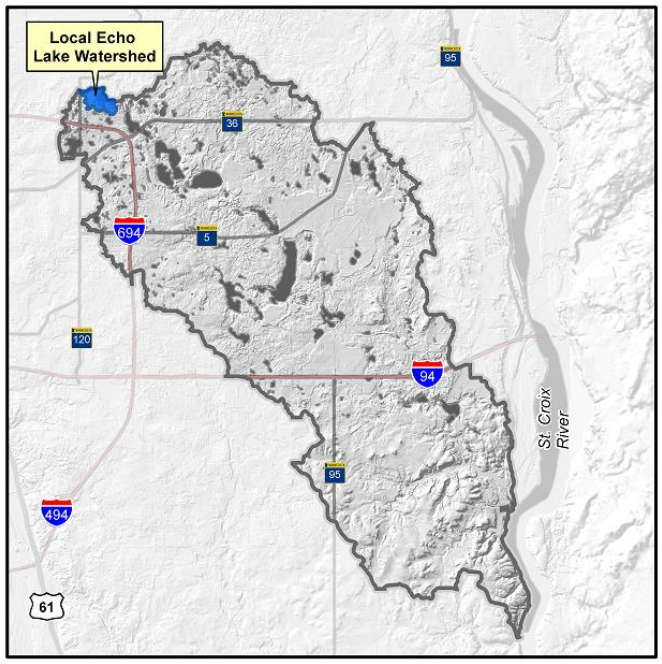
List of Tables

List of Figures

List of Appendices

5.3 Echo Lake Watershed Management Plan

5.3.1 General Information



Echo Lake Local Watershed Information	
Tributary Area (acres)	194
MDNR-Designated Basins within Watershed	82-0135W
Downstream Watershed	Weber Pond
Echo Lake Information	
MDNR Designation	82-0135W
Surface Area (acres)	40.9 at El. 995.5
Approximate Mean Depth (feet)	2.6
Approximate Maximum Depth (feet)	6
Approximate Volume Below Discharge Elevation (acre-feet)	91
Discharge Elevation	994.4
Outlet Type	Staged (Orifice, Weir, Culvert, & Overflow)
MDNR Ordinary High Water Level (OHW)[1]	996.3
100-Year Flood Level	997.6
VBWD "Allowable Fill" (cubic yards/lineal foot of shoreline) (See Section 4.7.)	0.7
VBWD Water Quality Priority Category	High

[1] Elevations in NGVD29 vertical datum

The Echo Lake watershed is entirely within the City of Mahtomedi (see Figure 5.3-1). Echo Lake is a small, shallow lake located approximately one half mile northeast of the Long Lake Road – Century Avenue (T.H. 120) intersection. Parts of the Century College campus and medium-density residential housing lie within the Echo Lake watershed west of Echo Lake. Other land uses include natural area/open space to the north, and low density residential areas to the east and south. Current (2010) and future (2030) estimated land use conditions for Echo Lake are shown on Figure 5.3-2.

Recreational use of Echo Lake is currently limited to lake residents who use the lake for canoeing, small rowboats, and aesthetic viewing. Echo Shores Park, located on the northwest shore of Echo Lake, provides pedestrian access to Echo Lake and includes woodchip trails and benches for aesthetic viewing. The City's Park System Plan (Sanders, Wacker Bergly, Inc., 2006) identifies the potential to work with Century College to expand the existing park.

The lake and surrounding areas is home to a variety of wildlife, birds, and waterfowl have made their homes in and around the lake.

The VBWD is aware of some issues within the Echo Lake watershed. In the past, Echo Lake residents have been concerned about the algal blooms which

give the lake a green, murky appearance during the summer months. Some residents have expressed their wishes to have the lake's fisheries managed, while other residents prefer no management.

In addition to water quality issues, residents of the neighborhood on the east side of Echo Lake have complained about high water levels of stormwater ponds in their back yards. These stormwater ponds are directly connected to Echo Lake.

5.3.2 Water Quality Management Plan

Although the lake and all of its drainage area is within the jurisdiction of the City of Mahtomedi, the water quality of Echo Lake can impact downstream water resources in other communities. Echo Lake is the most upstream water of the Project 1007 drainage system (see Section 4.7.5). Therefore, the VBWD has prepared the following water quality management plan for Echo Lake.

Echo Lake is classified as a shallow lake by the Minnesota Pollution Control Agency (MPCA). Echo Lake is currently listed as impaired for aquatic recreation by the MPCA due to nutrients, eutrophication, and biological indicators, and is included in the MPCA's 303(d) impaired waters list. The VBWD classified Echo Lake as a High Priority waterbody according to its waterbody classification system (see Section 4.1 – Water Quality), due to the lakes inclusion in the MPCA's impaired waters list (see Table 4.1-4).

Historically, Echo Lake has had poor water quality. The VBWD previously classified Echo Lake as a Level III water body in the 1995 VBWD Water Management Plan and a low priority waterbody in its 2005 Plan; such lakes generally supported fishing and provided opportunities for aesthetic viewing, and observing wildlife.

The VBWD has a non-degradation water quality policy which sets "action triggers" for all of its major waterbodies. Section 4.1 – Water Quality discusses the action triggers in more detail. Action triggers for VBWD lakes consider the following water quality parameters (summer average) relative to MPCA water quality standards and prior water quality data (i.e., trend analysis):

- Secchi disc depth
- Total phosphorus
- Chlorophyll a

Specific water quality implementation tasks for Echo Lake include the following:

1. The VBWD will cooperate with other entities to monitor the water quality of Echo Lake and perform the actions discussed in Section 4.1 – Water Quality for High Priority water bodies. The VBWD may conduct more intense monitoring of the lake as needed based on actions recommended in Table 4.1-6.

The VBWD will evaluate the average summertime water quality (total phosphorus, chlorophyll a, and Secchi disc transparency) and compare it to applicable water quality standards (Table 4.1-1) and applicable action triggers (described in Section 4.1.7.5). Currently, Echo Lake action triggers are met based on its impaired status. Based on Table 4.1-6, the VBWD may perform Survey Level plus Supplemental Water Quality Monitoring, as necessary.

2. The VBWD will evaluate and implement the appropriate recommendations for Echo Lake that are listed in the draft August 2000 report, *Tri-Lakes (Lakes DeMontreville, Olson and Jane), Long, Echo, Mud (Acorn) and Silver Lakes, Watershed and Lake Management Plan, Volume I; Lake and Watershed Conditions, Water Quality Analysis, Improvement Options and Recommendations* (Tri-Lakes Watershed and Lake Management Plan).

   Through the Tri-Lakes Watershed and Lake Management Plan, the VBWD evaluated a number of water quality management practices to estimate their cumulative effect on the water quality of Echo Lake and downstream lakes. The management practices evaluated in the report include:

   - Wet detention of stormwater runoff
   - Prefabricated stormwater treatment units
   - Stormwater alum treatment plant
   - In-lake alum treatment
   - General best management practices

   For Echo Lake, the VBWD will consider implementing the following:

   a. More intense monitoring to better estimate how much phosphorus is entering the lake, and ultimately, determine the feasibility and cost-effectiveness of improvement options identified through the Tri-Lakes Watershed and Lake Management Plan.

   b. Evaluating the feasibility of enhanced treatment and small scale stormwater BMPs within the watershed tributary to Echo Lake. The VBWD's BMP cost-share program may provide opportunities for private landowners to implement water quality improvements. Collectively, many small residential BMPs may have a significant impact on the cumulative phosphorus loading to Echo Lake.

   c. If necessary, the VBWD will cooperate with the MDNR and others to reduce internal loading in Echo Lake. This may include an in-lake aluminum sulfate (alum) treatment of Echo Lake. In-lake alum provides a long-term control of the phosphorus release of lake sediments (see Section 4.1 – Water Quality). An in-lake treatment could be

effective for up to ten years, depending upon how well the watershed nutrient sources have been reduced. When alum is applied to shallow lakes, the improved water clarity usually results in increased (and often undesired) aquatic plant growth. This can be exacerbated by the presence of aquatic invasive plant species. The VBWD will need to consider improved water clarity versus increased aquatic plant growth before moving forward with alum application projects on these lakes.

d. Management of macrophytes (aquatic plants) of the lake. Treatment of areas containing dense, monospecific growths of Eurasian watermilfoil with an aquatic herbicide (2,4-D, Triclopyr, or low concentrations of Aquathol® K) is recommended to protect Echo Lake's native plant community. The VBWD will cooperate with the City of Mahtomedi or other entities in support of macrophyte management efforts. VBWD efforts may include

   - point-intercept surveys of aquatic vegetation
   - preparation of lake vegetation management plans (LVMP)
   - completion of Invasive Aquatic Plant Management (IAPM) Permit applications
   - design of herbicide treatment programs
   - participation in meetings with MDNR staff
   - other technical analysis

3. The VBWD will cooperate with the MPCA to participate in any required total maximum daily load (TMDL) study and TMDL implementation plan for Echo Lake. This may include collaboration with Municipal Separate Storm Sewer System (MS4) permit holders (e.g., City of Lake Elmo, Washington County, Minnesota Airports Commission, etc) to meet waste load allocations determined by the TMDL study.

4. The VBWD will consider collecting sediment core samples from Echo Lake to assess the potential for internal phosphorus loading from sediments.

5. The VBWD will continue to implement its Rules and Regulations (2013, as amended) in the Echo Lake watershed. The VBWD Rules address water quality performance standards for development and redevelopment projects, as well as required vegetated buffers around VBWD lakes, streams, and wetlands. The VBWD Rules and Regulations are included in this Plan as Appendix A-4.5.

5.3.2.1 Water Chemistry Data

Water quality monitoring of Echo Lake has been conducted since 1972 and at least every two years since 2006. Water quality samples are typically analyzed for total phosphorus and chlorophyll a, and Secchi disc transparency (see Appendix A-4.1 – Water Quality Background Information). Graphical depictions of Echo Lake's historical water chemistry from 1972 through 2014 are shown in Figure 5.3-3. Average water quality over the past 10 years is summarized in Table 5.3-1.

Table 5.3-1 Summary of Echo Lake summer average water quality (2005 – 2014)

Parameter	Units	10-year Average (2004-2013)	Trend in Average	MPCA Standard
Total Phosphorus	ug/L	65.05	None	60
Chlorophyll a	ug/L	43.3	None	20
Secchi Disc Depth	m	1.17	None	1.0

Water quality in Echo Lake has historically been poor, but has improved in recent history. Through 2010, Secchi disc transparency was consistently less than 1 meter. In 2012 and 2013, Secchi disc transparency improved to 1.8 and 2.5 meters, respectively. Similarly, chlorophyll a was consistently poorer than the 20 ug/L standard for shallow lakes until 2012 and 2013, when it met the standard. Over the most recent 10 year period, total phosphorus has averaged 65 ug/L, which is worse than the MPCA standard. Summer average total phosphorus was better than 60 ug/L in 2014 and 2008, but worse than the standard in 2006, 2007, 2010, and 2012 (see Figure 5.3-3).

5.3.2.2 Biological Data

Various types of biological data have been compiled and evaluated for Echo Lake, in addition to physical and chemical parameters. Macrophyte (aquatic plant), phytoplankton (non-rooted floating plants – algae), zooplankton (microscopic aquatic animals), and fisheries data provide insight into the ecological quality of Echo Lake.

The MDNR has no fisheries information and does not currently manage the fisheries in Echo Lake. Should the MDNR consider actively managing the fishery in Echo Lake, it may be beneficial to monitor the winter oxygen concentration in the lake. The lake may be suitable for bluegills and largemouth bass, if a sufficient winter oxygen concentration exists to permit their survival.

