
Andover	Pond Inspection	$250					$250
	Pond Repair						

Outcome Measures Total phosphorus
Chlorophyll-a

Milestones
1. CCWD x ACD Annual Monitoring Plan
2. Andover Annual NPDES Inspection Plan

Problem Title Muck

Problem Statement Muck was the third most-often cited issue facing Crooked Lake, yet was listed 6th in the aspects of Crooked Lake that people would like to see improved.

Physical Factors: Watershed & Lake Characteristics

Original Soil and Substrate	A channel from the public access to the main body of the lake is informally maintained through repeated boat traffic traveling to and fro during various water levels. Both the boat hull and engine prop act to mechanically clear a channel of vegetation and push the substrate aside. However, saturated sapric substrate (muck) is largely fluid or viscous and if the channel is not used for a period of time and/or lake levels drop, much of the access channel will readily fill in.
Bathymetry and Slope of North Bay	The north bay is a relatively shallow and flat area of the lake. The 1,000 feet south from the Boat ramp has a fairly uniform and average slope of less than 0.5%. The result is that for each 0.5 feet the lake surface drops in elevation from 860.0 feet, approximately 94 feet of lake bed is exposed and another 94 feet becomes almost too shallow for most boats.
Water Level Fluctuations	Crooked Lake will experience an average annual fluctuation in water levels of approximately 1 foot. Annual high water is typically recorded in May with water levels dropping and reaching an annual low sometime between the end of August and freeze-up.
Historic Water Levels	Prior to 1934, Crooked Lake was at an elevation of approximately 860.0. Between 1934 and 1940 several earthen dams were constructed at the south end of the lake to raise the lake level. The first two dams had leakage problems so were replaced or repaired. The dam raised the normal water level of Crooked Lake first by 1 foot and then 1.6 feet to the current elevation of 861.6.

Current Management Programs and Policies

Excavation Of Public Waters	Minnesota Rule 6115.0220 limits the excavation of materials from the beds of public waters in order to: A. preserve the natural character of public waters and their shorelands B. regulate the nature, degree, and purpose of excavations so that excavations will be compatible with the capability of the waters to assimilate the excavation; and

Problem Title Muck

Prohibited excavation.
Excavation is prohibited in the following cases:

A. Where it is intended to gain access to navigable water depths when such access can be reasonably attained by alternative means which would result in less environmental impact;

C. When the proposed excavation will be detrimental to significant fish and wildlife habitat and there are no feasible, practical, or ecologically acceptable means to mitigate the effects;

Soil Borings

In February, 2008, two borings of the lake bottom were taken on the north end of the lake. The northern most boring showed an undisturbed soil profile with 24 inches of black (N 2.5/) sapric material over a dark to very dark brown sand (10YR 2/2 to 10YR 4/2).

The southern boring (which is within the northeast bay that outlets subwatershed 9&10) showed approximately 28 inches of Brownish (7.5YR 4/2 to 7.5YR 6/3) sandy overburden followed by 13 inches of black (N 2.5/) sapric material underlain by 14 inches brown and dark brown (10YR 3/1 & 10YR 5/3) sand with approximately 10% strong brown mottles (7.5YR 5/6).

The colors of the overburden are consistent with Hubbard sand, the adjacent upland soils. However, the texture appeared more fine than the coarse sand described for Hubbard soil

Social Factors: Demands and Preferences

North Bay near Public Access

Discussions with Lakeshore owners and lake users focused on the north bay of the lake in the vicinity of the boat access. Concerns appeared to address:

1. Weed growth
2. The potential contribution of 'muck' from
    a. Stormsewer outlets
    b. Carp and turtles stirring up the bottom
    c. Detritus from previous years plant growth

Current Situation

Muck is the natural substrate of Crooked lake. While it is underlain by dark brown sand, the upper part which provides an anchoring medium and nutrients for aquatic plants is muck.

Muck is by definition organic in nature, meaning it is comprised

usually of plant material that has been broken down to the point where the plant material is no longer identifiable. The source of the organic material is the plant and animal life in and adjacent to the lake.

At present, the lake is in an acceptable resource condition where muck is concerned. A possible issue is the occurrence of a potential area of sedimentation in the northeast bay.

The size and shape of the potential sedimentation area is unknown at this time. Should the sediment need to be removed, a DNR permit for work in public waters would need to be obtained. To obtain that permit, details on the nature and extent of the sedimentation would need to be documented.

Management Goal(s) Determine the nature and extent of sedimentation/fill in the northeast bay of Crooked Lake.

Strategies to Achieve these goals

Investigate the Extent of Sedimentation in the Northeast Bay

Mode of Action	**Advantages**	**Disadvantages**
The southern lake core boring clearly shows approximately 28 inches of fill. The fill has occurred over a long period of time (approx 30 years) as evidenced by the banding in the soil profile.	Determining and mapping the area of fill provides a factual basis for pursuing a dredging in public waters permit.	*Investigation will need to consider existing use of area by fishery and existing macrophyte population.

Dredge Boat Channel for Public Access

Mode of Action	**Advantages**	**Disadvantages**
Mechanical removal of sediment and substrate	Directly clears channel for boating use	* To consider or allow dredging will be evaluated in terms of potential effect on the fishery and plant community of the lake. *Dredging requires a dredge disposal site to allow the material to drain and dry

Problem Title Muck

			before it is removed from the area. * Access for boats would still be dependent on water levels

Recommended Management Activities

Continue Taking Lake Core Samples	Minnesota State University has expressed an interest in continuing to take core samples within Crooked Lake. These samples would be critical in determining the extent and depth of sedimentation in the North bay area.

Education:

Implementation

Method	Unit Cost	Means ACD	CLAA	CCWD	Andover	CR	DNR
Lake Core Samples		Tech Assist	Lead	Tech Assist			
Dredge Boat Channel	5,000-10,000		Lead		Finance		Permit Review

Costs

Agency	Activity	2009	2010	2011	2012	2013	Total
Crooked Lake Area Assoc	Lake Core Samples						
	Dredge Boat Channel				5,000 – 10,000		5,000 – 10,000

Outcome Measures 3-D map of lake substrate and extent of sedimentation

Milestones Annual sampling of lake cores
Map of sedimentation area

Problem Title Nonpoint Source Pollution

Problem Statement Nonpoint source pollution was the fourth most-often cited problem facing Crooked Lake and tied second for the aspect of Crooked Lake people would like to see addressed.

Physical Factors: Watershed & Lake Characteristics

Land use and Loadings

70% of the contributing drainage area into Crooked Lake is residential. It is the largest single land use affecting Crooked Lake. Residential land uses contribute approximately 89% (38,395 lbs/acre/yr) of the suspended solids to the lake and approximately 90% of the total phosphorus (132 lbs/acre/yr).

Other contributors are:

- vehicular traffic
- lawn care
- pets
- eroded sediment
- vegetative litter

Low Phosphorus Levels

Phosphorus concentrations have significantly decreased from 1983 to 2006. The annual average phosphorus concentration over the last 12 years is 30 µg/l.

