1.0 Introduction

1.1 Black Dog Water Management Organization Water Quality Policies and Goals

The goals of the Black Dog Water Management Organization (BDWMO) are to:

- Manage the BDWMO water resources on a regional basis to meet their established goals.
- Maintain or restore the water quality of the BDWMO water resources to allow for the continuation or enhancement of existing recreation activities and habitat.

To accomplish its goals, the BDWMO established a water body classification system and determined the respective roles of the BDWMO and the cities in water quality management.

1.1.1 Policies

1. All water bodies in the BDWMO will be classified according to either the BDWMO lake and pond classification system or the city's wetland classification system. The BDWMO lake and pond classification system contains five categories that will be used by the BDWMO and member cities to classify lakes and ponds, defined as follows (see Table 1-1 for detailed descriptions of the categories and water quality parameters associated with each category):

Category I Water bodies in this category are typically used for swimming and other direct contact recreational activities. These water bodies have the highest/best water quality and are usually the most popular water bodies with the public. Category I lakes are managed to provide water quality capable of supporting direct contact activities, such as swimming, scuba diving, snorkeling, and waterskiing. A reasonable water quality goal for Category I lakes is a minimum Secchi disc transparency of 1.0 meters, and a summer average Secchi disc transparency of at least 1.4 meters. Transparencies in this range are considered moderately eutrophic (i.e., nutrient rich).

Category II Water bodies in this category are typically used for indirect contact recreational activities such as boating and fishing, that involve incidental contact with lake water. These water bodies have poorer water quality than Category I water bodies, but are still popular with the public.

Category III Water bodies in this category serve important functions for wildlife habitat and aesthetic enjoyment, and may also provide opportunities for warm-water fishing, provided winter kill does not occur. These water bodies may have poorer water quality than Category I and II water bodies and typically are not viewed as swimmable because of lower water quality or the nature of their shorelines.

Category IV Nutrient Traps Water bodies in this category are intended to reduce downstream loading of phosphorus and other nutrients that contribute to water pollution. These ponds are designed to have phosphorus removal efficiencies of at least 50 percent.

Category V Sediment Traps These water bodies are similar to Category IV water bodies, but are too small to effectively remove a significant fraction of nutrients. These basins will generally have phosphorus removal efficiencies of less than 50 percent.

2. Category I to III water bodies will be managed for non-degradation of water quality, with allowance for natural variability. This means that developments and city projects should be designed to preserve existing water quality so far as reasonably possible, even when existing water quality is better than the water body classification might otherwise infer. To conform to this policy, implementation of BMPs will be required during development and other types of construction.

3. Category I-III water bodies will also be managed to preserve and promote bio-diversity and improve aesthetics.

4. The BDWMO set criteria for determining which water bodies should be managed by the BDWMO ("strategic" water resources). Strategic water resources are water resources of broad watershed significance that are important to a larger population than just the municipalities in which they are located. Water bodies need to meet four of the following five criteria to be considered strategic water resources:

   - Water bodies or streams that receive drainage from more than one community or municipality.
   - Water bodies that are an important regional resource for either: (1) recreational (e.g., swimming, boating, adjacent regional park, etc.) or (2) wildlife/natural resource reasons.
   - Water bodies that directly discharge into a significant downstream resource such as the Minnesota River, a trout stream, or another significant resource as determined by the BDWMO.
   - Water bodies that have higher water quality than typically found in similar lakes, ponds, or streams.
   - Water bodies wit a surface area of 50 acres or more

