TRUSTED CARE OF LAND & WATER

BIG BEAR AND LITTLE BEAR LAKE MANAGEMENT PLAN 2022-2026

Updated 12-20-2021

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INTRODUCTION

Mission

Big Bear and Little Bear Lakes are managed by the Vernon Hills Park District. The Park District's mission is to "promote diverse community based recreational opportunities by providing a variety of programs, services, facilities and natural spaces to enhance the quality of life for our residents".

Lake Overview and History

Big and Little Bear Lakes are in Vernon Hills, Illinois (Figure 1). The lakes were constructed in the 1970s along the Seavey Drainage Ditch (Figure 2). Seavey Ditch enters at the northern end of Big Bear Lake, which is 25.1 acres in size (Table 1, Figure 3). Big Bear Lake is connected to Little Bear by a short channel. Little Bear Lake is 26.4 acres and water flows out under a bridge to the south (Photos 1 & 2). The lakes serve as stormwater storage and are in a designated floodway.

The Lakes are located within Century Park and are used by the community for various recreational activities such as fishing, and they provide an ecological resource including fish and wildlife habitat.

Over time, the Big and Little Bear Lakes have been impacted by nutrient and sediment pollution. The lakes have seen increases in nuisance invasive aquatic vegetation growth and harmful algal blooms. Regions of the shoreline have also been experiencing erosion. This management plan is designed to evaluate factors impacting water quality in Big and Little Bear Lake, possible management strategies to address concerns, and present a 5-year timeline for implementing management actions to improve the ecological health and recreational and aesthetic value of the lakes.

Parameter	Big Bear	Little Bear
Surface Area (acres)	25.1	26.4
Maximum Depth (feet)	10.0	21.9
Average Depth (feet)	5.0	7.0
Volume (acre-feet)	125.8	186.0
Shoreline Length (linear feet)	5322	8794
Lake Elev. (feet above sea level)	681.4	681.4
Watershed Area (acres)	4277.1	4277.1
Avg. Water Residence Time (days)	10.1	10.1

Table 1. Big Bear Lake and Little Bear Lake morphometric information. **Adapted from *2019 Lake Summary Report, LCHD-ES.***

Figure 1. 2018 Satellite image of Big and Little Bear Lakes.

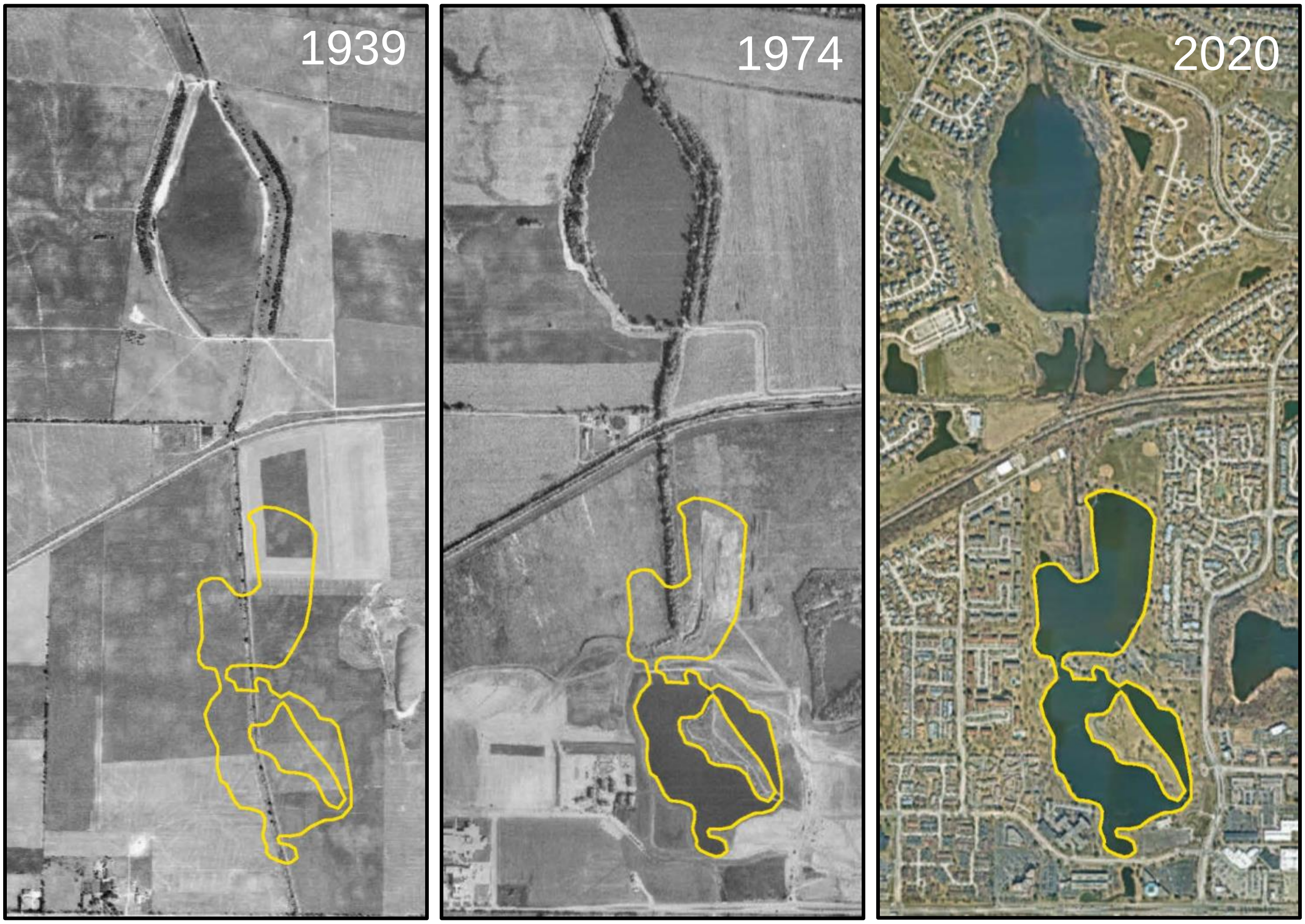

Figure 2. 1939, 1974, and 2020 aerial image of Big and Little Bear Lake, current shoreline outlined. Lake County Maps Online.

Photo 1. Outlet at Little Bear Lake.

Photo 2. Water level gauge at Little Bear Lake.

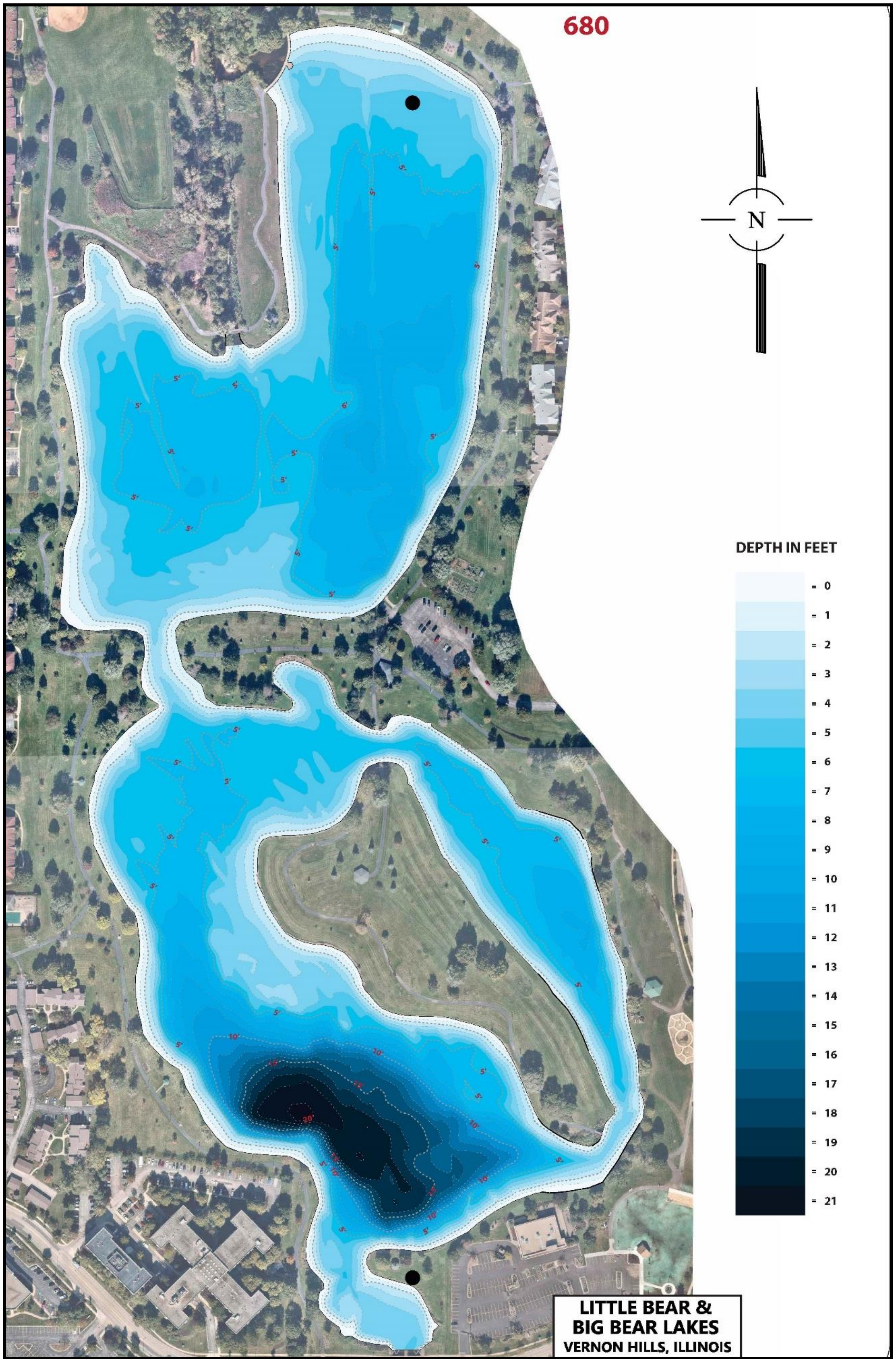

Figure 3. Bathymetric map of Big and Little Bear Lake. LCHD-ES.

CURRENT LAKE CONDITIONS

Big and Little Bear Lakes are periodically assessed by the Lake County Health Department – Environmental Services (LCHD-ES) for various water quality parameters. The last two assessments occurred in 2012 and 2019. This report includes relevant findings from those assessments. Other resource materials referenced in the plan include the Indian Creek Watershed-Based Plan (2009), volunteer lake monitoring data from 2017-2018, and information provided by the Vernon Hills Park District. More detailed explanations of sampling methods and additional results can be found in those reports (Table of reports referenced in this document are listed in Appendix A). ILM staff surveyed the lake in November 2021 to evaluate lake conditions and correlate current conditions with past surveys.

WATERSHED CONDITIONS

Big and Little Bear Lake's watershed is 4277.07 acres, according to the 2019 LCHD-ES Report (Figure 4). The waterway that flows through the lakes is Seavey Ditch. Seavey Ditch is a tributary of Indian Creek, which then flows into the Des Plaines River. The 2019 LCHD-ES report estimated over 60% of stormwater runoff that enters the lakes comes from transportation and single-family homes, with an estimated 4538.5 acre-feet (1,478,875,000 gallons) of runoff flowing through Big and Little Bear Lake each year. Before entering the lakes, the Seavey Ditch first flows through Lake Charles to the north, then through a channel and into Big Bear Lake. Big Bear Lake flows into Little Bear Lake, and then out the south end of the lake. Directly to the east of Little Bear Lake is Harvey Lake. The culvert connecting Harvey Lake to Little Bear Lake is sloped so that when Little Bear is at normal water level, a slow trickle of water flows from Harvey Lake to Little Bear Lake. After a rain event, however, Little Bear Lake increases in water level faster than Harvey Lake, leading to water flowing from Little Bear Lake into Harvey Lake. In this way, Harvey Lake appears to be providing extra stormwater storage for Little Bear Lake.

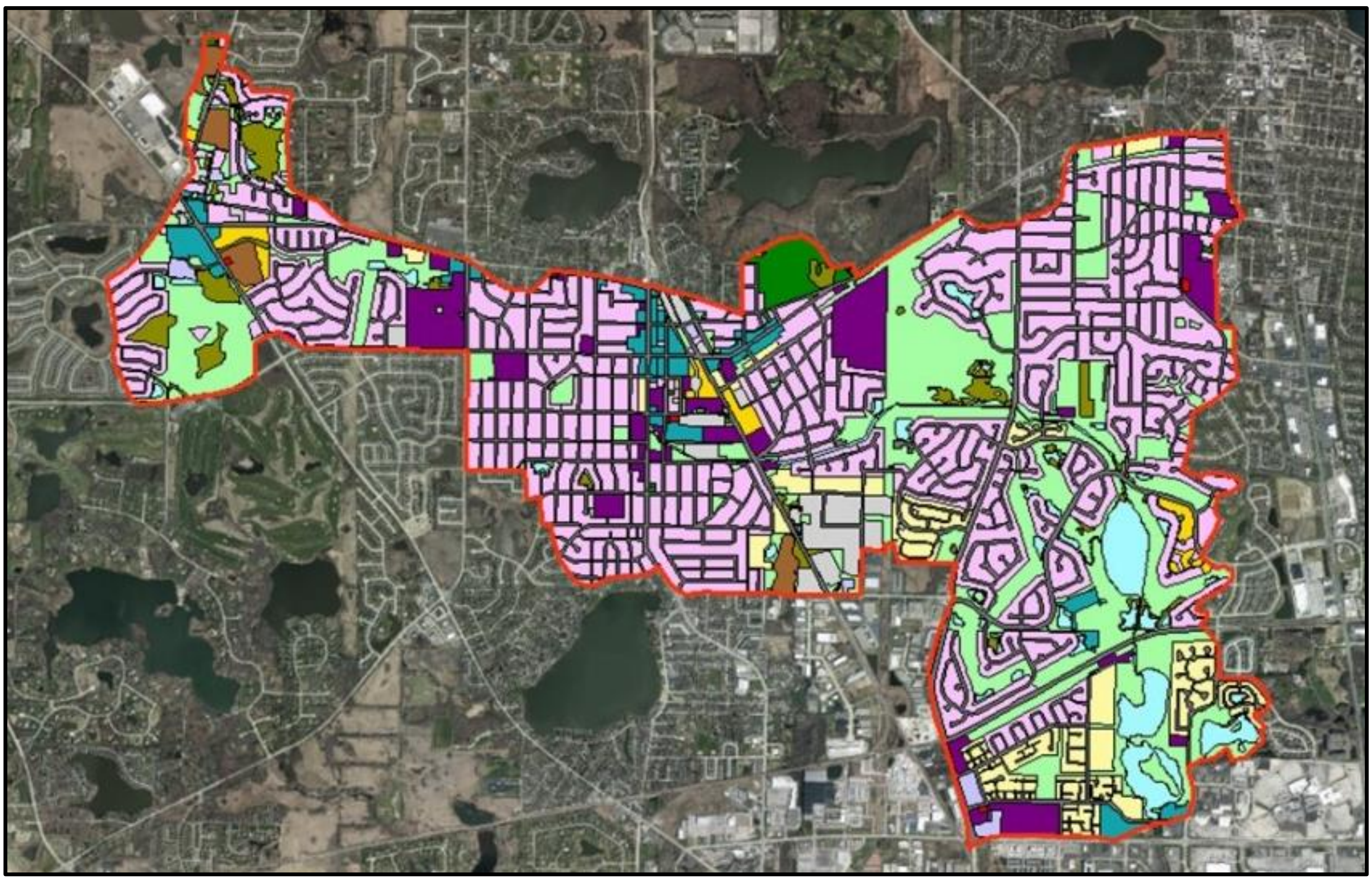

***Figure 4. Big and Little Bear Lake watershed boundary and land use, 2019.* LCHD.**

Nutrients

Phosphorus

Phosphorus is a vital nutrient for regulating plant growth. It comes from various sources, including lawn runoff, erosion, and waste. When excessive concentrations build up in a watershed, phosphorus can lead to nuisance aquatic plant and algae growth and degrade the ecological health of the system. Increases in toxic cyanobacteria blooms have been linked to nutrient pollution, and excess plant growth caused by high nutrient concentrations can lead to a hazardous depletion in dissolved oxygen levels when plants die off and decompose.

LCHD-ES surveys from 1997, 2002, 2012, and 2019 found most tested water samples to have total phosphorous concentrations above the desired maximum of 0.05 mg/l. A 2019 Illinois Environmental Protection Agency (IEPA) survey also found elevated levels of total phosphorous in the lake water. This suggests that excess nutrient pollution in the water is contributing to the increase in nuisance algae and aquatic plant growth.

Nitrogen

Nitrogen is another nutrient that regulates plant growth and can be a pollutant in excess quantities. Agricultural runoff from manure and fertilizer is a common source of nitrogen pollution. The LCDH-ES surveys did not find excessive levels of nitrogen in its various forms (Nitrate/Nitrite, Total Kjeldahl Nitrogen, Organic Nitrogen) in the lakes. The 2019 IEPA survey found ammonia nitrogen levels below the threshold of 15 mg/l.

Trophic State Index

The Trophic State Index (TSI) indicates the productivity of a lake (Figure 5). In general, lower productivity in lakes is desirable for aesthetics, as there is less nuisance aquatic plant and algae growth. More productive "eutrophic" lakes can support more fish, but these fish tend to me more adapted to lower oxygen and lower quality conditions that occur with excessive nutrient buildup. The TSI is calculated by accounting for phosphorus concentrations, chlorophyll concentrations and transparency of the water. A lake with low phosphorus and chlorophyll levels and high water clarity is considered oligotrophic and has a TSI of less than 40. Such lakes tend to have little aquatic plant or algae growth. Lakes with high levels of nutrients and a TSI greater than 50 are considered eutrophic and have high productivity. In 2019, LCHD-ES estimated the TSI for Big Bear Lake to be 61, and 55.7 for Little Bear Lake. This puts both lakes in the eutrophic "high nutrient" range.

