Kitsap County
Long Lake Management District
614 Division Street
Port Orchard, WA 98366

INTEGRATED AQUATIC VEGETATION MANAGEMENT PLAN - DRAFT

Long Lake

TETRA TECH

With review by:

ESA

August 2022

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Long Lake

August 2022

PRESENTED TO

Kitsap County
Long Lake Management District
614 Division Street
Port Orchard, WA
98366

PRESENTED BY

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ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
Al/L	aluminum per liter
µg/L	micrograms per liter
DNR	Washington State Department of Natural Resources
Ecology	Washington Department of Ecology
EPA	U.S. Environmental Protection Agency
°C	degrees Celsius
CILL	Citizens for Improving Long Lake
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
HAB	harmful algae bloom
HPA	Hydraulic Project Approval
mg/L	milligrams per liter
NWCB	Washington State Noxious Weed Control Board
NWI	National Wetland Inventory
PCBs	polychlorinated biphenyls
Plan	Integrated Aquatic Vegetation Management Plan
spp.	species pluralis (Latin abbreviation for multiple species)
TMDL	Total Maximum Daily Load
WDFW	Washington Department of Fish and Wildlife
WISC	Washington Invasive Species Council
WSDA	Washington State Department of Agriculture

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GLOSSARY

Term	Definition
Anoxic	*Completely lacking in oxygen.*[1]
Humic	*Rich in organic material*
Hypolimnion	*The bottom, and most dense layer of a stratified lake. It is typically the coldest layer in the summer and warmest in the winter. It is isolated from wind mixing and typically too dark for much plant photosynthesis to occur.*[1]
Epilimnion	*The upper, wind-mixed layer of a thermally stratified lake. This water is turbulently mixed throughout at least some portion of the day and because of its exposure, can freely exchange dissolved gases (such as O2 and CO2) with the atmosphere.*[1]
Euphotic zone	*Layer of water where sunlight is sufficient for photosynthesis to occur*.[1]
Eutrophic	*Pertaining to a lake or other body of water characterized by large nutrient concentrations such as nitrogen and phosphorous and resulting high productivity. Such waters are often shallow, with algal blooms and periods of oxygen deficiency.*[2] *Productivity refers to biological productivity, e.g., the growth of plants and algae.*
Littoral	*Nearshore [zone] out from shore to the depth of the euphotic zone where it is too dark on the bottom for [aquatic plants] to grow.*[1]
Palustrine	*Pertaining to a marsh or wetlands; wet or marsh habitats.*[2]
Rotovation	*The use of aquatic rotovators that have underwater rototiller-like blades to uproot aquatic plants as a means of control.*[3]
Thermal Stratification	*Existence of a turbulently mixed layer of warm water (epilimnion) overlying a colder mass of relatively stagnant water (hypolimnion) in a water body due to cold water being denser than warm water coupled with the damping effect of water depth on the intensity of wind mixing.*[1]

[1] Source: Water on the Web, 2011
[2] Source: NALMS, 2018
[3] Source: WDFW, 2015

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EXECUTIVE SUMMARY

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Long Lake is a shallow, lowland lake located approximately 4 miles south of Port Orchard on the Kitsap Peninsula. The Long Lake watershed drains approximately 6,016 acres (9.4 square miles) within southern Kitsap County. Historically, the Long Lake watershed consisted primarily of unproductive lowland forests and small agricultural operations. Over the past several decades, there has been an accelerated transition from a rural to more suburban watershed with increased residential and commercial development on all sides of the lake. The watershed currently encompasses increasingly urbanized land uses.

Long Lake is a multi-use resource, supporting a variety of human and wildlife uses. Long Lake is a popular site for recreation and is frequently used by lake residents as well as the larger community. Beneficial uses of Long Lake include swimming; fishing; motorized and non-motorized boating; aesthetic value; fish migration; resident fish spawning and rearing; and aquatic habitat. The water quality of Long Lake has been extensively characterized since the early 1970s. Long Lake is a very productive and eutrophic waterbody that suffers from poor water quality at times. Dense growth of invasive aquatic plants has severely impeded recreational beneficial uses and negatively impacted the aquatic habitat in the lake. There has been a long history of aquatic plant management in Long Lake that dates back to the late 1970s. Historic aquatic plant control has included various manual, mechanical, chemical, and environmental manipulation methods.

Dense invasive aquatic plants, as well as excessive growth of native plants, has negatively impacted navigation, recreational activities, water quality, and aquatic habitat in Long Lake for several decades. Recently excessive non-native plant growth and increases in plant coverage and density have caused dangerous recreation and safety conditions. Some lake residents and users have also reported that they can no longer enjoy activities such as boating, kayaking, canoeing, swimming and fishing due to the excess expansion of aquatic plants.

