MAINE PUBLIC DRINKING WATER
SOURCE WATER ASSESSMENT PROGRAM
KENNEBEC WATER DISTRICT
CHINA LAKE WATERSHED

MARCH 2003

prepared for

Source Water Assessment Program
Drinking Water Program
Maine Department of Human Services

prepared by

Drumlin Environmental, LLC
Portland, Maine

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Augusta, Maine 04333

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KENNEBEC WATER DISTRICT
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EXECUTIVE SUMMARY

The Kennebec Water District (KWD) serves approximately 40,000 people in the towns of Waterville, Winslow, Fairfield, Vassalboro, Benton and Oakland from its China Lake supply. The 16,975-acre watershed of China Lake is located in the towns of China (primarily), Vassalboro and Albion, Maine. Narrow projections of land divide the lake into two sections known as the East and West Basins. Approximately 25 tributaries flow into the lake, however, only one outlet stream is present in the northwest corner of the lake. The lake is relatively large and the basins are moderately deep.

KWD owns most of the shoreland located in the West Basin. The East Basin shoreland and upland areas located throughout the lake watershed are held in private ownership. Land use controls that provide protection for water quality consist of 250-foot Shoreland Zoning and a Phosphorus Control Ordinance. A Watershed Management Plan has also been adopted to implement Best Management Practices and other strategies that will prevent further degradation of lake quality.

Approximately 69 percent of the watershed is forested. Wetlands, urban grasses, pastures and croplands cover about 28 percent of the watershed. The East Basin watershed and shoreland are significantly more developed than the West Basin. Historically, agricultural, forestry, residential and recreational land uses contributed to significant nutrient enrichment of the lake with phosphorus loading being the primary pollutant of concern.

The KWD water supply intake is located in the West Basin near the lake outlet. Recent analytical testing shows the source meets applicable state and federal drinking water standards.

China Lake is eutrophic with algae blooms occurring routinely in the summer and fall months. The Maine DEP has developed a TMDL for allowable phosphorus loading into the lake. Available information indicates that current external loading of phosphorus is below the assimilative capacity of the lake, however, lake sediments provide an additional source for algae growth. Under these existing conditions, the lake is more sensitive to runoff from existing land uses and more susceptible to future growth.

The susceptibility of China Lake to land uses is ranked moderate to high. The lake's natural capacity to buffer runoff has been diminished. Water quality has deteriorated to a state where additional phosphorus loading would be highly detrimental to the health and environment of the lake. Stakeholders have undertaken significant steps to develop policies and programs that will prevent further degradation and help guide the lake toward recovery. Some improvement in lake quality may have already started to occur, therefore, these efforts need to continue and be strengthened in order to protect the lake from future growth impacts.

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1.0 INTRODUCTION

The operation of public water systems in Maine is governed by the federal Safe Drinking Water Act (SDWA), which was first passed in the 1970s and later amended in 1986 and 1996. The federal government delegated authority for enforcing the SDWA to the state under the Maine Department of Human Services (DHS) Drinking Water Program (DWP). In 1998, the Source Water Protection Section was established in the DWP to implement the Maine Public Drinking Water Source Water Assessment Program (SWAP). The SWAP process is being conducted through a cooperative effort between the DWP staff, Kennebec Water District (KWD) staff and Drumlin Environmental, LLC (Drumlin), the environmental consulting firm contracted through DHS to provide technical assistance for the project.

The purpose of the SWAP evaluation for the KWD is to assess the susceptibility of its China Lake drinking water supply (PWSID 90750) to potential threats of contamination. The long-term goal is to protect the water supply source. To do this, the SWAP process has compiled information to assist the KWD in future planning that will help to control potential threats to the water quality of China Lake.

This Report describes the SWAP for the KWD and is organized as follows:

- **Section 2.0** summarizes the physical characteristics of the water supply at China Lake;
- **Section 3.0** describes the variety of conditions and activities that could pose a threat to water quality;
- **Section 4.0** provides an assessment of the threats within the China Lake watershed; and,
- **Section 5.0** ranks the susceptibility of the water quality at China Lake and provides recommendations for future protection of water quality.