Table 1-1 Water Body Classification Categories

Description of Desired Use[1]	Guidelines for Desired Use[2]
Category I: Water bodies typically used for direct contact recreational activities, including swimming, scuba diving, snorkeling and waterskiing.	Minimum summer Secchi disc depth of at least 1.0 meters; summer average of at least 1.4 meters. Total phosphorus concentrations less than 45 µg/L. Chlorophyll *a* concentrations less than 20 µg/L. Carlson TSI index (Secchi disc based) no greater than 55.
Category II: Water bodies typically used for indirect contact recreational activities, including sail boating, motor boating, canoeing, and fishing. These activities involve incidental contact with lake water, but do not generally require the water clarity found in direct contact recreational waters. Algal blooms in mid-to late-summer may limit direct contact recreational activities such as swimming and waterskiing.	Mean summer Secchi disc depth of at least 0.9 meters, but less than 1.4 meters Total phosphorus concentration of at least 45 µg/L, but less than 75 µg/L Chlorophyll *a* concentration of at least 20 µg/L, but less than 40 µg/L Carlson TSI index (Secchi disc based) should be no greater than 60
Category III: Water bodies that typically serve important functions such as wildlife habitat and aesthetics. May also provide opportunities for warm water fishing, provided winterkill does not occur. Generally accessible to the public for education, interpretation, and nature appreciation.	Of primary importance are guidelines related to aesthetic enjoyment and wildlife habitat to maintain/improve desired use of these water bodies—see Table 5-2 for a listing of aesthetic and habitat indicators. Of secondary importance are the following water quality guidelines: Mean summer Secchi disc depth of at least 0.7 meters Total phosphorus concentration of at least 75 µg/L, but less than 105 µg/L Chlorophyll *a* concentration of at least 40 µg/L, but less than 60 µg/L Carlson TSI index (Secchi disc based) no greater than 65.
Category IV—Nutrient Traps: The intended use of these water bodies is to reduce downstream loading of phosphorus and other nutrients that contribute to water pollution. These ponds are generally artificially modified to improve their nutrient trapping capacity. These ponds may become hypereutrophic, and frequent summer algal blooms would be considered normal.	Design for phosphorus removal efficiencies of at least 50 percent. Depth should be managed to prevent or reduce odors associated with algal blooms. No numeric standards for water quality parameters are defined for this category.
Category V—Sediment Traps: These water bodies are similar to Category IV water bodies, but too small to effectively remove a significant fraction of nutrients.	Generally have phosphorus removal efficiencies less than 50 percent. No numeric standards for water quality parameters are defined for this category.

[1]Categories I-III could also include ecologically or biologically unique resources, or water bodies that directly or indirectly affect such a resource.
[2]The water quality criteria for Categories I-III may not apply in the case of ecologically or biologically unique resources; resource-specific criteria may be required.

The BDWMO considers Crystal Lake, Orchard Lake, Keller Lake, Kingsley Lake, Lac Lavon and Sunset Pond to be strategic water resources. Other water bodies could be considered strategic, if agreed to by the cities and the BDWMO.