The excessive growth of the non-native fragrant water lily or white lily (*Nymphaea odorata*) in recent years has resulted in floating masses of aquatic plant material, especially at the southern end of the lake. In 2020, one of these masses became a free-floating island and posed a significant hazard to lake users, and directly impacted aquatic habitat both physically and chemically. The excessive vegetation has also led to sediment accretion, and lake depth is decreasing in most locations due to sedimentation from largely organic material from aquatic plant vegetation. This is accelerating the overall production within the lake and contributing to the eutrophication process and lake aging.

Aquatic plant surveys in May and September 2021 found that the non-native invasive species Brazilian elodea (*Egeria densa*) and fragrant water lily dominate the aquatic vegetation community in Long Lake. Brazilian elodea is listed as a Class B weed by the WA State Noxious Weed Board and is designated as a weed of concern by the Kitsap County Noxious Weed Board. Note that in the 1990's, Brazilian elodea covered over 80% of the lake but density and cover have been reduced through management activities in 2006 through 2010 and 2018 through 2021. Fragrant water lily is listed as a Class C Weed by the WA State Noxious Weed Board. The aquatic plant surveys in 2021 also found scattered patches of the non-native curlyleaf pondweed (*Potamogeton crispus*), listed as a Class C weed by the WA State Noxious Weed Board and designated as a weed of concern by Kitsap County.

In the fall/winter of 2021, Kitsap County applied for and awarded a small grant from the Washington Department of Ecology (Ecology) to develop a plan to manage the invasive aquatic plants in Long Lake and bring back a balanced plant community that will improve navigation, aquatic habitat, recreational activities, and the overall water quality and health of the lake.

The overall goal of this Integrated Aquatic Vegetation Management Plan (Plan) are to reduce the distribution and density of invasive aquatic plant in Long Lake to support the lake's beneficial uses. Specific aquatic plant management goals include:

- Improve recreation usability, safety, and navigability of the lake
- Improve water quality and overall lake health and restore a balanced lake ecosystem
- Keep swimming areas and boat launch areas clear of plants for optimal usability and safety
- Improve habitat for fish and other aquatic species
- Maintain beneficial uses including recreation, wildlife use, water quality, water rights, and aesthetics
- Slow lake aging and the eutrophication process, and manage aquatic plants to help limit harmful algae bloom (HAB) events
- Eradicate small infestations of non-native invasive plant species, specifically curlyleaf pondweed, if possible
- Educate residents and lake users on the spread and prevention of invasive aquatic plant species establishment in the lake
- Educate landowners on available, effective, control options for fragrant water lily that they can individually implement near their shorelines to complement and support the overall community plan
- Prevent the spread of invasive species to and from Long Lake
- Develop long-term, on-going funding sources for integrated adaptive plant management

In Long Lake, management of aquatic invasive plant species will prioritize shorelines and nearshore areas (out to approximately 8 to 10 ft deep), high-use recreational areas, and the south end of the lake where the non-native fragrant water lily has significantly expanded in density and coverage. This will prioritize most residential swimming and boat areas. The high-use recreational areas include the shoreline and lake area near the Long Lake County Park at the north end of the lake as well as the Washington Department of Fish and Wildlife (WDFW) boat launch on the western shore.

The recommended plan is…

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The proposed alternative will target invasive species in areas where beneficial uses are currently impeded by excessive plant growth. This will greatly improve conditions for recreation and other beneficial uses of the lake. In addition, controlling the population of invasive aquatic plants will lead to an increase in the diversity of aquatic plants, improving the quality of aquatic habitat.

1.0 INTRODUCTION

1.1 PROBLEM PLANTS IN LONG LAKE

Invasive and non-native aquatic plants (also referred to as aquatic noxious weeds and aquatic invasive species) threaten the health of lakes as they displace the native plant community, negatively impact fish and aquatic habitat, and decrease water quality. Invasive plants also can directly interfere with recreational activities including swimming, boating, and fishing.

Long Lake, Kitsap County, has a documented presence of noxious invasive non-native aquatic plants that have impaired water quality and caused dangerous recreation and safety conditions that have required costly responses. Long Lake suffers from infestations of three priority noxious weeds that are affecting the health of the lake, have reduced the lake's open water area, and have accelerated lake aging or eutrophication. These noxious weeds also pose a threat to other area lakes. Long Lake also has dense growth of a native pondweed along the littoral shorelines that could potentially negatively impact lake health. The noxious weeds observed in Long Lake include:

- *Nymphaea odorata* (Fragrant waterlily)
  - Class C Weed – WA State Noxious Weed Board
- *Egeria dense* (Brazilian elodea)
  - Noxious Weed of Concern – Kitsap County
  - Class B Weed – WA State Noxious Weed Board
- *Potamogeton crispus* (Curlyleaf pondweed)
  - Noxious Weed of Concern – Kitsap County
  - Class C Weed – WA State Noxious Weed Board
- (Note *Myriophyllum spicatum* [Eurasian Watermilfoil] was previously present in the lake but has not been observed during plant surveys in 2019 through 2021 due to past aquatic plant management activities)

Figure 1-1 shows recent coverage and extent of aquatic plants in Long Lake. A full discussion of the aquatic plant community in Long Lake and the threat they pose is provided in Section 6.