2.0 WATER SUPPLY SOURCE

2.1 Description

The China Lake watershed is located primarily in the Town of China, Maine. The lake and watershed cover an extensive area over 17,000 acres. A small portion of the lake and watershed is located in the Town of Vassalboro. In addition, a small area located at the northern tip of the watershed is located in the Town of Albion. China Lake consists of two segments referred to as the East and West Basins. The East Basin is long and narrow and heavily developed along most

of its shoreline. The West Basin is more rounded in shape and the shoreland is mostly undeveloped. The water supply intake is located in the West Basin. The lake basins and watershed are depicted in Figure 1. The components and description of the KWD source are presented below in Table 1.

TABLE 1
CHINA LAKE SUPPLY

Category	Description
Water System Name:	Kennebec Water District
Surface Water Source(s):	China Lake
Water System Type:	Non-transient, community system
Watershed Location:	China, Vassalboro and Albion, Maine
Source Surface Water Area:	3,939 Acres
Source Watershed Area:	16, 975 Acres
Average/Maximum Depths (estimated):	28 ft; 51 ft East Basin, 93 ft West Basin
Water Volume in Storage:	35 billion gallons; 0.65 flushes/year
Population Served (customers):	Services: 8,600 Population: 40,000
Type of Treatment:	Coagulation, Chlorination, Fluoridation and Sodium Hydroxide for pH control & corrosion control
Filtration:	GAC filtration system in use
Estimated Daily Water Use:	5.86 MGD average; 8.5 MGD peak use

The KWD was originally established in 1899 and currently serves drinking water to the towns of Waterville, Winslow, Fairfield, Vassalboro and Benton with water for resale to Oakland. The water treatment facility is located in North Vassalboro and has a treatment capacity of 12 million gallons per day (MGD).

The KWD intake is positioned in the lake at a distance of approximately 250 feet from shore. The intake pipe enters the lake within a few hundred feet to the east of the outlet known as Outlet Stream. The 36-inch diameter intake pipe rests on the lake bottom at a depth of 17 feet of water. At the end of the intake pipe, the pipe is equipped with brass bars and bends upward at a 45- degree angle to be in open water above the lake bottom. The area around the intake is designated by a perimeter of marker buoys.

Water flows by gravity through an intake building located on shore, which has two screens to prevent fish, leaves, sticks, etc. from entering the pipe connected to the filtration plant. The plant is located ¾ of a mile to the north along Route 1. Raw water enters the plant into deep sump structures called “pump cans”. The water is pumped through three Microfloc upflow clarifiers and is subsequently filtered through six granular activated carbon (GAC) units to remove suspended solids and organics. Alum, hydrochloric acid and a cationic polymer are added prior to the clarifiers for coagulation. The filtered water is chlorinated with sodium hypochlorite and flows into large clearwells to provide contact time for disinfection. The pH of the water is adjusted with sodium hydroxide, then fluoride and polyphosphate are added to the finish water prior to the distribution system. The water subsequently flows by gravity into the distribution system.

2.2 Land Use

The KWD owns a buffer of shoreland around the entire West Basin portion of the lake except for about 600 feet of shoreline. On average, the buffer strip is approximately 200 feet wide. The buffer includes the shores that form the narrows between the East and West Basins. The total area of KWD ownership in China and Vassalboro is approximately 307 acres. All the shoreland in the East Basin, except for one parcel owned in trust, is held in private ownership. The main characteristics of land use around the lake are as follows:

- The northern and southwestern shoreland of the West Basin consists primarily of undeveloped forest growth.
- The near shoreland located further south on the western side of the West Basin, including the associated inland areas, are in active agricultural use.
- The shoreland located at the northern and southern ends of the East Basin is densely settled with summer camps, year-round homes and a few commercial land uses.
- The eastern and western shoreland of the East Basin is mostly developed with a mix of summer camps, year-round homes and agricultural uses. In several locations, summer camps are clustered close together on small shoreland lots.

Sand and gravel deposits located in the watershed are small and not used by the KWD as a source of drinking water. Figure 2 shows the mapped aquifers and land under permanent protection in the watershed.

