

mechanical harvesting, and Grass Carp (*Ctenopharyngodon idella* Val.), with some biological controls currently being researched. However, use of the Grass Carp in Michigan is currently not permitted by the Michigan Department of Natural Resources (MDNR).

Water Chestnut (*Trapa natans*) is a non-native, annual, submersed, rooted aquatic plant that was introduced into the United States in the 1870's, yet may be found primarily in the northeastern states. The stems of this aquatic plant can reach lengths of 12-15 feet, while the floating leaves form a rosette on the lake surface. Seeds are produced in July and are extremely thick and hardy and may last for up to 12 years in the lake sediment. If stepped on, the seed pods may even cause deep puncture wounds to those who recreate on the lake. Methods of control involve the use of mechanical removal and chemical herbicides. Biological controls are not yet available for the control of this aquatic plant.

5.0 KEY FINDINGS AND OVERALL ASSESSMENT OF BEAR LAKE

5.1 Key Watershed Findings

The watershed around Bear Lake is vulnerable to nutrient loads from surrounding agricultural lands and residential development around the lake shoreline. The highly developed shoreline around Bear Lake emphasizes the need for riparians to follow sound land use management practices to protect the water quality of the lake. The abundant forested land and wetlands will help to reduce nutrients and should be preserved. Furthermore, the low density of commercial or industrial development also decreases potential pollutants to the lake from point-source locations. Land use activities around Bear Lake may also affect the water quality of Little Bear Creek and eventually Bear Creek since the water from Bear Lake exits there.

5.1.1 Bear Lake Soils and Land Use Implications

A few shoreline areas around Bear Lake contain soils that may compromise the water quality of Bear Lake. The Pipestone (Southeast shore of lake and Northeast bay) sands are prone to ponding, are poorly drained, and may experience saturation during periods of increased precipitation. Such increased saturation may cause bacteria (from waterfowl feces) or nutrients (from lawn fertilizers) to directly enter into the lake. The other soils around Bear Lake are well-drained and are not susceptible to ponding or flooding; however they are likely to be affected by mobility of nitrogen through septic drainfields since that nutrient is often the most mobile in groundwater plumes.

5.2 Key Lake and Water Quality Findings

The overall quality of the Bear Lake aquatic ecosystem is currently healthy, yet remains susceptible to land use activities and external nutrient sources. The single largest problem that threatens the ecological stability of Bear Lake is the overabundance of *M. spicatum* that is currently displacing favorable native aquatic plant species and could alter the balance of the Bear Lake ecosystem if not properly managed. Below are the overall key findings from this Feasibility Study that ultimately lead to suggestions for successful management and protection of Bear Lake.

5.2.1 Bear Lake Water Chemistry

Based on all of the water chemistry parameters, Bear Lake may be classified as meso-eutrophic. Meso-eutrophic lakes with abundant residential development and nutrient inputs are vulnerable to becoming eutrophic systems if the nutrient loads are not decreased over time. The total phosphorus concentrations around the lake are highly variable both spatially and temporally. This is indicative of a highly dynamic ecosystem that may rapidly respond to areas of concentrated nutrient inputs. Both the total phosphorus and total Kjeldahl nitrogen concentrations near the bottom of the lake deep basin indicate that the deep basin functions as a “sink” for nutrients. Thus, this concentration is likely to

increase as nutrient inputs to the lake from the surrounding watershed continue. Bear Lake contains significantly more nitrogen than phosphorus and may be classified as being phosphorus-limited. This means that extra inputs of phosphorus to the lake are likely to exacerbate the growth of photosynthetic biota (i.e. aquatic plants and algae), since that is the nutrient most critical for photosynthetic growth. Furthermore, the high water clarity and low conductivity and turbidity of the lake indicate that erosion and sedimentation inputs are not currently problematic, yet the preservation of riparian vegetation and shoreline emergent vegetation is encouraged to keep the land materials (i.e. sands and other soils) from entering the lake and compromising water clarity and depth. The high Secchi transparency allows a great amount of light to reach most of the Bear Lake bottom and could increase the depths at which aquatic plants can colonize. Historically, Secchi transparency readings are highly variable due to the frequent wind activity and associated wave action that may re-suspend lake bottom particles that scatter light and may reduce transparency readings. The dissolved oxygen content of the lake is high in all areas and is critical to sustaining a healthy fishery.

5.2.2 Bear Lake Aquatic Biota

The biota of Bear Lake include the living components such as algae, aquatic plants, fish, macroinvertebrates, snails and shelled organisms, and mammals. There are currently four threatened or species of special concern located within the Manistee River Watershed (MNFI data, 2007), including the Red-shouldered Hawk (*Buteo lineatus*), Wood Turtle (*Glyptemys insculpta*), Bald Eagle (*Haliaeetus leucocephalus*), and the Lake Huron Locust (*Trimerotropis huroniana*). Some of these higher organisms may visit Bear Lake and thus forested and wetland habitat should be preserved.

The Bear Lake fishery is highly diverse with some fish species that are sensitive to pollution such as the Lake Sturgeon (*Acipenser fulvescens*) and Walleye (*Sander vitreus vitreus*). The presence of these species indicates that the water quality of Bear Lake is currently good with plentiful dissolved oxygen and adequate food sources. Every effort should be taken to preserve submerged structures

for fish habitat, and fish spawning habitats such as the floating-leaved and emergent aquatic plant communities located in the West and East Bays.

Native submersed aquatic plants (i.e. Pondweeds, Naiad, and Water Marigold) within Bear Lake are plentiful in select areas (i.e. the West and East Bays) and in depths of between 5-12 feet; however, these communities are currently stressed by the invasion of *M. spicatum* which threatens to displace them. Furthermore, the presence of *M. spicatum* at depths of between 18-21 feet indicates the ability of this plant to colonize a vast majority of Bear Lake. Floating-leaved aquatic plants are rare in the open water areas of Bear Lake due to the high wave energy and inability to successfully root under those environmental conditions. Emergent aquatic plants are also sparse around Bear Lake and are critical habitats for insects and other lake biota. Additionally, they function as erosion guards by stabilizing beach sands that may wash into the lake. A few individual Purple Loosestrife (*Lythrum salicaria*) plants were found during the study and should be removed immediately to avoid further colonization which could out-compete favorable native emergent aquatic plants. The current algal population is well-balanced, yet continuous monitoring of the relative abundance and diversity of the blue-green algal communities is recommended since many of these species can produce microtoxins and are indicative of nutrient loading issues.

6.0 PROJECT RECOMMENDATIONS AND FINANCING

It is highly recommended that the Bear Lake Improvement Board and the residents around Bear Lake adopt the lake water quality and aquatic vegetation guidelines suggested in this management plan. To protect the good biodiversity of native aquatic plants within Bear Lake, chemical herbicides should be minimized and reserved for exotic species only. Additionally, an integrated management approach involving the use of aquatic herbicides and weevils is recommended for the management of *M. spicatum* in Bear Lake.