5. The classification and numeric goals for the Crystal and Keller Lakes are as follows:

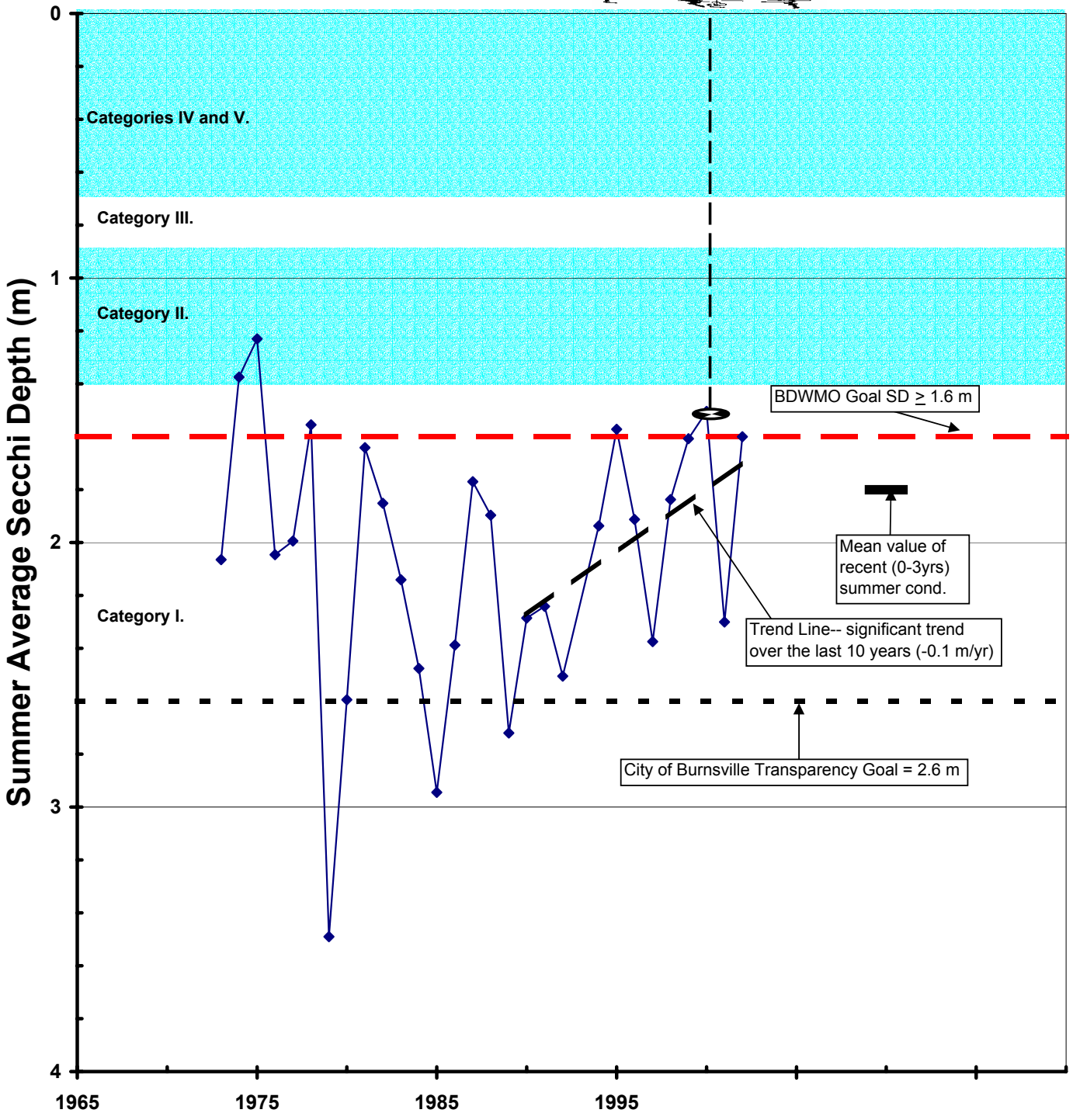
   Crystal Lake —Based on its existing and desired use, the BDWMO classified Crystal Lake as a Category I water body. The current (2002) water quality of Crystal Lake (total phosphorus concentration, chlorophyll *a* concentration and Secchi disc transparency) places the lake within Category I, but the water quality varies greatly over the summer, typically beginning the recreational season with Category I water quality, then the degrading to Category II levels as chlorophyll *a* concentrations increase during the latter part of the summer. The specific goal for Crystal Lake is a trophic state index based on Secchi disc transparency (TSI_{SD})$\leq$53 (see Section 2.2 for further discussion on TSI), which is equivalent to a Secchi disc reading of 1.6 meters. Additional water quality goals for Crystal Lake are listed below:

   - Summer average Secchi disc depth of at least 1.6 meters
   - Total phosphorus concentration of less than 45 µg/L
   - Chlorophyll *a* concentration of less than 20 µg/L

   Based on the 2002 summer average Secchi disc data, the goal has already been breached on Crystal Lake and management actions are needed. Figure 1-1 shows the Secchi disc transparency goal in ***relation*** to historic summer average data.

   In response to the City of Burnsville's request to elevate the water quality goal for Crystal Lake from a summer average Secchi disc transparency of 1.6 meters (the action level given in the BDWMO *Watershed Management Plan*) to a goal of from 2.3 to 2.6 meters, the BDWMO decided to accelerate completion of this diagnostic-feasibility study. Models indicate that in its "pre-development" state, the water clarity of Crystal Lake was between 2.3 meters and 2.7 meters. This means that achieving a water clarity goal of 2.6 meters will very likely require extensive remedial measures.