Shoreland Zoning has been adopted for land set back 250 feet from the shore of the lake. The entire shoreland is designated as a Resource Protection District, which prohibits new building construction. Land bordering on tributary streams located in the watershed is included in the Stream Protection District. Outside of these districts, the upland watershed area is zoned as a Rural District. The Town of China has adopted a Phosphorus Control Ordinance to oversee land use activities throughout the watershed with the goal of mitigating phosphorus loading into the lake. This ordinance is currently being reviewed to consider new provisions to control runoff impacts in existing development. The Town of Vassalboro has a program to upgrade wastewater disposal systems installed in the shoreland zone prior to July 1974 in order to meet current standards and protect lake quality. The China Region Lake Alliance (CRLA) developed a Watershed Management Plan in 1999 to establish Best Management Practices (BMPs) for mitigating land use impacts and to prevent further degradation of water quality in China Lake and in two other ponds located nearby. The Water District is actively working with the CRLA, China Lake Association (CLA) and Kennebec County Soil and Water Conservation District to improve lake quality by reducing or eliminating phosphorus loading.

Major roadways in the watershed include Route 32 located to the west of the lake, Route 202 located to the east and Route 3 crossing through the southern end of the watershed. These roadways and other paved and gravel roads drain into tributaries that flow into the lake. The main tributaries include Muldoon Stream, Starkey Brook and Jones Brook, which flow into the East Basin, and Ward Brook, which flows into the West Basin. Approximately 20 other smaller tributaries carry runoff into the lake.

The Outlet Stream is the only point of natural outflow of surface water from the lake. Due to the shape and natural setting of the lake and outlet, nutrients in the East Basin must be transported through the West Basin before flushing out of the lake. The northern and southern portions of the East Basin, which are heavily developed, are located in the furthest reaches of the lakes' natural flushing cycle.

A dam, located north of the lake along the stream, is owned and managed by the Town of Vassalboro. The spillway and water control gates located at the dam control the amount of flow leaving the lake. The water level in China Lake is managed in accordance with a Maine Board of Environmental Protection (BEP) Order issued in 1997. The provisions of this Order require the lake level to remain within a range from 1.5 feet below to 0.5 feet above the spillway level. The lake level is allowed to change within this range depending on the time of year, i.e., spring high water vs. fall low water conditions.

Approximately 69 percent of the watershed of China Lake is covered by evergreen, deciduous and mixed forest growth. Wetlands, urban grasses, pastures and croplands comprise about 28 percent of the remaining watershed area. Historically, the West Basin was more highly developed than the East Basin. In the early 1900s after the Water District purchased most of the shoreland to protect the drinking water supply, residential and agricultural development expanded into the East Basin. Farming was much more significant in years past and contributed significantly to the existing water quality of the lake. Only about 25 percent of the East Basin watershed remains undeveloped. A map of the land use classifications for the watershed and surrounding area is shown in Figure 3.

The public is allowed to access the lake for recreational activities. The East Basin is generally unrestricted. Boat landings are present at the north and south ends (China Village and South China) of the East Basin. The West Basin is somewhat restricted with swimming and jetskis prohibited. Fishing, motorboats and other motorized recreational equipment (e.g., snowmobiles, RVs, etc.) can traverse the ice in the winter. A public boat landing is located in Vassalboro on the western shore in the near vicinity of the water supply intake. Marker buoys inform the public to stay clear of the intake area.

China Lake was identified by Maine under Section 303(d) of the 1972 Clean Water Act as an impaired surface water body and was required to have Total Maximum Daily Loads (TMDLs) established for pollutants of concern. The Maine DEP prepared a TMDL Report dated October 10, 2001, which was subsequently reviewed and approved by the U.S. Environmental Protection Agency in November 2001. The TMDL is calculated as the maximum amount of pollutants that the lake can receive and still meet water quality standards of the Clean Water Act. The TMDL for China Lake was focused on limiting total phosphorus loading. The TMDL Report was reviewed as part of the SWAP Assessment and some of the findings are incorporated into this report.

3.0 INVENTORY OF POTENTIAL WATER QUALITY CONCERNS

3.1 Background

The Source Water Assessment Program (SWAP) is intended to assist water companies and departments in protecting the quality of their surface water supply by identifying potential threats to water quality. Two factors have been considered in identifying and assessing the potential risk posed by a threat: (a) location in relation to the intake and (b) the nature of a potential threat.

This SWAP assessment looks for potential threats to water quality in three zones:

1. The intake zone within 1,000 feet of the intake;

2. The shoreline zone, within 250 feet of the shoreline of the surface water body; and,

3. The watershed zone, extending to the limits of the surface watershed.

Activities in each of these zones have a different potential effect on the quality of water in the surface supply.