Current Management Programs and Policies

Meadow Creek Church Pond

In 1999 Bunker Lake Blvd was reconstructed. At that time, stormwater from the roadway was routed to the pond at Meadow Creek Church securing treatment of all of Drainage Area 7.

Coon Creek Aqueduct

The aqueduct from Coon Creek to Crooked Lake is the outlet for subwatershed 10. The old channel and the remaining adjacent wetland areas provide sufficient storage for a long enough period of time to gain non-point treatment for subwatershed 10.

Storm Water Pollution Prevention Planning (SWPPP)

The cities of Andover and Coon Rapids and the Coon Creek Watershed District are MS4s under the NPDES program administered by the MPCA. All three units of government are required to develop plans and programs for the protection and improvement of water quality within their jurisdictions to the maximum extent practicable.

Social Factors: Demands and

Nonpoint source pollution was the fourth most often cited problem facing Crooked Lake and tied second for the aspect of

Problem Title Nonpoint Source Pollution

Preferences	Crooked Lake people would like to see addressed.		
Current Situation	Non-point pollution is pollution that occurs when rainfall, snowmelt, or irrigation runs over land or through the ground, picks up or dissolves pollutants, and deposits them into rivers, lakes, and other waters or introduces them into ground water. Urban surfaces are subject to the deposit of various contaminants which are then subject to wash-off by rainfall or snowmelt. Typical contributors to pollutants in runoff include vehicular traffic, industry, power production, lawn care, pets, eroded sediment, and vegetative litter. The major nonpoint-source pollutants include sediment, nutrients, oxygen-demanding substances, toxic chemicals, chloride, bacteria and viruses, and temperature changes.		
Management Goal(s)	Phosphorus, Total Chlorophyll-a Secchi disk transparency Oxygen, dissolved	40 mg/L <15 mg/L >1.2 meters 5 mg/L daily average 4 mg/L daily minimum	
Strategies to Achieve these Goals			
Buffer Strips: Subwatershed 8/Lakeshore	**Mode of Action** Can nearly halt discharge of water through physical filtering and bio-uptake of surface water flow through obstruction by plants and then bio uptake intercepted nutrients	**Advantages** *****Provides a permanent source of protection to the lake from direct drainage of water borne pollutants. * Provides wildlife habitat immediately adjacent to lake.	**Disadvantages** ***** Homeowner concerns about "looks"
Catch Basin Stenciling	**Mode of Action** Act as a public system to discourage the placement of pollutants in street	**Advantages** *Act to draw public attention to drainage system and that everything is	**Disadvantages** *relies on volunteer effort and compliance

	or curb systems that drain to the lake	connected	
Curb Cut Rain Gardens Subwatersheds 6, 5, & 3	**Mode of Action** Curb cut rain gardens act as a type of infiltration/ bioretention BMP. The rain gardens are installed adjacent to the curb so that stormwater flowing down the curb line is routed into the rain garden where it is either infiltrated or utilized by the landscaping.	**Advantages** * Will treat an average of 65% of total phosphorous generated by drainage area * Can be adapted to 'fit' the landscaping objectives of the property on which they are located	**Disadvantages** * Uncertainty about new practice among home owners * Maintenance of rain gardens and long term performance are unknowns
Clarify Potential Encroachment on Coon Creek aqueduct	**Mode of Action** Air photos appear to indicate that the Coon Creek Aqueduct in subwatershed 10 may have experienced encroachment and fill. If this is the case, then both the storage and water quality benefits provided by this area would be compromised.	**Advantages** If this area needs to be and can be restored, then Crooked Lake would benefit through enhanced water quality treatment.	**Disadvantages** If encroachment has occurred over a long period of time and among numerous owners, then enforcement can be prolonged.

Recommended Management Activities	1. Install buffer strips on 50% of shoreline 2. Clarify potential encroachment on Coon Creek Aqueduct 3. Install curb cut rain gardens: Subwatersheds 6, 5, & 3 4. Implement SWPPP 5. Stencil catch basins

Implementation

Method	Unit Cost	Means ACD	CLAA	CCWD	Andover	CR	DNR

Problem Title Nonpoint Source Pollution

Stencil catch basins	$400		Lead	Finance			
Install Buffer Strips	$50/lf	Tech Assist	Lead				
Inspect Aquaduct	$250			Tech Assist	Lead		
Install Rain Gardens	$5/sf	Tech Assist		Tech Assist	Lead		
Implement SWPPP				Lead	Lead	Lead	

Costs

Agency	Activity	2009	2010	2011	2012	2013	Total
CLAA	Stencil catch basins						$0
	Install Buffer Strips		$4,500-7,500	$4,500-7,500	$4,500-7,500	$4,500-7,500	$18,000-30,000
Andover	Inspect Aquaduct	$250					$250
	Install Rain Gardens	$5,000	$5,000	$5,000			$15,000

Outcome Measures

Phosphorus, Total	40 mg/L
Chlorophyll-a	<15 mg/L
Secchi disk transparency	>1.2 meters
Oxygen, dissolved	5 mg/L daily average 4 mg/L daily minimum

Milestones

CLAA stenciling project
Active installation and maintenance of buffer strips
Inspection of Coon Creek Aqueduct
Demonstration project grant to City of Andover for Curb Cut rain gardens

Problem Title Trash

Problem Statement

Trash and garbage were the fifth most-cited issue facing Crooked Lake and the third most-cited issue that citizens noted as wanting to be addressed
Attendees to the workshop spoke adamantly about the amount of trash being left at the public access in both summer and winter as well as what appears may be dumping at the public access.

In addition, attendees spoke about the amount of trash left on the ice by ice-fishermen and others using the lake in winter.

Physical Factors: Watershed & Lake Characteristics

NA- littering and dumping of garbage are not issues of the natural resource but a by-product of human misuse of the resource.

Current Management Programs and Policies

Enforcement

Crooked Lake is currently patrolled by the Anoka County Sheriff Department at the request of the City of Andover. The public access is also patrolled by the DNR Conservation officer. The public access is part of a routine patrol route.

Social Factors: Demands and Preferences

Increased Enforcement

Citizens on the lake have indicated that they have requested increased enforcement and an increased enforcement presence on the lake from the Cities, Anoka County, and the DNR.

Current Situation

Citizens continue to request increased enforcement and an increased enforcement presence on the lake and at the public access.