Figure 1-1
Crystal Lake Historic Water Transparency



Keller Lake—The BDWMO classified Keller Lake as a Category III water body, based on its existing and projected future use, its historic water quality. The BDWMO *Water Management Plan* lists the following criteria for a Category III water body:

- Summer average Secchi disc depth of at least 0.7 meters
- Total phosphorus concentration of at least 75 µg/L, but less than 105 µg/L
- Chlorophyll *a* concentration of at least 40 µg/L, but less than 60 µg/L

Keller Lake will be monitored for Secchi disc transparency and habitat/aesthetics. More emphasis will be placed on the habitat and aesthetics monitoring results than the water quality results. According to the BDWMO *Water Management Plan*, actions to be taken will be based on the results of the habitat and aesthetics monitoring, as shown in Table 1-2. As a result, Figure 1-2 does not show a BDWMO Secchi disc transparency action level.

However, the City of Burnsville also requested an elevated water quality goal for Keller Lake—a summer average Secchi disc transparency of 1.7 meters. Since Keller Lake is tributary to Crystal Lake, this diagnostic-feasibility study investigated improving the water quality of Keller Lake to improve the water quality of Crystal Lake.

Table 1-2 Aesthetic and Habitat Indicators and Recommended City Actions—Revised

Indicator	Prevalence	Recommended Actions[1]
Localized Shoreline Erosion	10 percent or less of shore	A (note # of sites), B
	10 percent to 25 percent	A (note # of sites), B, C
	25 percent or more	A (note # of sites), B, D
Shoreline Erosion Resulting from Upstream Activity	Present	E
Sedimentation/Deltas	Present	E
	10 cubic yards or more	F
Shoreline Buffer/Percent Vegetated[2]	>75 percent	A
	50 percent to 75 percent	A, B
	25 percent to 50 percent	A, B, C
	<25 percent	A, B, D
Purple Loosestrife, Non-native Invasive Species	Present	A (note # of colonies), G, H
	Not Present	A
Glossy and Common Buckthorn, Non-native Invasive Species	Present	A, G, I
	Not Present	A
Average-density of Shallow Water Aquatic Plants[3]	<1.5	A, B (to encourage growth of desirable plants), J
	1.5 to 2.5	A
	>2.5	A, K
Non-native Invasive Shallow Water Aquatic Plants[4]	Present	A, B (to encourage growth of desirable plants), L
	Not Present	A

Notes:

[1]Key to Recommended City Actions

A: Monitor annually

B: Targeted education materials regarding the importance of lakescaping and buffers

C: Lakescaping demonstration project

D: Lakescaping incentive program (e.g. small grants to encourage residents to implement lakescaping techniques)

E: Evaluate source of problem and develop methods to address problem

F: Excavate sediment

G: Targeted education materials regarding the detrimental impacts of the plants, the importance of removing them, methods to remove them, and replacement plantings

H: Recruit citizens to take part in the MDNR's purple loosestrife (beetle) program to eradicate plants

I: Recruit citizens to remove/replace plants

J: Evaluation needed to determine why so few plants are present and if more are needed

K: Evaluate extent of plant growth and develop/implement aquatic plant management plan