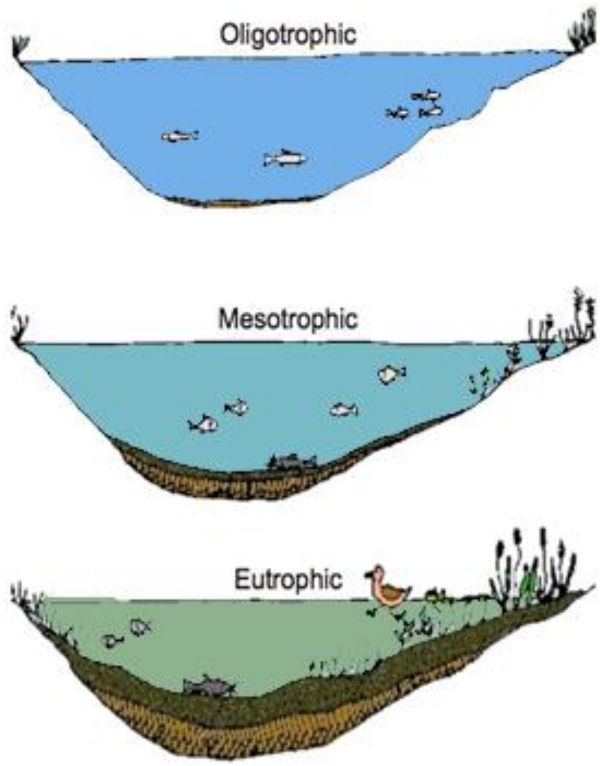

Figure 5. Varying states of lake productivity.

Chlorides

The 2019 LCHD-ES survey found average chloride concentrations in Big and Little Bear Lakes to measure 101 mg/l and 108 mg/l respectively, which is below the recommended limit of 230 mg/l. This suggests that the surrounding communities in the watershed are taking precautions to be responsible with applying road salt. LCHD-ES recommended communities continue with education efforts to minimize the impact of salt accumulation in the waterway.

Total Suspended Solids

Water clarity is an indicator of water quality in a lake. Lakes with low water clarity are considered turbid. Planktonic algae growth as well as suspended sediment can lead to low water clarity. The measure of suspended material in the water is measured as total suspended solids (TSS). Sediment can enter a lake when it erodes upstream and is carried in stormwater. Sediment can also be resuspended in shallow lakes by winds and waves, or bottom-feeding fish such as carp can turn up sediment while they forage. High TSS levels often indicate poor water quality, as high suspended sediment typically means other pollutants are also being carried in the stormwater. Big Bear and Little Bear Lake are on the IEPA Section 303(d) list of impaired waterways for high levels of total suspended solids.

Secchi disk readings are a measure of water clarity. A painted disk is lowered in the water until is it no longer visible, and that depth is recorded as the secchi reading. A reading of over 4.0 feet is recommended for recreational lakes. The average secchi reading in Big Bear Lake in 2019 was 2.6 feet and 4.4 feet in Little Bear Lake. LCHD-ES explained that sediment carried into Big Bear Lake from Seavey Ditch likely settles out before flowing to Little Bear Lake, leading to higher water clarity in Little Bear Lake.

Seavey Ditch Pollution

A 2019 inlet survey conducted by the Des Plaines River Watershed Workgroup Lakes Committee and LCDH-ES found that the Seavey Ditch inlet in Big Bear Lake averaged 10.9 mg/l of TSS. The Parks Department also noted that sediment seems to be accumulating at the north end of Big Bear Lake. Again, this is likely because sediment-laden stormwater entering the lake slows down when it hits the larger body of water, allowing suspended solids to settle to the lakebed. The same survey found that Lake Charles, located upstream of Big Bear Lake, had TSS concentrations of 9.0 mg/l at the outlet. Stormwater retention basins between Big Bear Lake and Lake Charles had TSS concentrations of 10.9 mg/l, indicating some sediment is entering the waterway between these two lakes (Figure 6).

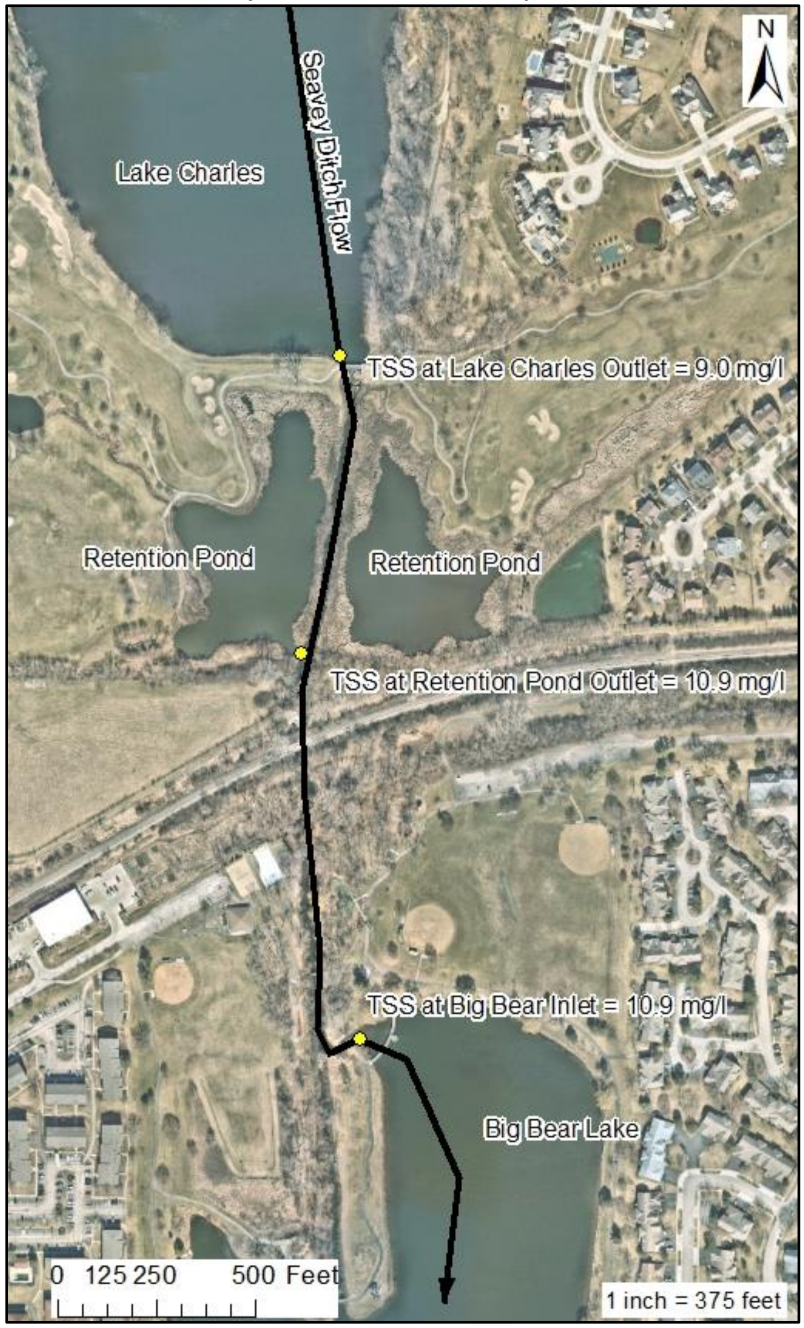

Figure 6. Average total suspended solids at various sample points, 2019. Adapted from LCDH-ES.

Vegetation

Aquatic Plants and Algae

During the LCHD-ES survey in 2019, seven different aquatic plant species were found on the lakes – brittle naiad, coontail, curlyleaf pondweed, duckweed, Eurasian watermilfoil (EWM), sago pondweed, and white water lily (Photos 3-7). Three of these species – brittle naiad, curlyleaf pondweed, and Eurasian watermilfoil – are non-native and invasive. EWM and coontail were the most prevalent species in the lakes, being present at 54% and 70% of sites, respectively (Figure 7). In 2020, four sites were chosen to treat EWM. Chinook, an aquatic herbicide, was applied. The product was effective at reducing the vegetative growth in the treatment areas, but the rest of the lake had high plant density.

When aquatic vegetation reaches the surface, filamentous green algae tends to grow on the topped out plants, furthering aesthetic impairment (Photo 8). Manual plant and algae removal has been used to control plant density on the lakes, but the process is time-intensive, which can make it cost-prohibitive to clear a large area of vegetation. Blue-green algae blooms have also occurred on the lakes. These species are technically a type of cyanobacteria and can sometimes reach high number and create toxins that sicken or kill wildlife. This is known as a harmful algal bloom (HAB). When these blooms occur, pets and people should stay out of the water. LCHD-ES recommended Vernon Hills post signs to help visitors recognize and report HABs.

Blue-green algae can also reduce water clarity, making it difficult for aquatic vegetation to get sunlight. While less vegetation in Big and Little Bear Lakes may be desirable, the tradeoff is that algae blooms tend to then worsen, as more nutrients are available for them instead of being bound up in plant growth.

Photo 3. Coontail, Ceratophyllum demersum.

Photo 4. White water lily, Nymphaea odorata.

Photo 5. Curlyleaf pondweed, Potamogeton crispus.

Photo 6. Eurasian watermilfoil, Myriophyllum spicatum.

Photo 7. Heavy subsurface Eurasian watermilfoil growth in Big Bear Lake.

Photo 8. Algae growing atop aquatic plants.

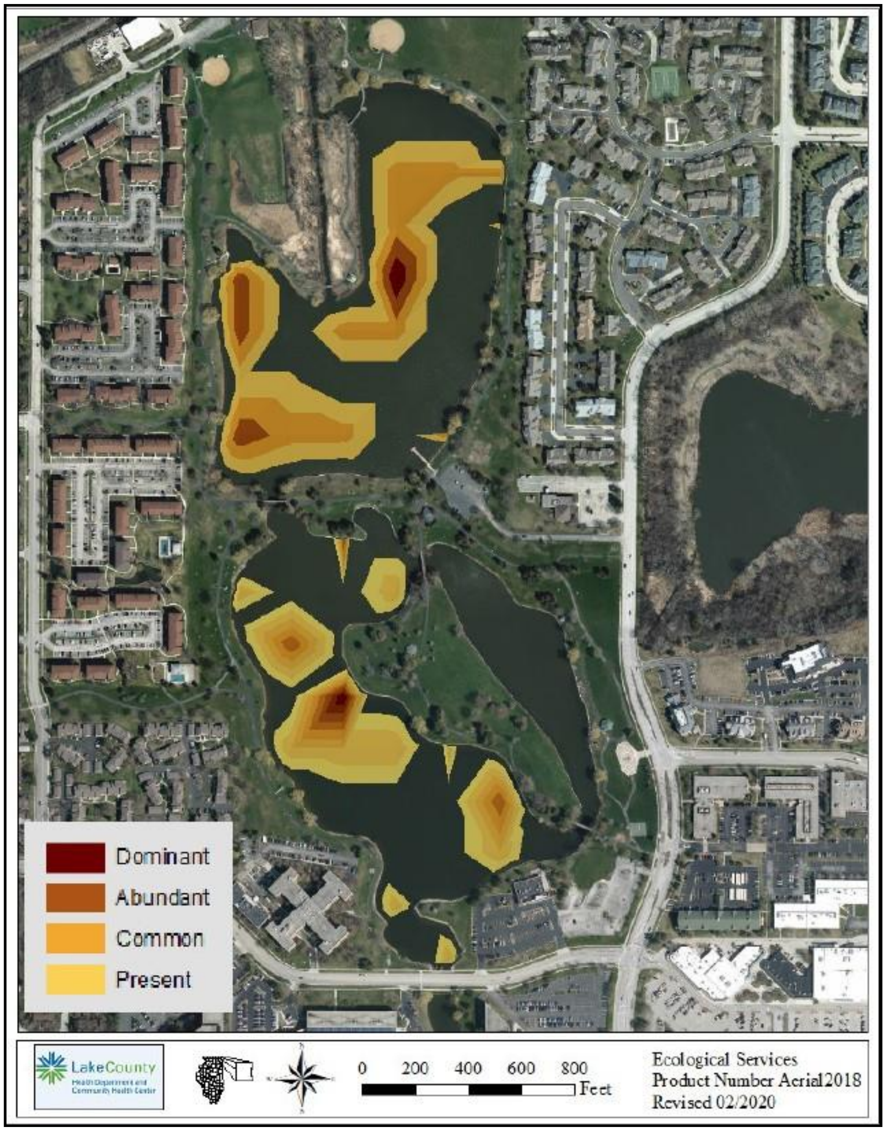

Figure 7. Eurasian watermilfoil distribution and density in Big and Little Bear Lake, 2019. LCHD.

Emergent and Terrestrial Plants

Sporadic emergent vegetation was observed along the Big and Little Bear Lake shoreline during the November 2021 visit. Cattails and *Phragmites* were seen at the south end of Little Bear Lake (Photos 9 & 10). These species are aggressive invasive species and can overtake shorelines and other shallow wetlands, outcompeting more desirable native species. Additionally, the cattails were in front of two inlets, which can impede water flow during rain events. Most of the upland shoreline vegetation consisted of either turfgrass mown to the water's edge (Photo 11) or a narrow unmown vegetative buffer (Photo 12). In certain reaches, the buffer was mainly composed of European buckthorn, an invasive shrub (Photo 13). Other reaches of the shoreline had cut and treated stumps, showing the Park District is managing the buffer to some degree (Photo 14). In 2019, LCHD-ES surveyed the shoreline and estimated 3.4% of the shoreline buffer to be in "Good Condition". The remainder of the shoreline was classified as "Fair" or "Poor" condition. A good buffer should be at least 25 feet wide and composed of native plants.

Photo 9. Cattails around outlet.

Photo 10. Phragmites in buffer.

Photo 11. Turfgrass to edge of shore.

Photo 12. Unmown vegetative buffer.

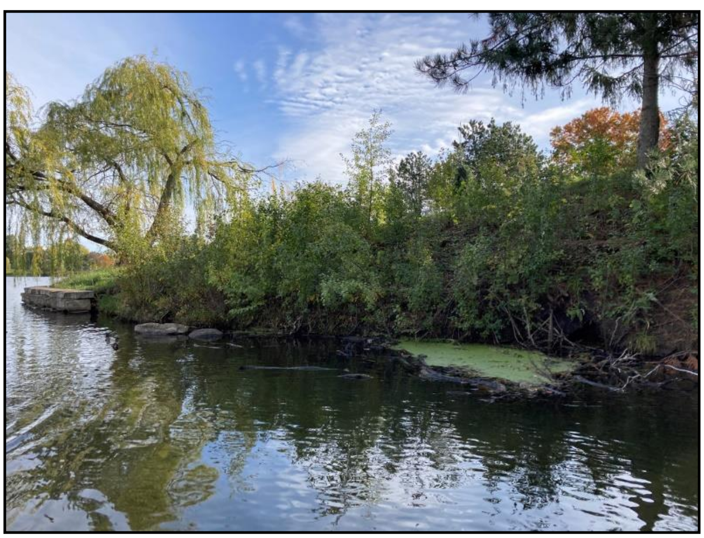

Photo 13. European buckthorn on bank.

Photo 14. Cut and treated shrub in buffer.

Shoreline Erosion

During 2019, the lakeshore was assessed by LCHD-ES. In the assessment, 64% of the shoreline experiencing some form of erosion (Figure 8). The western shore of Little Bear Lake and the island had the highest proportion of erosion. Photos of the shoreline were taken during the 2021 visit to document different examples of shoreline conditions occurring in the lake (Photos 15-24). The photo lettering corresponds with the letters on the map in Figure 8.

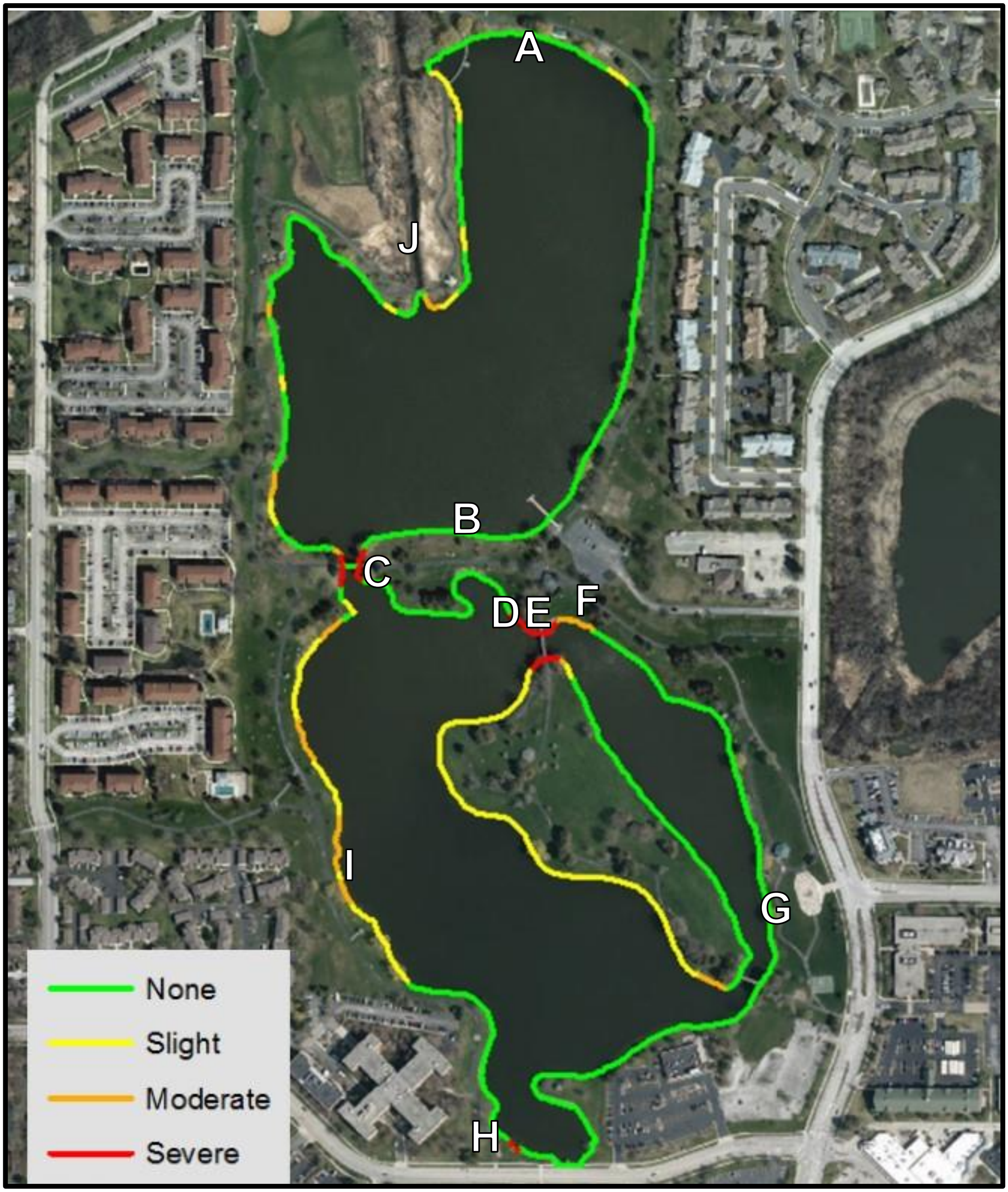

Figure 8. Big and Little Bear Lake shoreline condition, 2019. **Letters correspond with photos on following page.** ***LCHD.***

The eastern edges of both lakes are mainly stabilized with a stone retaining wall, which has reduced erosion along those reaches. Some portions of the shoreline appear to be in good condition (Photo 16) but other portions are beginning to slump into the lake (Photo 21). This often occurs when water scours out sediment at the base of the rocks, compromising their structural integrity. Installation of rock along the shoreline was halted by the U.S. Army Corps of Engineers (USACE) around 2010, as the work was not authorized. The USACE allowed the completed work to remain but did not allow for additional stonework and required additional stabilization to be vegetative or biotechnical practices, which is a combination of structural and vegetative stabilization.