Management Goal(s)

Keep Crooked Lake Clean

Strategies to Achieve these Goals

	Mode of Action	Advantages	Disadvantages
Install garbage cans and signage	By making the issue of trash and the need to pick up trash more visible. And by making trash	*Makes the issue of trash, pollution, and public dumping more visible	* Can act as an invitation to litter and dump * Increased cost

	containers more available, it is hoped that littering and dumping will decrease.	* Makes disposal easier and more convenient	
Increased frequency of garbage pick up	**Mode of Action** Keeping the public landing picked up should decrease the tendency for littering	**Advantages** *Can decrease the tendency for littering	**Disadvantages** * Increased cost * Building momentum to keep an area looking nice can be a lengthy process and can achieve limited success if increased enforcement does not also occur.
Enforcement blitz/campaign	**Mode of Action** Maintaining a presence or increasing the frequency of a public presence with enforcement ability will decrease littering and potentially displace those individuals	**Advantages** *Catch those individuals who are creating the problem	**Disadvantages** *Increased cost
Recommended Management Activities	Install garbage cans and signage Increased frequency of garbage pick up Enforcement blitz/campaign		

Implementation

		Means					
Method	**Unit Cost**	**ACD**	**CLAA**	**CCWD**	**Andover**	**CR**	**DNR**
Install garbage cans and signage	$200				Lead		
Increased frequency of garbage pick up	$1,500				Lead		
Enforcement blitz/campaign	5,000				Lead		

Problem Title **Trash**

Costs

Agency	Activity	2009	2010	2011	2012	2013	Total
Andover	Install garbage cans and signage	$200					$200
	Increased frequency of garbage pick up	$1,500	$1,500	$1,000			$4,000
	Enforcement blitz/campaign	$5,000	$5,000				$10,000

Outcome Measures Number of garbage pick ups/year
Number of litter pick ups/year

Milestones Keep Crooked Lake Clean Sign
Crooked Lake Area Association Annual Report

Problem Title Water Levels

Problem Statement

Water levels were the sixth most-cited issue facing Crooked Lake, and the fourth most-cited aspect that workshop attendees wanted to see addressed. It is an issue for boating and lake access at the north and south ends of the lake. The bottom slopes of the lake are very gradual and small variations in the surface elevation of the lake can render both ends un-navigable as well as more conducive to emergent plant growth.

The water level in Crooked Lake is the oldest issue on the lake, dating back to at least 1934. Prior to 1934, Crooked Lake was at an elevation of approximately 860.0. At that time, the public sought to raise the average lake elevation approximately one foot.

Between 1934 and 1940 several earthen dams were constructed at the south end of the lake to raise the lake level. The first two dams had leakage problems so were replaced or repaired. The dam raised the normal water level of Crooked Lake one foot and then again to the current elevation of 861.6

Physical Factors: Watershed & Lake Characteristics

Current Elevations

On November 5, 2007, Crooked Lake was at 860.64. This elevation is 0.06 feet below the 10 year average water level of the Lake and 0.10 feet below of 20 year average. Both fluctuations are well within the normal fluctuating range of 0.86 feet (10.32 inches) for the lake.

On October 24, 2008, the last posted reading for Crooked Lake was an elevation of 859.96.

Water Sources

Decreased Precipitation: Four of the last five years have been dry (13.4% below normal). In addition, such droughty conditions have an affect on the amount of runoff due to the decreased amount of soil moisture and a decline in ground water elevations.

Groundwater Flux: Observed values for the permeability of sandy soils is approximately 70 meters/day (230 feet/day).

Water Losses

Increased Temperatures/Evapotranspiration. The 1990s and 00s have been 5% to 10% warmer than the long term average. Such a temperature increase will contribute significantly to water loss from the lake through increased evapotranspiration.

Potential Leakage due to declines in surficial aquifer levels. The best available information shows that ground water levels

have been as high as approximately 859. The most current information indicates groundwater would intercept the bed of Crooked Lake at an elevation of approximately 850 (18% of the lake bottom) (Hickok & Associates, 1972). Should ground water drop lower, a "slow leak" could be expected.

Potential leakage of earthen dam. The dam was inspected in fall 2008. Water levels were at least 0.5 feet below the toe of the lake side of the dam. No leakage was observed and no signs of recent discharge were observed.

Current Management Programs and Policies

Dam at South End of Lake with a Runout Elevation of 861.6	In 1940 the State of Minnesota completed an earthen dam with the goal of establishing a new lake level of 861.6.
Lake Level Monitoring	The elevation of the surface of Crooked Lake has been monitored several times a month for the past 30 years.

Social Factors: Demands and Preferences

Water levels were the sixth most-cited issue facing Crooked Lake, and the fourth most-cited aspect that workshop attendees wanted to see addressed. It is an issue for boating and lake access at the north and south ends of the lake.

Current Situation	There are several unknowns about the behavior of water elevations of Crooked Lake, particularly the connection between lake levels and groundwater .
Management Goal(s)	To develop a better understanding of the water budget, particularly water supply of Crooked Lake

Strategies to Achieve these Goals

Inspect Dam	**Mode of Action** Site inspection by engineer & DNR Hydrologist	**Advantages** Documentation of the condition and performance of the nearly 70 year old structure	**Disadvantages**
Lake Level Monitoring	**Mode of Action** Weekly to bi-weekly	**Advantages** Long and short	**Disadvantages** Causes of lake level

Problem Title Water Levels

	measurements of lake levels	term record of lake elevations separates perception from reality	fluctuations can not be determined solely through lake level monitoring
Ground Water Monitoring	**Mode of Action** Record depth to ground water in observations wells designed to monitor the surficial aquifer	**Advantages** May provide early warning of declines in ground water and therefore water source for lake	**Disadvantages** Installation of an adequate network of ob-wells to predict impacts on Crooked Lake would be expensive to install and maintain

Recommended Management Activities

Inspect the earthen dam
Continue lake level monitoring
Ground water monitoring

Implementation

Method	Unit Cost	Means ACD	CLAA	CCWD	Andover	CR	DNR
Inspect Dam	$250			Lead			Tech Assist
Lake Level Monitoring	$120	Tech Assist		Lead			
Ground Water Monitoring	$525	Tech Assist		Lead			Tech Assist

Costs

Agency	Activity	2009	2010	2011	2012	2013	Total
CCWD	Inspect Dam	$250					$250
	Lake Level Monitoring	$ 120	124	127	131	135	$637
	Ground Water Monitoring	$1,575	1,575	1,575	1,575	1,575	$7,875

Outcome Measures

Inspection Report every 5 years
Annual county water atlas

Milestones

Inspection Report every 5 years
Annual county water atlas

8.0 Implementation Plans

This section of the plan addresses recommended management activities for Crooked Lake over the next five years. These activities discussed will be in the order identified at the public workshop of major issues facing Crooked Lake. The discussion of each issue will be organized as follows:

Management Activity is the activity title

Description provides a brief explanation of the activity

Goal(s) gives objective(s) of management activity

Specific Components & Notes includes details of activity methods

Measures are quantitative actions to be taken to achieve goal

Milestones are actions as results of the Measures

Implementation Timeline

Responsible Person for this Activity provides contact information

Educational Component Related to this Activity is broken down into:
Audience Involved, Educational Goals, Activities Used

The Management Activities are:

- **8.01 Annual Chemical Treatment**
- **8.02 Annual Plant Survey**
- **8.03 Application for Treatment of 20% of Littoral Zone**
- **8.04 Boat Inspection**
- **8.05 Buffer Strips**
- **8.06 Curb Cut Rain Gardens**
- **8.07 Dam Inspection**
- **8.08 Dredge Boat Channel**
- **8.09 Enforcement Blitz**
- **8.10 Ground Water Monitoring**
- **8.11 Increased Garbage Pick Up**
- **8.12 Pond Inspection**
- **8.13 Install Garbage Cans & Signage**
- **8.14 Lake Core Samples**
- **8.15 Lake Level Monitoring**
- **8.16 Lake Water Quality**
- **8.17 (Aquatic) Plant Restoration**

Management Activity **8.01 Annual Chemical Treatment**

Description Involves application of liquid or pelletized herbicides applied to target area or to plants directly

Goal Reduce Eurasian watermilfoil and Curly leaf pondweed to below nuisance levels:
Plants rarely reach the surface
Navigation and recreational activities not generally hindered
Stem density is 0-160 stems/m^2
Biomass is 0-50 g dry wt/ m^2
Estimated Total Phosphorus (TP) load is <1.7 lbs/acre

Specific Components & Notes: Aquatic plants growing in public waters are owned by the state and can interfere with riparian property owners' access to lakes. The use of herbicides in lakes to control submerged vegetation, or the destruction of emergent vegetation by any means, require DNR permits.

Overall program coordination within DNR is managed by staff in Ecological Services. Permit applications require the following items:

4. Applicant information:
    a. Crooked Lake Area Association
       13415 Heather St NW
       Coon Rapids, MN 55433
    b. (763) 422-0682
    c. Permit Number

5. Lake information:
    Crooked Lake, Anoka County
    Inventory Number: 02-0084-00

6. Treatment information:
    Justification
    Fee information
    Enclosures

Measures Plants rarely reach the surface
Navigation and recreational activities not generally hindered
Stem density is 0-160 stems/m^2
Biomass is 0-50 g dry wt/ m^2
Estimated Total Phosphorus (TP) load is <1.7 lbs/acre

Milestones CLAA Board action on DNR permit application
Bids for annual application

Implementation Timeline	March: Apply to DNR for Aquatic Plant Management Permit Mid-March to Mid April: Seek bids from licensed aquatic herbicide applicators Mid to End of April: Apply herbicide
Responsible Person for this Activity	Agency: Crooked Lake Area Association Title: President Phone: (763) 422-0682

Educational Component Related to this Activity:

The Audience Involved	Educational Goals	Activities Used
Lakeshore Owners	Areas to be treated	Newsletter Webpage for treatment
City Council Members	Benefits of treatment	Annual report

Management Activity	**8.02 Annual Plant Survey**
Description	A survey of aquatic macrophyte species distribution, diversity, and frequency in Crooked Lake
Goal	The primary goals of surveying aquatic macrophytes are 1) Comparing year-to-year data within a lake, 2) Comparing data among lakes.
Specific Components & Notes:	The formal quantitative survey is conducted at pre-determined sampling locations distributed evenly over the lake surface (point-intercept method). This method, when combined with a boat survey to gather additional information on areas not sampled directly, will best characterize the lake plant community. The baseline sampling should be conducted between early July and mid-August. Although changes (such as biomass) in the plant community through this long sampling window might complicate data interpretation, we are mostly interested in species diversity and frequency, variables that should be fairly constant through the growing season.
Measures	Surveys completed Surveys budgeted Surveys planned
Milestones	Publication/posting of past survey data Mapping of past survey data Budgeting and planning for survey
Implementation Timeline	September – Budget adoption & preliminary work plan January – Annual work plan June – Conduct survey
Responsible Person for this Activity	Agency: Crooked Lake Area Association Title: President Phone: (763) 422-0682

Educational Component Related to this Activity:

Audience	Goals	Activities
Lakeshore Owners	1. Awareness of vegetative makeup of the Lake	Winter meeting presentation
City Councils (Andover & Coon Rapids)	2. Awareness of distribution of plants in the Lake	Lake management plan on Website Survey results on Web

Management Activity	**8.03 Apply for Treatment of 20% of Littoral Zone**
Description	Involves application of liquid or pelletized herbicides applied to target area or to plants directly over 20% of the littoral zone.
Goal	Reduce Eurasian watermilfoil and Curly leaf pondweed to below nuisance levels: Plants rarely reach the surface Navigation and recreational activities not generally hindered Stem density is 0-160 stems/m^2 Biomass is 0-50 grams dry wt/ m^2 Estimated Total Phosphorus (TP) load is <1.7 lbs/acre
Specific Components & Notes:	Apply for a permit to apply pesticides to submerged vegetation in 20% of the littoral zone (M.R. 6280.0350, Subp 4, A). The procedure for increasing the size/percent of the treatment area is essentially the same as for chemical treatment except that applicant is requesting a variance from the 15% policy. Limiting chemical treatment to 15% of the littoral zone is a standard that attempts to allow a reasonable, but not excessive portion of the lake to be treated. By limiting treatment areas, the 15% rule also forces treatment to occur in the highest priority areas; limiting treatment to 20% of littoral zone achieves the same ends.
Measures	1. Plants rarely reach the surface 2. Navigation and recreational activities not generally hindered 3. Stem density is 0-160 stems/m^2 4. Biomass is 0-50 grams dry wt/m^2 5. Estimated Total Phosphorus load is <1.7 lbs/acre
Milestones	1. CLAA Board action on DNR permit application 2. Bids for annual application
Implementation Timeline	March: Apply to DNR for Aquatic Plant Management Permit Mid-March to Mid April: Seek bids from licensed aquatic herbicide applicators Mid to End of April: Apply herbicide
Responsible Person for this Activity	Agency: Crooked Lake Area Association Title: President Phone: (763) 422-0682

Educational Component Related to this Activity:

Audience	Goals	Activities
Lake Shore Owners	Areas to be treated	Newsletter Webpage for treatment
City Council Members	Benefits of treatment	Annual report

Management Activity **8.04 Boat Inspection**

Description Monitor the public access and watch for boats, trailers, or other equipment that may contain plant fragments or other material that can be viably introduced to the lake.

Goal To intercept all boats leaving from or coming to Crooked Lake which carry invasive species, and oversee the disposal of those species so that they do not enter the lake.

Specific Components & Notes:

The presence of inspectors should:

4. Occur during high use periods
5. Provide an enforcement presence by photographing and documenting equipment containing plant fragments
6. Emphasize invasive species and general public education on the nature of the lake by providing individual with Crooked Lake and Invasive Species Brochure

Measures

Number of inspections
Number of brochures distributed

Milestones

Annual training by MDNR
Annual volunteer schedule

Implementation Timeline

Annually
April: Train boat inspection volunteers
May: Begin inspections

Responsible Person for this Activity

Agency: Crooked Lake Area Association
Title: President
Phone: (763) 422-0682

Educational Component Related to this Activity:

Audience	Goals	Activities
Boat Inspection Volunteers	5. How to approach a boater 6. How to inspect a boat 7. How to identify invasive species 8. How to properly dispose of invasive species	Lecture Film Brochure
Boaters	4. How to inspect a boat 5. How to identify invasive species 6. How to properly dispose of invasive species	Demonstration by volunteer Brochure

Management Activity **8.05 Buffer Strips**

Description

Buffer strips are a vegetated area bordering a lake or stream that exist or are established to:

- Protect water quality
- Stabilize shoreline
- Provide aquatic and terrestrial habitat

For water quality, buffer strips work by intercepting sheet flow of surface water before it reaches the water body. By slowing the water and forcing it to flow through the buffer vegetation, increased settling occurs as well as filtration. In addition, the plants take up and utilize the nutrients deposited in the buffer.