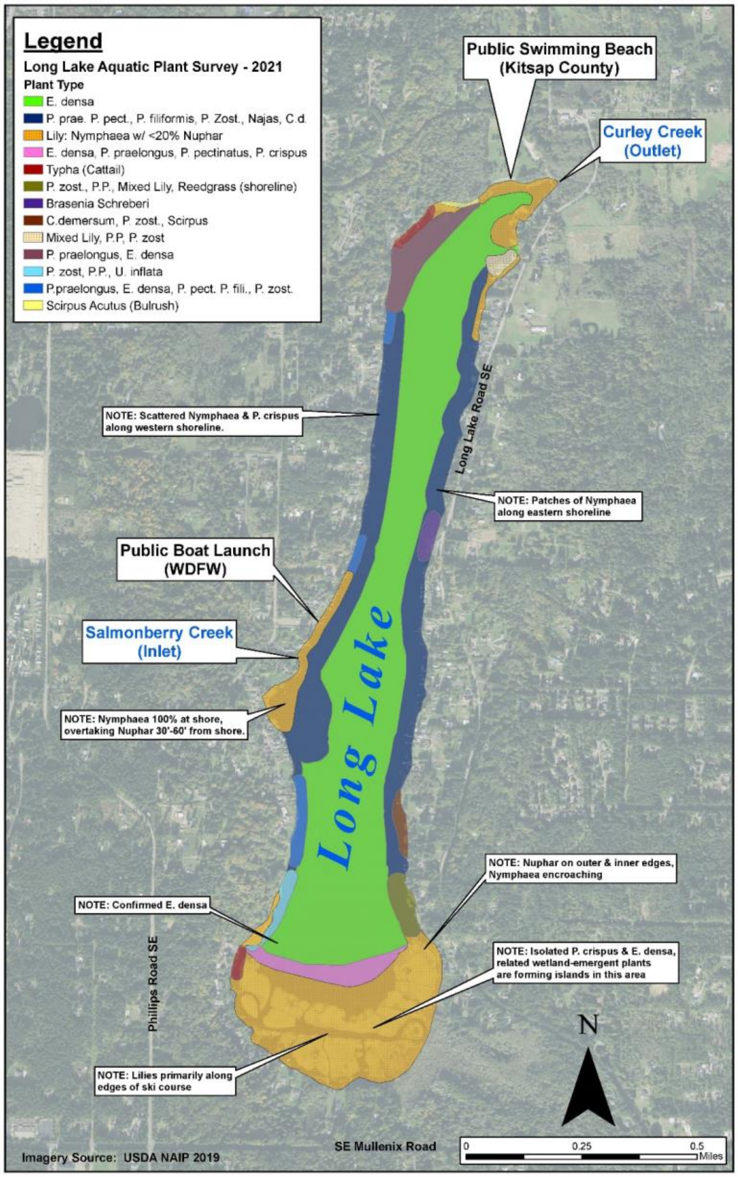

Figure 1-1. Aquatic plant coverage and extent in Long Lake, 2021 Aquatic Plant Survey

1.2 BENEFICIAL USES DISRUPTED BY PROBLEM PLANTS

Dense growth of invasive aquatic plants significantly disrupts several beneficial uses in Long Lake including swimming, recreational fishing, the use of motorized boats and non-motorized vessels; aesthetic value; property values; resident fish spawning and rearing and overall aquatic habitat.

1.3 PROBLEM STATEMENT

Dense invasive aquatic plants, as well as excessive growth of native plants, has negatively impacted navigation, recreational activities, water quality, and aquatic habitat in Long Lake for several decades. Recently excessive non-native plant growth and increases in plant coverage and density have caused dangerous recreation and safety conditions. Some lake residents and users have also reported that they can no longer enjoy activities such as boating, kayaking, canoeing, swimming and fishing due to the excess expansion of aquatic plants.

The excessive growth of the non-native fragrant water lily or white lily (*Nymphaea odorata*) in recent years has resulted in floating masses of aquatic plant material, especially at the southern end of the lake. In 2020, one of these masses became a free-floating island and posed a significant hazard to lake users, and directly impacted aquatic habitat both physically and chemically. The excessive vegetation has also led to sediment accretion, and lake depth is decreasing in most locations due to sedimentation from largely organic material from aquatic plant vegetation. This is accelerating the overall production within the lake and contributing to the eutrophication process and lake aging.