While no fish surveys have been completed for Echo Lake, macrophyte surveys were conducted by the VBWD at Echo Lake in 1996, 2002, 2006, and 2012. The VBWD conducted Phytoplankton and zooplankton surveys in 2002.

5.3.2.2.1 Macrophytes (Large Aquatic Plants)

The VBWD conducted macrophyte surveys in 1996, 2002, 2006 and 2012 at Echo Lake. to identify the conditions of plant growth throughout the lake. Macrophytes are the primary producers in the aquatic food chain, converting the basic chemical nutrients in water and soil into plant matter through photosynthesis, which becomes food for all other aquatic life. While macrophytes can negatively impact the recreational use of a water body, they are critical to the ecosystem as fish and wildlife habitat.

Appendix A-5.3 includes information from the June 1996, August 1996, June 2002, August 2002, June 2006, and June 2012 macrophyte surveys. Stands of plants, floating, submergent and emergent were found around the entire shoreline in varying densities and compositions. There were no macrophytes found at depths greater than 3 to 4 feet. The heaviest macrophyte growth occurred along the western and eastern shorelines.. Included in the thirteen to twenty-four species observed during each plant survey was a species that is tolerant of poor water clarity. Pondweed (*Potamogeton pusillus*) is tolerant of turbid, low light conditions (Borman et. al., 1997). The presence of this species in all surveys is consistent with the lake's poor water transparency resulting from nuisance summer algal blooms.

A light growth of curlyleaf pondweed (*Potamogeton crispus*) was observed on the west side of the lake during August 1996. Once a lake becomes infested with curlyleaf pondweed, this plant typically replaces native vegetation, thereby increasing its coverage and density. However, in Echo Lake, the curlyleaf pondweed was not observed in the 2002 and 2006 surveys. Two locations of light density curlyleaf pondweed were observed on the south side of Echo Lake in 2012; both locations. Although intermittently observed and of light density, the presence of curlyleaf pondweed in Echo Lake should continue to be monitored..

The growth of purple loosestrife (*Lythrum salicaria*) along the shore of Echo Lake is of concern. Although not observed during 1996 or during June 2002, purple loosestrife growth was observed along the south and southeast shore in August 2002, and was observed in the 2006 and 2012 macrophyte surveys. Once a waterbody becomes infested with purple loosestrife, the plant typically replaces native vegetation and rapidly becomes the sole emergent species.

In some instances, purple loosestrife has been effectively managed through the use of leaf-eating beetles, which reduce plant growth and seed production by feeding on the leaves and new shoots. At the request of the VBWD, the MDNR released 1,000 beetles (*Galerucella pusilla*) at a location on the southeast shore of Echo Lake in the spring of 2009. In October of 2009, a MDNR follow-up survey did not find any of the beetles near the release site, and observed no damage to the purple loosestrife at that location. The 2012 macrophyte surveys indicated purple loosestrife present at this location as well. The MDNR has not released additional beetles at Echo Lake since the 2009 release. The VBWD will cooperate with others entities in their efforts to manage aquatic invasive species, including the MDNR if the MDNR recommends additional release of leaf-eating beetles. The VBWD will continue to provide technical assistance to entities seeking to manage aquatic invasive species.

This may include development of lake vegetation management plans and surveys conducted in the years following treatments to track purple loosestrife extent.

5.3.2.2.2 Phytoplankton (Non-Rooted, Floating Plants - Algae) and Zooplankton (Microscopic Aquatic Animals)

The VBWD has collected phytoplankton and zooplankton samples from Echo Lake in 2002. Appendix B-5.3 and Appendix C-5.3 present information from the 2002 samples.

Phytoplankton derive energy from sunlight and use nutrients dissolved in lake water. They provide food for several types of animals, including zooplankton, which in turn are eaten by fish. A phytoplankton population in balance with the lake's zooplankton population is ideal for fish production. An inadequate phytoplankton population reduces the lake's zooplankton population and adversely impacts the growth of the lake's fishery. However, excess phytoplankton, especially blue-green algae, can interfere with recreational use of a lake and is considered problematic.

High numbers of algae in 2002 affirmed the lakes water chemistry data. High phosphorus levels (nutrient consumed by algae), high chlorophyll concentrations (pigment in algae), and poor water transparency were measured during June through September of 2002. Analyses of surface water (0- to 2-meter depth) phytoplankton samples indicated from 25,946 to 156,553 algae cells, filaments, or colonies were found in each milliliter (about a drop) of lake water. The algal numbers and chlorophyll concentrations indicate that nuisance algal blooms occurred throughout the summer.

The lake's phytoplankton community is dominated by several species of blue-green algae (cyanobacteria) throughout the summer. In 2002, blue-green algae comprised 79 to 95 percent of the algal community from June through September. Dominance by blue-green algae is undesirable because they are inedible to zooplankton due to their large size. Furthermore, blue-green algae generally float on the waters' surface where they are aesthetically undesirable and impede recreational use. Blue-green algae are best managed by reducing the lake's phosphorus concentration. Conversely, increases in the lake's phosphorus concentration may result in increased growth of blue-green algae. Profuse algal growth may adversely impact the lake's plant community by reducing lake transparency and limiting light available to aquatic plants. Judicious management of the lake's phosphorus concentration is recommended to reduce objectionable algal blooms and to prevent adverse impacts to the lake's plant community.

In addition to ecological and nuisance impacts, excessive numbers of blue-green algae can have human health impacts. Some blue-green algae produce toxins that are released to the lake when algae cells die. All samples collected in 2002 had a blue-green algae count above 20,000 individuals per mL, which is the World Health Organization (WHO) threshold for low adverse health effects, including skin irritation and gastrointestinal illness. The concentrations of toxins cannot be determined from algal counts, and toxin levels in Echo Lake was not tested in 2002.

The lake's zooplankton community is dominated by small-bodied forms. While these animals provide food for the lake's panfish community, they are unable to control the lake's algae community due to

their small size. The most common type of zooplankton present in Echo Lake is rotifera, a family of microscopic animals who consume detritus and contribute to nutrient cycling. They also serve as a food source for the population of copepods, a family of small freshwater crustaceans also found in Echo Lake. Appendix C-5.3 presents the distribution of zooplankton in Echo Lake throughout the year.

5.3.3 Water Quantity Management Plan

The current outlet from Echo Lake is a staged outlet with and orifice and weir located on the south side of the lake (see Figure 5.3-4). The overflow point of the weir is at Elevation 996.5. The Echo Lake outlet was re-constructed in 1999. The former outlet from Echo Lake was a deformed corrugated metal pipe approximately 12 inches high and 23 inches wide. A second 12-inch diameter clay culvert was located next to the metal culvert, but the clay culvert had been completely plugged with mud for some time prior to reconstruction. The upstream invert of the metal pipe was approximately Elevation 994.4. A tree located downstream of the culverts appeared to control the water level of Echo Lake at approximately Elevation 995.0.

The VBWD issued a permit to the City of Mahtomedi in 1999 to re-construct the Echo Lake outlet. The new outlet has an 18-inch diameter reinforced concrete culvert inlet to a weir structure. The weir structure contains a 4-inch diameter orifice below the structure outlet at Elevation 994.4. The outlet of the structure is a 12-inch diameter reinforced concrete pipe. The structure sets the outlet elevation of Echo Lake at Elevation 994.4, and includes an emergency overflow at Elevation 997.45. Figure 5.3-4 shows the outlet structure. Water discharged from the Echo Lake outlet makes its way south and east through a series of wetlands to Weber Pond.
The VBWD has no plans to modify the outlet of Echo Lake. The VBWD will work with the City of Mahtomedi and/or adjacent landowners to make any necessary repairs or will contract for repairs. If others propose changes to the lake's outlet, the project will need to be approved by the VBWD.

The VBWD began monitoring Echo Lake water levels on a regular basis in 2010. Additionally, the VBWD has water level data from various surveys and development plans. Water surface elevation data for Echo Lake are presented in Figure 5.3-5.
The VBWD has established the 100-year flood level of Echo Lake at Elevation 997.6.

5.3.3.1 Water Quantity Issues and History

The VBWD is aware of high water problems within the Echo Lake Addition subdivision (once called Parkview), which is located east of Echo Lake. The subdivision was permitted by the VBWD on July 9, 1992. The VBWD set the minimum floor elevations of the homes two feet above the 100-year flood level of Echo Lake and internal wetlands and ponds. These calculations were provided by the developer's engineer and assumed a future restricted outlet of Echo Lake and that the internal wetlands and ponds would have the same flood level as the lake because of pipe connections. Most of the homes in the area were constructed in mid-1990s, but several homes were constructed lower than the VBWD-required elevations and some other drainage features were constructed incorrectly.

In 2000, after receiving several complaints from residents about high water, the City of Mahtomedi investigated an emergency overflow for the pond bordered by Dunbar Way, Windsor Lane, Berwick Lane, and Kilbirnie Way. The City found that the overflow was constructed higher than shown on the permit-approved plans. Therefore, the City lowered the emergency overflow of the pond to about the elevation shown on the originally approved plans (approximately Elevation 998.9).

2002's extremely wet weather caused the water levels in the area to remain high all summer. Trails adjacent to the lake and some residents' sprinkler systems were inundated. Vegetation was killed. Residents worried that additional precipitation would flood their homes. Some residents reported water within inches of entering their homes.

Some residents pointed to the modified outlet on Echo Lake as their problem. The ponds in the subdivision are essentially backwater of Echo Lake. When the water level of Echo Lake is above Elevation 995.5, water backs up into the subdivision. When the water level of Echo Lake is below Elevation 995.5, there is no surface outlet for the ponds – the water only leaves by evaporation and seepage. In 1999, the City modified the Echo Lake outlet to restrict its outflows to protect downstream areas (like Long Lake) from flooding. The VBWD required the City to make the modification. The restriction had been planned for over a decade and was discussed in the VBWD's 1986 and 1995 Water Management Plan and listed in the VBWD's 1995 capital improvement program section of the Plan. The purpose of the Echo Lake outlet restriction is to provide additional flood storage and prevent increases in flood levels in Long Lake and other downstream waters. The VBWD's 1986 Plan states:

> *A 100-year flood level (Elevation 998) 3 feet above the normal level is proposed for Echo Lake. The increase in storage volume is proposed to be done by the City or developer at the time when development in this subwatershed is occurring. Storage in the uneven terrain northwest of the lake should be preserved during development and the lake itself should have maximum utilization of its storage volume during development to keep outflow rates very low.*

The modified outlet is a staged outlet (see Section 5.3.3) which reduced outflow rates under normal conditions, but did not change the emergency overflow of the lake (Elevation 997.45). The City of Mahtomedi owns, and is responsible for the maintenance of the Echo Lake outlet. Figure 5.3-4 shows the Echo Lake outlet.

In 2002, the City of Mahtomedi found the Echo Lake outlet to be partially plugged with debris. The City removed the debris and placed wire fencing in front of the outlet, in hopes of preventing future plugging. Following the high water levels in 2002, the VBWD calculated approximate flood levels based on various starting water levels to determine if homes were in jeopardy of flooding. Those calculations showed that the homes within the Echo Lake Addition would be protected from the 100-year flood level if they had been constructed to the elevations approved by the VBWD. However, the homes were constructed lower than approved. The City of Mahtomedi surveyed homes and important features in the Echo Lake neighborhood in 2004.