The most severe erosion on the lakes is occurring under and adjacent to two bridges and around culverts (Photos 17, 19, & 22). The bank has collapsed, and mature pine trees have fallen into the lake (Photo 18). The erosion of soil around a bridge foundation is known as scour and is a leading cause of bridge failure. Exposed soil below the bridge connecting the lakes is leading to uncontrolled erosion, while the soil has completely washed away below the bridge connecting the north end of the island in Little Bear Lake to the shore. This has exposed the supports for the structure. A structural engineer surveyed the bridges in 2018 and found them to be structurally sound but said the erosion below the bridges needed to be addressed.

Other reaches of shoreline are experiencing erosion to a moderate degree, with 1-3 feet of exposed soil and undercut banks (Photos 20, 23, & 24). Portions of the bank experiencing slight or no level of erosion typically had gentler slopes and were fully vegetated (Photo 15) or were stabilized by the rock retaining wall.

Photo 15. Shallow bank slope with minimal erosion.

Photo 16. Stable bank behind retaining wall.

Photo 17. Severe erosion under bridge.

Photo 18. Bank failure – trees falling in lake.

Photo 19. Severe erosion under bridge.

Photo 20. Moderate bank erosion.

Photo 21. Rocks slumping into lake.

Photo 22. Erosion around culvert.

Photo 23. Mowed turfgrass and vertical bank.

Photo 24. Undercut bank with exposed roots.

Fisheries

The most recent Illinois Department of Natural Resources (IDNR) fishery survey occurred in 2008. Currently, the lakes are stocked on a more-or-less annual basis (Table 2). Anecdotally, the Park District has received feedback from anglers that the fishing has been great the past few years. Different fishing clubs from northern Illinois have visited to fish on the lake. Anglers have reported catching bluegill, largemouth bass, northern pike, perch, catfish, and walleye. Anglers have mentioned the lakes can be difficult to fish from shore, due to the relatively shallow nearshore water depths and lack of nearshore underwater structure for fish to congregate at. Recently, dead trees were anchored in the lakes along shore to provide more fish habitat in shallow areas and manmade structures were placed in the lakes. The Park District said feedback from most residents has been positive, other than during July and August when aquatic plant density is at its highest. In 2020, fishing could only occur in areas that were treated with herbicide, as locations outside the treatment areas had plant growth that was too dense. The 2008 fish survey found common carp in the lakes. Common carp negatively impact water clarity, as they resuspend sediment and uproot plants while foraging in the lake sediment.

There is a fishing pier and boat launch is in Big Bear Lake. Fishing occurs from shore or watercraft. The lake is catch and release only, although the district has had problems with anglers taking catch. There is a line disposal container by the pier (Photo 25), but discarded fishing line, lures and other fishing gear was seen around the lakes (Photo 26).

		Species										
Year	**Season**	**Bluegill**	**Bluegill-Sunfish Hybrid**	**Channel Catfish**	**Crappie**	**Largemouth Bass**	**Minnows (lbs)**	**Northern Pike**	**Redear Sunfish**	**Smallmouth Bass**	**Walleye**	**Yellow Perch**
2015	Spring		200			130						
2015	Fall							10			200	300
2017	Spring		200	200		100						200
2018	Spring		500	300	200		50					400
2018	Fall					200		20		20	200	
2019	Spring	100				50	25		50	20		
2019	Fall										25	50
2020	Fall	50			100	50			50			

Table 2. Recent fish stocking records for Big and Little Bear Lakes.

Photo 25. Posted fishing regulations.

Photo 26. Abandoned fishing tackle in the water.

Wildlife

During the 2021 visit in early November, several dozen mallards were seen on the lake (Photos 27 & 28). Many were using the installed logs to perch along the shore. A great blue heron was also seen during the site visit. A fair amount of manmade debris was in the lake during a site visit, including abandoned lures and fishing line. Trash, but particularly fishing line and hooks, are very detrimental to wildlife. Fish, turtles, and frogs can swallow abandoned lures and birds can become tangled in the line, causing death and upsetting park visitors.

Photo 27. Mallards eating aquatic vegetation.

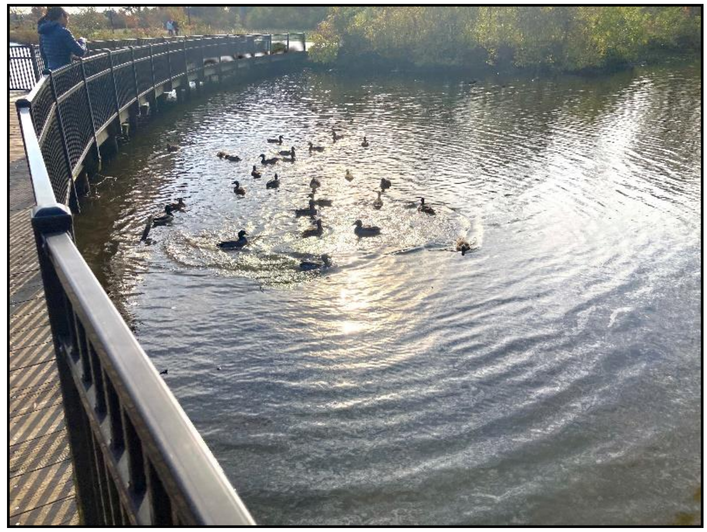

Photo 28. Mallards being fed in the lake.

Recreation

Big and Little Bear Lakes are in Century Park. Many stakeholders fish from shore, the pier, or in boats (Photo 29). There are no beaches located on lake. A public boat launch is available for residents. The lakes are mainly used for non-motorized boating, although electric motors are also allowed (Photo 33). There is a walking path around the perimeter of the lakes and many amenities in the park, including playgrounds, picnic shelters, and benches (Photos 30-32). The park is classified as an arboretum and there is a self-guided tour for people to learn about trees as they walk around.

Photo 29. Fishing pier.

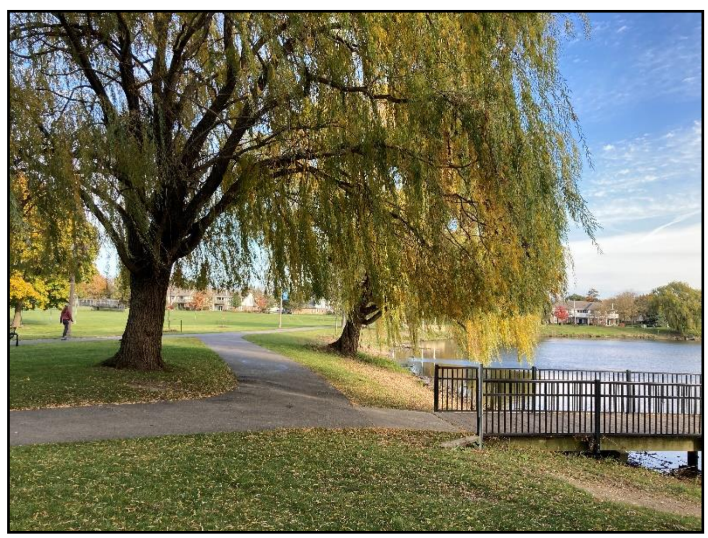

Photo 30. Walking path around lake.

Photo 31. Bench along path.

Photo 32. Picnic shelter on island.

Photo 33. Big and Little Bear boating rules sign posted at launch.

CONCERNS, POTENTIAL SOLUTIONS AND ALTERNATIVES

Various management concerns and potential objectives have been identified for Big and Little Bear Lakes:

In the *2019 Big Bear and Little Bear Summary Report* (LCHD-ES), the main management recommendations were:

- Encourage homeowners or the village to participate in the Volunteer Lake Monitoring Program
- Continue following best management practices for salt application in winter
- Develop a lake management plan to manage aquatic vegetation, targeting invasive Eurasian Watermilfoil and Curlyleaf Pondweed
- Educate the public on the appearance of harmful algal blooms and report blooms to the LCHD-ES
- Continue adding coarse woody debris to Big Bear Lake
- Remove carp
- Contact the IDNR to conduct a fish survey
- Repair shoreline erosion and improve the buffer
- Investigate the inlets experiencing high nutrient loads to see if any best management practices can be implemented and investigate the drain between Harvey Lake and Little Bear Lake.

The 2019-2023 Parks Master Plan developed for the Vernon Hills Par District made the following recommendations for improving the lakes and surrounding shoreline:

- Develop terraced retaining walls at each of the three bridges to minimize shoreline erosion and add aesthetic beauty to this central focal area of the park.
- Prepare an overall plan for the entire shoreline stabilization, incorporating a variety of measures including, but not limited to, sheet piling, bio-log wetland plantings in less steep areas, and erosion matting as options to consider.
- Develop an overall landscape master plan that addresses a long-term plan for aesthetic landscape planting enhancements, reforesting the park, shoreline stabilization planting approach, and turf renovation where appropriate.
- Implement the aeration systems within the lake to maintain higher water quality for fish life within the lakes.
- Plan for fishing opportunities throughout the property by developing “fishing outcroppings” with large ledge rock style boulders or small piers along the edge of the lake.

The IEPA placed Big Bear and Little Bear Lakes on the list of impaired waters in 2002 for excess total suspended solids (TSS).

The Vernon Hills Park District wants to manage aquatic vegetation to benefit the ecological health of the lake to the greatest extent. They are open to improving the shoreline buffer to better stabilize the shoreline.

Accounting for these different suggestions and priorities led to the creation of two main management goals for this lake management plan:

Goal 1: Manage aquatic vegetation and algae to promote native aquatic plant communities
Goal 2: Increase the ecological value and stability of the shoreline
Goal 3: Enhance the water quality of Big and Little Bear Lakes
Goal 4: Continue improving the fishery and other recreational opportunities on the lake

Broad management categories to address the goals are listed in Table 3. The main goal(s) addressed by possible management actions within each management category are indicated. It is understood that not all presented management actions can be implemented in Big and Little Bear Lakes, due to various environmental or practical constraints. Considering as many management actions as possible, however, allows for the best combination of strategies to be chosen to reach the goals and improve the health of the lake. This process also allows to readjust management strategies as needed. The remainder of this section outlines the different possible management actions and considerations related to their implementation.

Main Goal Addressed					
Goal 1: Promote native aquatic veg.	Goal 2: Shoreline improvement	Goal 3: Enhance water quality	Goal 4: Improve fishery and rec.	**Management Category**	**Possible Management Action**
●		●		Aquatic Vegetation and Algae Management	Herbicide application
●			●		Physical removal
●		●			Desirable aquatic species establishment
●			●		Aquatic invasive species education
●					Aquatic vegetation monitoring
●		●	●		Algae monitoring and treatment
	●			Shoreline Management	Retaining wall maintenance and repair
	●	●			Vegetative stabilization practices
	●				Biotechnical stabilization practices
	●	●			Buffer maintenance
	●		●		Bridge and culvert erosion repair
	●		●		Fishing access installation
	●	●			Muskrat control
		●		Watershed Pollution Management	Community nutrient and BMP education
		●			Public green infrastructure installations
		●			Salt application reduction
		●			Goose control
		●		In-Situ Water Quality Management	Water quality monitoring
		●			Aeration
		●			Sediment removal
		●			Nutrient deactivation
		●	●		Debris removal
			●	Fishery Management	Fish survey
		●	●		Stocking plan
			●		Fish habitat improvements
●		●	●		Carp control

Table 3. Management strategies and potential management activities for Big and Little Bear Lakes.

Aquatic Vegetation Management

In 2019, LCHD found three aquatic invasive species in Big and Little Bear Lakes: Eurasian watermilfoil (EWM), curlyleaf pondweed, and brittle naiad. EWM was present at 53.6% of locations, whereas curlyleaf pondweed and brittle naiad were only found at 5.4% and 5.4% of sites, respectively. EWM typically reaches nuisance conditions more frequently than the other two species, as it grows in dense stands, excluding other vegetation and topping out in the water column. Therefore, the focus over the next five years should be on reducing EWM densities. Controlling all aquatic vegetation is not desirable, as lakes tend to become algae dominated if aquatic vegetation is not present to sequester nutrients and provide wildlife habitat. Ideally, a lake has about 20% plant coverage to allow for aquatic life to flourish. The two most practical methods for invasive aquatic vegetation control are aquatic herbicide applications and physical (mechanical, manual, DASH) removal. These methods are discussed below.

Herbicide Application

Aquatic herbicides are frequently used to control invasive aquatic vegetation. Table 4 lists common aquatic herbicides and considerations in their use. Experienced applicators are needed to get the best results, as the environmental conditions can significantly impact effectiveness. In 2020, four areas were treated with Chinook herbicide (active ingredients: dipotassium salt of endothall, 2,4-Dichlorophenoxyacetic acid, dimethylamine salt). The Park District saw strong results in those treatment areas, with vegetation dying back. Outside of those treatment areas, however, aquatic vegetation remained dense and marred aesthetics of the lake. The Park District expressed a desire to have aquatic vegetation to support a healthy fishery but keep aquatic vegetation from becoming dense and topped out throughout the lake.

Annual management of non-native species can reduce the seed bank over time and decrease their pervasiveness in the lake, allowing for management to shift to physical removal of small nuisance areas. Application rates and products used will shift over time to best fit the species present and their density.

Hebicide		Considerations
Examples of Trade Names	**Active Ingredient**	
ProcellaCOR	Florpyrauxifen-benzyl	Manufacture guarantee on Eurasian watermilfoil control for 3 years, dependent on treatment area Does not control curlyleaf pondweed Can be costly in large applications
Sonar, Avast!	Fluridone	Controls plants as they sprout, reducing visibility Helps reduce algae blooms following die-off, as nutrients remain in sediment Contains irrigation restrictions Requires long contact time in water Can be applied at a rate that leaves native plants less affected
Reward	Diquat	Generally less expensive alternative Algae blooms may occur following die-back, as decaying plants release nutrients Will impact non-target native species Less effective in cloudy water Contains irrigation restrictions
Aquathol K, Chinook	Dipotassium salt of Endothall	Algae blooms may occur following die-back, as decaying plants release nutrients Can impact non-target native species
Aqua-Kleen, Navigate, Weedar 64	2,4-D	Widely used and inexpensive Can be relatively slow to be taken up by plants and can migrate out of the treatment area Dicot-specific herbicide

Table 4. Common herbicides used in aquatic vegetation management.

Florpyrauxifen-benzyl is a relatively new aquatic herbicide that is specifically formulated to control Eurasian watermilfoil. It does not control curlyleaf pondweed. The product is formulated to be quickly taken up by plants, meaning it does not remain in the environment for a long period of time following application. This makes it a good alternative to use in ecologically-sensitive areas. The manufacture has a 3-year guarantee for applications covering 10 acres or more in size.

Fluridone can be applied in early spring. It prevents photosynthesis in plants as they emerge to keep populations at lower densities. It can control Eurasian watermilfoil and curlyleaf pondweed and can be applied at lower rates that will not impact native species like sago pondweed to the same degree. Pelletized versions can be applied so the product will remain in the lake following periods of higher flow, allowing it to continue releasing the active ingredient where designed.

Diquat is a contact herbicide that provides broad-spectrum aquatic plant control, which can make it difficult to only control non-native species. Reward loses effectiveness in cloudy water as it will bind with sediment and may need to be combined with another product to improve results. This product can be more cost-effective than other options presented.

Endothall is another common broad-spectrum aquatic herbicide and would control all aquatic vegetation in the lake. This product does not have irrigation restrictions, like Reward or Sonar.

2-4 D is a common, inexpensive herbicide that can be applied at rates to control dicots like EWM but it has minimal effect on monocots like curlyleaf. This can be helpful as the product will not cause all aquatic vegetation to die back.

For Big and Little Bear Lakes, the application of Fluridone was recommended by the current lake management provider to reduce plant density. Based on the lake conditions, this appears to be an appropriate strategy to reducing overall aquatic vegetation biomass, but it is recommended that the application rate be designed to target non-native species while minimally impacting native species. The chosen rate should also consider the high level of lake turnover that occurs during storm events. Water samples could be collected and tested to ensure the appropriate concentrations are being maintained in the lake throughout the treatment. If a heavy storm event occurs during the treatment period, a partial treatment may need to be reapplied.

After an initial year of treatment, the plant population should be reassessed through a survey to determine if another year of Fluridone application is appropriate or if treatments of smaller areas the following year is more appropriate. For example, switching to Florpyrauxifen-benzyl would allow for more selective targeting of Eurasian watermilfoil in future years, allowing native species to flourish.

Physical Removal

Physical removal of aquatic vegetation provides immediate improvement to aesthetics, as the plants are physically removed from the lake. This method has the added benefit of removing the nutrients stored within the plants. The strategy of growing and harvesting plants to remove nutrients or contaminants from a site is known as bioremediation. In a lake the size of Big Bear or Little Bear, however, removing vegetation is not likely to lead to a substantial decrease in nutrient concentrations.

Photo 34. Mechanical removal of coontail.

Hand-Raking or Weed Harvesting

Manual removal is desired over chemical management when there are concerns about impacts to native aquatic plant populations. While hand raking can work as a small-scale management strategy, it is very time-intensive to control these species in large lakes. Additionally, Eurasian watermilfoil can spread by fragments that break off, and curlyleaf pondweed can re-sprout from small buds on the stems, called turions. Therefore, caution should be taken during removal to ensure complete removal of plants.