The overly dense growth of non-native aquatic plants also greatly impairs habitat for fish and other aquatic species. Non-native plants displace native species which provide a critical food source and cover for fish and aquatic life. The dense growth and decay of invasive plants negatively impacts lake water quality by increasing nutrient recycling and lowering dissolved oxygen (DO). Overall, the excessive plant growth has and will continue to diminish lake aesthetics, impair beneficial uses, and lower property values.

Aquatic plant surveys in May and September 2021 found that the non-native invasive species Brazilian elodea and fragrant water lily dominate the aquatic vegetation community in Long Lake. Brazilian elodea is listed as a Class B weed by the WA State Noxious Weed Board and is designated as a weed of concern by the Kitsap County Noxious Weed Board. Note that in the 1990’s, Brazilian elodea covered over 80% of the lake but density and cover have been reduced through management activities in 2006 through 2010 and 2018 through 2021. Fragrant water lily is listed as a Class C Weed by the WA State Noxious Weed Board. The aquatic plant surveys in 2021 also found scattered patches of the non-native curlyleaf pondweed (*Potamogeton crispus*), listed as a Class C weed by the WA State Noxious Weed Board and designated as a weed of concern by Kitsap County.

Several native aquatic plant species were also observed during the surveys in 2021 including several native pond weeds, the most dominant being the white-stemmed pondweed (*Potamogeton praelongus*), as well as, coontail (*Ceratophyllum demersum*), water-shield (*Brasenia schreberi*), and yellow waterlily (*Nuphar polysepala*). Dense growth of white-stemmed pondweed has at times negatively impacted the lake’s beneficial uses.

Adaptive management of non-native invasive plant species will bring back a balance plant community that will improve navigation, aquatic habitat, recreational activities, and the overall water quality and health of the lake.

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2.0 COMMUNITY INVOLVEMENT

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2.1 ORGANIZATIONS INVOLVED IN LAKE MANAGEMENT

Organizations and entities that have been involved in the management of Long Lake include WA Department of Ecology (Ecology), Kitsap County, Citizens for Improving Long Lake (CILL) and the University of Washington (UW). UW conducted a 20-year study on Long Lake aquatic plant community during the 1970s through 1990s. Water Environmental Services and KCM prepared an Integrated Aquatic Vegetation Management Plan (IAVMP) for Long Lake in 1997. This IAVMP was prepared for the Kitsap County Fair and Parks Department and the Save Long Lake Association.

Kitsap County applied to Ecology for funding to develop this IAVMP. Upon receipt of funding, the Long Lake steering committee was formed to help guide the plan and the general management of plants in Long Lake. The steering committee includes representatives from Kitsap County, Tetra Tech, CILL, and several Long Lake residents and locals that use the lake for swimming and other forms of recreation.

2.2 LAKE AND COMMUNITY RESIDENTS

Commented [BS4]: Get input from Kitsap County

How have residents been involved? What management actions have they taken on themselves?

Lake and community residents have been involved in Long Lake management efforts through participation in CILL and the Lake Management District (LMD), as well as through volunteer water quality monitoring efforts. In addition, some residents along shore of the lake have attempted to control aquatic plants in the vicinity of their docks by cutting and/or raking.

2.3 STEERING COMMITTEE MEETINGS

The Long Lake Steering Committee met virtually on February 16, 2022 and on June 21, 2022. At these meetings, the group discussed management goals, priority target areas, and preferred control options. The first meeting focused on the 2021 plant survey findings, key invasive plant species found and all potential management options for each plant. The steering committee provided input to identify the problem statement and attainable and measurable goals for the plan. They also voiced concerns over potential management options. After the first meeting, the committee provided feedback on the draft plan problem statement and management goals.

The second steering committee meeting included clarification of plant-specific goals, a review of all applicable management options, proposal of recommended management alternatives for all target invasive species, and methods to prevent new invasive species. The steering committee provided input on proposed plant management options to recommend to the Long Lake community via email and through completion of a survey following the meeting. The steering committee agreed upon several management goals as well as the proposed recommended management options. The steering committee meeting presentations were posted on the LMD website for all interested community members to view.

2.4 PUBLIC MEETING

Commented [BS5]: Update after public meeting in September

A public meeting was held…

A copy of the public meeting presentation, a copy of the sign-in sheet, and a summary of comments received at the meeting are included in Appendix A.

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3.0 MANAGEMENT GOALS

3.1 MANAGEMENT AREA

In Long Lake, management of aquatic invasive plant species will prioritize shorelines (out to approximately 8 to 10 ft (2.4 to 3.0 m) deep), high-use recreational areas, and the south end of the lake where the non-native fragrant water lily has significantly expanded in density and coverage. This will prioritize most residential swimming and boat areas. The high-use recreational areas include the shoreline and lake area near the Long Lake County Park as well as the Washington Department of Fish and Wildlife (WDFW) boat launch.