Following the VBWD's 2008 stormwater pond inventory, the VBWD Managers ordered maintenance of three stormwater ponds within the Echo Lake subwatershed. The stormwater ponds were excavated in 2009. The water levels remained below their outlets for all of 2009 and the spring of 2010. After an on-site Echo Lake Addition neighborhood meeting, the VBWD Managers ordered an evaluation of options to control the seepage from these stormwater ponds. The Managers began to implement a plan to drain the stormwater ponds, mix seepage-control material into the pond soils, and then compact the soils. However, soon after the Managers sent letters to the residents stating their intentions, the water levels of the stormwater ponds came back to near their outlets. The Managers then chose to continue to monitor the water levels of the ponds rather than drain them and apply the sealant. In August 2010, the VBWD vice president and engineer attended the Mahtomedi City Council meeting to discuss the stormwater ponds. After discussion, the Mahtomedi City Council recommended that the VBWD leave the stormwater ponds as they were. Soon afterward, the VBWD sent a letter to the residents around the stormwater ponds stating that given the increased precipitation, apparent water level stability, resistance from the Mahtomedi City Council and the VBWD Managers duties to carefully and wisely expend taxpayer dollars, the VBWD Managers had decided not to drain the ponds that fall to amend and compact the soils. Instead, the VBWD resumed monitoring the water levels. Since 2010, the residents have not complained to the VBWD Managers about the water levels of the stormwater ponds and the VBWD Managers have taken no additional actions.

Residents have not complained about high water levels in the Echo Lake addition since the outlet maintenance and stormwater pond excavation. The City of Mahtomedi will continue to monitor water levels in the area and develop a mitigation plan, as necessary (WSB, 2014).

In 2013, the National Oceanographic and Atmospheric Administration (NOAA) published Atlas 14, Volume 8 (see Section 4.7.6). Atlas 14 contains updated precipitation data for Minnesota and supersedes TP-40 and TP-49 (the precipitation sources used in the 2005 VBWD Plan). Comparison of precipitation depths between TP-40 and Atlas 14 indicates increased precipitation depths for more extreme events. Within the VBWD, the 100-year, 24-hour event within the VBWD increased from 6.0 inches to 7.3 inches. The 100-year water level established for Echo Lake predates Atlas 14 and does not reflect the most current data. The VBWD plans to update the 100-year flood level for lakes, including Echo Lake, to reflect Atlas 14 precipitation data and other current data sources. These updates may result in an increased flood level, which may place additional structures within the floodplain.

5.3.4 References

Barr Engineering Company. September 1995. *Water Management Plan, Valley Branch Watershed District*.

Barr Engineering Company. August 2000. *Draft Report, Tri-Lakes (Lakes DeMontreville, Olson and Jane), Long, Echo, Mud (Acorn) and Silver Lakes Watershed and Lake Management Plan,*

Volume I: Lake and Watershed Conditions, Water Quality Analysis, Improvement Options and Recommendations. Prepared for Valley Branch Watershed District.

Barr Engineering Company. December 2005. *Valley Branch Watershed District Watershed Management Plan.*

Borman, S., R. Korth, and J. Temte. 1997. *Through the Looking Glass … A Field Guide to Aquatic Plants*. Wisconsin Lakes Partnership (Cooperative Extension of the University of Wisconsin—Extension and the Wisconsin Department of Natural Resources). Stevens Point, WI.

Minnesota Department of Natural Resources. Lakefinder information report from website (http://www.dnr.state.mn.us/lakefind/index.html).

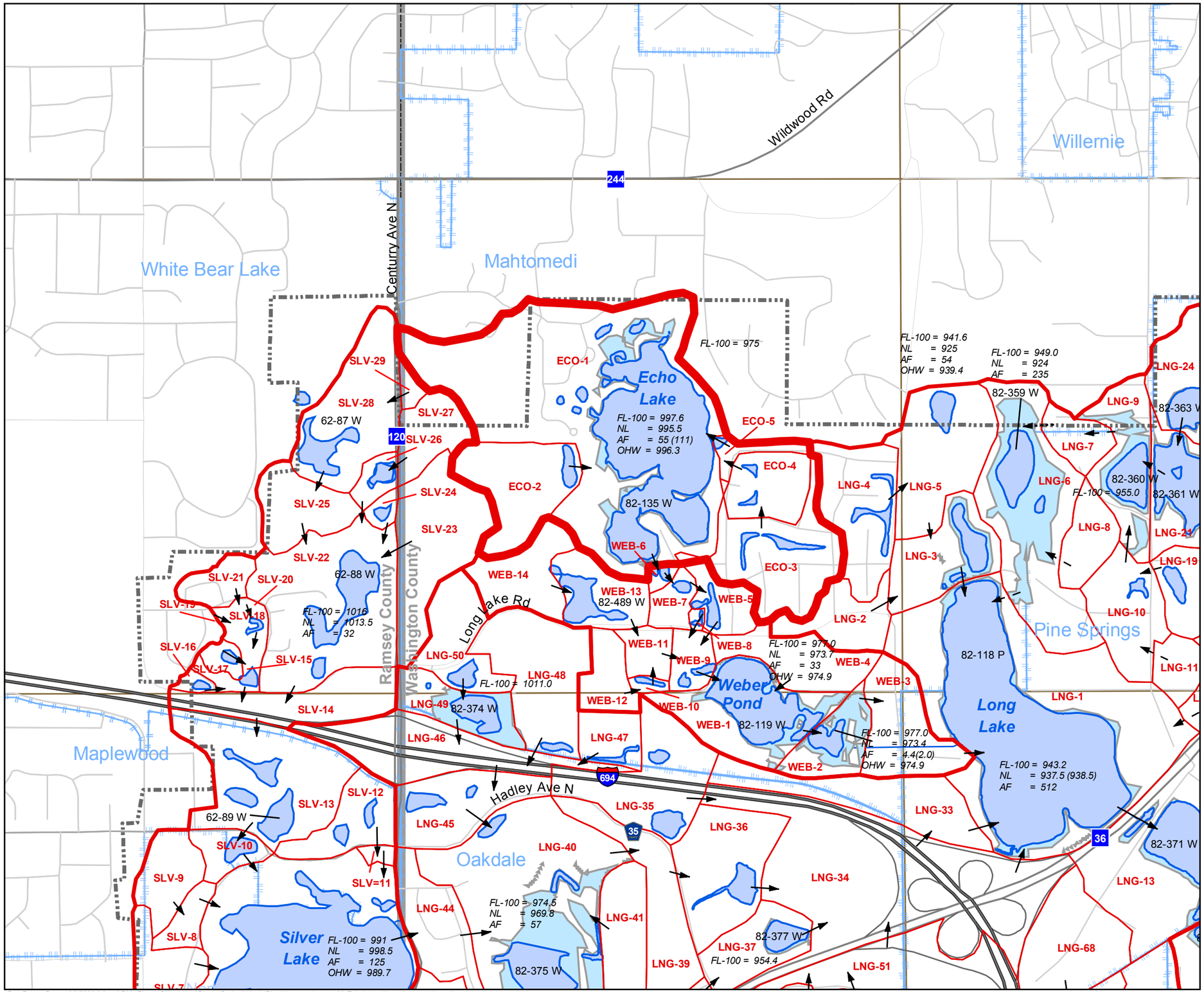
Minnesota Department of Natural Resources. 1992. *An Ecological Classification of Minnesota Lakes with Associated Fish Communities,* Investigation Report 412. Dennis H. Schupp.

National Oceanographic and Atmospheric Administration (NOAA). 2013. Atlas 14 Precipitation-Frequency Atlas of the United States – Volume 8.

Sanders Wacker Bergly, Inc. – Planners and Landscape Architects. 2006. City of Mahtomedi Park System Plan. Prepared for the City of Mahtomedi.

World Health Organization. 2003. *Guidelines for Safe Recreational Water Environments, Volume 1, Coastal and Fresh Waters*.

WSB and Associates, Inc. February 2014. *City of Mahtomedi Local Water Management Plan (draft)*. Prepared for the City of Mahtomedi



1,000 500 0 1,000 2,000

Scale in Feet

LEGEND

- Echo Lake Watershed
- Major Watershed Divide
- Subwatershed Divide
- ECO-1 Subwatershed Designation
- 82-135W DNR Protected Waters Designation
- Subwatershed Contributing Runoff
- Overflow Path from Landlocked Watershed (Non-Contributing Subwatershed)
- Overflow Path from Semi-Landlocked Watershed
- Lakes, Ponds, Wetlands, Approximate Normal Water Surface Level
- Lakes, Ponds Wetlands, Approximate 100 Year Flood Surface Level
- FL-100 100 Year Flood Level
- NL Normal Level
- AF Acre Feet of Storage at 100 Year Flood Level
- OHW DNR Established Ordinary High Water Elevation

Project 1007

- Catch Basin
- Manhole Cover
- Open Channel
- Pipe
- MN-DOT Pipe
- Section Lines
- VBWD Legal Boundary
- Municipal Boundary
- County Boundary

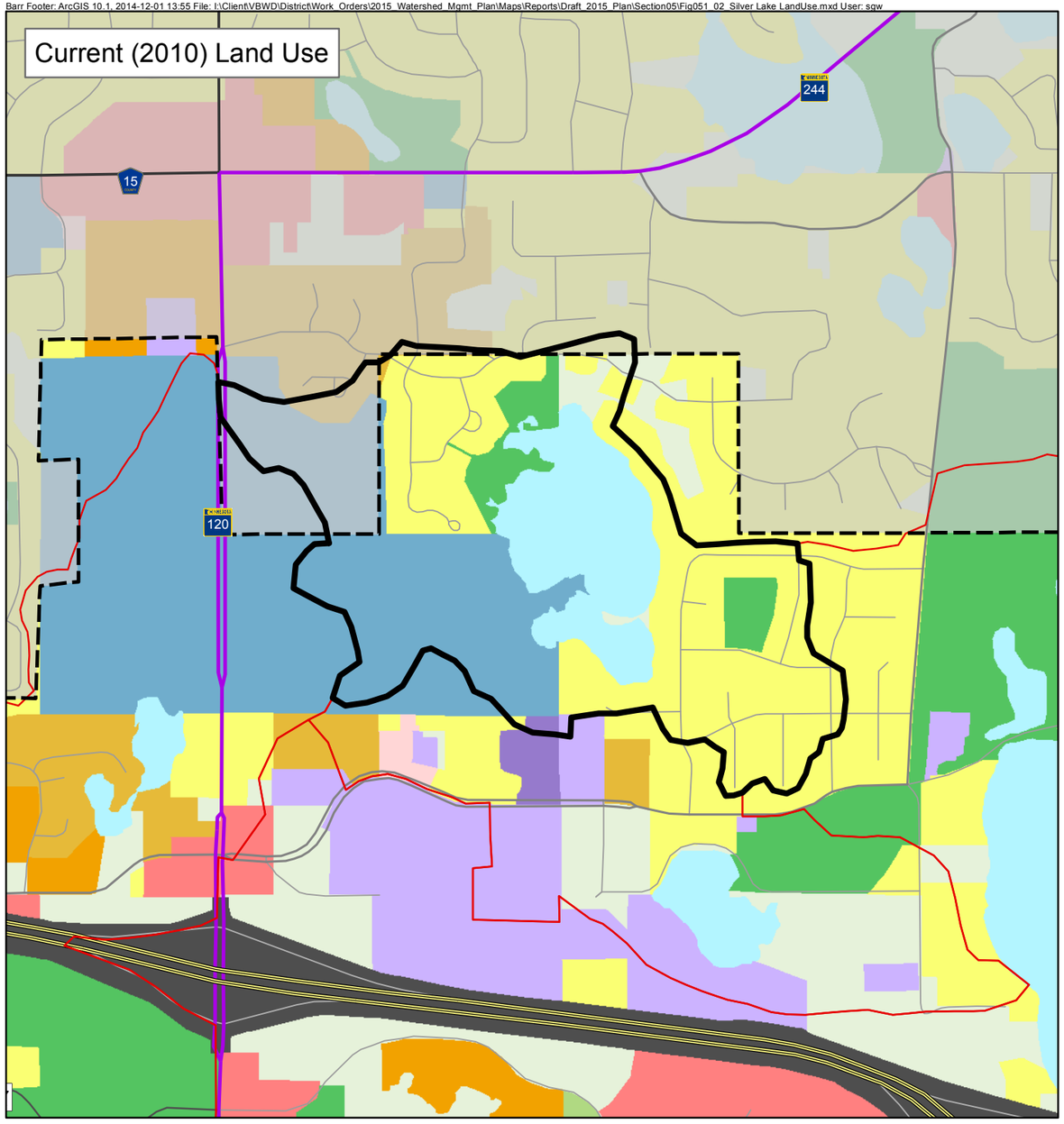
Landlocked: Basin does not overflow using VBWD simplified method for calculating its 100-year flood level or using a more detailed analysis, such as the 1% probability flood level.