The same principle applies for weed harvesters, where a machine cuts and collects plants (Photo 34). Plant pieces can break off and regrow in other parts of the lake, so care needs to be taken to remove as much material as possible.

Diver-Assisted Suction Harvesting

Diver-assisted suction harvesting (DASH) involves a person in the water removing plants through a suction hose, where they are collected in bags. This harvesting technique is potentially more effective than raking or cutting, as the goal is to remove the roots as well. This method is preferred when targeted removal of only invasive plants is desired, as the divers can maneuver through native plants and selectively harvest non-native species. Removing the vast beds of Eurasian watermilfoil currently in Big and Little Bear Lake would likely be cost-prohibitive. Once the density of Eurasian watermilfoil is significantly reduced, however, DASH harvesting small populations as they appear can be effective for removing only invasive species, while keeping native aquatic vegetation in place.

Desirable Aquatic Species Establishment

Big and Little Bear Lakes had seven aquatic species present in the 2019 survey, and three of those species are considered invasive. The remaining 4 species are not typically considered high-quality plants and tend to be aggressive and impair aesthetics. Therefore, improving the diversity of aquatic vegetation should be part of the long-term management strategy in Big and Little Bear Lakes. This can involve planting aquatic species, although this is not a common practice. Planted species would need to be protected from carp and waterfowl during establishment. Applying herbicides to spot treat areas of invasive or nuisance vegetation, applying species-specific herbicides, or applying at rates that only impact certain species can allow desirable native vegetation to become more dominant in the lake.

Aquatic Invasive Species Education

The “Transport Zero” campaign has been administered through the Illinois DNR, Illinois-Indiana Sea Grant and Prairie Research Institute to help educate recreation water users on how to prevent the spread of invasive species. While Eurasian watermilfoil, zebra mussels, and other non-native invasive species have been accidentally introduced to many of the lakes in the surrounding area, it is important to continue encouraging boaters to thoroughly clean their boats when moving between waterbodies. There are other potential invasive species that have been found in the Midwest, such as hydrilla and starry stonewort, and cleaning boats is one of the simplest and most important steps in preventing their spread.

Photo 35. Invasive species education at the Lakefront Park boat launch.

The current sign at the boat launch (Photo 35) provides information about the importance of cleaning gear.

Providing a spigot and hose near the boat launch could allow people to rinse of equipment before transporting it from the lake. Since the lake is not highly trafficked by boaters, this may not be a high priority for Big and Little Bear Lakes.

Aquatic Vegetation Monitoring

As recommended in the 2019 LCHD-ES Summary Report, performing periodic aquatic vegetation surveys allows the managers to track and control the spread of invasive species. Since curlyleaf pondweed is present in the lakes, the survey should occur when it is growing, usually in May or June. Brittle naiad, another invasive species found in the lakes, emerges later in the summer, and may need to be surveyed for after July.

Algae Management

Big and Little Bear Lakes experience algae blooms in the summer, both of filamentous green algae and blue-green planktonic cyanobacteria. This is likely due to the high levels of nutrients found in the lakes. Green and blue-green algae can mar aesthetics, but because blue-green algae can lead to harmful algae blooms, lake managers try to take proactive approaches to keep large blooms from occurring. This can mean treating the lake at regular intervals throughout the summer, even when growth appears minimal to the naked eye. Both types of algae can be treated with copper-based algaecide products. There are also technologies available to continuously monitor algae growth in the lake, such as “AlgaeTracker”. A lake manager can remotely access data and see when algae growth is reaching the stage of exponential growth and treat the bloom before it becomes severe. Treating a dense blue-green algae bloom is not typically recommended, as there is a large amount of biomass in the cells and if they all die back and decompose at the same time, the oxygen used during decomposition can cause a fish kill. Therefore, proactively treating blue-green or green algae at the early stages of a bloom is the most effective and safe method of control.

Shoreline Management

The Vernon Hills Park District (VHPD) began stabilizing the shoreline with a rock retaining wall in the 2000s, but the USACE halted the installation in 2010, as it was not permitted. The USACE declined the VHPDs application to continue stabilizing the shoreline with a rock retaining wall, stating that a shoreline stabilized with native vegetation was preferable. Retaining walls lead to increased wave energy. Walls can also increase flooding, as water can only move straight up a vertical wall instead of also spreading out in a more natural “bowl-like” lake during storms. The shoreline has three main areas of focus: reaches stabilized by the retaining wall, reaches not stabilized with rock, and reaches experiencing erosion around bridges and culverts.

By referencing the buffer condition and shoreline assessment conducted by LCHD-ES in 2019, ILM classified regions of the shoreline according to their buffer condition and severity of erosion. Reaches with no erosion and “good” buffer are classified as “Good condition” in figure 9 and would be a low priority for restoration. Areas with no erosion and poor or fair buffer condition could likely be stabilized with vegetative practices only. The shoreline behind the rock retaining wall could also be better stabilized with a vegetative buffer. Areas with slight erosion may maintain stability if coir logs and native vegetation are installed, while areas with “moderate” erosion likely need to utilize a mix of structural and vegetative stabilization, such as rip rap and native plants. Areas with severe erosion were around infrastructure and engineering plans should be created to stabilize these areas.

Incorporating the shoreline stabilization into the overall landscaping plan for the park is recommended prior to beginning stabilization to ensure the aesthetic and area of native buffer installations fits with the long-term plans for the park. The following subsections detail each of these options more thoroughly.

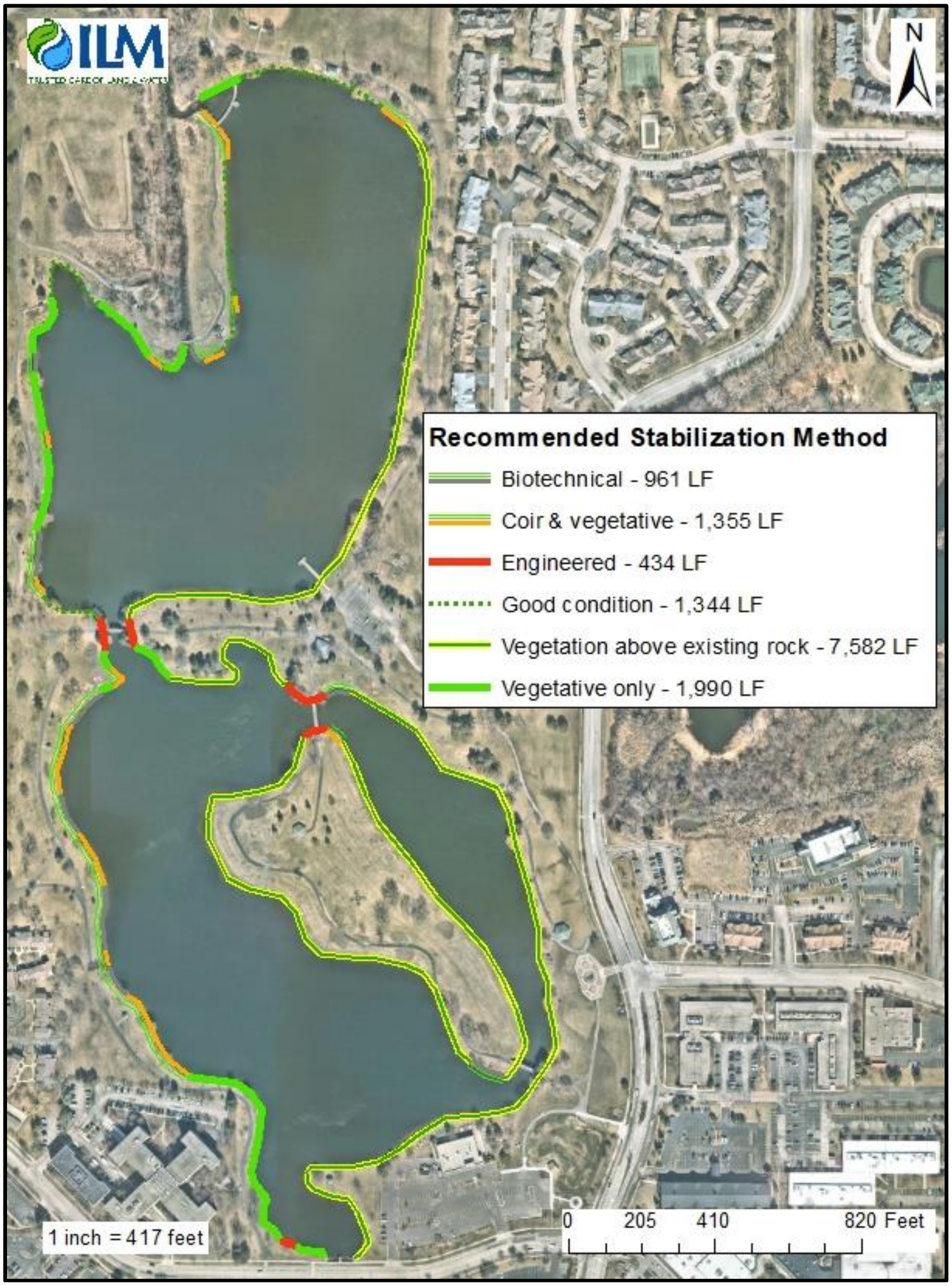

Figure 9. Potential stabilization methods for different reaches of shoreline.

Vegetative Stabilization Practices

Installing native vegetative buffers have the benefits of reducing shoreline erosion, as well as intercepting nutrient runoff during rain events. As discussed above in the "Desirable Species Establishment" subsection of "Invasive Emergent and Terrestrial Vegetation Control", native shoreline plants can be chosen for different aesthetic desires. Native buffer installation typically involves applying herbicide to the restoration area to remove turfgrass and weeds. For areas of shoreline with a vertical drop off, the bank should be graded back to a stable slope of at least 3:1, but preferably 5:1. Then, small plants, called plugs, can be planted into the dead grass. If bare soil is present, the ground should be protected with erosion control blanket to prevent erosion while plants establish. Native buffers typically take 2-3 years to fully establish, during which time the restored area should be monitored, with weeds promptly removed and bare areas seeded.

Along shoreline reaches with minimal erosion and a relatively flat slope, native vegetation can often be established as a buffer without much structural work. The western and northern edges of Big Bear Lake had the most amount of shoreline experiencing minimal erosion. For Big and Little Bear Lakes, the main considerations to maintaining a native shoreline are the fluctuations in water level during rain events, as the lakes are in a floodway, and water velocities that may occur during such high flow events. Therefore, the shoreline should be planted with deep-rooted species that can withstand inundation and flowing water for several days.

Photo 36. Lake Glenview shoreline in Glenview, IL.

To establish a native buffer, the existing turfgrass is typically killed with an herbicide. Then seed can be sown directly into the bed. If there is a fair amount of exposed soil, a straw erosion mat or other equivalent product should be secured over the seeds to prevent erosion or bird predation while the plants establish. For restoring larger buffer areas, seeds are typically used, but small plants can be planted in high-traffic locations to quickly establish plants for the community to enjoy. The seed mix can be selected to contain lower growing, species, allowing for views of the lake (Photo 36). Native species also tend to be relatively balanced in their rate of spread, so one species is not likely to dominate the landscape.

There is a vast array of aesthetically attractive native species that can be planted along shorelines and in frequently inundated wetland areas. The general types of vegetation that are planted include:

- Emergent species for water depths greater than 1 foot, such as American lotus (*Nelumbo lutea,* Photo 37), white water lily (*Nymphaea odorata*), or pickerelweed (*Pontederia cordata,* Photo 38). These species have the added benefit of absorbing wave energy and reducing their impact on the shoreline.
- Shoreline species for less than 1 foot of water depth, including bur-reed species (*Sparganium spp.*), blue flag iris (*Iris versicolor*, Photo 39), or arrowhead (*Sagittaria spp.*)
- Upland species with deep roots to stabilize the shoreline, which typically consist of native grasses and forbs (Figure 10).

Any species planted in the water will need to be protected from carp and geese during establishment. Plantings are often surrounded by staked fencing to prevent these nuisance animals from uprooting plants before they establish. These native species occupy space where cattails or *Phragmites* would otherwise establish. They tend to be lower-growing, allowing for unobstructed view of the lake. Native species also provide better habitat for wildlife. In Big and Little Bear Lakes, emergent species may be difficult to grow if carp are present in high numbers, meaning carp control should occur prior to attempting to establish emergent vegetation.

Photo 37. Lotus and lilies.

Photo 38. Pickerelweed.

Photo 39. Blue Flag iris.

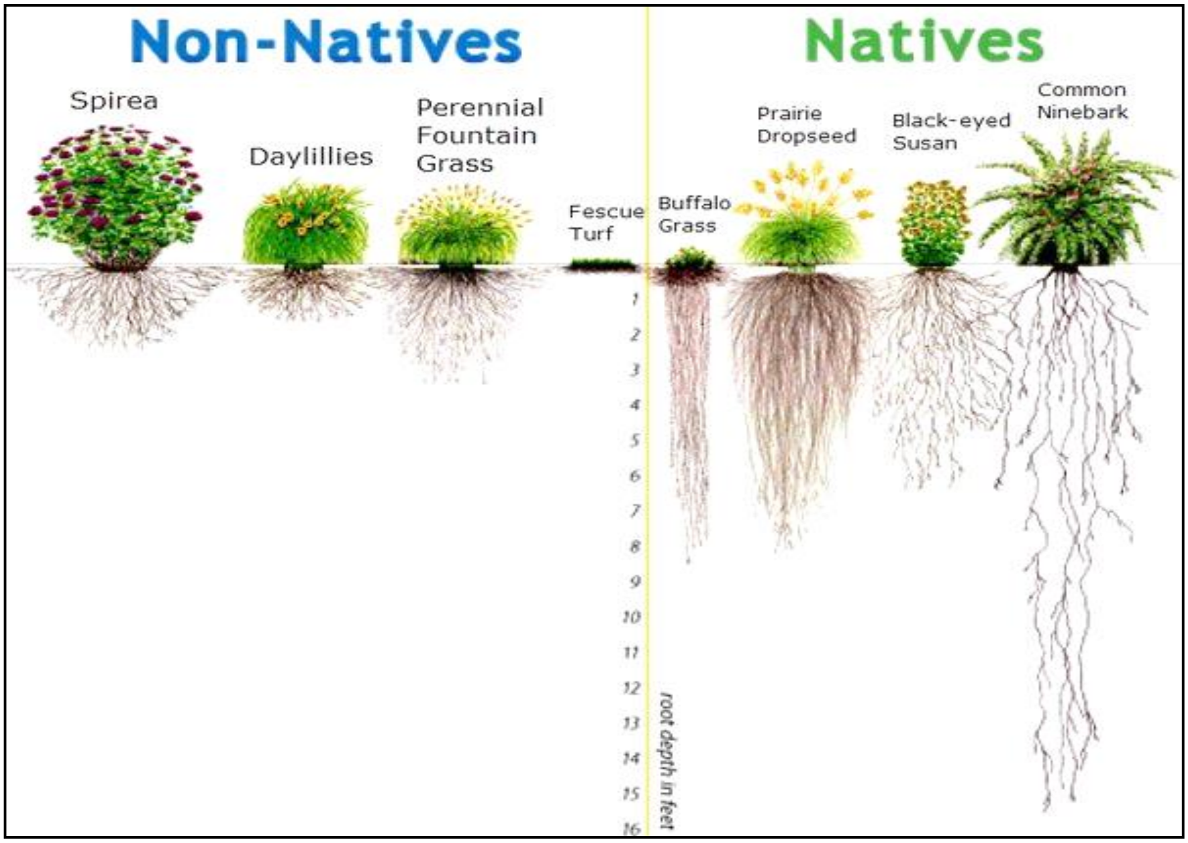

Figure 10. Non-native vs. native species root depths.

Retaining Wall Maintenance and Repair

Approximately half of the lake shoreline is stabilized with a stone retaining wall. The wall is experiencing degradation in some reaches, with the wall pitching towards the water or stones tumbling into the lake (Photos 40-43). Where individual stones have fallen in, these should be replaced. The voids behind the rocks are likely due to a combination of factors including floodwaters overtopping the stones, erosion at the base of the wall causing the rocks to pitch towards the water, and stormwater runoff coming down the slope and pooling behind the rocks. These issues can all lead to seawall failure.

Seawall repair is expensive, as erosion at the base of the wall is difficult to access. Therefore, funds should either begin to be set aside for eventual maintenance or a “retrofit” shoreline could be designed to incorporate the rocks into a more naturalized shoreline. If there are shallow regions in front of the rocks, emergent aquatic vegetation could be planted to reduce the impact of wave energy and slow the erosion of soil under the wall. Another option could be to establish a native vegetative buffer immediately behind the wall. The rocks will continue may erode into the lake, but deep-rooted vegetation behind the rocks will prevent soil from eroding and the rocks will break up wave energy even if they are partially submerged.

At this point, the reaches of rock retaining wall are in relatively good condition. Repair or replacement of rocks that have fallen into the lake should occur, with native buffer expansion occurring in the future as funding becomes available.

Photo 40. Fallen rocks in water.

Photo 41. Missing seawall cap.

Photo 42. Erosion behind rocks.

Photo 43. Slumping rocks along shore.

Biotechnical Stabilization Practices

The practice of combining both structural stabilization practices such as rip rap or coir logs with native plantings to maximize the effectiveness of the stabilization is known as biotechnical stabilization. In reaches that cannot be stabilized with vegetative practices alone, biotechnical practices may need to be used.

Coir Logs

Coir logs are a biodegradable material packed in netting and shaped into a log. This is placed at the base of the shoreline to reduce water velocity on the shoreline. Native vegetation is then planted up the rest of the slope (Figure 11, Photos 44 & 45). These “logs” offer biodegradable shoreline protection and easy installation but they are not effective in high water velocity areas and are moderately expensive.

Photo 44. Before - Eroding streambank.

Photo 45. After – Stabilized with coir logs.