3.2 MANAGEMENT GOALS

The overall project goal is to reduce the distribution and density of invasive aquatic plants in Long Lake to support beneficial uses. Specific aquatic plant management goals include:

- Improve recreation usability, safety, and navigability of the lake
- Improve water quality and overall lake health and restore a balanced lake ecosystem
- Keep swimming areas and boat launch areas clear of plants for optimal usability and safety
- Improve habitat for fish and other aquatic species
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- Develop long-term, on-going funding sources for integrated adaptive plant management

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4.0 WATERSHED AND WATERBODY CHARACTERISTICS

4.1 LONG LAKE WATERSHED

The Long Lake watershed drains approximately 6,016 acres (9.4 square miles) in southern Kitsap County, in western Washington State. Historically, the Long Lake watershed consisted primarily of unproductive lowland forests and small agricultural operations (McConnel et al., 1976). Over the past several decades, there has been an accelerated transition from a rural to more suburban watershed with increased residential and commercial development on all sides of the lake (WATER et al., 1997). The watershed currently encompasses increasingly urbanized land uses.

Salmonberry Creek is the major inlet to Long Lake, entering on the western shore. Several unnamed streams enter at the southern end of the lake. The single outlet, Curley Creek, drains the lake at the northeastern end and eventually flows into the Puget Sound.

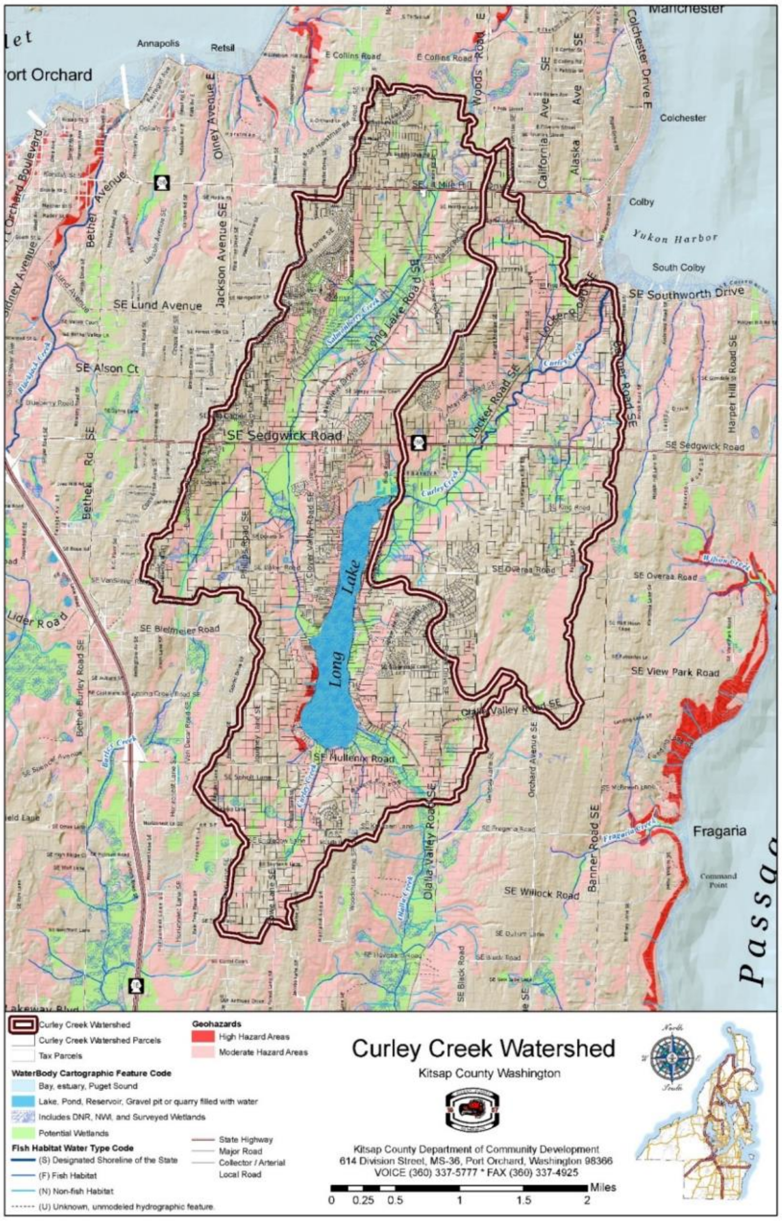

Figure 4-1. Map of Long Lake (Curley Creek) Watershed and surrounding area

4.2 LAND USE ACTIVITIES IN WATERSHED

Land use activities in the Long Lake watershed are primarily rural residential. Other activities include public recreation and county management. Along the southern, eastern, and western lake shore are residential houses and private lots. The 27-acre Long Lake County Park resides at the north end of the lake and was acquired as a result of the Lake Rehabilitation Project conducted on Long Lake in the mid-1970s (WATER et al., 1997). The watershed is within a moderately developed area with 59.5% of the watershed covered with forest canopy (USGS StreamStats, 2022).