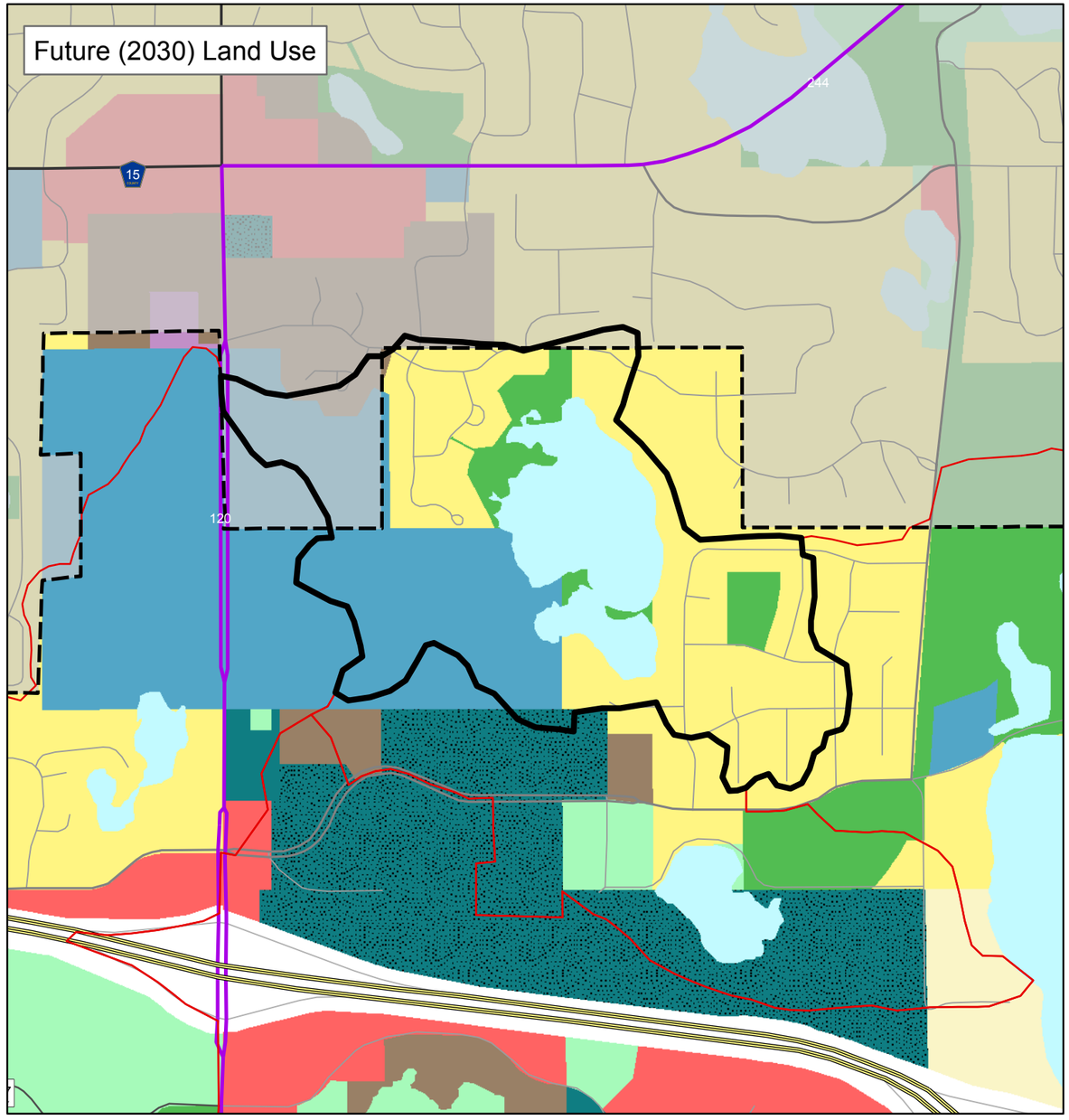
Semi-Landlocked: Basin does not overflow in the 100-year 24-hour rainfall total or the 100-year 10-day snowmelt event, but does overflow when calulating its 100-year flood level based on the VBWD simplified method or the 1% probablility flood level.

Figure 5.3-1

ECHO LAKE WATERSHED
Valley Branch Watershed District

Barr Footer: Date: 12/2/2005 3:04:19 PM File: I:\Client\Vbwd\District\Project\WtrshdPlan\Watershed_maps\03-EchoLake_Watershed.mxd User: lkp





Current (2010) Land Use
- Farmstead
- Seasonal/Vacation
- Single Family Detached
- Manufactured Housing Park
- Single Family Attached
- Multifamily
- Retail and Other Commercial
- Office
- Mixed Use Residential
- Mixed Use Industrial
- Mixed Use Commercial and Other
- Industrial and Utility
- Extractive
- Institutional
- Park, Recreational or Preserve
- Golf Course
- Major Highway
- Railway
- Airport
- Agricultural
- Undeveloped
- Water
- Echo Lake Subwatershed
- Major Subwatershed Boundary
- VBWD Legal Boundary

Future (2030) Land Use
- Agricultural
- Rural or Large-Lot Residential
- Single Family Residential
- Multifamily Residential
- Commercial
- Industrial
- Institutional
- Mixed Use
- Multi-Optional Development
- Park and Recreation
- Open Space or Restrictive Use
- Rights-of-Way (i.e., Roads)
- Railway (inc. LRT)
- Airport
- Vacant or Unknown
- Open Water
- Echo Lake Subwatershed
- Major Subwatershed Boundary
- VBWD Legal Boundary

Feet
1,000 0 1,000 2,000

1 inch = 1,000 feet

Source: Metropolitan Council 2010

Figure 5.3-2

ECHO LAKE WATERSHED
CURRENT (2010) AND FUTURE (2030) LANDUSE
2015-2025 Watershed Management Plan
Valley Branch Watershed District

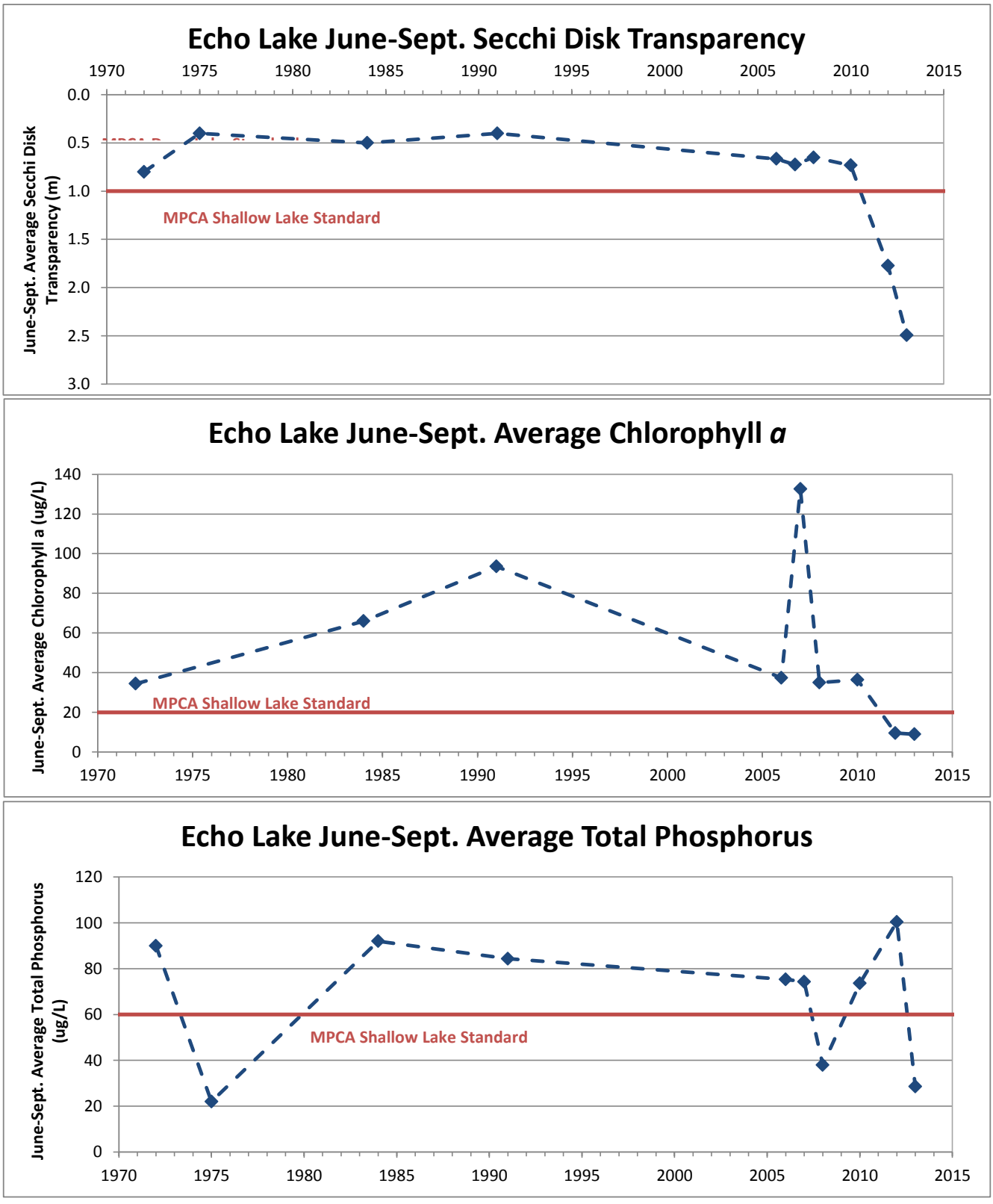
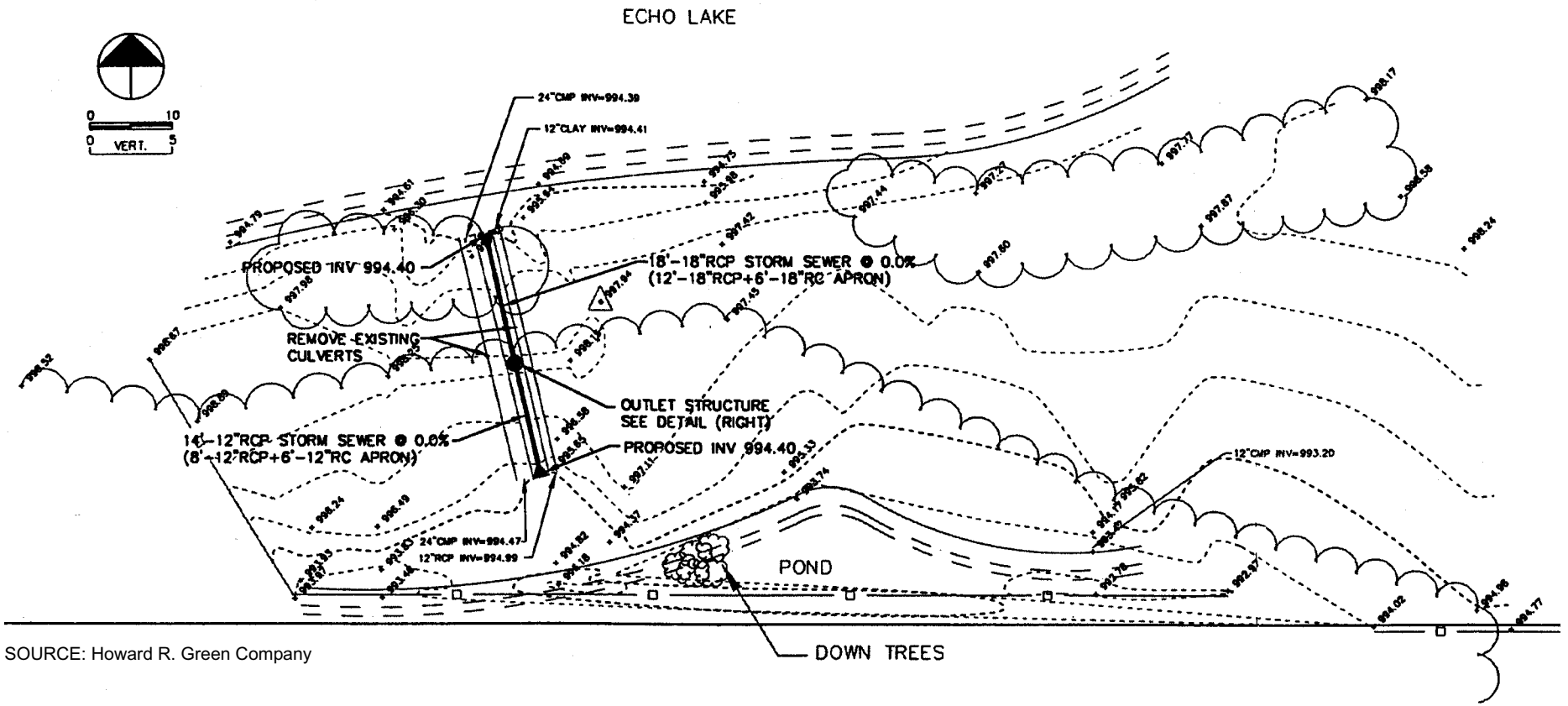