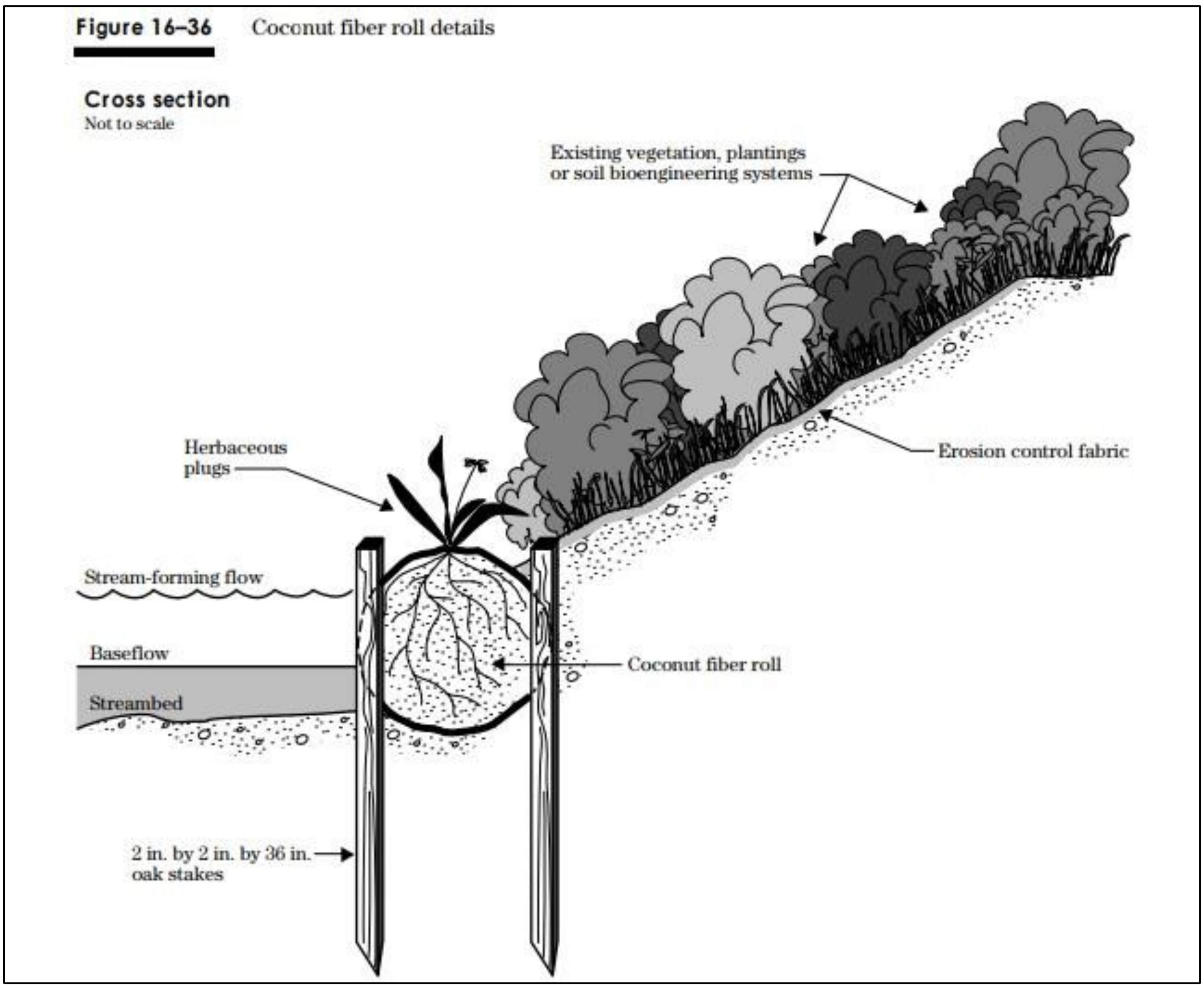

Figure 11. Coir log and vegetative stabilization. USDA-NRCS EFH Chapter 16.

Rip-Rap

Rip rap consists of loose stone placed strategically on the shoreline to reduce erosion due to water (Figure 12). Native vegetation can them be placed above the stone to allow for a more natural transition to the water. Rip rap is and easy-to-use method for decreasing water velocity and protecting slopes from erosion. Additionally, it is easy to install and maintain. The rocks are loose, allowing them to continually conform to a changing shoreline. Rip rap is more expensive to install then solely vegetated slopes, does not provide habitat enhancement, and there is the possibility of increased erosion at the outsides of the riprap.

As seen in Photo 46, the rip rap can be interplanted with vegetation as well, allowing for it to become incorporated into the plants over time to increase the benefit to wildlife.

Photo 46. Buffer demonstration area in Round Lake.

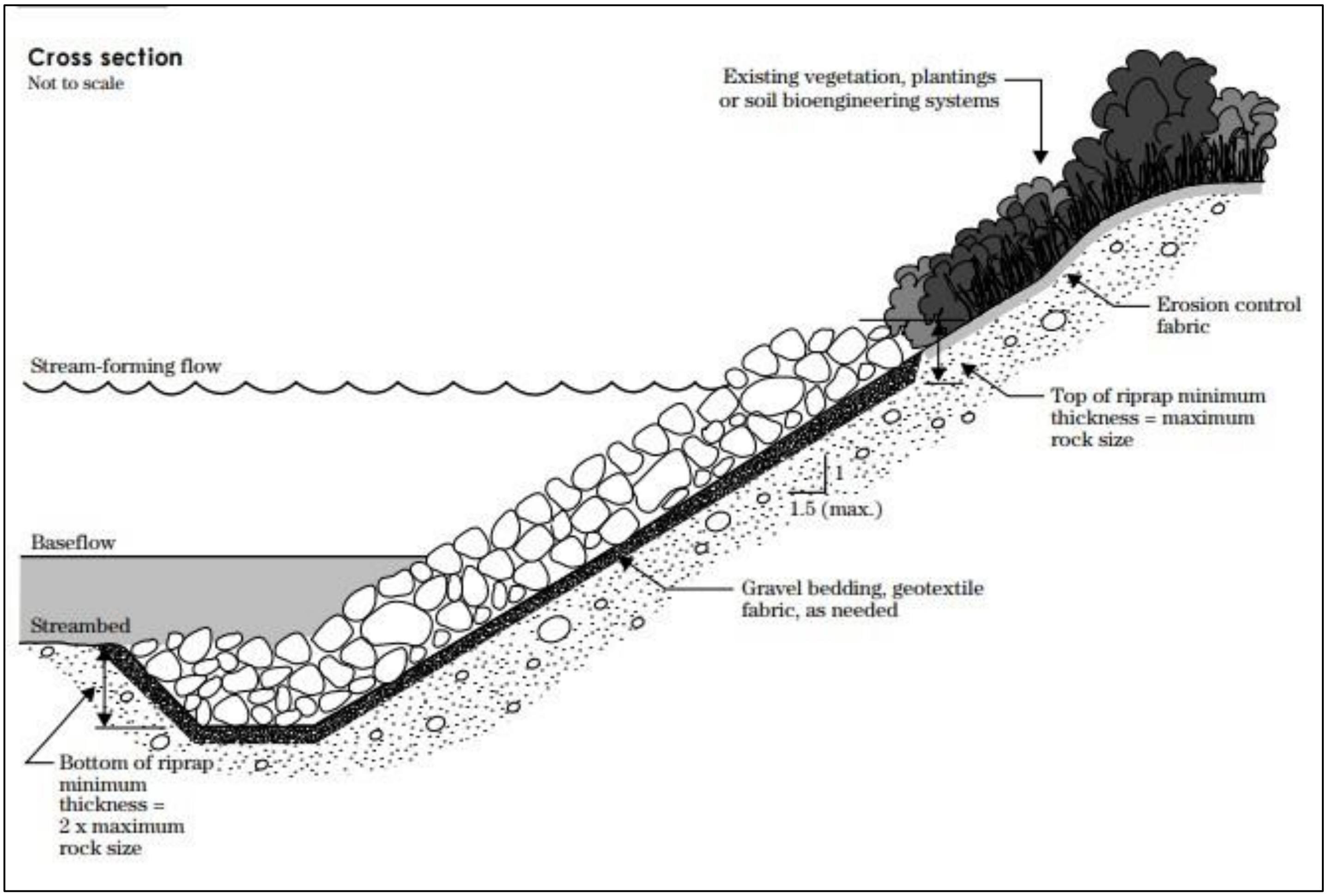

Figure 12. Rip rap and vegetative stabilization. USDA-NRCS EFH Chapter 16.

Buffer Maintenance

Once a vegetative buffer is planted, the area will need to be actively managed to ensure invasive species do not establish populations and degrade the ecological health of the area. Typically, 3-4 visits are required throughout a growing season to target species that grow or are more susceptible to treatment at different points in the year. If a buffer is managed properly from the start, the cost to install and maintain the area over ten years can be one-fifth the cost of managing the same area for turfgrass (https://archive.epa.gov/greenacres/web/html/chap2.html).

Herbicide Application

Different invasive species require distinct strategies to control their spread:

Invasive Shrub Herbicide: European buckthorn and Japanese honeysuckle are two non-native, invasive shrubs seen around the park. These species are most effectively controlled by cutting back plants and applying a treatment of herbicide to the cut stump. Large plants are typically targeted first, as these produce the most berries. If the lake freezes over, restoration technicians can access plants from the lake side, making it easy to see and remove plants. Sometimes, volunteer days are planned where community members can cut the plants, followed with stump treatment by licensed applicators. This allows for a reduction in costs and promotes community investment.

Cattail, Phragmites or Reed Canary Grass Herbicide: These are all common, aggressive species found in wetlands around most lakes. All three of these species were seen in Big and Little Bear Lakes, although not in high densities, likely due to the high level of shoreline development and narrow buffer area. Cattails are most effectively controlled by an herbicide application before seed-set in late summer. There are several herbicides approved for application around water. Cattails did not appear to be abundant to the point of nuisance on the lake, although they should be controlled where they are blocking inlet culverts on the south end of Little Bear Lake. They provide shoreline stabilization, so some presence can be beneficial, but they also encroach on shallow areas of lakes over time. Therefore, cattail stands should be monitored and controlled if they are taking over areas of the lake where open water is desired. *Phragmites* and reed canary grass are both considered invasive species and were seen in the buffer. These species should be controlled wherever they occur, although any treated areas should be restored with native vegetation to reduce reestablishment of these invasive species from the seedbank.

Community Plant Removal Events

As stated in the previous section regarding invasive shrub herbicide, community volunteer days to cut and remove invasive shrubs are a common activity. While usually more prevalent in woodlands, garlic mustard is another invasive plant that is relatively easy to remove by pulling out the plant and roots. Park community cleanup events can be paired with garlic mustard pulls or buckthorn removal to promote interest in public spaces. Typically, volunteers are trained to identify and saw down invasive shrubs, followed with a stump herbicide treatment by a licensed applicator.

Bridge and Culvert Erosion Repair

Severe erosion is occurring under and around some of the bridges and culverts. The 2018 engineering survey of the bridges recommended this be addressed. This process will involve an engineering survey to assess the conditions and plans created to repair the damage and ensure the bridges can withstand the velocity of water flowing by them.

Muskrat Control

Muskrats are a common rodent found on lakes and ponds throughout Illinois. Unfortunately, they can burrow into banks, creating dens that eventually collapse (Figure 13). These collapsed dens can lead to severe bank erosion over time and create tripping hazards for lake visitors. Steep banks, such as seen in Photo 20, tend to encourage burrowing the most, so bank stabilization in those areas should consider regrading to a slope greater than 3:1. No muskrats were seen during the November 2021 visit, but they should be removed if they establish a population in the lake and cause the shoreline to begin eroding.

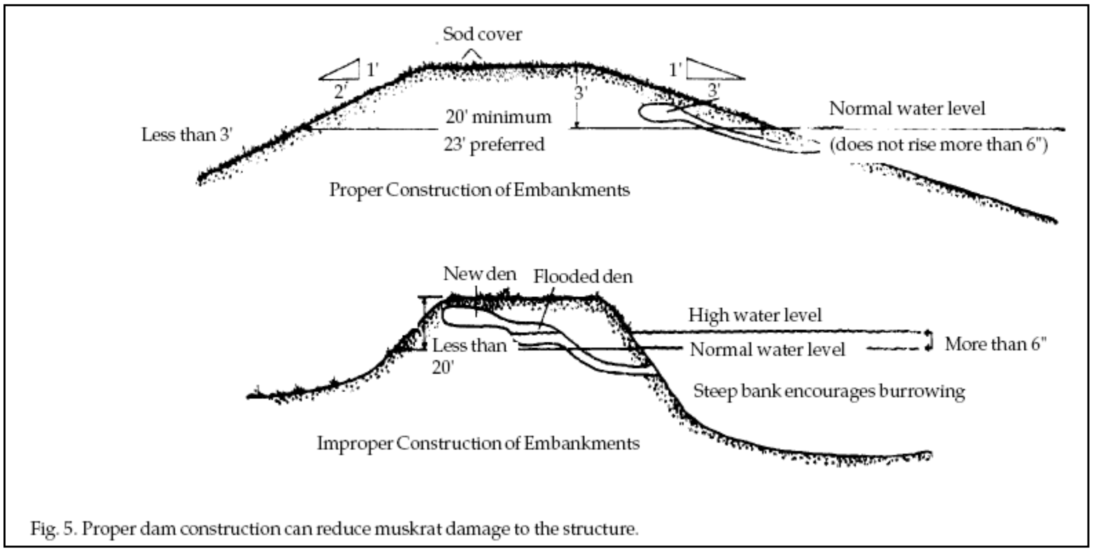

Figure 13. How embankment construction can discourage or encourage muskrat damage.

Watershed Pollution Management

Pollutant inputs from terrestrial sources should be reduced to the greatest extent possible. Pollutants of greatest concern identified for Big and Little Bear Lakes include phosphorus, total suspended solids, and trash. Best management practices (BMPs) are techniques that can help citizens and municipalities protect lakes and streams from polluted runoff. BMPs include practices such as ensuring new developments are not impacting waterways and leading to erosion, preventing pollution though practices such as reducing the use of or banning harmful pollutants, retrofitting existing developments to better reduce pollutant runoff, performing inspections on septic systems, and conducting maintenance on existing BMPs to maintain functionality.

Community Nutrient and BMP Education

A major contributor of watershed nutrient pollution in developed communities is lawn fertilizer and grass clipping runoff. Single family housing and transportation covers 54% of the Big and Little Bear watershed. Reducing these sources of pollution to the greatest extent possible is vital to the long-term success of water quality improvement actions. There are many watershed groups in Lake County with experience promoting successful pollution reduction strategies through community outreach and education. Such practices include:

- Implement phosphorus-free fertilizer practices
- Educate homeowners regarding lawncare (Photo 47)
- Reduce grass runoff through buffers and lawncare best management practices

Photo 47. Example of educational material mailed to residents in a watershed.

Public Green Infrastructure Installations

Green infrastructure installations showcase the possibilities for reducing stormwater pollution. These installations are site-specific and should be accompanied with educational signs to help community members understand their benefit. Common examples of green infrastructure include installing permeable pavement, creating a rain garden, installing a bioswale where water flows during rain events, or encouraging residents to install rain barrels to store rainwater and reduce flooding. Grant funding is available for green infrastructure projects through agencies such as the Lake County Stormwater Management Commission and the IEPA.

Seavey Ditch Sediment Loading Reduction

The stretch of Seavey Ditch between Lake Charles and Big Bear Lake found suspended solid concentrations increased between the lakes. This could mean sediment is eroding along the shoreline or washing in from the surrounding watershed. Performing a survey of this stretch and identifying sources of sediment or nutrient pollution is recommended.

Salt Application Reduction

Road salt application during the winter - whether by municipalities on roads or private property owners on sidewalks, driveways, and parking lots - is quickly becoming one of the emerging pollutant issues in Illinois watersheds. Salt dissolves in water and washes into lakes and streams during the spring melt. The Lake County Health Department – Environmental Services works with the "Salt Smart" Collaborative (www.saltsmart.org) to educate residents, road agencies, and private contractors to ensure salt is being applied in the more effective manner, to reduce pollution into lakes.

Goose Control

Canada geese present a nuisance on many lakes, as they are aggressive when nesting, and their feces can pollute waterways with both bacteria and excess nutrients. While some presence is natural, large flocks of geese should be discouraged from remaining on and around the lake for extended periods of time. The main ways to discourage goose presence include reducing habitat, harassing geese, removing them through hunting, and reducing preferred food sources.

Shoreline Barriers or Buffers

Geese prefer entering waterbodies when the transition between upland and water consists of short vegetation. Turf grass encourages this behavior, as geese eat grass as well. Planting taller vegetation along the shoreline discourages them from using that portion of shoreline to access the water. See the "vegetative stabilization practices" subsection of the "Shoreline Stabilization" section for further details on planting native vegetation along the shore.

Many shoreline owners will place physical barriers along the shoreline to deter geese from accessing water at that point. Common methods include installing a low fence or stringing a line 12 inches or less from the ground, which the geese cannot step over or go under.

Goose Harassment and/or Removal

Goose harassment or removal can take different forms:

- Installing objects that make geese uneasy, such as shiny objects or false predators. These objects need to be regularly moved, however, or geese will become desensitized to them.
- Hiring a company to bring a dog to chase geese off properties on a very regular basis
- Regularly spraying grass with a product that makes the grass taste bitter to geese so they won't graze on lawns
- Hiring a certified professional to "addle" goose eggs. This can involve oiling or shaking the eggs so they are no longer viable. This can reduce the population of geese in an area over time.
- Setting up hunting availability on the lake. This can be difficult to do on a lake the is used by the public like Big and Little Bear Lakes, as there may be gun ordinances and there is an increased safety risk.

Anti-feeding Campaign

Feeding waterfowl is generally detrimental to their health, as birds are not adapted to eat large quantities of human food, especially items like bread. Therefore, feeding geese and other birds should continue to be discouraged around Big and Little Bear Lakes. Signs are already posted at bridges and access points, telling residents not to feed the waterfowl. While doing the site visit in November, however, people were feeding mallard ducks right next to the sign. Adding more context to signs about why feeding birds bread and other common food and be injurious to birds can help people better understand the reason feeding wildlife is discouraged.

E. coli

Harmful bacteria are found in animal waste, with *E. coli* presence in water being an indicator of fecal contamination. Signs to encourage waste removal are around the lake, as well as bag dispensers and trash cans. These programs should be continued to help keep fecal contamination from entering the lakes. Upstream parks in the Seavey Ditch watershed could also have such signs installed. The lakes are not used for recreational swimming, so people are unlikely to ingest the water, but preventing pet waste from entering the lakes can also improve water quality by keeping the bacteria and nutrients in them (similar to geese) from polluting the waterway.