Goal

Twelve buffer strip projects within the next five years

Specific Components & Notes:

The Anoka Conservation District (ACD) has a buffer strip program where they provide technical and financial assistance to homeowners in the design and construction of buffer strips. Financial assistance is usually 50%.

Measures

Number of projects annually
Percent of lake frontage in buffer strip

Milestones

Crooked Lake Area Association winter meeting
Annual sign up
ACD annual report
Crooked Lake annual report

Implementation Timeline

Responsible Person for this Activity

Agency:	Anoka Conservation District
Title:	Water Quality Specialist
Phone:	763-434-2030

Educational Component Related to this Activity:

Audience	Goals	Activities
Lakeshore Homeowners	Program awareness	Brochure Annual meeting presentation Article in Crooked Lake Area Association Newsletter
	Programs options and benefits	Brochure Program description on web

Management Activity

8.06 Curb Cut Rain Gardens

Description

A rain garden is a planted depression that is designed to absorb rainwater runoff from impervious urban areas like roofs, driveways, walkways, and compacted lawn areas. This reduces rain runoff by allowing stormwater to soak into the ground (as opposed to flowing into storm drains and surface waters which causes erosion, water pollution, flooding, and diminished groundwater). Rain gardens can cut down on the amount of pollution reaching creeks and streams by up to 30%.

Native plants are recommended for rain gardens because they generally don't require fertilizer and are more tolerant of local climate, soil, and water conditions. The plants — a selection of wetland edge vegetation, such as wildflowers, sedges, rushes, ferns, shrubs and small trees — take up excess water flowing into the rain garden. Water filters through soil layers before entering the groundwater system. Root systems enhance infiltration, moisture redistribution, and diverse microbial populationshttp://en.wikipedia.org/wiki/Rain_garden - cite_note-wolverton-1#cite_note-wolverton-1 involved in biofiltration. Also, through the process of transpiration rain garden plants return water vapor into the atmosphere. A more wide-ranging definition covers all the possible elements that can be used to capture, channel, divert, and make the most of the natural rain and snow that falls on a property.

Goal

Reduce neighborhood impact on Crooked Lake

Specific Components & Notes:

- Rain gardens for individual houses or buildings are generally between 100 to 400 square feet in size, although they can be much larger if you have a very large impervious area to treat.
- The exact size of the garden should be determined by calculating the square footage of roof or pavement which will drain to the garden, and making the garden about 30% of this area.
- Rain gardens should be sited in a level to gently sloping area and at least 10 feet from building foundations.
- If a building has rain gutters, it is usually simplest to site the garden where rainwater from one of the gutter downspouts can easily be directed into the garden.
- Edging (rocks, cobbles, plastic, etc.) can be used to create a defined look and help keep out weeds & grass.
- Be aware of underground service lines or utilities! Call the local utility company or Gopher State One Call before digging!

Cuts in the curb allow stormwater to enter the gardens from the street.

Measures Reductions in the volume and quality of runoff from the subwatershed

Milestones
Demonstration grant application
Location and survey work for rain gardens
Construction

Implementation Timeline Spring

Responsible Person for this Activity

Agency:	City of Andover
Title:	Natural Resources & SWPPP Coordinator
Phone:	763-755-5100

Educational Component Related to this Activity:

Audience	Goals	Activities
Home owners	Nature of rain gardens	Rain garden brochure
	Condition of Crooked Lake	Presentation at Crooked Lake Area Association winter meeting

Management Activity	**8.07 Dam Inspection**
Description	Ensure that the earthen dam and outlet of Crooked Lake is in proper repair
Goal	Detect and repair, if needed, dam leakage
Specific Components & Notes:	The dam was inspected in fall 2008. Water levels were at least 0.5 feet below the toe of the lake side of the dam. No leakage was observed and no signs of recent discharge were observed.
Measures	Inspection completed every 5 years
Milestones	Inspection Report every 5 years Annual county water atlas
Implementation Timeline	Fall 2008 (completed) Fall 2013

Responsible Person for this Activity	Agency:	Coon Creek Watershed District
	Title:	Administrator
	Phone:	763-755-0975

Educational Component Related to this Activity:

Audience	Goals	Activities
Lakeshore Owners	Notification of inspection results	Lake association newsletter

Management Activity	**8.08 Dredge Boat Landing Channel**
Description	IF 1. Water levels continue to drop, or 2. Sufficient borings of the lake bottom on the north end are taken to define an area where siltation has occurred, Then it may be prudent to pursue a DNR permit for "Works in the bed of public waters" to dredge a channel from the boat access to the main body of the lake.
Goal	Maintain recreational public access to the Lake
Specific Components & Notes:	**Lake Core Samples**: This action is tied to the results of action 9.14 Lake Core Samples and the plotting of those samples to determine and define any siltation that has occurred on the northern end of the lake. **DNR Permit**: A permit would be required from the DNR Division of Waters for work within the bed of a public water; the DNR Area Hydrologist would be the initial contact. **Dredge Disposal Site**: A site near the project site would need to be secured for at least temporary placement of the dredged material to allow it to drain so that it can be handled and trucked from the site. **Contractor**: A contractor with equipment capable of working in shallow water or a dredge would need to be secured.
Measures	Lake level elevations
Milestones	Annual core samples Annual update of core sample map
Implementation Timeline	Depends on the adequacy and number of core samples
Responsible Person for this Activity	Agency: Andover Title: Public Works Director Phone: 763-755-5100

Educational Component Related to this Activity:

Audience	Goals	Activities
Lake Shore Owners	Nature of problem & project	Information meeting Brochure
Public Access Users	Nature of problem & project	Brochure

Management Activity	**8.09 Enforcement Blitz Campaign**
Description	A two-year effort of aggressive police patrol and enforcement to reduce or eliminate illegal dumping and uses occurring on the Lake.
Goal	"Keep Crooked Lake Clean" program
Specific Components & Notes:	Contact the City of Andover to explore adjustments or changes in patrol routes or frequencies. Work with Anoka County sheriff and DNR Conservation Officer to monitor uses occurring on the lake.
Measures	Decrease in large or nuisance debris and garbage on the lake
Milestones	Commitment by City of Andover to increased enforcement CLAA Newsletter article on increased efforts
Implementation Timeline	2009 through 2010
Responsible Person for this Activity	Agency: Andover Title: Public Works Director Phone: 763-755-5100