4.2.1 MAJOR STREAMS AND WETLANDS IN WATERSHED

The topography of the area is such that Long Lake forms a low point with surrounding areas contributing drainage directly to the lake via surface flow and overland flow (runoff). Salmonberry Creek, which enters on the western shore, is the major inlet stream and maintains perennial flow throughout the year. Curley Creek is the outlet that drains the lake at the northeastern end. There has also been evidence that considerable subsurface inflow of water may occur around the lake in the form of interflow or groundwater movement (WATER et al., 1997).

Wetlands in the watershed include freshwater forested/shrub wetlands along upstream Salmonberry Creek east of Port Orchard and along the unnamed streams on the south end of Long Lake. Freshwater emergent wetlands appear in several locations along Salmonberry Creek and its tributaries. The south end of Long Lake is also a freshwater emergent wetland, as well as a few small sections of the unnamed streams to the south. Just outside the southeast shore of the lake is a small pond (Figure 4-2).

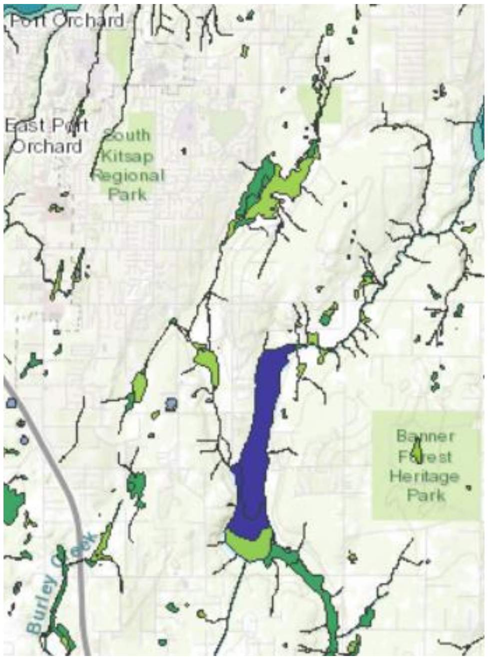

Figure 4-2. Map of wetlands in Long Lake watershed Source: National Wetlands Inventory, 2022

4.2.2 NON-POINT NUTRIENT SOURCES IN WATERSHED

Stormwater runoff in the Long Lake watershed is collected in storm drains and is discharged into Salmonberry Creek through seven outfalls, eventually flowing into Long Lake. Ecology requires that new developments in Western Washington with substantial new or replaced hard surface include flow control and water quality treatment. The lake receives direct surface runoff from lawns and pavement in the residential neighborhoods abutting the lake to the west, south, and east as well as from Long Lake Park to the north. As 40 to 50 percent of the full watershed is covered by impervious surfaces, surface runoff is generated quickly during storm events. This runoff may transport contaminants such as sediment, trash, zinc, copper, and fertilizers to the lake.

Commented [BS6]: Need input from Kitsap County to confirm, revise, or provide additional information

Need to confirm # of storm drains
Need to confirm amount of impervious surfaces

Commented [GH7R6]: Note that the overall nutrient average concentration has averaged about 35 mg/L P over the past two decades, due in part to KC management and buffering. This is below the average Puget Sound stream concentration of 50 mg/L P for background levels.

4.3 LONG LAKE

Long Lake is a shallow, lowland lake located approximately 4 miles south of Port Orchard in southern Kitsap County (Figure 4-3). Long Lake has a surface area of 339 acres (137 hectare) and a historical volume of approximately 2,200 acre-ft. The perimeter of the lake is approximately 26,700 linear feet (Ecology, 1998). A bathymetric survey was conducted in 1976 (Figure 4-4). At that time, the center depth of the lake was 12 ft (4 m) and the average depth was 6.5 feet (2 m) (Bortleson et. al., 1976). Nearly 75% of the lake is less than 10 ft (3 m) in depth, providing a large littoral area. Accelerating lake aging in the past 10 years and dense expansion of aquatic plants most likely has led to some lake shallowing. However, a recent bathymetric survey has not been completed.