In-Situ Water Quality Management

Water Quality Monitoring

LCHD-ES performs water quality monitoring every 5-10 years on Big & Little Bear Lake, as does the IEPA. These surveys provide valuable information to inform management decisions. Supplementing with survey years with water quality sampling on the off years can better help visualize changes in the lakes. Some water quality metrics, such as secchi depth or lake level, can be measured by volunteers. Other factors involve more complicated sampling procedures and provide more accurate information when collected by trained scientists. Some examples of recommended parameters to collect include nutrient concentrations in the lake, temperature and oxygen levels, and other relevant data like total suspended solids or chloride levels. The frequency of sampling can occur on a range of time scales and is usually budget dependent. Some managers will collect data once during the height of summer, while others will do so monthly during the growing season. An ecological consulting firm can best help design a water quality monitoring program to optimize visit frequency and what parameters to collect based on funding.

As mentioned in the subsection regarding Algae Management, there are also technologies available to monitor water quality with in-situ sensors. The data is wirelessly transmitted to allow for remote, instantaneous access to data.

“AlgaeTracker” was mentioned to track algae growth, but other sensors could be installed if there are specific concerns. The cost of installing such sensors has decreased dramatically in recent years, making it a more appealing option for monitoring changing water quality throughout the seasons.

Volunteer Water Quality and Lake Level Monitoring

Many Park districts sponsor community events, allowing residents to donate their time for events such as a lake cleanup or to perform volunteer water quality monitoring. Any stakeholders showing interest in lake management activities should be encouraged to apply their strengths to help in whatever way they can. This could be by organizing a community event, monitoring water clarity, or many other beneficial activities.

Photo 48. Lake level gauge.

The Volunteer Lake Monitoring Program (VLMP) was managed by the IEPA but was suspended in 2019. One of the main aspects of this program involved trained volunteers submitting secchi disk readings. Volunteers can still submit data through the North American Lake Management Society (NALMS) “Secchi Dip-In” website. These citizen science programs should be encouraged. Other opportunities for lake users to provide data include creel surveys, where anglers are surveyed regarding details of the fish they are catching, or reporting the lake levels (Photo 48). All collected data can help the agencies make informed management recommendations. Creating a website and simple form to submit data and posting signs with information on how to report the data at the collection location can encourage community engagement.

Aeration

Implementing aeration systems within the lake to maintain higher water quality for fish life within the lakes was suggested in the 2019-2023 Parks Management Plan. Low dissolved oxygen levels (<5 mg/l) can stress fish and only species tolerant of lower oxygen levels will thrive. Aeration could potentially increase water quality within the lake, but the upfront installation and maintenance costs are often cost prohibitive for large bodies of water, as the number of units needed to keep dissolved oxygen levels at healthy levels increases in larger lakes. For Big and Little Bear Lakes, keeping a healthy ratio of aquatic vegetation can help keep dissolved oxygen at desired concentrations and would likely be more effective. Avoiding heavy algae or vegetation herbicide treatments can also prevent dangerous drops in oxygen. Heavy rain events are also a common cause of fish stress, as an influx of rainwater can quickly change water temperatures and dissolved oxygen levels. Aeration installations would not be able to offset such events. These factors, coupled with installation and maintenance costs in the hundreds of thousands of dollars, make installing aeration on the lakes a low priority at this time.

Sediment Removal

Sediment is carried in stormwater and part of the natural function of a stream. When the stream flows into a relatively deep, wide area, the water slows in velocity. This allows suspended particles to settle out, which can lead to detrimental levels of sedimentation in impoundments. While Big and Little Bear Lakes do not appear to be experiencing sediment accumulation to the degree of impacting hydrologic function, park managers have noticed that sediment appears to be accumulating at the north end of Big Bear Lake. Removing excess sediment around inlets allows for those areas to continue acting as sediment traps, therefore protecting the rest of the lake from excess sediment accumulation.

Sediment Survey

Performing a sediment survey can allow for lake managers to determine how much silt has accumulated in the lake and when performed at intervals, the rate of accumulation can also be determined. An entire lake survey could be done, or smaller areas can be surveyed where sediment is impacting function. These surveys involve collecting sediment thickness points along transects on the lake to quantify volumes of material. The quality of the sediment can also be determined, such as particle size, nutrient levels, and if contaminants are present.

Dredging

Dredging is a common method employed to remove excess sediment and nutrient accumulation.

In addition to removing nutrients, dredging can lead to other ecological benefits within a lake. Reducing the amount of soft sediment can improve spawning habitat for certain fish species that prefer firm substrate to spawn. Additionally, dredging can reduce the presence of seeds from various undesirable aquatic weeds.

A critical component of dredging to consider is the method for removal and how sediment will be treated and disposed of. One option would be to mechanically fill barges or dumpsters to be hauled offsite immediately (Photo 49).

Photo 49. Mechanical dredging.

Another method of dredging is hydraulic removal. With hydraulic removal, a cutterhead is used to suction up a slurry of sediment and water to a dewatering facility. The sediment is then dewatered, and clean water returns to the lake (Photo 50). Hydraulic dredging can remove material faster than mechanical dredging depending on the equipment, but requires space for the material to dry out up to 6 months before it can be hauled away.

Photo 50. Sediment dewatering bag.

The processes through which nutrients are released from sediment are complex and dependent on various environmental factors. For example, low dissolved oxygen levels alter biotic processes, leading to increased rates of nutrient release from the sediment. Under certain conditions, even low levels of sediment nutrients can lead to increases in nuisance vegetative growth. While dredging these lakes will likely lead to an overall decrease in nutrients in the sediment, reducing sediment volume alone is not a guarantee of a reduction of nuisance algae and plant growth.

Reductions in nutrient inputs from upstream sources (such as agricultural runoff) and monitoring biological conditions within the lake (i.e. ensuring adequate dissolved oxygen levels, limiting carp presence) are also vital for reducing nutrient loading.

Dredging would be an extensive endeavor for these lakes and more study should be undertaken into the extent of accumulation and the degree to which it is impacting water quality and lake function prior to moving forward on considering sediment removal.

Nutrient Deactivation

Nutrient deactivation in a lake is the process of applying a product that binds with reactive phosphorous in the water, making it unavailable for algae growth. Due to the relatively high turnover of water in Big and Little Bear Lakes, such products may not provide long-lasting results, as new water will quickly replace the treated water.

Phoslock Application

Phoslock is a relatively new product, which is more frequently applied to drinking reservoirs to reduce the risk of cyanobacteria growth in the lake. This product consists of an activated clay that binds with reactive phosphorous in the water column as it is applied. The clay then sinks to the sediment, where it continues to bind with phosphorous as it is released from the sediment.

Aluminum Sulfate Application

Aluminum sulfate, or "alum" applications are a more traditional method for reducing available phosphorous in the water column and increasing water clarity. This product, however, does not remain active in water for long and would not provide phosphorous reduction after application for sediment that is resuspended by carp, erosion or other activities. Alum must be applied by trained applicators, as the reaction that occurs can be hazardous to aquatic life if not monitored closely.

Debris Removal

During the site visit in November 2021, trash was present floating in the water and in the buffer. Fishing line, lures, water bottles, caps and straws were some of the most common items seen. Besides contributing to an unsightly aesthetic, trash can be harmful to wildlife. Waterfowl, fish, and amphibians can die after ingesting abandoned hooks or getting caught in fishing line. Lake communities often schedule multiple visits per year for debris removal and these can either be done at a defined interval (i.e. monthly), after heavy rains, or as needed at the request of the parks department. The hired management company would launch a boat or amphibious craft and travel around the lakes to collect large debris.

Strengthen Partnerships and Revenue Streams

While there are many potential management strategies to improve the ecological health of Big and Little Bear Lakes, it can be difficult to make lasting changes without a stable funding source and a shared vision between the community and the managing body. Strengthening partnerships and establishing sustainable revenue streams, while not a direct lake management activity, will help ensure the coordinated and long-lasting success of implemented management activities. Continuing to grow and foster community engagement is vital to obtaining stakeholder buy-in and to recruit passionate individuals to join leadership efforts. Before attempting any large management projects, the VHPD should ensure strong partnerships with stakeholders and residents exist to maintain momentum and achieve long-term goals.

Regular Website and Newsletter Updates

The Vernon Hills Park District has an active online presence and has many opportunities for residents to interact with public spaces. When new projects are being implemented, sharing the design vision for the result can help promote community interest and buy-in. This is especially important for any naturalization projects, as the initial stages can worry people who are concerned the result will be "weedy", unsafe, or not aesthetically pleasing.

Fishery Management

Fish Surveys

The most recent IDNR fishery survey was in 2008. Requesting an updated survey from the IDNR is needed to assess the relative health of the fishery. A private firm could also be contracted to perform the survey. A survey can help determine indicators such as if the size distribution of fish is healthy (i.e. not too many small, stunted fish), if there are any threatened or endangered species present, or if stocked fish are successfully reproducing. Ideally, a fishery survey would occur at least every 5 years. Some lake managers even perform annual surveys to reassess harvest limits and stocking guidelines. A fish survey can also determine if there are high abundances of ecologically damaging fish like common carp and whether control of them is needed.

Stocking Plans

The Parks Department works with their fish supplier and considers recommendations for stocking. A lake manager can obtain better control of algae and aquatic vegetation growth through a balanced fishery. Therefore, developing and following a stocking plan is recommended. The results of an updated fishery survey can help determine what species should be stocked and the frequency. For example, some lakes have an abundance of prey fish and only need to focus on stocking predatory species. These lakes may stock on a multi-year rotating basis, such as 4 years of only walleye, then 4 years of only pike, and so on.

Fish Habitat Improvements

Structures have been installed in recent years to provide shelter for fish and aggregate them to improve opportunities for anglers. The dead trees placed in shallow areas along the shore are a good example of improvements. Generally, natural materials are recommended for fish habitat placement, as they provide more complex structure than manmade objects. If the next fish survey does not find high levels of spawning success, it could be that the lakebed does not have ideal spawning conditions, such as low oxygen levels or soft sediment. Most fish prefer a firm substrate, so that the eggs do not sink into the sediment (Photo 51). If that is the case, restorative options such as installing aeration or dredging out accumulated silt in shallow spawning areas may need to be considered to improve fishery health.

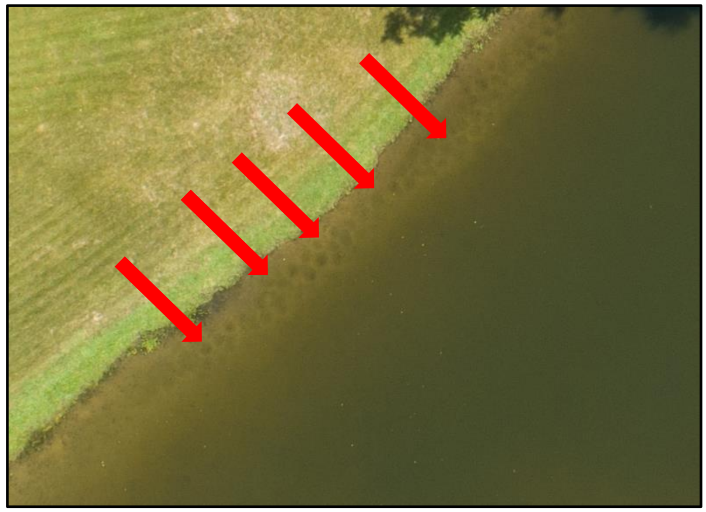

Photo 51. Bluegill nests along the shore of a pond (not Big or Little Bear Lake).

Carp Control

Carp were observed in the 2008 IDNR fish survey. Carp tend to uproot vegetation and stir up sediment while foraging, leading to higher water turbidity. The resuspended sediment can lead to more nutrient availability and an increase in nuisance algae blooms. Therefore, management to reduce the population of these fish is recommended to improve water quality.

Rotenone

The most common strategy for removing unwanted fish species is to use rotenone. This product will kill *all* fish in a waterbody. Because Big and Little Bear Lake appear to support a relatively healthy fishery based on angler feedback, rotenone is not recommended at this time. Coordination with the IDNR would be needed to apply rotenone.

Seining or Electroshocking

While more time consuming, seining or electrofishing can be done to target only carp. These methods are unlikely to remove all fish but can keep biomasses below the level where fish become damaging to the lake ecosystem. Typically, bait is left in a certain area of the lake during the winter. Fish congregate by the bait and then a seine net is used to gather the fish and remove them.

Carp Roundup & Encouraging Removal

A potential community engagement event that some lake associations partake in is a carp roundup. Anglers are given an allotted time to catch the most carp they can for a prize. If enough people partake, this strategy can be effective enough to keep carp biomass below damaging levels. Carp roundups can also act as educational opportunities for the community to learn how different fish species impact lake health. In addition to a carp-removal event, removing carp any time they are caught should be encouraged. The lake could establish a “no limit” for common carp removal.

GOALS, OBJECTIVES, & ACTIONS

Establishing clear goals and objectives is necessary for developing appropriate management strategies. Goals must align with the agreed upon vision for the lake as well as the needs of stakeholders in the community. Achievable goals consider the feasibility of reaching the desired outcome when considering budgetary, environmental, legal, and time constraints.

As outlined in the previous section, the management goals for Big and Little Bear Lakes are:

Goal 1: Manage aquatic vegetation and algae to promote native aquatic plant communities
Goal 2: Increase the ecological value and stability of the shoreline
Goal 3: Enhance the water quality of Big and Little Bear Lakes
Goal 4: Continue improving the fishery and other recreational opportunities on the lake

Each goal is followed by measurable objectives and actions to achieve each objective. A management timeline follows. This management plan is structured to provide recommendations at three budgetary levels – the current annual operating budget of approximately $8,000, an increased budget of $40,000 - $80,000, and additional projects that would likely require outside funding through grants or partnerships. This management plan is designed as a dynamic document and the timeline and objectives can and should be altered as funding sources develop or community focus changes.

Goal 1: Manage aquatic vegetation and algae to promote native aquatic plant communities

Objective 1.1: Reduce percentage of Eurasian watermilfoil in Bear Lakes to less than 10% of survey sites in 5 years and maintain curlyleaf pondweed and brittle naiad below 5% of the survey sites
- Action: Apply large-scale herbicide treatments to target dense invasive species growth throughout the lake
- Action: Apply spot treatments or mechanical removal in areas of infestation when densities are low and detected through surveys

Objective 1.2: Reduce aquatic vegetation density in high-traffic areas
- Action: Perform aquatic spot treatment herbicide or mechanical removal around fishing pier and bridges

Objective 1.3: Maintain 20-50% aquatic vegetation coverage in the lakes
- Action: Conduct an annual aquatic plant survey and update treatment plans with survey results annually to balance plant and algae growth

Objective 1.4: Reduce frequency and severity of blue-green algae blooms
- Action: Proactively treat blue-green algae in the lake, prior to becoming a large bloom
- Action: Install signs to help visitor identify and report HABs and stay out of the water when one occurs

Goal 2: Increase the ecological value and stability of the shoreline

Objective 2.1: Create a comprehensive shoreline management plan
- Action: Consult with ecological restoration firm or landscape designer to create a plan with a timeline and budget for implementation.

Objective 2.2: Increase the percentage of shoreline experiencing no erosion from 70% to 80% within 5 years
- Action: Repair areas of moderate erosion with rip rap and native plantings (biotechnical stabilization)
- Action: Stabilize areas of slight erosion with coir logs and native vegetation
- Action: Compare 2019 LCHD-ES shoreline erosion survey with next survey that occurs around 2026

Objective 2.3: Increase the percentage of shoreline with "good condition" buffer from 3.4% to 20% within 5 *years*

Action: Where no erosion is occurring, plant shoreline with up to 25-foot-wide native vegetative buffer
Action: Plant native buffer behind reaches stabilized with rock retaining wall
Action: Maintain buffer areas through 3-4 annual visits to control invasive species
Action: Compare 2019 LCHD-ES shoreline buffer survey with next survey that occurs around 2026

Objective 2.4: Stabilize shoreline reaches around and bridges and other infrastructure

Action: Consult with engineer to design repair plan for areas of “severe” erosion
Action: Work with agencies to procure funding for shoreline stabilization
Action: Implement repair plan

Objective 2.5: Improve access to the lake from shore

Action: Install fishing access rocks along shore
Action: Install a small pier in Little Bear Lake for fishing access near deepest point

Goal 3: Enhance the water quality of Big and Little Bear Lakes

Objective 3.1: Reduce trash presence in the lake

Action: Schedule at least 2 trash/debris removal visits each year

Objective 3.2: Monitor water quality in the lakes

Action: Develop a water quality monitoring plan
Action: Perform annual water quality monitoring on both lakes
Action: Survey sediment accumulation and quality near Big Bear Inlet

Objective 3.3: Reduce total suspended solids entering through Seavey Ditch

Action: Perform assessment on ditch between Charles Lake and Big Bear Lake
Action: Remove invasive shrubs growing along ditch north of Big Bear Lake and plan with deep-rooted native vegetation
Action: Work with golf course to improve buffers and reduce runoff

Objective 3.4: Reduce pollutants entering the waterway within the watershed

Action: Continue to educate residents, business owners, and municipalities within the watershed on methods to minimize fertilizer and road salt use

Objective 3.5: Reduce bacterial pollution from animal waste from entering the waterway

Action: Continue to discourage feeding of waterfowl around the park
Action: Continue to encourage owners to collect pet waste, provide bags

Goal 4: Continue improving the fishery and other recreational opportunities on the lake

Objective 4.1: Update fish survey

Action: Contact IDNR or private firm to update the fish survey for the lakes

Objective 4.2 Create stocking plan

Action: Use survey results to work with IDNR and stocking manager to create recommendations
Action: Follow plan in subsequent years

Objective 4.3: Reduce carp density in the lakes

Action: Update fishing regulations to allow take of carp and other harmful species
Action: Hold a community carp removal derby

Objective 4.4: Improve reported success of anglers

Action: Continue adding coarse woody debris in lakes
Action: Install signage to encourage anglers to provide feedback and report catches

MANAGEMENT TIMELINE

The proposed management timeline presented in Table 5 is designed to help meet goals by the dates set in the objectives (assuming year 1 is 2022). While many of these actions will be done on an as-needed basis, this timeline sets general expectations for what events might occur in a given year. Following the table is a more detailed breakdown of each action by year and budgetary level. The numbers preceding each action corresponds to the objective it addresses. Table 6 follows the timeline breakdown, condensing the estimated costs within a given year for the different objectives and cost brackets.