Figure 5.3-3

Echo Lake Water Quality
2015 - 2025 Waterhsed Management Plan
Valley Branch Watershed District

P:23\82\174\VBWD Plan\Figures\Figure 5.3_4.CDR RLG 09-07-04



SOURCE: Howard R. Green Company

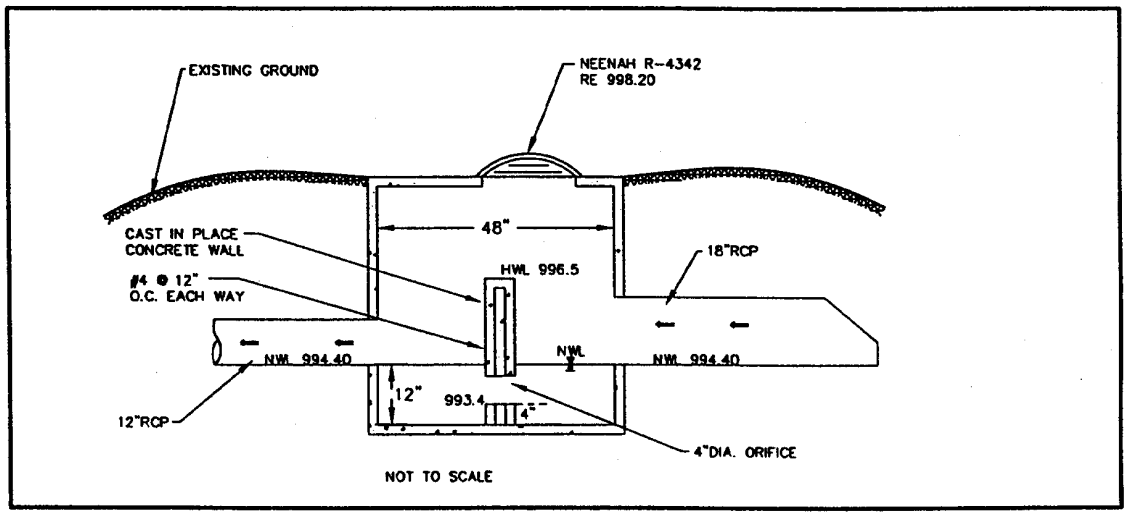
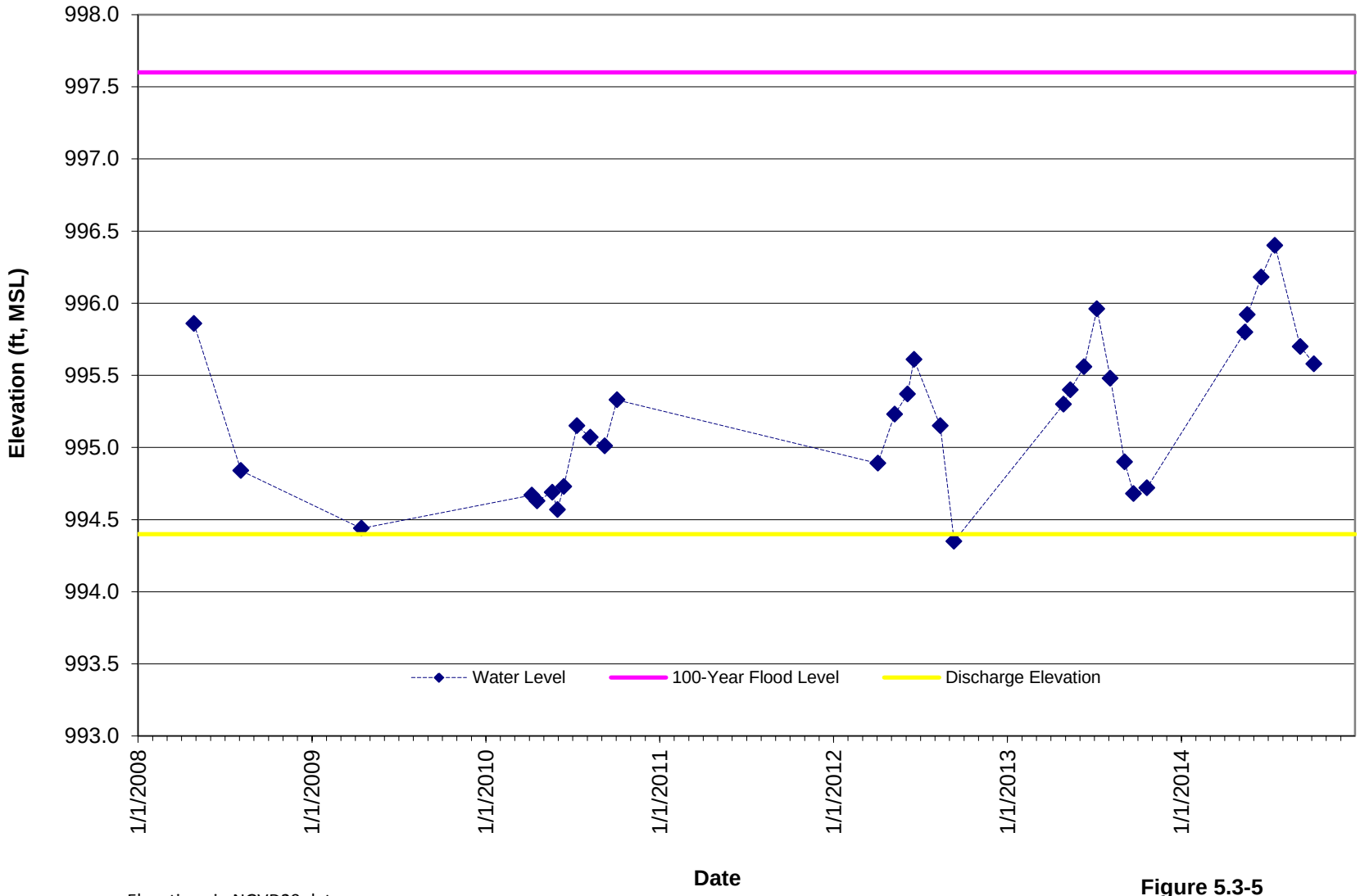


Figure 5.3-4

ECHO LAKE OUTLET STRUCTURE
Valley Branch Watershed District



Elevations in NGVD29 datum

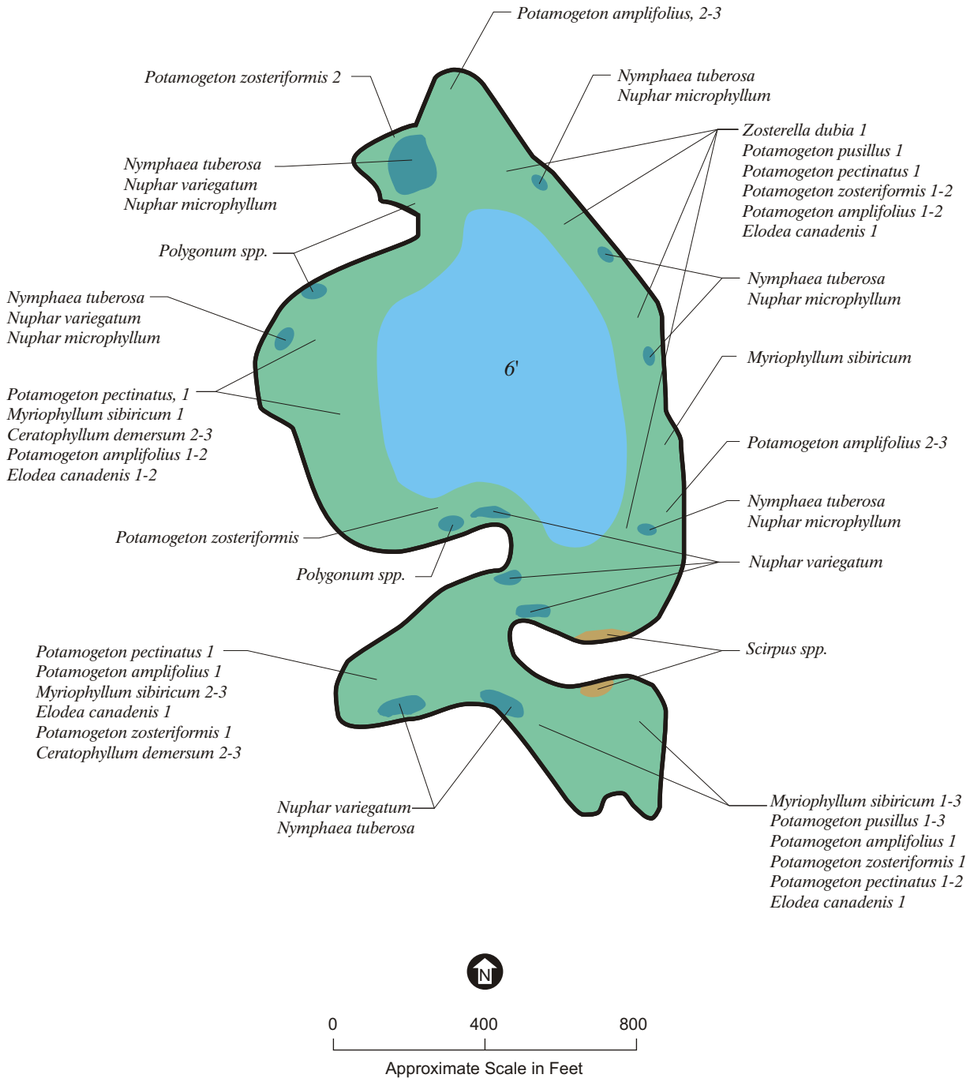
Figure 5.3-5

ECHO LAKE WATER LEVELS
2015 - 2025 Watershed Management Plan
Valley Branch Watershed District