Educational Component Related to this Activity:

Audience	Goals	Activities
Lake Users	Stewardship and responsible uses of lakes	Brochure

Management Activity	**8.10 Ground Water Monitoring**
Description	This activity involves monitoring the elevations of the surficial aquifer up and down gradient from Crooked Lake.
Goal	To protect ground water supplies
Specific Components & Notes:	Collect and analyze well logs in the hydrogeologic vicinity of Crooked Lake. Develop a Hydrogeologic atlas and picture of the groundwater supply and loss to and from Crooked Lake. Establish transects, wells, and peizometers to monitor the surficial aquifer.
Measures	Surficial groundwater elevations
Milestones	Hydrogeologic atlas Calculation of 1, 5, and 10 year times of travel
Implementation Timeline	2009 Acquire well logs Establish monitoring transects 2010 Develop hydrogeologic atlas
Responsible Person for this Activity	Agency: Coon Creek Watershed District Title: District Administrator Phone: 763-755-0975

Educational Component Related to this Activity:

Audience	Goals	Activities
Lakeshore and ground watershed Owners	Nature of groundwater	Brochure Articles on nature of groundwater

Management Activity	**8.11 Increased Garbage Pick Up**
Description	This activity involves an aggressive program of garbage and litter pick up at the Crooked Lake public access and park in an effort to present a facility where it is not okay to dump or leave debris.
Goal	"Keep Crooked Lake Clean" program
Specific Components & Notes:	This activity is linked to 9.09 Enforcement Blitz campaign 9.13 Install garbage cans and signage The three activities are intended to work as a single effort to change the perception and nature of the public access
Measures	Garbage hauled Maintenance frequency
Milestones	Decrease in garbage hauled
Implementation Timeline	2009 - 2011

Responsible Person for this Activity	Agency:	City of Andover
	Title:	Public Works Director
	Phone:	763-755-5100

Educational Component Related to this Activity:

Audience	Goals	Activities
Lake Users	Stewardship and responsible uses of lakes	Brochure

Management Activity	**8.12 Pond Inspection**
Description	The Watershed District will inspect best management practices (BMPs) on a regular basis to ensure proper installation and maintenance Involves inspection of the ditch channel for efficiency and any obstructions or other problems.
Goal	Annually inspect 20% of stormwater infrastructure
Specific Components & Notes:	The inspection will take specific note of any object or condition affecting the course, current, cross section, or quality of the public ditch, drainage way, or conveyance. The District will conduct an annual inspection of the trunk system. The District Inspector will continue to perform a spring flood inspection program at critical points within the hydrologic system. Inspections will occur: 6. During or immediately following installation of BMPs 7. Following severe storms/critical events 8. Prior to seeding deadlines, particularly in the fall 9. Prior to return of escrows 10. On report of issue
Measures	Inspection reports
Milestones	Annual inspection Annual SWPPP report
Implementation Timeline	January – Annual public review and discussion of SWPPP June – Annual report due to NPDES
Responsible Person for this Activity	Agency: City of Andover Title: Public Works Director Phone: 763-755-5100

Educational Component Related to this Activity:

Audience	Goals	Activities
Public Works	How water quality ponds function	Workshop
CLAA members	How water quality ponds function Pond condition	Newsletter

Management Activity	**8.13 Install Garbage Cans and Signage**
Description	Install appropriate number and size of garbage containers that ensures "extra refuse, debris, and material can be disposed of, and the public landing maintains an ordered and policed appearance."
Goal	"Keep Crooked Lake Clean" program
Specific Components & Notes:	This activity is linked to 9.09 Enforcement Blitz campaign 9.11 Increased garbage pick up The three activities are intended to work as a single effort to change the perception and nature of the public access
Measures	Decrease in extra refuse, debris, and material
Milestones	Decrease in garbage hauled Decrease in litter
Implementation Timeline	2009-2011
Responsible Person for this Activity	Agency: City of Andover Title: Public Works Director Phone: 763-755-5100

Educational Component Related to this Activity:

Audience	Goals	Activities
Lake Users	Stewardship and responsible uses of lakes	Brochure Signage

Management Activity	**8.14 Lake Core Sampling**
Description	In 2008 faculty from Coon Rapids Middle School worked with St Cloud State University to have core samples of Crooked Lake taken as part of a National Science Foundation outreach program. The cores were split; half archived at the University of MN Limnological Research Center, the other half at Coon Rapids Middle School. The cores proved valuable in demonstrating the substrate of Crooked Lake and raising the concern of a potential fill area in the northeast portion of the lake. St. Cloud State University has expressed an interest in continued core sampling within Crooked Lake.
Goal	Assessment of Lake substrate
Specific Components & Notes:	Cores – The actual taking and presentation of cores is a vital step. Description of cores – Description of the color and texture of the substrate is invaluable in understanding the lake. Sufficient sampling – sufficient sampling of the northeast portion of the lake is needed to assess whether fill or sedimentation has occurred within the lake.
Measures	Occurrence of sampling
Milestones	Annual sampling Description of the cores Mapping of core locations and profile description
Implementation Timeline	2009-2013
Responsible Person for this Activity	Agency: Crooked Lake Area Association Title: President Phone: (763) 422-0682

Educational Component Related to this Activity:

The Audience Involved	Educational Goals	Activities Used
Lakeshore Owners	Notification of results	Newsletter
Middle School Students	Experiential science	Core Sampling
Middle School faculty	Use of science in management	Core Sampling

Management Activity	**8.15 Lake Level Monitoring**
Description	Understanding lake hydrology including impact of climate or other water budget changes. These data are useful for regulatory, building/development, and lake management decisions such as resolving water level disputes, determining flood elevations, ground water to surface water recharge relationships, surficial ground water fluctuations, flows and trends, and local zoning (floodplain, shoreland).
Goal	Lake water levels will be recorded weekly by volunteers during ice-out conditions.
Specific Components & Notes:	• Install and survey lake gauge • Coordinate volunteers; for example, provide equipment and datasheets • Troubleshoot problems such as moving gauges in low or high water conditions • Receive data, check its quality, and submit to state databases.
Measures	Lake elevation in feet above mean sea level
Milestones	Data periodically submitted to the DNR for inclusion on their Lakefinder website database. Final report in the Anoka Water Almanac
Implementation Timeline	Spring ice-out: install and survey Open water season: volunteers take weekly readings. Late October: remove gauges from lakes in locations where they could be a danger to snowmobiles or others. Feb. 15 following year: rough draft of Anoka Water Almanac report. March 31 following year: final draft of Anoka Water Almanac report.
Responsible Person for this Activity	Agency: Anoka Conservation District Title: Water Quality Specialist Phone: 763-434-2030

Educational Component Related to this Activity:

Audience	Goals	Activities
CLAA, CCWD, Andover, Coon Rapids, DNR	Lake level and trends in levels	Website: DNR, ACD Anoka Water Almanac

Management Activity **8.16 Lake Water Quality Monitoring**

Description Monitor water quality twice monthly from May-September.