Main Goal Addressed	Objective	Recommended Management Action	Year 1	Year 2	Year 3	Year 4	Year 5
Goal 1: Manage aquatic vegetation and algae to promote native aquatic plant communities	1.1 Reduce invasive species presence management	Main aquatic herbicide application for dense populations	Medium	Medium	Medium	Medium	Medium
		Spot treat herbicide/ mechanical small populations		Dark	Dark	Dark	Dark
	1.2 Reduce density in high-traffic areas	Spot herbicide/ mechanical removal in high traffic areas	Dark	Dark	Dark	Dark	Dark
	1.3 Maintain 20-50% vegetation coverage	Aquatic vegetation survey and update mgmt. plans	Medium	Medium	Medium	Medium	Medium
	1.4 Reduce blue-green algae blooms	Proactively treat blue-green algae growth when seen	Medium	Medium	Medium	Medium	Medium
		Install signs to help identify and report HABs	Medium				
Goal 2: Increase the ecological value and stability of the shoreline:	2.1 Create shoreline plan	Shoreline restoration plan development	Medium				
	2.2 Reduce shoreline erosion	Biotechnical shoreline stabilization				Light	Light
	2.3 Improve buffer	Vegetative stabilization and buffer expansion		Medium	Medium	Medium	Medium
	2.4 Infrastructure stabilization	Infrastructure stabilization engineering and fundraising	Light	Light	Light		
		Infrastructure repair and stabilization				Light	
	2.5 Improve lake access from shore	Install fishing rock access points				Light	
		Install fishing pier in Little Bear Lake				Light	
Goal 3: Enhance the water quality of Big and Little Bear Lakes	3.1Trash removal	Trash removal from lakes	Medium	Medium	Medium	Medium	Medium
	3.2 Monitor water quality	Develop water quality monitoring plan	Medium				
		Implement annual water quality monitoring program		Medium	Medium	Medium	Medium
		Survey areas of sediment accumulation					Medium
	3.3 Reduce total suspended solids entering lake	Erosion assessment upstream of Big Bear Lake		Light			
		Upstream vegetation management			Light	Light	Light
		Work with golf course to decrease pollution runoff		Light			
	3.4 Reduce nutrient pollution	Continue pollution reduction education	Dark	Dark	Dark	Dark	Dark
	3.5 Reduce bacterial pollution	Discourage feeding waterfowl	Dark	Dark	Dark	Dark	Dark
		Encourage pet waste removal	Dark	Dark	Dark	Dark	Dark
Goal 4: Continue improving the fishery and other recreational opportunities on the lake	4.1 Update fish survey	Obtain updated fishery survey	Dark				
	4.2 Create stocking recommendations	Create fish stocking plan	Dark				
		Follow fish stocking guidelines	Dark	Dark	Dark	Dark	Dark
	4.3 Reduce carp populations	Update fishing regulations		Dark			
		Hold carp removal derby			Dark		
	4.4 Improve fishing success	Add coarse woody debris to lakes	Medium	Medium	Medium	Medium	Medium
		Implement feedback opportunity for anglers	Dark				

Table 5. Proposed management timeline. Dark blue cells can be pursued with existing budget ($8,000/year), Medium blue cells are recommended with increased revenue ($40,000+/year) and light blue cells would likely require outside funding sources, such as grants and partnerships.

Year 1

Within Existing Budget (Approximate cost: $4,500+)

1.2 – Apply spot herbicide treatments or perform mechanical removal around high-traffic areas as needed to allow for boat access and fishing. *Approximate cost: $2,000 - $3,000 per acre of herbicide. $1,800 - $3,000 per day of mechanical removal, depending on haul off*

2.1 – Consult with ecological consulting firm or landscape designer to create management plan for shoreline restoration and landscaping to improve the ecological health of the lakes and surrounding parkland. *Approximate cost: $2,000 - $8,000, depending on depth of design*

3.4 – Continue to educate residents, business owners and municipalities within the watershed on methods of minimize fertilizer and road salt use. LCHD-SMC offers educational materials and workshops to promote proper use of such products to reduce environmental harm. *Approximate cost: In-kind*

3.5 – Continue to discourage feeding of waterfowl and encourage removal of pet waster around the lakes and watershed through signage and providing disposal options *Approximate cost: In-kind*

4.1 – Contact IDNR or private firm to update fishery survey for the lakes. *Approximate cost: In-kind (IDNR) - $5,000 for private survey.*

4.2 – Use results of fishery survey to create a stocking plan for improving the health of the fishery. *Approximate cost: $0 - $1,000, depending on company consulted for plan.*

4.4 – Install signage to encourage angler feedback and report species caught and create a website to report data to. Use feedback to update stocking guidelines. *Approximate cost: $500 for 5 signs*

With Increased Revenue (Approximate cost: $34,300 +)

1.1 – Apply lake-wide Fluridone herbicide treatment to lake, preferably with a pelletized product. Work with applicator and product manufacturer to apply rate designed to impact invasive species but allow native species to grow to some extent, so as not to flip the lake to becoming algae dominated. *Approximate cost: $17,000 - $25,000 for 15 ppb Sonar One treatment to target Eurasian watermilfoil*

1.3 – Conduct a survey of aquatic vegetation in the lake and update treatment plan for the next year depending on the impact of management on plant populations. *Approximate cost*: $1,000 - $2,000 depending on point density

1.4 – Treat blue-green algae growth before it becomes a large bloom. Proactive, lake-wide treatments of the upper 2 feet may be required on a reoccurring basis during the warmer summer months *Approximate cost: $1,800-$2,700 per treatment of both lakes ($14,000+ for 8 visits)*

1.4 – Install signs to help visitors identify blue-green algae blooms and report them to the health department. Signs should be posted at boat launches or other access points were pets might enter the water. *Approximate cost: 500 for 5 signs*

3.1 – Have two scheduled trash removal visits, where the entire shoreline is boated and all debris removed, with special focus on fishing gear *Approximate cost: $900-$1,600 per visit, depending on amount of debris*

3.2 – Develop water quality monitoring plan. See Appendix B for example water quality sampling plan. Consider installing remote monitoring equipment to monitor for blue-green algae blooms *Approximate cost: $ In-kind*

4.4 – Continue adding coarse woody debris to the lake. *Approximate cost: In-kind if done by volunteers up to $10,000 for larger trees anchored professionally*

Grants and Partnerships (Approximate cost: $10,000+)

2.4 – Consult with engineer to create plan for repairing the reaches around and under the bridges and culverts experiencing severe erosion. The plans could also encompass the shoreline stabilization and installing fishing rocks and a pier to improve access to reduce permitting for multiple projects. *Approximate cost: $10,000 - $20,000, depending on scope*

2.4 – Work with other governmental agencies to produce funding for stabilizing and repairing infrastructure and shoreline erosion. *Approximate cost: In-kind - $100 per hour for grant writing consultation*

Year 2

Within Existing Budget (*Approximate cost: $5,500 +)*

1.1 - Apply spot herbicide treatments or perform mechanical removal in areas with small populations of invasives aquatic vegetation, as identified in the annual aquatic vegetation survey. *Approximate cost: $2,000 - $3,000 per acre of herbicide. $1,800 - $3,000 per day of mechanical removal, depending on haul off*

1.2 – Apply spot herbicide treatments or mechanical removal around high-traffic areas as needed to allow for boat access and fishing. *Approximate cost: $2,000 - $3,000 per acre of herbicide. $1,800 - $3,000 per day of mechanical removal, depending on haul off*

3.4 – Continue to educate residents, business owners and municipalities within the watershed on methods of minimize fertilizer and road salt use. LCHD-SMC offers educational materials and workshops to promote proper use of such products to reduce environmental harm. *Approximate cost: In-kind*

3.5 – Continue to discourage feeding of waterfowl and encourage removal of pet waster around the lakes and watershed through signage and providing disposal options *Approximate cost: In-kind*

4.2 – Follow the stocking guidelines established from the fishery survey and developed stocking plan. *Approximate cost: $1,000 - $2,000, depending on species, size, and amount of fish stocked*

4.3 – Update fishing guidelines according to IDNR recommendations, potentially to encourage removal of common carp or other undesirable species. *Approximate cost: $100 per sign*

With Increased Revenue (*Approximate cost: $43,000+)*

1.1 – If required, apply large-scale herbicide treatment to lake. Selected products should be adjusted to target desired species as determined from previous plant survey. Work with applicator and product manufacturer to determine best products and application rates to impact invasive species but allow native species to grow to some extent, so as not to flip the lake to becoming algae dominated. *Approximate cost: $10,000 - $30,000 depending on products used*

1.3 – Conduct a survey of aquatic vegetation in the lake and update treatment plan for the next year depending on the impact of management on plant populations. *Approximate cost*: $1,000 - $2,000 depending on point density

1.4 – Treat blue-green algae growth before it becomes a large bloom. Proactive, lake-wide treatments of the upper 2 feet may be required on a reoccurring basis during the warmer summer months *Approximate cost: $1,800-$2,700 per treatment of both lakes ($14,000+ for 8 visits)*

2.3 – Following the shoreline restoration plan developed by landscaped designer in Year 1, begin to stabilize shoreline. Figure 14 presents an example timeline for stabilizing different reaches, but costs and timelines will differ in shoreline restoration plan. The presented example is used to calculate approximate pricing to provide an idea of costs. In year 2, stabilizing approximately 1,265 linear feet with solely vegetative methods by converting turfgrass to native vegetation with a buffer width of 25 feet (0.72 acres). *Approximate cost: $16,000 - $30,000 per acre, depending on species selected, seeding versus plugs (est. $13,000 for 0.72 acres)*

2.3 – Following planting, 3-4 stewardship management visits will need to occur every year to control various invasive weedy species that may sprout in the natural areas. Visits need to occur throughout the growing season to control species that grow or seed at different times during the summer. *Approximate cost: $2,300 per season (includes 4 visits)*

3.1 – Have two scheduled trash removal visits, where the entire shoreline is boated and all debris removed, with special focus on fishing gear *Approximate cost: $900-$1,600 per visit, depending on amount of debris*

3.2 – Perform annual water quality monitoring according to deigned sampling schedule. An annual summary report should incorporate results of aquatic vegetation monitoring and other management activities that occurred to make updates to management recommendations for the following year. *Approximate cost: $1,500 per visit ($5,000 for 3 visits and annual report)*

4.4 – Continue adding coarse woody debris to the lake. *Approximate cost: In-kind up to $10,000 for large trees anchored professionally*

Grants and Partnerships (*Approximate cost: $16,000+)*

2.3 – If funding allows and following the shoreline management plan created in year, convert turfgrass to a native buffer behind the rock retaining walls, up to 25 feet in width. *Approximate cost: $16,000 - $30,000 per acre, depending on species selected, seeding versus plugs*

2.4 – Continue working with other governmental agencies to produce funding for stabilizing and repairing infrastructure and shoreline erosion. *Approximate cost: In-kind - $100 per hour for grant writing consultation*

3.3 – Perform erosion and buffer assessment of Seavey Ditch reach between Lake Charles and Big Bear Lake to identify sources of sediment and pollution runoff. Coordinate with golf course to identify potential sources of sediment and nutrient runoff from the course and propose mitigation measures. *Approximate cost: In-kind*

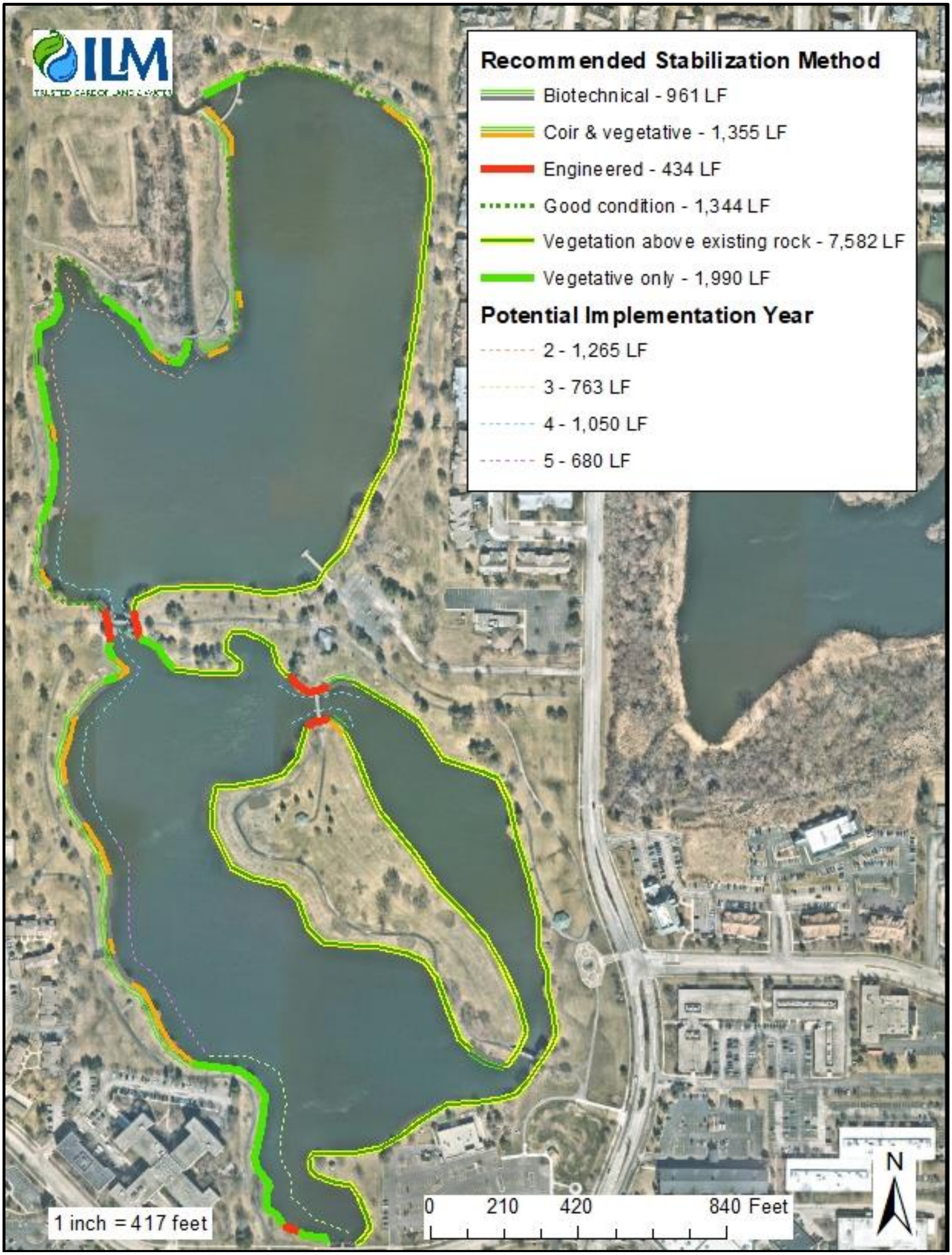

Figure 14. Potential shoreline stabilization timeline.

Year 3

Within Existing Budget (*Approximate cost: $6,000+)*

1.1 - Apply spot herbicide treatments or perform mechanical removal in areas with small populations of invasives aquatic vegetation, as identified in the annual aquatic vegetation survey. *Approximate cost: $2,000 - $3,000 per acre of herbicide. $1,800 - $3,000 per day of mechanical removal, depending on haul off*

1.2 – Apply spot herbicide treatments or mechanical removal around high-traffic areas as needed to allow for boat access and fishing. *Approximate cost: $2,000 - $3,000 per acre of herbicide. $1,800 - $3,000 per day of mechanical removal, depending on haul off*

3.4 – Continue to educate residents, business owners and municipalities within the watershed on methods of minimize fertilizer and road salt use. LCHD-SMC offers educational materials and workshops to promote proper use of such products to reduce environmental harm. *Approximate cost: In-kind*

3.5 – Continue to discourage feeding of waterfowl and encourage removal of pet waster around the lakes and watershed through signage and providing disposal options *Approximate cost: In-kind*

4.2 – Follow the stocking guidelines established from the fishery survey and stocking plan. *Approximate cost: $1,000 - $2,000, depending on species, size, and amount of fish stocked*

4.3 – Hold a community carp derby to encourage removal of undesirable species, if the fish survey done in Year 1 found high population levels of such species. *Approximate cost: $1,000 for coordinating event*

With Increased Revenue (*Approximate cost: $38,000+)*

1.1 – If required, apply large-scale herbicide treatment to lake. Selected products should be adjusted to target desired species as determined from previous plant survey. Work with applicator and product manufacturer to determine best products and application rates to impact invasive species but allow native species to grow to some extent, so as not to flip the lake to becoming algae dominated. *Approximate cost: $10,000 - $30,000 depending on products used*

1.3 – Conduct a survey of aquatic vegetation in the lake and update treatment plan for the next year depending on the impact of management on plant populations. *Approximate cost*: $1,000 - $2,000 depending on point density

1.4 – Treat blue-green algae growth before it becomes a large bloom. Proactive, lake-wide treatments of the upper 2 feet may be required on a reoccurring basis during the warmer summer months *Approximate cost: $1,800-$2,700 per treatment of both lakes ($14,000+ for 8 visits)*

2.3 – Continue following the shoreline restoration plan developed in Year 1, In year 3, stabilize approximately 763 linear feet with vegetative methods to a buffer width of 35 feet (0.44 acres).
Approximate cost: $16,000 - $30,000 per acre, depending on species selected, seeding versus plugs (est. $8,000 for 0.5 acres)

2.3 – Following planting, 3-4 stewardship management visits will need to occur every year to control various invasive weedy species that may sprout in the natural areas. Visits need to occur throughout the growing season to control species that grow or seed at different times during the summer. *Approximate cost: $2,300 per season (includes 4 visits)*

3.1 – Have two scheduled trash removal visits, where the entire shoreline is boated and all debris removed, with special focus on fishing gear *Approximate cost: $900-$1,600 per visit, depending on amount of debris*

3.2 – Perform annual water quality monitoring according to deigned sampling schedule. An annual summary report should incorporate results of aquatic vegetation monitoring and other management activities that occurred to make updates to management recommendations for the following year. *Approximate cost: Approximate cost: $1,500 per visit ($5,000 for 3 visits and annual report)*

4.4 – Continue adding coarse woody debris to the lake. *Approximate cost: In-kind up to $10,000 for larger trees anchored professionally*

Grants and Partnerships (*Approximate cost: $16,000+)*

2.3 – If funding allows and following the shoreline management plan created in year, convert turfgrass to a native buffer behind the rock retaining walls, up to 25 feet in width. *Approximate cost: $16,000 $30,000 per acre, depending on species selected, seeding versus plugs*

2.4 – Continue working with other governmental agencies to produce funding for stabilizing and repairing infrastructure and shoreline erosion. Finalize funding and plans. *Approximate cost: In-kind - $100 per hour for grant writing consultation*