Appendix A-5.3 Additional Macrophyte Information

- No Macrophytes Found in Water > 3.0' - 4.0'
- Macrophyte Densities Estimated as Follows: 1 = light; 2 = moderate; 3 = heavy

		Common Name	Scientific Name
Submerged Aquatic Plants:		Large-leaf pondweed	*Potamogeton amplifolius*
		Sago pondweed	*Potamogeton pectinatus*
		Pondweed	*Potamogeton pusillus*
		Flatstem pondweed	*Potamogeton zosteriformis*
		Water stargrass	*Zosterella dubia*
		Elodea	*Elodea canadenis*
		Northern milfoil	*Myriophyllum sibiricum*
		Coontail	*Ceratophyllum demersum*
Floating Leaf:		White water lily	*Nymphaea tuberosa*
		Yellow water lily	*Nuphar variegatum*
		Little yellow water lily	*Nuphar microphyllum*
		Water smartweed	*Polygonum spp.*
Emergent:		Bulrush	*Scirpus spp.*
No Aquatic Vegetation Found:			

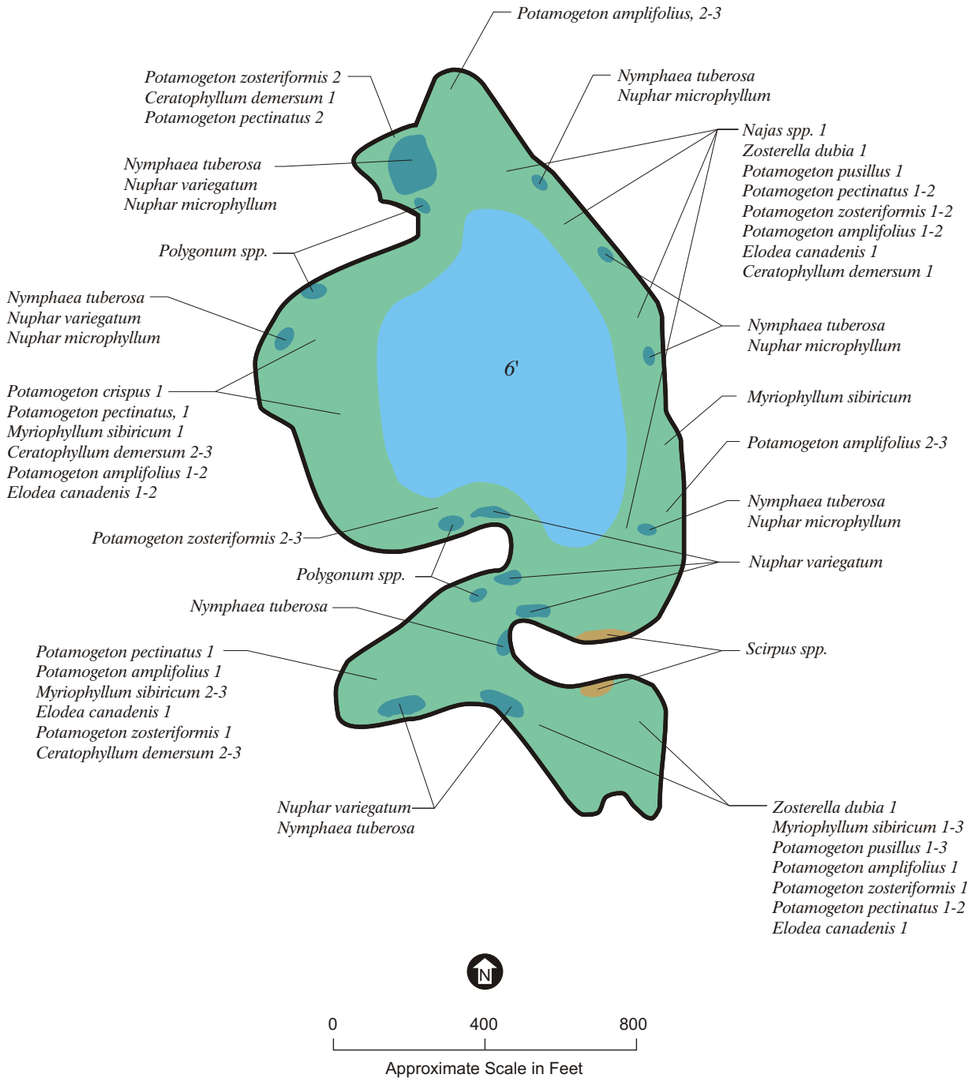


ECHO LAKE
MACROPHYTE SURVEY
JUNE 21, 1996

P:23\82\207\LakeMacrophyteMaps\EchoLake\1996\JUNE1996.CDR RLG 03-25-04

- No Macrophytes Found in Water > 3.0' - 4.0'
- Macrophyte Densities Estimated as Follows: 1 = light; 2 = moderate; 3 = heavy

	Common Name	Scientific Name
Submerged Aquatic Plants:	Curlyleaf pondweed	*Potamogeton crispus*
	Largeleaf pondweed	*Potamogeton amplifolius*
	Sago pondweed	*Potamogeton pectinatus*
	Pondweed	*Potamogeton pusillus*
	Flatstem pondweed	*Potamogeton zosteriformis*
	Water stargrass	*Zosterella dubia*
	Elodea	*Elodea canadenis*
	Northern water milfoil	*Myriophyllum sibiricum*
	Coontail	*Ceratophyllum demersum*
	Bushy pondweed and naiad	*Najas spp.*
Floating Leaf:	White water lily	*Nymphaea tuberosa*
	Yellow water lily	*Nuphar variegatum*
	Little yellow water lily	*Nuphar microphyllum*
	Water smartweed	*Polygonum spp.*
Emergent:	Bulrush	*Scirpus spp.*
No Aquatic Vegetation Found:		

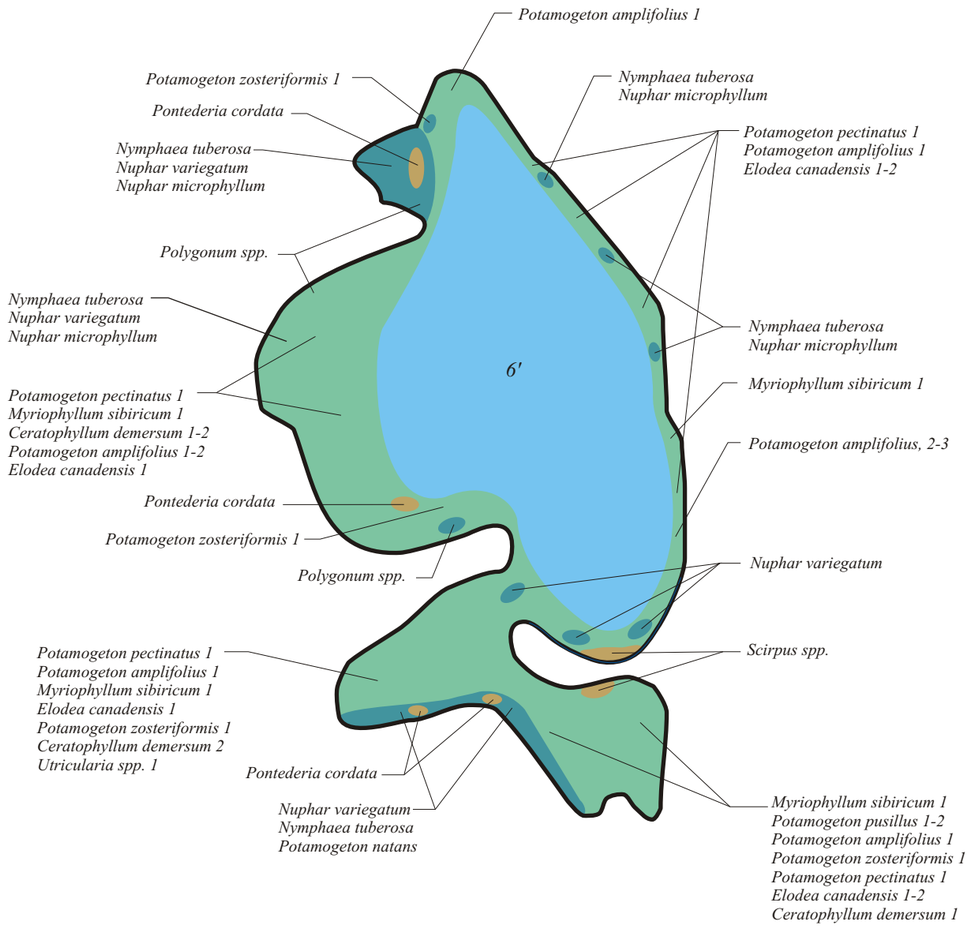


ECHO LAKE
MACROPHYTE SURVEY
AUGUST 21, 1996

P:23\82\207\LakeMacrophyteMaps\EchoLake\1996\AUGUST1996.CDR RLG 03-25-04

- No Macrophytes Found in Water > 3.0' - 4.0'
- Macrophyte Densities Estimated as Follows: 1 = light; 2 = moderate; 3 = heavy

		Common Name	Scientific Name
Submerged Aquatic Plants:		Large-leaf pondweed	*Potamogeton amplifolius*
		Sago pondweed	*Potamogeton pectinatus*
		Pondweed	*Potamogeton pusillus*
		Flatstem pondweed	*Potamogeton zosteriformis*
		Elodea	*Elodea canadensis*
		Northern water milfoil	*Myriophyllum sibiricum*
		Coontail	*Ceratophyllum demersum*
		Bladderwort	*Utricularia spp.*
		Floating leaf pondweed	*Potamogeton natans*
Floating Leaf:		White water lily	*Nymphaea tuberosa*
		Yellow water lily	*Nuphar variegatum*
		Little yellow water lily	*Nuphar microphyllum*
		Water smartweed	*Polygonum spp.*
Emergent:		Bulrush	*Scirpus spp.*
		Pickerelweed	*Pontederia cordata*
No Aquatic Vegetation Found:			

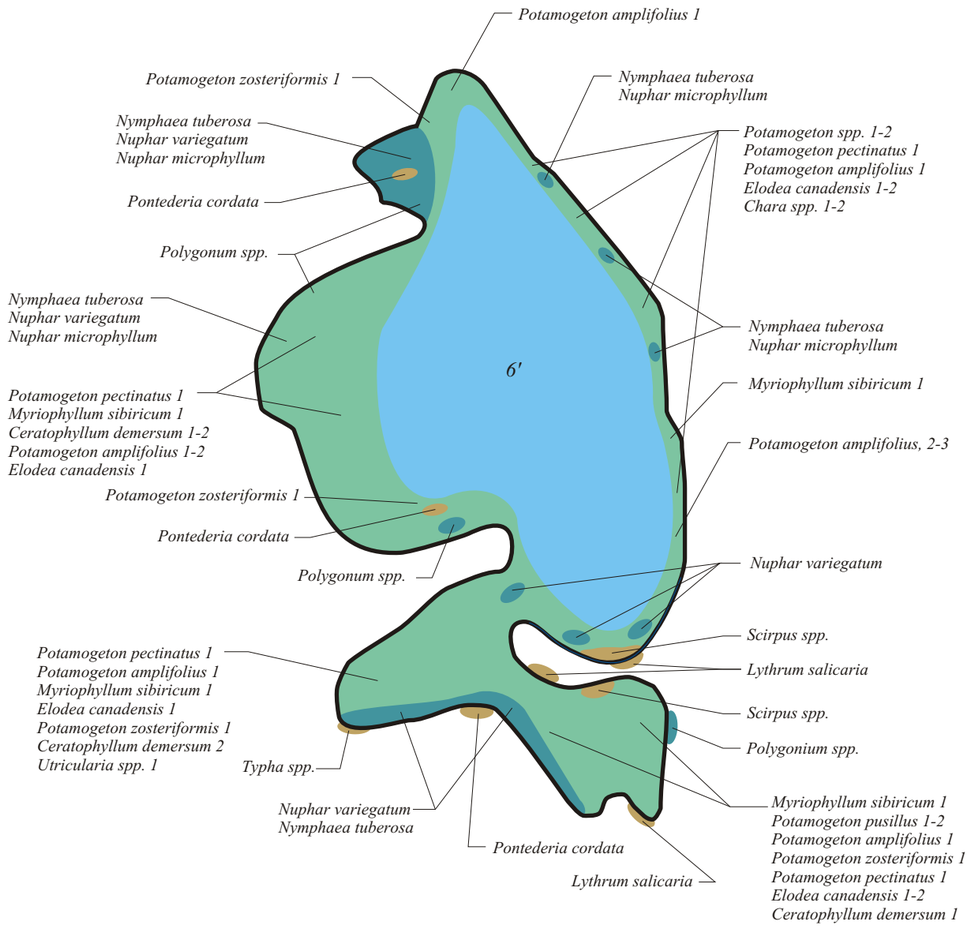


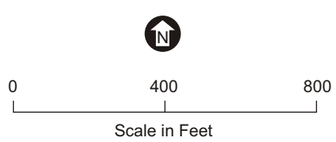
ECHO LAKE
MACROPHYTE SURVEY
JUNE 13, 2002