The Long Lake basin is somewhat spoon shaped, stretching nearly two miles in length. Previous studies have discussed the lake in terms of four different basins, based on substrate type, water depth, and macrophyte community (Jacoby, 1981; WATER et. al., 1997). The north basin consists of narrow shoreline (< 6.5 ft [2 m]), with steep slopes and heterogeneous substrate. The north basin has been described as comprising 14% of the lake area. The deep (6.5 – 12 ft [2 – 3.5 m]) mid-lake basin represents 51% of the lake area, and has flocculent, find-grained sediments. The south basin accounts for 17% of the lake area and is gently sloping with depths between 6.5 and 10 ft (2 and 3 m). The final basin is the very shallow “south lilies region” which averages less than 3 ft (1 m) in depth and represents 18% of the lake area. This “south lilies region” has historically been densely populated by waterlilies both native *Nuphar* species (spatterdock) and non-native fragrant waterlily (WATER et. al., 1997).

Figure 4-3. Map of Long Lake and surrounding area Source: Tetra Tech, 2022

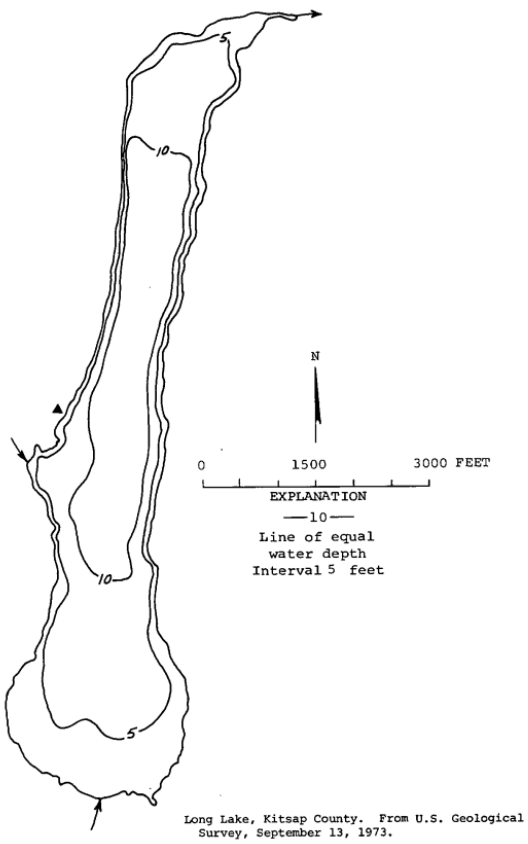

Figure 4-4. Map of Long Lake bathymetry. Bathymetric survey conducted in January 1976

4.3.1 HYDROLOGY OF LONG LAKE

Salmonberry Creek enters Long Lake from the west and small unnamed streams enter the lake from the south end. Overland runoff from surrounding areas also contribute directly to the lake. Long Lake is oriented in a north-south direction and general movement of flow is toward the outlet in the north. Long Lake exhibits a rather high flushing rate varying from 3.6 to 8.0 yr^{-1} (Jacoby et. al., 1982). Water level logger data from 2021 suggests that there is some correlation of lake depth with precipitation records, indicating that the level in Long Lake is, at times, responsive to local rainfall, as well as dependent on recharge from groundwater or upstream storage (Tetra Tech, Inc., 2022).

4.3.2 WATER QUALITY IN LONG LAKE

The water quality of Long Lake has been extensively characterized since the early 1970s. The first significant source of data on eutrophic Long Lake was the limnological sampling and survey conducted by Ecology and USGS in 1973 (Bortleson et. al., 1976 and McConnell et. al., 1976). A diagnostic study covering four seasons was conducted during 1974-1975 prior to the start of the Long Lake Rehabilitation Project that was completed in 1980 (Entranco, 1980). Since the mid-1970s, a variety of lake restoration and plant management activities have been implemented in Long Lake (WATER et. al., 1997). The University of Washington was also extensively involved with several monitoring studies and various implementation project on Long Lake.

Historic and recent water quality data indicate that Long Lake is a very productive and eutrophic waterbody that has suffers from poor water quality at times. High biological productivity of rooted aquatic plants has been characteristic of Long Lake for close to 60 years (WATER et. al., 1997). The first federal environmental restoration project, the Long Lake Rehabilitation Project, occurred in Long Lake in 1977 to address sediment phosphorus recycling and tributary nutrient inputs that supported the high biological production. Alum treatments have reduced phosphorus and subsequent cyanobacteria blooms, temporarily improving water quality since 1980 (Tetra Tech, Inc., 2010). The most recent alum treatment occurred in 2019.

Eutrophication of Long Lake has been attributed to the combined effect of a historically enriched lake substrate/watershed, which may be attributed to early peat-mining in the watershed, the invasion and successful colonization of Brazilian elodea, which has continually enriched lake sediments, and increased shoreline and watershed development (Entranco, 1980; WATER et al., 1997).