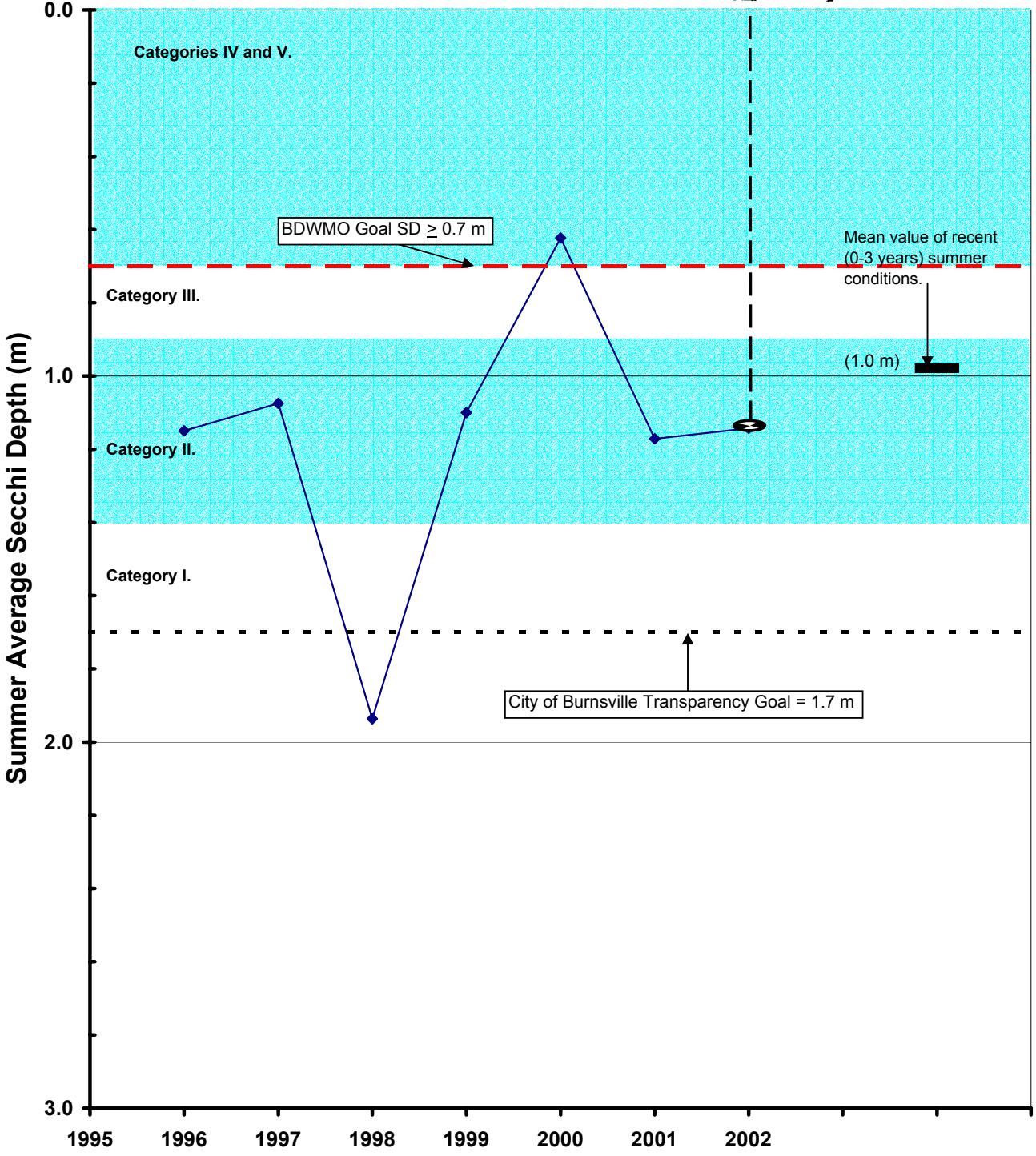
L: Evaluate extent of plant growth and develop/implement aquatic plant management plan—may not include eradication of non-native invasive plants, especially if they are the only aquatic plants present

[2]Percent Vegetated—Percent of shoreline that is vegetated, exclusive of landscaped lawns, with buffer at least 10 feet in width.

[3]Based on density ratings given for numerous locations within the littoral zone of each water body; density of 1 = low, 2 = moderate, 3 = high.

[4]Non-native invasive aquatic plants include Eurasian watermilfoil and curlyleaf pondweed.

Figure 1-2
Keller Lake Historic Water Transparency



1.2 Overview of Lake Use

1.2.1 Crystal Lake

Crystal Lake is considered one of the most important water bodies in the City of Burnsville. The lake has a public boat access and fishing pier on its north side, and is intensively used during both summer and winter months. Fishing, boating, swimming, water-skiing and aesthetic viewing are some of the major recreational-uses made of the lake. In addition, the City of Burnsville's Tyacke Park, Crystal Lake West Park, and Crystal Beach Park are all located along the lakeshore. The Metropolitan Council considers Crystal Lake a "Priority Lake" because of its recreational-uses and public access.

The Minnesota Department of Natural Resources (MDNR) manages its fisheries. Fisheries management has been limited to lake surveys, population assessments, and stocking of tiger muskellunge since 1984. The MDNR has managed the lake as a panfish fishery. MDNR reports have concluded the lake has abundant northern pike, sunfish (bluegill, pumpkinseed, and hybrid sunfish), and large mouth bass indicating that the fisheries goals are being met for Crystal Lake. The reports also indicated an average sampling of bullhead (yellow and black), perch, and black crappie. Only one tiger muskie and walleye were sampled during the most recent lake survey (2000).