P:\2382207\LakeMacrophyteMaps\EchoLake\2002\JUNE2002.CDR RLG 03-25-04

- No Macrophytes Found in Water > 3.0' - 4.0'
- Macrophyte Densities Estimated as Follows: 1 = light; 2 = moderate; 3 = heavy

		Common Name	Scientific Name
Submerged Aquatic Plants:		Leafy narrowleaf pondweed	*Potamogeton spp.*
		Large-leaf pondweed	*Potamogeton amplifolius*
		Sago pondweed	*Potamogeton pectinatus*
		Pondweed	*Potamogeton pusillus*
		Flatstem pondweed	*Potamogeton zosteriformis*
		Elodea	*Elodea canadensis*
		Northern water milfoil	*Myriophyllum sibiricum*
		Coontail	*Ceratophyllum demersum*
		Bladderwort	*Utricularia spp.*
		Floating leaf pondweed	*Potamogeton natans*
		Muskgrass	*Chara spp.*
Floating Leaf:		White water lily	*Nymphaea tuberosa*
		Yellow water lily	*Nuphar variegatum*
		Little yellow water lily	*Nuphar microphyllum*
		Water smartweed	*Polygonum spp.*
Emergent:		Bulrush	*Scirpus spp.*
		Pickerelweed	*Pontederia cordata*
		Purple loosestrife	*Lythrum salicaria*
No Aquatic Vegetation Found:			



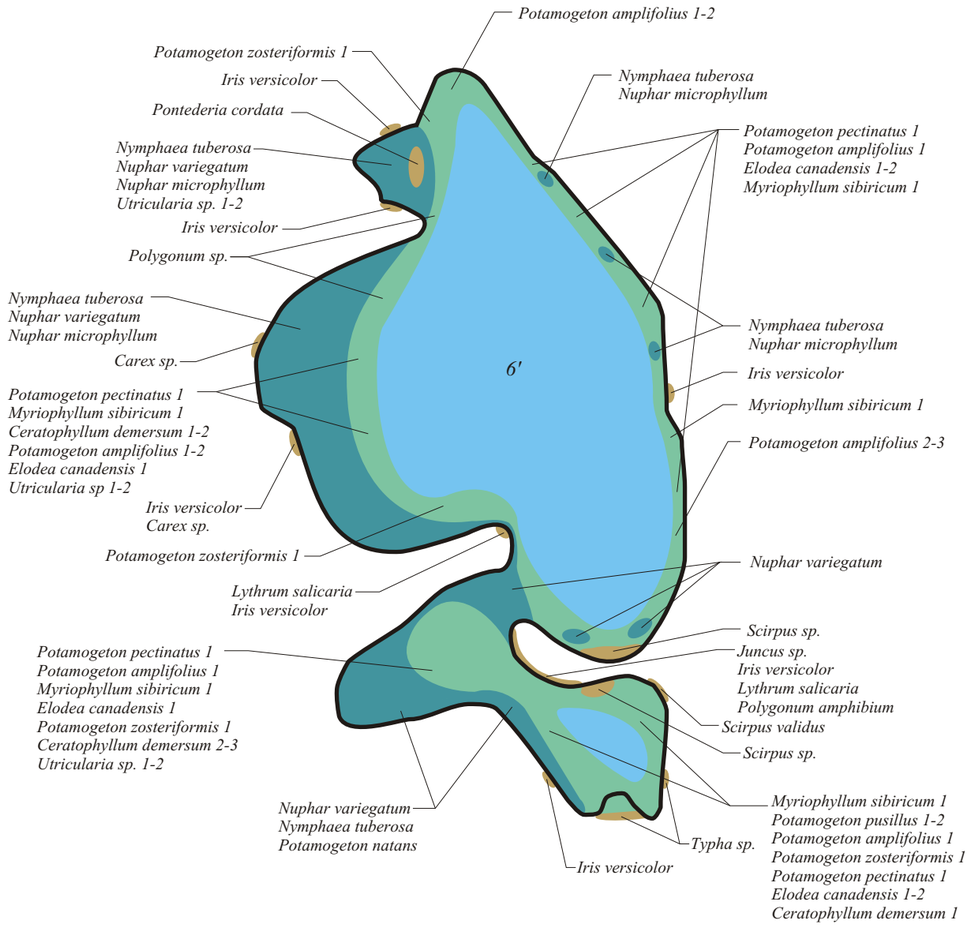


ECHO LAKE
MACROPHYTE SURVEY
AUGUST 22, 2002

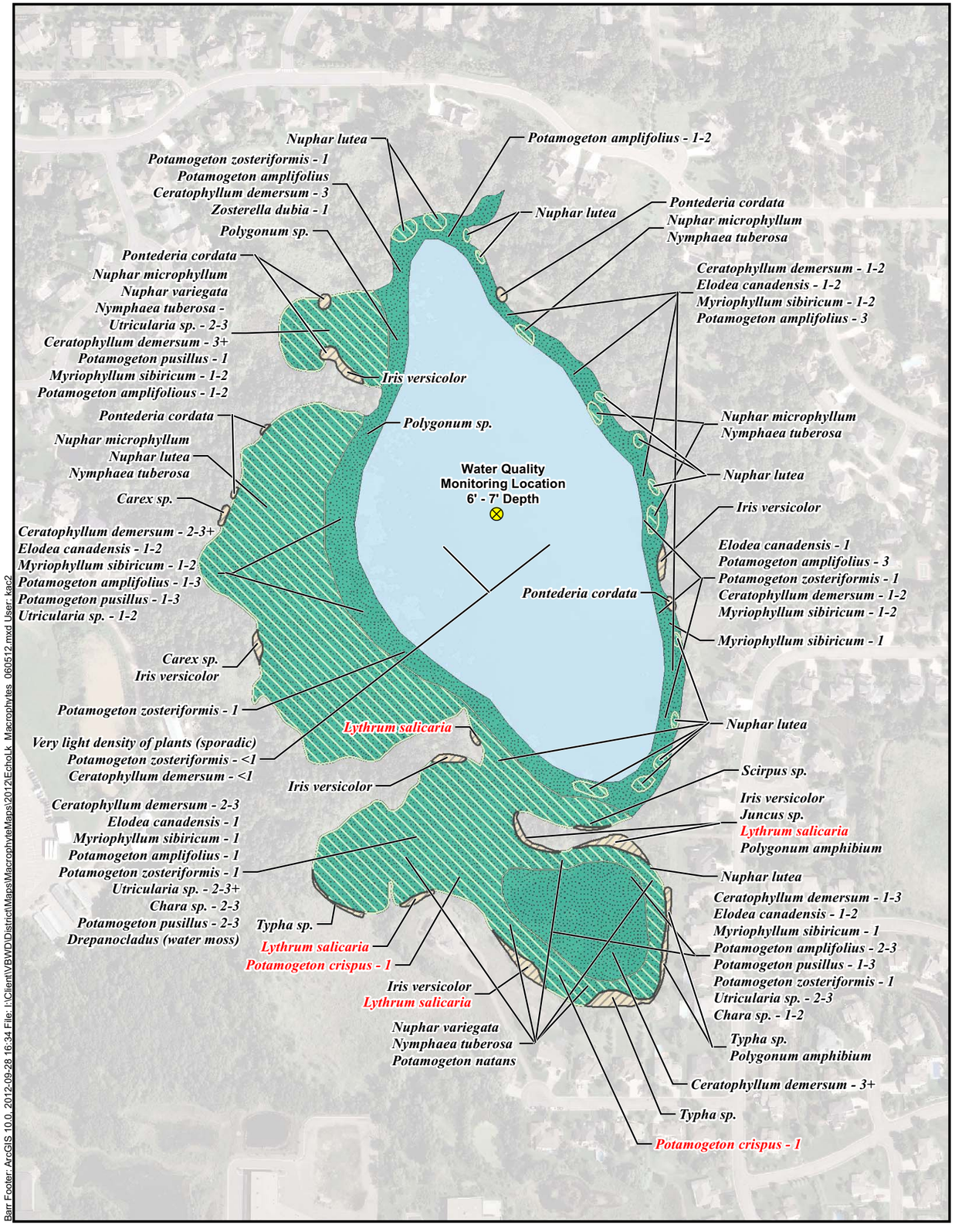
P:\2382207\LakeMacrophyteMaps\EchoLake\2002\AUGUST2002.CDR RLG 03-25-04

- No Macrophytes Found in Water > 3.0' - 4.0'
- Macrophyte Densities Estimated as Follows: 1 = light; 2 = moderate; 3 = heavy

		Common Name	Scientific Name
Submerged Aquatic Plants:		Large-leaf pondweed	*Potamogeton amplifolius*
		Sago pondweed	*Potamogeton pectinatus*
		Pondweed	*Potamogeton pusillus*
		Flatstem pondweed	*Potamogeton zosteriformis*
		Elodea	*Elodea canadensis*
		Northern water milfoil	*Myriophyllum sibiricum*
		Coontail	*Ceratophyllum demersum*
		Bladderwort	*Utricularia sp.*
		Water smartweed	*Polygonum sp.*
Floating Leaf:		White water lily	*Nymphaea tuberosa*
		Yellow water lily	*Nuphar variegatum*
		Little yellow water lily	*Nuphar microphyllum*
		Floating leaf pondweed	*Potamogeton natans*
Emergent:		Purple loosestrife	*Lythrum salicaria*
		Bulrush	*Scirpus sp.*
		Pickerelweed	*Pontederia cordata*
		Northern blue flag	*Iris versicolor*
		Common rush	*Juncus sp.*
		Sedge	*Carex sp.*
		Water smartweed	*Polygonum sp.*
No Aquatic Vegetation Found:			



ECHO LAKE
MACROPHYTE SURVEY
JUNE 5, 2006



Barr Footer: ArcGIS 10.0, 2012-09-28 16:34 File: I:\Client\VBWD\District\Maps\MacrophyteMaps\2012\EchoLk_Macrophytes_060512.mxd User: kac2

Submerged Aquatic Plants

Common Name	Scientific Name
Bladderwort	*Utricularia sp.*
Canada waterweed	*Elodea canadensis*
Coontail	*Ceratophyllum demersum*
Curlyleaf pondweed	***Potamogeton crispus***
Flatstem pondweed	*Potamogeton zosteriformis*
Floating leaf pondweed	*Potamogeton natans*
Largeleaf pondweed	*Potamogeton amplifolius*
Muskgrass	*Chara sp.*
Northern watermilfoil	*Myriophyllum sibiricum*
Pondweed	*Potamogeton pusillus*
Sago pondweed	*Stuckenia pectinatus*
Smartweed	*Polygonum sp.*
Water moss	*Drepanocladus (observed in sw corner of lake)*
Water stargrass	*Zosterella dubia*

Floating Leaf Plants

Common Name	Scientific Name
White waterlily	*Nymphaea odorata*
Yellow waterlily	*Nuphar lutea*

Emergent Plants

Common Name	Scientific Name
Bulrush	*Scirpus sp.*
Cattail	*Typha sp.*
Common rush	*Juncus sp.*
Northern blue flag	*Iris versicolor*
Pickerelweed	*Pontederia cordata*
Purple loosestrife	***Lythrum salicaria***
Sedge	*Carex sp.*
Water shortweed	*Polygonum amphibium*

*Note: Bold red name indicates extremely aggressive/invasive introduced species.