3.3 – Work with other managing agencies in Vernon Hills to manage and restore the stretch of stream between Lake Charles and Big Bear Lake to reduce erosion, as identified in assessment in Year 2 of plan. *Approximate cost: unknown, dependent on survey findings*

Year 4

Within Existing Budget (*Approximate cost: $5,000+)*

1.1 - Apply spot herbicide treatments or perform mechanical removal in areas with small populations of invasives aquatic vegetation, as identified in the annual aquatic vegetation survey. *Approximate cost: $2,000 - $3,000 per acre of herbicide. $1,800 - $3,000 per day of mechanical removal, depending on haul off*

1.2 – Apply spot herbicide treatments or mechanical removal around high-traffic areas as needed to allow for boat access and fishing. *Approximate cost: $2,000 - $3,000 per acre of herbicide. $1,800 - $3,000 per day of mechanical removal, depending on haul off*

3.4 – Continue to educate residents, business owners and municipalities within the watershed on methods of minimize fertilizer and road salt use. LCHD-SMC offers educational materials and workshops to promote proper use of such products to reduce environmental harm. *Approximate cost: In-kind*

3.5 – Continue to discourage feeding of waterfowl and encourage removal of pet waster around the lakes and watershed through signage and providing disposal options *Approximate cost: In-kind*

4.2 – Follow the stocking guidelines established from the fishery survey and stocking plan. *Approximate cost: $1,000 - $2,000, depending on species, size, and amount of fish stocked*

With Increased Revenue (*Approximate cost: $73,000)*

1.1 – If required, apply large-scale herbicide treatment to lake. Selected products should be adjusted to target desired species as determined from previous plant survey. Work with applicator and product manufacturer to determine best products and application rates to impact invasive species but allow native species to grow to some extent, so as not to flip the lake to becoming algae dominated. *Approximate cost: $10,000 - $30,000 depending on products used*

1.3 – Conduct a survey of aquatic vegetation in the lake and update treatment plan for the next year depending on the impact of management on plant populations. *Approximate cost*: $1,000 - $2,000 depending on point density

1.4 – Treat blue-green algae growth before it becomes a large bloom. Proactive, lake-wide treatments of the upper 2 feet may be required on a reoccurring basis during the warmer summer months *Approximate cost: $1,800-$2,700 per treatment of both lakes ($14,000+ for 8 visits)*

2.2 – Continue following the shoreline restoration plan developed in Year 1, In year 4, stabilize approximately 550 linear feet with biotechnical methods to a buffer width of 25 feet (0.32 acres). Combining shoreline regrading with bridge stabilization project may reduce expenses and permitting effort. *Approximate cost: $16,000 - $30,000 per acre for planting vegetation, depending on species selected, seeding versus plugs, etc. $50 per linear foot of light regrading and coir log installation. $65 per linear foot for light regrading and rip rap (~$42,000 for 550 linear feet)*

2.3 – Following planting, 3-4 stewardship management visits will need to occur every year to control various invasive weedy species that may sprout in the natural areas. Visits need to occur throughout the growing season to control species that grow or seed at different times during the summer. *Approximate cost: $2,300 per season (includes 4 visits)*

3.1 – Have two scheduled trash removal visits, where the entire shoreline is boated and all debris removed, with special focus on fishing gear *Approximate cost: $900-$1,600 per visit, depending on amount of debris*

3.2 – Perform annual water quality monitoring according to deigned sampling schedule. An annual summary report should incorporate results of aquatic vegetation monitoring and other management activities that occurred to make updates to management recommendations for the following year. *Approximate cost: $1,500 per visit ($5,000 for 3 visits and annual report)*

4.4 – Continue adding coarse woody debris to the lake. *Approximate cost: In-kind up to $10,000 for larger trees anchored professionally*

Grants and Partnerships (*Approximate cost: $180,000 +)*

2.3 – If funding allows and following the shoreline management plan created in year, convert turfgrass to a native buffer behind the rock retaining walls, up to 25 feet in width. *Approximate cost: $16,000 - $30,000 per acre, depending on species selected, seeding versus plugs*

2.4 – Implement repair plan for scour around bridges and culverts, pending funding. Combining project with shoreline regrading and stabilization may reduce overall costs. *Approximate cost: $100,000 + depending on extent of damage*

2.5 – Install fishing pier in Little Bear Lake and large boulders along shore to improve access for anglers. Wrapping up permitting and project implementation with the infrastructure repairs and banks stabilization can help reduce overall costs. *Approximate cost: $50,000 - $100,000 + depending on scope of design*

3.3 – Continue coordinating with managing agencies in Vernon Hills to manage and restore and manage the stretch of stream between Lake Charles and Big Bear Lake to reduce erosion, as identified in assessment in Year 2 of plan. *Approximate cost: unknown, dependent on survey findings*

Year 5

Within Existing Budget (*Approximate cost: $5,000+)*

1.1 - Apply spot herbicide treatments or perform mechanical removal in areas with small populations of invasives aquatic vegetation, as identified in the annual aquatic vegetation survey. *Approximate cost: $2,000 - $3,000 per acre of herbicide. $1,800 - $3,000 per day of mechanical removal, depending on haul off*

1.2 – Apply spot herbicide treatments or mechanical removal around high-traffic areas as needed to allow for boat access and fishing. *Approximate cost: $2,000 - $3,000 per acre of herbicide. $1,800 - $3,000 per day of mechanical removal, depending on haul off*

2.2 & 2.3 – Compare 2019 buffer and shoreline stabilization maps created by LCHD-ES with next survey to determine if objectives to reduce erosion and increase buffer health have been met. *Approximate cost: In-kind*

3.4 – Continue to educate residents, business owners and municipalities within the watershed on methods of minimize fertilizer and road salt use. LCHD-SMC offers educational materials and workshops to promote proper use of such products to reduce environmental harm. *Approximate cost: In-kind*

3.5 – Continue to discourage feeding of waterfowl and encourage removal of pet waster around the lakes and watershed through signage and providing disposal options *Approximate cost: In-kind*

4.2 – Follow the stocking guidelines established from the fishery survey and stocking plan. *Approximate cost: $1,000 - $2,000, depending on species, size, and amount of fish stocked*

With Increased Revenue (Approximate cost: $80,000+)

1.1 – If required, apply large-scale herbicide treatment to lake. Selected products should be adjusted to target desired species as determined from previous plant survey. Work with applicator and product manufacturer to determine best products and application rates to impact invasive species but allow native species to grow to some extent, so as not to flip the lake to becoming algae dominated. *Approximate cost: $10,000 - $30,000 depending on products used*

1.3 – Conduct a survey of aquatic vegetation in the lake and update treatment plan for the next year depending on the impact of management on plant populations. *Approximate cost*: $1,000 - $2,000 depending on point density

1.4 – Treat blue-green algae growth before it becomes a large bloom. Proactive, lake-wide treatments of the upper 2 feet may be required on a reoccurring basis during the warmer summer months *Approximate cost: $1,800-$2,700 per treatment of both lakes ($14,000+ for 8 visits)*

2.2 – Continue following the shoreline restoration plan developed in Year 1, In year 5, stabilize approximately 680 linear feet with biotechnical methods to a buffer width of 25 feet (0.40 acres). *Approximate cost: $16,000 - $30,000 per acre for planting vegetation, depending on species selected, seeding versus plugs, etc. $50 per linear foot of light regrading and coir log installation. $65 per linear foot for light regrading and rip rap ($51,000+)*

2.3 – Following planting, 3-4 stewardship management visits will need to occur every year to control various invasive weedy species that may sprout in the natural areas. Visits need to occur throughout the growing season to control species that grow or seed at different times during the summer. *Approximate cost: $2,300 per season (includes 4 visits)*

3.1 – Have two scheduled trash removal visits, where the entire shoreline is boated and all debris removed, with special focus on fishing gear *Approximate cost: $900-$1,600 per visit, depending on amount of debris*

3.2 – Perform annual water quality monitoring according to deigned sampling schedule. An annual summary report should incorporate results of aquatic vegetation monitoring and other management activities that occurred to make updates to management recommendations for the following year. *Approximate cost: $1,500 per visit ($5,000 for 3 visits and annual report)*

3.2 – If silt accumulation in the lake appears to be impacting the hydrology of the lake, leading to increased nuisance aquatic plant and algae growth, or reducing the success of fish reproduction, areas where silt seems to be accumulating to the greatest degree. *Approximate cost: $1,500 - $6,000, depending on size of area surveyed.*

4.4 – Continue adding coarse woody debris to the lake. *Approximate cost: In-kind up to $10,000 for larger trees anchored professionally*

Grants and Partnerships (*Approximate cost: $30,000+)*

2.3 – If funding allows and following the shoreline management plan created in year 1, convert turfgrass to a native buffer behind the rock retaining walls, up to 25 feet in width. *Approximate cost: $16,000 - $30,000 per acre, depending on species selected, seeds versus plugs*

3.3 – Continue coordinating with managing agencies in Vernon Hills to manage and restore and manage the stretch of stream between Lake Charles and Big Bear Lake to reduce erosion, as identified in assessment in Year 2 of plan. *Approximate cost: unknown, dependent on survey findings*

	Year 1	Year 2	Year 3	Year 4	Year5
Existing Budget	**$4,500 +**	**$5,500 +**	**$6,000 +**	**$5,000 +**	**$5,000 +**
1.1 Spot Herbicide Smaller invasive spots	$2,000 - $3,000/acre	$2,000 - $3,000/acre	$2,000 - $3,000/acre	$2,000 - $3,000/acre	$2,000 - $3,000/acre
1.1 Mechanical Removal Smaller invasive spots	$1,800 - $3,000/day	$1,800 - $3,000/day	$1,800 - $3,000/day	$1,800 - $3,000/day	$1,800 - $3,000/day
1.2 Spot Herbicide High Traffic	$2,000 - $3,000/acre	$2,000 - $3,000/acre	$2,000 - $3,000/acre	$2,000 - $3,000/acre	$2,000 - $3,000/acre
1.2 Mechanical Removal High Traffic	$1,800 - $3,000/day	$1,800 - $3,000/day	$1,800 - $3,000/day	$1,800 - $3,000/day	$1,800 - $3,000/day
2.1 Professional Services Shoreline Restoration	$2,000 - $8,000				
2.2 - 2.3 LCHD-SMC					In Kind
3.4 Fert/Salt Reduce Publication	In kind	In Kind	In Kind	In Kind	In Kind
3.5 Discourage Feeding	In kind	In Kind	In Kind	In Kind	In Kind
4.1 IDNR Fish Survey	In Kind - $5,000				
4.2 Fish Stocking	$0 - $1,000	$1,000 -$2,000	$1,000 - $2,000	$1,000 - $2,000	$1,000 - $2,000
4.3 IDNR Signage		$100/ sign x 5			
4.3 Carp Catching Event			$1,000		
4.4 Angler Feedback Sign	$100/sign x 5				

Increased Budget	**$34,000 +**	**$43,000 +**	**$38,000 +**	**$73,000 +**	**$80,000 +**
1.1 Herbicide Treatment	$17,000 - $25,000	$10,000 - $30,000	$10,000 - $30,000	$10,000 - $30,000	$10,000 - $30,000
1.3 Aquatic Plant Survey	$1,000 - $2,000	$1,000 - $2,000	$1,000 - $2,000	$1,000 - $2,000	$1,000 - $2,000
1.4 Algae Treatment	$1,800 - $2,7000	$1,800 - $2,7000/visit x 8	$1,800 - $2,700/visit x 8	$1,800 - $2,700/visit x 8	$1,800 - $2,700/visit x 8
1.4 Algae Signage & Info	$100/sign x 5				
2.2 Shoreline				$16,000 - $30,000/acre	$16,000 - $30,000/acre
2.2 Coir Log or Rip Rap				$50/linear ft or $65/linear ft	$50/linear ft or $65/linear ft
2.3 Shoreline Restoration		$16,000 - $30,000	$16,000 - $30,000		
2.3 Land Stewardship		$2,300	$2,300	$2,300	$2,300
3.1 Trash/Debris	$900 - $1,600/visit	$900 - $1,600/visit	$900 - $1,600/ visit	$900 - $1,600/ visit	$900 - $1,600/ visit
3.2 Annual Monitoring	In Kind	$1,500/visit x 3	$1,500/visit x 3	$1,500/visit x 3	$1,500/visit x 3
3.2 Silt survey					$1,500 - $6,000
4.4 Woody Fish	In Kind - $10,000	In Kind - $10,000	In Kind - $10,000	In Kind - $10,000	In Kind - $10,000

Grants/Outside	**$10,000 +**	**$16,000 +**	**$16,000 +**	**$180,000 +**	**$30,000 +**
2.3 Shoreline Restoration		$16,000 - $30,000/acre	$16,000 - $30,000/acre	$16,000 - $30,000/acre	$16,000 - $30,000/acre
2.4 Bridge Erosion	$10,000 - $20,000			$100,000 +	
2.4 Grant Writing	In Kind - $100/hr	In Kind - $100/hr	In Kind - $100/hr		
2.5 Fishing Outcroppings				$50,000 - $100,000 +	
3.3 Creek/Ditch Survey	N/A	N/A	N/A	N/A	N/A

Table 6. Estimated minimum budget for Lake Management Plan.

EVALUATION & MOVING FORWARD

The Big and Little Bear Management Plan was designed as a dynamic document, which can be adjusted as management priorities change.

Potential Grant Opportunities

Grants are an important way fund management activity for larger projects. Most grantors encourage partnerships and lean towards funding projects that benefit multiple stakeholders. Working with the local watershed group can be one way to take a partnership approach to a project. The grants identified as most applicable the Big and Little Bear Lake and therefore the most likely to be successfully applied to are listed in Table 7. While these grants are best suited for directly improving water quality for Big and Little Bear Lake, there are many other grant opportunities available, which may indirectly improve water quality. Contacting local management groups can help identify additional opportunities that may fit with a desired project.

Source	Grant	Project Amount and Match	Purpose	Eligibility
Illinois Environmental Protection Agency (IEPA)	Green Infrastructure Grant Opportunity (GIGO)	$75,000 - $2.5 million, Minimum 25% match (15% for underserved communities)	Install stormwater management technique or practice employed with the primary goal to preserve, restore, mimic or enhance natural hydrology	Watershed groups, land conservancies, private institutions, nonprofits organizations, units of government (County, municipal, township or state), universities or colleges. Must be GATA certified.
LCSMC	WMB (Watershed Management Board) Cost Share Projects	$20,000-$50,000, 50%/50% match	projects that reduce flood damage, improve water quality and/or protect natural resources.	HOA's, nonprofits, local units of government
USFWS	North American Wetlands Conservation Act – Small Grants	Up to $100,000, At least 1:1 matching funds	Long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitats for the benefits of all wetlands associated migratory birds	Tribal, State, or local unit of gov't, nongovernmental organization, or individual
National Fish and Wildlife Foundation	5 Star Wetland and Urban Waters Restoration Grant Program	$10,000-$40,000	Environmental education and training for students, conservation corps, youth groups, citizen groups, corporations, landowners and government agencies through projects that restore wetlands and streams.	Non-profit 501(c) orgs, state gov't agencies, local & municipal gov'ts, Indian tribes, educational institutions
IEPA	Section 319(h) Nonpoint Source Pollution Control Financial Assistance Program	Up to 60% of eligible project costs; minimum 40% local match requirement in cash and/or in kind services. No set limit on awards.	Any entity that has legal status to accept funds from the state of Illinois, incl. state & local gov'ts, nonprofit orgs, citizen & environmental groups, individuals, businesses.	Funds may be used for the development, update, and implementation of watershed based management plans including the development of information/education programs and for the installation of best management practices.
IEPA	Illinois Clean Lakes Program	Phase 1: $75,000 Phase 2: $300,000 *When funding appropriated*	Owners/managers of lakes that have public access.	Two types of grants are awarded: Phase I identifies problems and sources of pollution. Phase II grants support implementation or procedures recommended in the Phase I report to improve water quality.
ComEd	Green Region Program	Up to $10,000 50% match requirement	Public agencies w/in ComEd's service territory	Open space planning, acquisition, or improvements for local parks, natural areas, and recreation resources.

Table 7. Potential funding opportunities for management activities.

The Illinois Environmental Protection Agency offers two grants appropriate for lake communities. The Green Infrastructure Grant Opportunity (IGOG) funds projects that deal with stormwater and flooding. The 319 (h) funds projects that improve water quality by addressing sources of non-point source pollution. It should be noted that both require pre-registration through the Grant Accountability and Transparency Act (GATA) and these requirements are significant. Some of the GATA pre-registration requirements include the DUNS #, FEIN, and SAMS Cage Code. Because of the complexity of applying for these grants, partnering with LCSMC is recommended if considering a 319 grant. LCSMC will manage all aspects of grant writing and project management for a 10% fee. LCSMC does not manage IGOG grants. There are also programmatic and fiscal and administrative risk assessments, and any requirements that they generate, including development of a 'fraud awareness program''. There are also in-progress and post project reporting requirements. Groups that aren't already GATA-ready can partner with an organization that is already GATA-ready. Local soil and water conservation districts, counties, municipalities, etc. are good possibilities. Depending on their staffing levels, Lake County SMC will sometimes manage IEPA grant writing and reporting for an HOA for a 10% administration fee.

APPENDIX A – Referenced Reports

Date	Report Type	Author	Summary
2009	Watershed Plan	LCSMC, AES	Indian Creek Watershed-Based Plan
2012	Summary Report	LCHD-ES	2012 Big and Little Bear Lake Summary Report
2019	Summary Report	IEPA	2019 Little Bear and Big Bear Lakes Resource Assessment
2019	Summary Report	LCHD-ES	2019 Big and Little Bear Lake Summary Report
2019	Master Plan	VHPD	2019-2013 Parks Master Plan

APPENDIX B – Example Water Quality Testing Parameters

Test water quality parameters three times per year (May, July, September) using standard sampling methods and lab analyses. Field parameters to be tested at the **four** in-lake sites (two in Big Bear, two in Little Bear) include dissolved oxygen profile, depth, pH profile, secchi depth, temperature profile, alkalinity, conductivity, suspended sediment, algae, weeds. Chemical and biological parameters to be tested from **one site in each lake** include BOD, COD, chloride, nitrogen ammonia, nitrogen nitrate/nitrite, Kjeldahl nitrogen , orthophosphorus, phosphorus total, total suspended solids, total dissolved solids, total volatile solids, chlorophyll *a*, *e. coli*, phytoplankton, and zooplankton. Provide written reports to include the data obtained and a detail annual report interpreting the results and their implications for lake management.