Within each of the three zones, the SWAP assessment examined a variety of conditions, land uses and practices that have a potential to influence water quality. These features generally fall into one of the following categories:

- Physical characteristics of the watershed, for example the presence of wetlands, steep topography or erodible soils;

- General land uses and development patterns, for example the percentage of developed versus undeveloped land and controls to guide future development; and,

- Specific activities that involve chemical handling or may release pathogens (e.g., fecal coliform) with the potential to degrade water quality.

The SWAP assessment also considered available water quality data from the surface supply as an indicator of existing conditions. Appendix A describes specific guidance used during the SWAP to inventory potential factors influencing water quality. Appendix A also lists specific activities included in the SWAP assessment. Table 2 lists general sources of information consulted during SWAP research.

TABLE 2
SOURCES OF SWAP INFORMATION

Information Type	Information Source
Watershed Characteristics	US Geological Survey (Topography, Hydrology), Soil Conservation Service (Soils), Maine Geological Survey (Geology)
Raw Water Quality	Water District Monitoring, PEARL, TMDL Report
Potential Contamination Sources	DEP Databases and Water District
Land Use and Zoning	Water District and Municipal Records
Other Analyses	Other DEP Databases

3.2 Source Sensitivity to Land Use

The key watershed features that define the sensitivity of the water supply source to land uses are briefly described below:

- **Natural Features:** The West Basin watershed is largely forested and undeveloped. The East Basin watershed is mostly developed or has been altered by land use activity. The lake is large and has accumulated significant nutrient loading since before the 1900s. Current conditions indicate that internal loading from sediment is a greater source of phosphorus than external loading from runoff. Natural flushing of nutrients from the lake is limited with only one outlet stream, which is remote from the East Basin.

- **Man-made Features:** Residential, agricultural and forestry land uses exist throughout the watershed, particularly in the East Basin. A significant amount of shoreland is developed with seasonal camps and year-round homes. Significant runoff is contributed to the lake from the paved and gravel road system that exists in the watershed.

- **Specific Activities:** The lake is accessible for recreational activities through established boat landings and a large number of private camps and homes located on shorefront properties.

4.0 ASSESSMENT OF CHINA LAKE

China Lake is used as a filtered and chlorinated water supply source. Historically, the lake has been affected by algae blooms since the early 1980s, which has increased the extent of water treatment needed to meet public drinking water standards. Water quality monitoring data have been collected continuously from the lake since 1971.

The KWD tests raw water entering the treatment plant and finish water prior to distribution. The raw water is tested for turbidity, pH and color on a daily basis. Algae, total coliform, phosphorus, dissolved oxygen profile, chlorophyll-a and total organic carbon are tested in the raw water on a monthly basis. Volatile organic compounds are tested in the raw water annually. Based on the results of raw and finish water testing in 2001, all parameters were found to be

within applicable state and federal standards for public drinking water. In 1999, the system was granted a "synthetic organics waiver" which provides for a three-year exemption from certain testing requirements (i.e., pesticides, herbicides, fungicides and organic chemicals). The waiver status will need to be revisited for 2002.

4.1 Watershed

China Lake is considered by the Maine DEP to be "Most-At-Risk-From Development" because of the rapid growth and development of the watershed in the 1980s and continued sensitivity to growth today. The lake is eutrophic. Algae blooms occur on a regular basis in the summer and fall months since a significant amount of phosphorus remains in the bottom sediments of the lake. However, overall water quality in the lake has shown some slight improvement in recent years, which shows the need for a long period of recovery.

According to the October 2001 TMDL Report, the East and West Basins are nearly equal in the amount of active agricultural land; however, the East Basin has a significantly greater percentage of forest, grassland, wetland and shrubland vegetation cover. In addition, the East Basin has seven times more developed properties and four times more road system than the West Basin. Since the KWD controls most of the shoreland in the West Basin, the pressure for development of upland areas has been reduced somewhat compared to the East Basin. In summary, the land use setting in the East Basin (i.e., the combination of agricultural, forestry, residential development and road network) poses a greater potential to be an external source of phosphorus to the lake than the West Basin watershed.