There are flooding and other stormwater system capacity issues starting at Crystal Lake and continuing downstream past Earley Lake. Crystal Lake has experienced high water levels for the last 4 years. A proposed solution to the flooding problem involves the replacement of about 1,000 feet of pipe with larger diameter pipe. The City of Burnsville will be assessing the downstream impacts of the proposed project. Since Crystal Lake receives water from areas outside of Burnsville, the BDWMO will assist in allocating the project costs among the member cities.

The BDWMO constructed and operated the Crystal Lake water quality demonstration project, a cooperative venture of the BDWMO, the MPCA, and the United States Environmental Protection Agency (USEPA) under the Clean Lakes Program. The hypolimnetic withdrawal system added ferric chloride to water taken from the deepest portions of Crystal Lake to remove phosphorus. The treated water was then pumped to Keller Lake. The system operated during the 1996 and 1997 recreational-use seasons and half of the 1998 season. Lake monitoring data suggest that operation of the hypolimnetic withdrawal system was successful in reducing the total phosphorus concentration in the deepest portions of Crystal Lake. However, the overall benefit to the lake was insignificant. The decrease in phosphorus in the lower lake levels did not affect the phosphorus concentrations at the lake surface, nor did it increase the water clarity during the summer season.

A side effect of the phosphorus removal system was a "rotten egg" odor. Operation was suspended in July 1998 after strong neighborhood opposition to the odor. The BDWMO decided to discontinue operation of the treatment system in April 1999. The BDWMO reached this decision after considering public input, the seasonal operating costs of $20,000, and the marginal improvements to the water quality during the recreational-use season.

1.2.2 Keller Lake

Keller Lake is a 55-acre water body located on the Burnsville/Apple Valley border. The lake is used primarily for fishing, canoeing, and wildlife viewing by the local residents. There is a park on Keller Lake but no beach or public access. Keller Lake flows into Crystal Lake and has experienced high water problems in the past that may be solved by the proposed project to lower flood levels on Crystal Lake.

The MDNR manages its fisheries. Fisheries management has been limited to lake surveys and population assessments. The MDNR has classified the lake as a rough-gamefish fishery that regularly winterkills. The most recent MDNR fisheries survey (1985) concluded the lake has high numbers of bluegill sunfish (very small in size), and a nice population of northern pike. Large mouth bass, black crappie, and black bullhead are also present in Keller Lake.

1.3 Report Coverage

Monitoring Secchi disc transparencies, along with other water quality measurements, help the BDWMO evaluate its water quality management practices and determine if water quality goals are achieved or attainable. In 2002, the main basin of Crystal Lake, its four bays (Bluebill Bay, Mystic Bay, Maple Island Bay, and Buckhill Bay), and Keller Lake were monitored on ten occasions for physical and chemical characteristics, such as Secchi disc transparency, dissolved oxygen concentrations, water temperatures, specific conductivities, and plant nutrients (phosphorus).

This report on Crystal and Keller Lakes' water quality will answer the following four questions that apply to properly managing lakes:

1. What is the general condition of the lakes and streams in the watershed?
2. Are there problems or trends evident in the water quality?
3. What is a reasonably achievable goal for water Secchi disc transparency?
4. If there are water quality problems, what would be the most effective solutions?

To answer the first question, this report begins with descriptions of the watershed, the lakes, methods of data collection, and analysis. The results of water quality monitoring are then summarized in tables, figures, and accompanying descriptions.

To answer the second question, water quality data are analyzed for trends and compared to established water quality standards for lakes.

To answer the third and final questions, a water quality model, developed specifically for the Crystal Lake watershed, is described. The model incorporates the water quality data, land use characteristics, and BMPs. The model is then used to evaluate the impact of changing land use patterns and BMPs on the water quality of Crystal and Keller Lakes. This includes the relative contributions of runoff and pollutants from each subwatershed. Based on these analyses, the cost and effectiveness of alternative management solutions are discussed. The final step is a set of recommendations for improving and protecting the water quality of Crystal and Keller Lakes.

Two background information sections are also included in the report. Section 2.0 covers general concepts in lake water quality, and the first part of the discussion section (Section 6.0) gives an overview of BMPs for controlling the quality of urban watershed runoff.