FIELD NOTES:
- Macrophyte densities estimated as follows: 1=light; 2=moderate; 3=heavy
- No macrophytes found in water >4.0' - 5.0'
- Low water levels
- Potamogeton amplifolius - 2-3 along entire perimeter
- Lythrum salicaria - sporadic along entire perimeter
- High water level

Emergent Plants
Floating Leaf Plants
Submerged Aquatic Plants
No Aquatic Vegetation
Water Quality Monitoring Location

N

0 300 600
Feet

0 100 200
Meters

Imagery Source: 2009 AE

BARR

ECHO LAKE MACROPHYTE SURVEY RESULTS
June 5, 2012
Valley Branch Watershed District

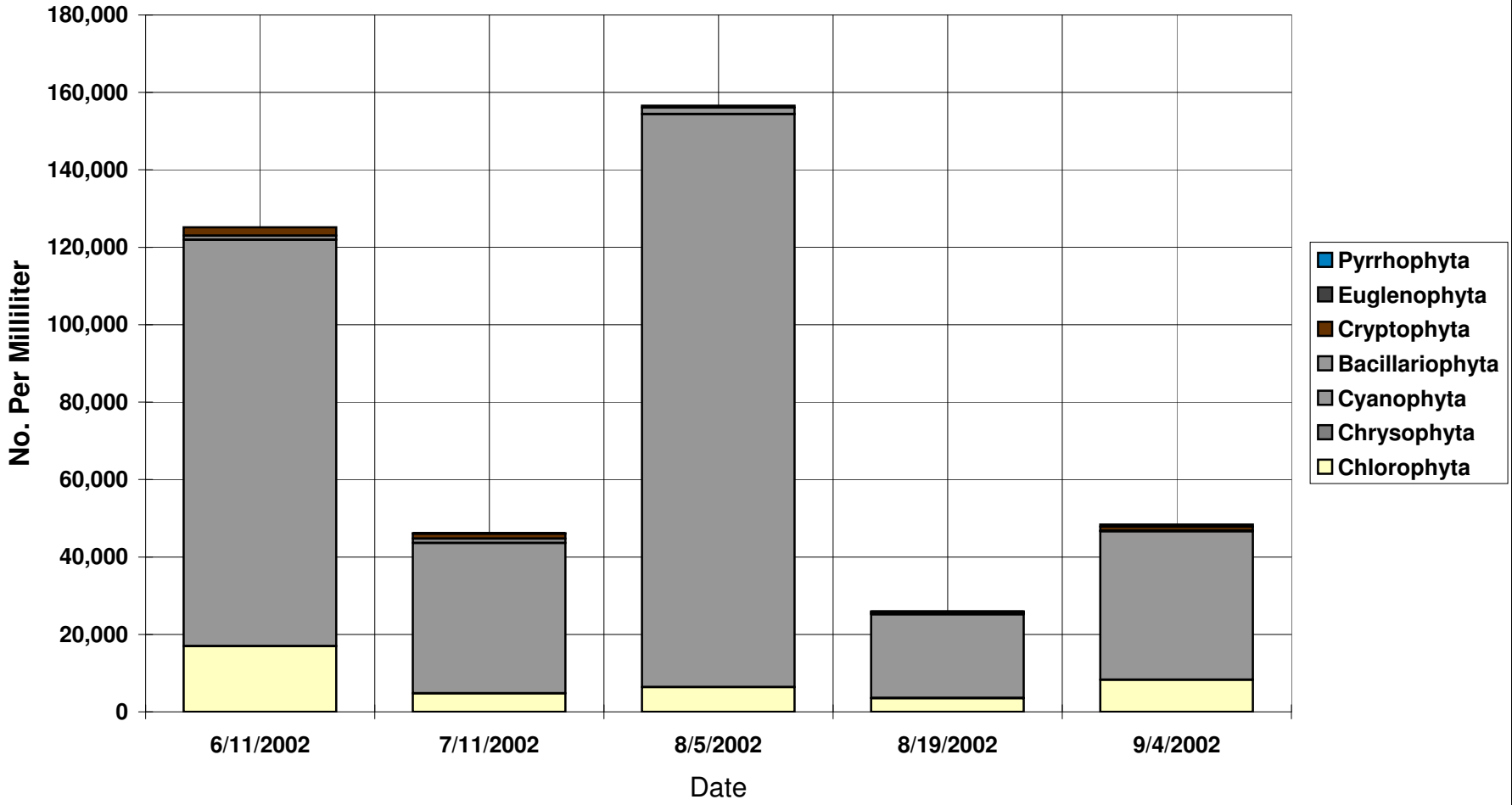
Appendix B-5.3 Additional Phytoplankton Information

ECHO LAKE

SAMPLE: 0-2 METERS
STANDARD PHYTOPLANKTON CLUMP COUNT

DIVISION	TAXON	6/11/2002 units/mL	7/11/2002 units/mL	8/5/2002 units/mL	8/19/2002 units/mL	9/4/2002 units/mL
CHLOROPHYTA (GREEN ALGAE)	*Ankistrodesmus falcatus*	1,579	317	3,079	553	1,800
	Chlamydomonas globosa	13,026	2,728	1,184	1,310	1,800
	Closterium sp.	0	0	0	0	95
	Coelastrum microporum	0	0	474	0	189
	Cricigenia quadrata	0	0	237	29	0
	Kirchneriella sp.	0	0	0	58	0
	Oocystis parva	0	0	0	58	0
	Pediastrum duplex	0	0	0	0	189
	Schroederia Judayi	0	0	0	29	0
	Scenedesmus dimorphus	0	0	237	116	379
	Scenedesmus quadricauda	197	508	474	233	95
	Scenedesmus sp.	0	317	0	58	568
	Selenastrum minutum	1,776	254	0	612	0
	Selenastrum sp..	0	63	0	0	1,232
	Sphaerocystis Schroeteri (Colony)	197	0	0	0	0
	Staurastrum sp.	0	0	0	58	95
	Tetraedron minimum	0	190	711	0	1,232
	Tetraedron sp.	197	190	0	349	474
	Treubaria setigerum	0	0	0	29	0
	Unidentified Green	0	190	0	29	95
	CHLOROPHYTA TOTAL	**16,974**	**4,758**	**6,395**	**3,524**	**8,242**
CHRYSOPHYTA (YELLOW-BROWN ALGAE)	*Dinobryon sociale*	0	0	0	87	0
	CHRYSOPHYTA TOTAL	**0**	**0**	**0**	**87**	**0**
CYANOPHYTA (BLUE-GREEN ALGAE)	*Anabaena affinis*	0	0	0	29	0
	Anabaena flos-aquae	0	0	0	0	95
	Anabaenopsis raciborski	197	634	12,316	6,901	1,232
	Aphanizomenon flos-aquae	4,145	444	1,421	874	0
	Coelosphaerium Naegelianum	0	254	0	0	0
	Merismopedia tenuissima	395	1,205	1,895	262	1,232
	Merismopedia sp.	0	0	0	0	95
	Microcystis aeruginosa	0	698	1,184	1,572	2,653
	Microcystis incerta	0	381	947	670	3,221
	Oscillatoria limnetica	100,263	35,146	130,263	11,269	29,842
	Oscillatoria Agardhii	0	127	0	0	0
	CYANOPHYTA TOTAL	**105,000**	**38,889**	**148,026**	**21,578**	**38,368**
BACILLARIOPHYTA (DIATOMS)	*Melosira granulata*	592	63	0	29	95
	Navicula sp.	0	0	0	0	95
	Stephanodiscus Hantzschii	395	0	0	0	0
	Synedra ulna	0	1,015	1,658	204	0
	BACILLARIOPHYTA TOTAL	**987**	**1,078**	**1,658**	**233**	**189**
CRYPTOPHYTA (CRYPTOMONADS)	*Cryptomonas erosa*	2,171	1,269	474	408	1,042
	CRYPTOPHYTA TOTAL	**2,171**	**1,269**	**474**	**408**	**1,042**
EUGLENOPHYTA (EUGLENOIDS)	*Euglena sp.*	0	0	237	204	95
	Phacus sp.	0	127	0	0	568
	Trachelomonas sp.	0	0	0	0	95
	EUGLENOPHYTA TOTAL	**0**	**127**	**0**	**0**	**568**
PYRRHOPHYTA (DINOFLAGELLATES)	*Peridinium cinctum*	0	0	0	116	0
	PYRRHOPHYTA TOTAL	**0**	**0**	**0**	**116**	**0**
	TOTALS	**125,132**	**46,121**	**156,553**	**25,946**	**48,411**

2002 Echo Lake
Phytoplankton Data Summary



Appendix C-5.3 Additional Zooplankton Information

ECHO LAKE

SAMPLE: BOTTOM TO SURFACE TOW
ZOOPLANKTON ANALYSIS

		6/11/2002	7/11/2002	8/5/2002	8/19/2002	9/4/2002
	Vertical Tow (m)					
DIVISION	**TAXON**	**#/m2**	**#/m2**	**#/m2**	**#/m2**	**#/m2**
CLADOCERA	*Daphnia galeata mendotae*	0	9,284	10,080	0	0
	Diaphanosoma leuchtenbergianum	0	0	0	20,336	0
	CLADOCERA TOTAL	**0**	**9,284**	**10,080**	**20,336**	**0**
COPEPODA	*Cyclops sp.*	15,518	167,113	70,559	30,505	9,284
	Diaptomus sp.	0	0	0	0	9,284
	Nauplii	36,208	222,817	352,793	254,206	46,420
	COPEPODA TOTAL	**51,725**	**389,930**	**423,352**	**284,711**	**64,988**
ROTIFERA	*Asplanchna priodonta*	15,518	0	10,080	50,841	37,136
	Brachionus havanaensis	5,173	74,272	0	30,505	18,568
	Filinia longiseta	0	46,420	967,662	376,225	0
	Lecane sp.	1,256,926	27,852	0	111,851	64,988
	Keratella cochlearis	320,697	185,681	917,263	1,301,534	3,240,129
	Kellicottia sp.	25,863	18,568	0	10,168	0
	Polyarthra vulgaris	1,205,201	139,261	1,522,052	0	129,977
	Trichocerca cylindrica	0	18,568	201,596	193,196	18,568
	Trichocerca multicrinis	0	0	0	50,841	9,284
	ROTIFERA TOTAL	**2,829,377**	**510,622**	**3,618,653**	**2,125,161**	**3,518,651**
	TOTALS	**2,881,102**	**909,836**	**4,052,085**	**2,430,208**	**3,583,639**

2002 Echo Lake
Zooplankton Data Summary