Review of the DEP databases of regulated activities and observations made during our reconnaissance of the watershed found both point and non-point sources of potential contamination that would be a concern to the water supply (see Figure 4). The types of land uses representing point sources include petroleum storage facilities, sand and salt storage, landfill, equipment and auto repair service and construction contractor facilities. Many of the potential point sources are located along the main roadways, which are set back some distance and are not a direct threat to the lake. Non-point sources include forest cutting, tilled farmland, livestock grazing areas, urban storm runoff and gravel pit operations. The contaminant of greatest concern is phosphorus and other nutrients that contribute to the eutrophic conditions in the lake.

4.2 Shoreland

The shoreland is protected through KWD ownership, the Shoreland Zoning Resource Protection District, the Phosphorus Control Ordinance and the 1999 Watershed Management Plan in addition to vigilant monitoring by the Water District, CRLA and CLA. In the West Basin, about 99 percent of the shoreland is undeveloped, mostly forested and controlled by KWD. In comparison, according to the October 2001 TMDL Report, approximately 75 percent of the lakeshore in the East Basin is developed with seasonal camps and year-round dwellings. There are numerous gravel roads to provide access to these homes and to the shore of the lake. On average, the buildings are set back about 45 feet from the lakeshore. An estimated 27 percent of the shorefront camps were built prior to 1960, and 53 percent of the camp septic systems were built prior to 1972. Many of these septic systems have been replaced or upgraded due to

malfunction or substandard construction; however, a fairly dense clustering of subsurface wastewater disposal systems remains along shorefront properties.

The shoreland topography located around the lake varies from gentle to steep slopes (see Figure 5). The main soil types are Hollis, Buxton and Scantic soils, which have a moderate to high erosion potential particularly if they are disturbed. Based on its inspection of the lake shore, the Maine DEP believes that shoreline erosion is a minor problem and much less significant than erosion and phosphorus loading caused by shorefront roads and human disturbance of the landscape. In 2000, CLA conducted a survey of the shoreline in the East Basin and found about four percent with some evidence of slow progressive erosion, which may be related to wave and ice action along the shore. In many locations of human encroachment, artificial barriers have been installed to prevent erosion. Such barriers include stone rip-rap, concrete or wood-crib walls and other types of landscaping.

4.3 Intake

The water supply intake is located approximately 250 feet from the northwest shore of the West Basin. The intake is located near the outlet of the lake. Since water in the East Basin moves into the West Basin to reach the lake outlet, the intake captures a blend of water derived from the entire lake system.

Recreational activities occur on the lake in the summer and winter. The West Basin is accessed by the boat landing located near the outlet. The public uses the lake for boating, fishing, ice-fishing, swimming, etc. although the area around the intake is marked with buoys and is closed to swimming and jetskis. The KWD monitors the intake area daily for unauthorized activity near the intake.

Lakes and ponds normally experience an aging process known as eutrophication, which is caused by various natural and man-made influences. Phosphorus from runoff, fertilizers, sewage and other sources is a primary factor affecting lake eutrophication since phosphorus nourishes plant and algae growth in the lake. The amount of algae productivity in the lake is characterized in terms of three Trophic States: (1) Oligotrophic = low, (2) Mesotrophic = moderate, and (3) Eutrophic = high. The Trophic State can be identified based on chlorophyll and phosphorus content and by secchi disk transparency data, which measures the clarity of the lake water.
China Lake is Eutrophic, however, significant efforts are being made to reduce or eliminate external sources of phosphorus and improve water quality.

Based on the October 2001 TMDL Report, the DEP has identified a water quality target TMDL of 15 parts per billion (ppb) of total phosphorus. This level is believed to correspond to conditions when algae blooms are less like to occur, secchi disk transparency readings are greater than 6.5 feet and chlorophyll-a values are less than 8 ppb. The KWD is currently implementing routine water quality monitoring at three deep-water locations of the East and West Basins between the months of May to October. Lake monitoring parameters include secchi disk, total phosphorus, dissolved oxygen, specific conductance, alkalinity, chlorophyll-a and temperature.