Goal Detect water quality trends and diagnose cause of changes.

Specific Components & Notes: Monitoring is done on the following parameters:

Chlorophyll-a
Conductivity
Dissolved Oxygen (DO)
pH
Salinity
Secchi transparency
Temperature
Total phosphorus (TP)
Turbidity

Detailed data provided annually in the Anoka Water Almanac including summaries of historical conditions and trend analysis.

Measures Standard for each parameter:

Parameter	**Measure**
Chlorophyll-a	Milligrams per liter
Conductivity	mS/cm
Dissolved oxygen	Milligrams per liter & %
pH	
Salinity	Percent
Secchi transparency	Feet & Meters
Temperature	F^o & C^o
Total phosphorus	Milligrams per liter
Turbidity	FNRU (a standard for measurement)

Milestones Work plan for Anoka Conservation District (ACD) and Coon Creek Watershed District (CCWD)
Draft Water Almanac report published

Implementation Timeline

January – Work plan for ACD and CCWD
May - Monitoring begins
September - Monitoring ends
Mid-February following year – draft Water Almanac published

Responsible Person for this Activity

Agency: Anoka Conservation District
Title: Water Quality Specialist
Phone: 763-434-2030

Educational Component Related to this Activity:

Audience	**Goals**	**Activities**
Crooked Lakeshore Owners	Awareness of the various types of monitoring	Brochure

Management Activity **8.17 (Aquatic) Plant Restoration**

Description

Approaches to the re-establishment of submerged macrophytes in shallow lakes can be broken down in two basic strategies: Internal and External.

Internal strategies rely on plant regeneration "internal" to the lake by relying on natural development of submerged macrophytes or volunteerism. This strategy relies on the ability of submerged vegetation to develop naturally from:

4. The existing bank of propagules
5. The remaining macrophyte stands
6. Naturally introduced propagation units.

The presence, density, and composition of a seed bank can influence the rate and extent of vegetation establishment. Unsuitable or unsatisfactory conditions for germination and herbivory by fish and waterfowl may delay recolonization.

External strategies rely on artificial support of macrophyte development. The more expensive and maintenance intensive artificial support by planting or seeding of submerged plants may be appropriate if:

4. If viable propagation units of desired macrophytes are insufficient or not viable
5. The lake was to become more turbid and establishment and immediate stabilization by submerged macrophytes was needed to salvage a clear-water state.
6. The promotion of specific low growth macrophytes in particular areas of the lake is required to enable recreational use.

Goal

Densities on native plants at either

1. 0.18-0.25 vegetative plant parts/m^2
2. Ten 10cm long fragment/ m^2
3. 0.4-0.8 complete plants/m2

Specific Components & Notes:

1. Sample lake sediments
2. Estimate the number of macrophyte propagules and viability
3. Determination of ability to naturally recolonize or reliance on external strategy

If external strategies are to be used, then plantings of submerged macrophytes should be carried out early in the season in sheltered bays and in depths not exceeding one meter. Planting should follow the following phases:

1. Trials using test species in small enclosures during the first season (2011)
2. Further protected plantation of successful species and test other species during second season (2012)
3. Natural propagation by sexual and vegetative reproduction

Measures

Changes in trends in plant diversity and richness

Milestones

Sediment samples
Determination of the presence, density, and composition of seed bank
Determination of internal or external strategy

Implementation Timeline

2009:

1. Sediment samples
2. Determination of the presence, density and composition of a seed bank
3. Determination of internal or external strategy

Responsible Person for this Activity

Agency: Crooked Lake Area Association
Title: President
Phone: (763) 422-0682

Educational Component Related to this Activity:

Audience	Educational Goals	Activities
Lakeshore Owners	Plant community makeup & changes	Newsletter Website
DNR Fisheries	Plant community makeup & changes	Annual report
CCWD	Plant community makeup & changes	Website

9.0 Implementation Plans

This section contains the implementation plans for each of the six organizations involved in management issues for Crooked Lake.

9.1 Anoka Conservation District (ACD)

The Anoka Conservation District will be involved with the following issues:

- Invasive Species
- Muck
- Nonpoint Source Pollution
- Water Clarity
- Water Levels

Goals

The Anoka Conservation District will pursue the following goals:

6. Identify strategies to restore or enhance lakeshore habitat
7. To reduce siltation to, and the pollution of Crooked Lake
8. Reduce interference with recreational use of Crooked Lake caused by Eurasian water milfoil and Curly leaf pondweed
9. Increase abundance of native submersed aquatic plants
10. Assist in the development of a 3-D map of lake substrate

Role	Activity	2009	2010	2011	2012	2013
Lead	Water Quality Monitoring	X	X		X	X
Tech Assist	Annual Plant Survey		X	X	X	X
Tech Assist	*Annual Plant Survey Map*		*X*	*X*	*X*	*X*
Tech Assist	Buffer Strips	X	X	X	X	X
Tech Assist	Curb Cut Rain Gardens	X	X	X		
Tech Assist	Ground Water Monitoring	X	X	X	X	X
Tech Assist	Lake Level Monitoring	X	X	X	X	X
Tech Assist	Plant Restoration	X	X	X	X	X

9.2 Crooked Lake Area Association

The Crooked Lake Area Association will be involved with the following issues:

- Invasive Species
- Muck
- Nonpoint Source Pollution
- Trash

Goals

The Crooked Lake Area Association will pursue the following goals:

7. Assist in developing a 3-D map of lake substrate
8. Identify strategies to restore or enhance lakeshore habitat
9. Increase abundance of native submersed aquatic plants
10. Reduce interference with recreational use of Crooked Lake caused by Eurasian water milfoil and curly leaf pondweed
11. Reduce siltation to and the pollution of Crooked Lake
12. Keep Crooked Lake Clean

Role	Activity	2009	2010	2011	2012	2013
Finance	Plant Restoration	X	X	X	X	X
Lead	Buffer Strips	X	X	X	X	X
Lead	Lake Core Samples	X	X	X	X	X
Lead	Annual Chemical Treatment	X	X			
Lead	Boat Inspection	X	X	X	X	X
Lead	Stenciling Catch Basins	X				
Lead	Apply For Treatment of 20% of Littoral Zone			X	X	X
Lead	Dredge Boat Channel				X	
Assist	Enforcement blitz/campaign	X	X			
Assist	Increased frequency of garbage pick up	X	X	X		

Costs

Activity	Unit Cost	2009	2010	2011	2012	2013	Total
Plant Restoration		1,500	1,000	5,000	7,500	10,000	25,000

9.3 Coon Creek Watershed District

The Coon Creek Watershed District will be involved with the following issues:

- Stormwater Management/ Nonpoint Source Pollution
- Muck
- Water Levels
- Water Clarity/Water Quality

Goals

The Coon Creek Watershed District will pursue the following goals:

7. Identify strategies to restore or enhance lakeshore habitat
8. To reduce siltation to, and the pollution of Crooked Lake
9. Reduce interference with recreational use of Crooked Lake caused by Eurasian water milfoil and Curly leaf pondweed
10. Increase abundance of native submersed aquatic plants
11. Assist in the development of a 3-D map of lake substrate

Roles

Role	Activity	2009	2010	2011	2012	2013
Financial Assist	Curb Cut Rain Gardens	X	X	X		
Finance	Lake Water Quality Monitoring	X	X		X	X
Finance	Lake Core Samples	X	X	X	X	X
Finance	Stenciling Catch Basins	X				
Finance & Lead	Dam Inspection	X				
Finance & Lead	Ground Water Monitoring	X	X	X	X	X
Finance & Lead	Lake Level Monitoring	X	X	X	X	X
Tech Assist	Plant Restoration	X	X	X	X	X
Tech Assist	Pond Inspection	X				

9.3 Coon Creek Watershed District

Costs

Activity	Unit Cost	2009	2010	2011	2012	2013	Total
Curb Cut Rain Gardens	$5,000	5,000	5,000	5,000			15,000
Lake Water Quality Monitoring	$587	587	605		641	660	2,493
Lake Core Samples							-
Stenciling Catch Basins	$400	400					400
Dam Inspection	$250	250					250
Ground Water Monitoring	$525	1,575	1,575	1,575	1,575	1,575	7,875
Lake Level Monitoring	$120	120	124	127	131	135	637
Plant Restoration	$10,000	10,000	10,000	10,000	10,000	10,000	50,000
Pond Inspection	$500	500					500
		18,432	17,303	16,702	12,347	12,370	77,155

9.4 City of Andover

The City of Andover will be involved with the following issues:

- Invasive Species (Eurasian water milfoil & curly leaf pondweed)
- Trash
- Water Clarity/Water Quality
- Nonpoint Source Pollution/Stormwater Management

Goals

The City of Andover will pursue the following goals:

5. Reduce interference with recreational use of Crooked Lake caused by Eurasian water milfoil (EWM) and curly leaf pondweed
6. Keep Crooked Lake Clean
7. To reduce siltation to and the pollution of Crooked Lake

Roles

Role	Activity	Unit Cost	2009	2010	2011	2012	2013
Finance	Annual Chemical Treatment	$4,500	X	X			
Finance	Apply For Treatment of 20% of Littoral Zone	$6,365			X	X	X
Finance & Lead	Curb Cut Rain Gardens	$5,000	X	X	X		
Finance & Lead	Dredge Boat Channel	$7,500				X	
Finance & Lead	Enforcement blitz/campaign	?	X	X			
Finance & Lead	Increased frequency of garbage pick up	?	X	X	X		
Finance & Lead	Install garbage cans and signage						
Finance & Lead	Pond Inspection	$500	X				
Finance & Lead	O&M-Meadow Creek Pond	?					

9.4 City of Andover

Costs

Activity	Unit Cost	2009	2010	2011	2012	2013	Total
Annual Chemical Treatment	$4,500	2,318	2,387				4,705
Apply For Treatment of 20% of Littoral Zone	$6,365			6,365	6,556	6,753	19,674
Curb Cut Rain Gardens	$5,000	5,000	5,000	5,000			15,000
Dredge Boat Channel	$7,500				10,000		10,000
Enforcement blitz/campaign	?	5,000	5,000				10,000
Increased frequency of garbage pick up	?	1,500	1,500	1,000			4,000
Install garbage cans and signage		200					200
O&M Meadow Creek Pond Pond Inspection	? $500	500					- 500
Total		**16,835**	**16,274**	**12,365**	**16,556**	**6,753**	**68,783**

Summary

Plan Assumes that the city of Andover will:

3. Continue to contribute money to the annual treatment of EWM in the lake, including a proposed increase to 20% of the lake in 2011
4. Will fund a "Blitz" campaign of enforcement and garbage pick up in 2009, 2010, & 2011
5. Inspect Meadow Creek Pond & the Aqueduct & Maintain to specs (NURP Stds.)
6. Pursue neighborhood rain garden effort in NW portion of the lake (Demonstration project)
7. Dredge the boat channel from the public access to the lake

9.5 City of Coon Rapids

The City of Coon Rapids will be involved with the following issues:

- Invasive Species (Eurasian water milfoil & curly leaf pondweed)
- Trash
- Nonpoint Source Pollution/Stormwater Management

Goals

The City of Andover will pursue the following goals:

5. Reduce interference with recreational use of Crooked Lake caused by Eurasian water milfoil (EWM) and curly leaf pondweed
6. Keep Crooked Lake Clean
7. To reduce siltation to and the pollution of Crooked Lake

Roles

Role	Activity	Unit Cost	2009	2010	2011	2012	2013
Finance	Annual Chemical Treatment	$4,500	X	X			
Finance	Apply For Treatment of 20% of Littoral Zone	$6,365			X	X	X
Finance & Lead	Enforcement blitz/campaign	?	X	X			
Finance & Lead	Increased frequency of garbage pick up	?	X	X	X		
Finance & Lead	Install garbage cans and signage						

9.5 City of Coon Rapids

Costs

Activity	Unit Cost	2009	2010	2011	2012	2013	Total
Annual Chemical Treatment	$4,500	2,318	2,387				4,705
Apply For Treatment of 20% of Littoral Zone	$6,365			6,365	6,556	6,753	19,674
Enforcement blitz/campaign	?	5,000	5,000				10,000
Increased frequency of garbage pick up	?	1,500	1,500	1,000			4,000
Install garbage cans and signage		200					200

Summary

Plan Assumes that the city of Coon Rapids will:

2. Continue to contribute money to the annual treatment of EWM in the lake, including a proposed increase to 20% of the lake in 2011
3. Will fund a "Blitz" campaign of enforcement and garbage pick up in 2009, 2010, & 2011

9.6 Minnesota DNR

The Minnesota Department of Natural Resources (MDNR) will be involved with the following issues:

- Invasive Species
- Muck
- Water Levels

Goals

The DNR will pursue the following goals:

4. Reduce interference with recreational use of Crooked Lake caused by Eurasian water milfoil (EWM) and curly leaf pondweed
5. Increase abundance of native submersed aquatic plants
6. Oversee the merit of potential removal of muck or sedimentation from the lake

Roles

Role	Activity	Unit Cost	2009	2010	2011	2012	2013
Finance	Plant Restoration	$10,000	10,000	10,000	10,000	10,000	10,000
Finance & Lead	Annual Plant Survey	$ 8,000		8,000	8,240	8,487	8,742
Regulatory Oversight	Annual Chemical Treatment	$4,500	4,635	4,774			
Regulatory Oversight	Apply For Treatment of 20% of Littoral Zone	$6,365			6,365	6,556	6,753
Regulatory Oversight	Dredge Boat Channel	$7,500				10,000	
Tech Assist	Dam Inspection	$ 250	250				
Tech Assist	Boat Inspection	-					