Continuous water quality monitoring has been conducted in China Lake since 1971. The available data for monitoring in the West Basin show average values for secchi disk at 13.1feet, total phosphorus at 17 ppb and chlorophyll-a at 10.9 ppb. In the southeast part of the East Basin, average values were 12.8 feet for secchi disk, 19 ppb for total phosphorus and 11.3 ppb for chlorophyll-a. In the northeast part of the East Basin, the average values were 13.8 feet for secchi disk, 18 ppb for total phosphorus and 11.8 ppb for chlorophyll-a. In the summer months, the turbidity increases with blooms of algae, secchi disk readings drop and phosphorus and chlorophyll-a increase. Under these conditions, the lake exhibits poor water quality.

When historical data are viewed with more recent findings, the overall pattern in lake quality appears to remain steady, i.e., not deteriorating further. In addition, there are preliminary indications in the KWD data that certain parameters may be showing improvement, although more data are needed to establish a definitive trend.

China Lake is ranked as a Class GPA water body. However, according to a surface water classification database developed by the DEP, the lake is considered to only partially support uses with respect to primary contact (i.e., swimming), aquatic life and trophic stability criteria. The lake is highly susceptible to ongoing land use activities because of historical practices that caused significant degradation of water quality.

5.0 SWAP RANKING AND RECOMMENDATIONS

5.1 Ranking of Susceptibility

The SWAP assessment factors indicate that overall susceptibility of the water quality in China Lake is high. The lake sediments retain a significant mass of phosphorus loading that will continue to support eutrophic conditions for many years. Thus, it is important to minimize or eliminate external sources of phosphorus loading in order to allow the lake to recover. Specific factors considered in assessing the overall risk are summarized in Table 3.

TABLE 3
CHINA LAKE SURFACE WATER ASSESSMENT

Zone	Measure	Findings	Risk Level
Watershed	Ambient Water Quality Existing Conditions & Future Development	Class GPA, partially supporting uses. Historical land use has caused the lake to be highly sensitive to human activity. Roadways serve as major collectors of residential and agricultural runoff. Land use activities are a continued threat to water quality if phosphorus and other nutrients reach the lake. CRLA, CLA, KWD are working to mitigate conditions through the Watershed Management Plan,	Moderate Moderate-High

	Overall	Phosphorus Control Ordinance and use of BMPs. Future development is likely to occur as the region continues to grow.	Moderate-High
Shoreland	Lake Classification Soils Activities Posing a Threat Potential for Future Threats Overall	Eutrophic – algae blooms common. Potential for erosion along the lake shoreline and on steep slopes with gravel roads or disturbance from residential construction. East Basin - shorefront development is dense with septic disposal systems, cultivated yards and road runoff. West Basin – KWD ownership protection of shoreland. Future development of remaining open shorefront. East Basin – Shoreland Zoning, local ordinance controls, BMPs, etc. may mitigate development threats and help to improve conditions cause by historical land use.	High Moderate-High Moderate-High Low Moderate Moderate-High
Intake	Raw Water Quality Ownership/Control Activities Posing a Threat Potential for Future Threats Overall	Meets applicable drinking water standards; nuisance algae requires treatment. Ownership protection for intake area and shoreland provided by KWD. Intake area marked with buoys although access is provided in the near vicinity from a public boat landing. Accidental or unauthorized activity with access to intake area generally unrestricted.	Low-Moderate Low Low-Moderate Low-Moderate Low-Moderate
Overall			**Moderate-High**

5.2 Recommendations

The overall ranking for the lake susceptibility to threats of contamination is moderate to high. The CRLA, CLA, KWD and local communities have developed and implemented programs to prevent further degradation of China Lake and to strive toward restoring the lake to a condition of improved water quality. The key efforts to continue in this regard include:

- Implement strategies set forth in the 1999 Watershed Management Plan which include: the use of BMPs, Youth Conservation Corps projects, sustaining financial support, conducting watershed surveys for sources of contamination, increased public education and awareness, and comprehensive water quality monitoring.

- The Phosphorus Control Ordinance is undergoing review to incorporate new provisions that will strengthen land use controls. It is important for the stakeholders of China Lake water quality to take an active role in the review process, to develop better controls and to gain public support through education and active participation.

Additional steps to be considered are as follows:

- Develop and implement a water quality program to assess the mass loading of phosphorus and other nutrients from tributaries that drain into the lake. Based on knowing the relative contribution of nutrient enrichment caused by each subwatershed, land use controls can be focused more on the areas that need improvement.

- Work with shoreland owners, particularly in the East Basin, to implement a strategy that will consolidate small shorefront lots into larger singular lots and thereby reduce the overall density of development along the shore of the lake and reduce mass loading from subsurface septic system discharges. Additional objectives to pursue with shoreland owners include reducing landscaped areas and increasing buffers of natural vegetation, increasing setback distances for lawns and gardens, and redirecting or minimizing runoff into the lake from gravel roads and pavement.

- Establish a long-range plan to protect land in the watershed through land purchases, conservation easements, etc., and by establishing protective agreements with local landowners. In particular, the plan should target shoreland owners in the East Basin in order to mitigate high use impact areas that have already become established and to protect any natural buffers and undisturbed properties remaining in the shoreland.

APPENDIX A

SWAP ASSESSMENT GUIDELINES

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APPENDIX A
ASSESSMENT GUIDELINES

Assessment Item/Threat	Low	Moderate	Significant
Physical Characteristics of the Watershed			
Watershed boundary, area	smaller	>>	larger
Area of water body	smaller	>>	larger
Tributaries	few	>>	many
Watershed topography	low	moderate	steep, rugged
Wetlands	many	>>	few
Water body depth	deep	>>	shallow
Sand and gravel aquifers	few	some	many
Soil types (erodibility and slope)	low	moderate	high
Raw Water Quality			
Secchi Disk Transparency	> 8 M	4-8 M	< 4 M
Turbidity	< 1 NTU	< 5 NTU	> 5 NTU
pH	6.5-8.5	N/A	< 6.5 or > 8.5
Phosphorus	< 10 ppb	< 20 ppb	> 30 ppb
Pesticides and herbicides	ND	N/A	detected
Color	< 5	5-15	> 15
Total Coliform and E Coli	> 29/100 ml	occasional	> 142/100 ml
Dissolved Oxygen	>7 mg/L	5-7 mg/L	< 5 mg/L
Temperature	ambient		> 10^{o} C ambient
VOCs	absent	N/A	detected
Chlorophyll-a	< 2 ppb	2-6 ppb	> 6 ppb
Total Organic Carbon	< 4 mg/L	4-8 mg/L	> 8 mg/L
Potential Contamination Source Inventory UST/AST leak sites Municipal/Comm/Special Landfill Compost sites Demolition debris sites Ash/septage storage/utilization Superfund site Sand/salt storage sites Petroleum spill sites Hazardous waste sites Wastewater treatment facilities Food residuals utilization sites Uncontrolled hazardous sites Tank farms Industrial complexes	Absent from watershed or actively monitored and controlled or fully remediated.	Present in watershed, some operational deficiencies and/or remediation is underway.	Present and unmonitored and/or unremediated.

Assessment Item/Threat	Low	Moderate	Significant
Potential Contamination Source Inventory Non-point pollution sources Transfer stations Sludge utilization sites Automobile graveyards Engineered subsurface systems Woodyards Underground injection wells Surface impoundments Mining/mineral processing sites Overboard discharges to rivers Active UST sites Roadways Railroads Utility Rights-of-way Boat launches Commercial farms CAFOs Commercial forest operations Private septic systems Home heating oil tanks Airports Bathing beaches Combined sewage overflows	If present, at low density, properly installed and operated. In compliance with applicable local, state and federal regulations.	>>>>	High density, little evidence of active management, documented incidence of problems and failures.
Land Uses and Zoning Residential density Percent of watershed Owned by PWS Public lands or conservation Forested With protective zoning Agricultural Impervious cover Industrial/commercial Waterbody uses: Restricted areas Ice fishing Boating Swimming Recreational vehicles	 > 2 Ac/lot total > 80% for all protected uses < 20 % total < 20 % total < 20 % total large, posted limited to absent	 1-2 Ac/lot intake and shoreland protected, others developed 20-30% total 20-30% total 20-30% total intake zone moderate, well- managed	 < 1 Ac/lot critical areas (intake, shoreland) unprotected or developed > 30% total of 3 > 30% total of 3 > 30% total of 3 small to none prevalent, uncontrolled
Other Analyses Trophic State Index Vulnerability Index Build-out Analysis	 < 25 low fully developed	 25-60 moderate >>>	 > 60 high high potential for development