Long Lake and its main contributing stream, Salmonberry Creek, are currently listed on Ecology's 303(d) list for failing to meet EPA criteria for total phosphorus (TP) (Ecology, 2018a). The lake does not have an active Total Maximum Daily Load (TMDL) for phosphorus as it is listed as a category 5 impaired water by Ecology.

A brief summary of recent water quality conditions and key parameters is below. The summary below includes excerpts from Tetra Tech, Inc., 2022.

Temperature, Dissolved Oxygen, and pH

In 2021, temperatures in the epilimnion of Long Lake ranged from 12.9 degrees Celsius (°C) in April to 25.8 °C in July. Temperature did not vary significantly throughout the water column, as Long Lake is a shallow lake that mixes frequently throughout the year. The lake typically undergoes weak thermal stratification in in the summer months. DO concentrations ranged from 0.02 to 10.8 milligrams per liter (mg/L) across all stations in 2021. Minimum DO occurred near the bottom at all stations and was lowest at the north and south lake stations during the summer months, when the water column was weakly stratified. Near the bottom, DO concentrations were especially low due to potential interactions with bottom sediment. This is due to the organic degradation that consumes DO. This low DO concentration combined with the low sediment pH enables the release of phosphorus from the bottom sediments that fertilizes phytoplankton (Tetra Tech, Inc., 2022). pH ranged from 4.6 to 8.7 throughout the water column. The low pH values were measured in October at the south end of the lake near the surface and were unusually low. These low measurements could have been the result of equipment malfunction although instrument calibration records indicate that the water quality sonde was calibrated correctly. Typically, minimum pH is around 6.5 as was measured in 2020. Water column pH in Long Lake typically follows a pattern of higher values near the surface due to photosynthetic activity, and lower values measured near the bottom due to respiration. pH is most likely influenced by photosynthesis by phytoplankton in the water column as well as aquatic plants (Tetra Tech, Inc., 2022).

Phosphorus and Nitrogen

In 2021, total phosphorus (TP) concentrations at the mid-lake station averaged 38 micrograms per liter (µg/L) at 0.5 and 2.5 m depth and ranged from 16 to 51 µg/L. Maximum recorded TP (51 µg/L) was observed in September at 2.5 m, and higher concentrations of TP generally corresponded with higher chlorophyll a (chl) concentrations in the lake (Tetra Tech, Inc., 2022).

Surface concentrations of TP were slightly lower than those observed in 2020 (average of 37.3 µg/L and range of 25 – 62 µg/L) and similar to surface concentrations in 2018 and 2019 that ranged from 18-34 µg/L. There is a consistent trend of lower TP concentrations observed in the spring and fall. In 2018, 2019, and 2021 the mid-lake TP concentrations were generally higher near the lake bottom however in 2020 higher surface concentrations of TP were observed during both July and September (Tetra Tech, Inc., 2022).

The concentration of TP in the inflow, Salmonberry Creek, averaged 29.7 µg/L in 2021, lower than in 2020 which had an average TP concentration of 45 µg/L. The highest TP concentrations in Salmonberry Creek occurred in spring and early summer and was higher than at the mid-lake station in early July. TP concentrations in Salmonberry Creek were lower than concentration at the mid-lake station in August, September, and October. In 2021, Salmonberry Creek had about average concentrations of TP when compared to recent years (average around 30 µg/L) (Tetra Tech, Inc., 2022).

Soluble Reactive Phosphorus (SRP) concentrations were low for all observations in 2021, with an average concentration of 2.3 µg/L. Low concentrations of SRP in the summer months are consistent with higher chl concentrations, indicating phytoplankton activity in the water column that results in low concentrations of SRP while TP concentrations are high. SRP concentrations in 2021 were generally consistent with low concentrations observed in recent years.

Nitrogen concentrations in Long Lake have not been monitored recently. Water quality data collected during 1993-1994 and reviewed by WATER et. al. (1997) showed moderate to high nitrogen levels in the lake and tributaries, particularly during the summer months.

Chlorophyll *a* (chl)

Surface concentrations of chl at the mid-lake station averaged 23.5 µg/L and ranged from 4.5 to 42 µg/L during April through October 2021. At a depth of 2.5 m, the average mid-lake chl concentration was 21.9 µg/L, slightly lower than at the surface. Maximum recorded chl (42 and 43 µg/L) was observed in August and September, and higher concentrations of chl generally corresponded with higher TP concentrations in the lake. Average chl concentrations observed in 2021 were somewhat higher than observations in 2020 when surface concentrations averaged around 19 µg/L. Average chl concentrations in 2020 and 2021 were higher than those in 2018 and 2019, when surface concentrations averaged only around 12 µg/L (Tetra Tech, Inc., 2022).

There were no observed algae blooms in 2019 following the alum treatment however several blooms were observed in 2020. There were no large blooms or scum accumulations reported in 2021 and no samples were collected for cyanotoxin analysis in 2021. However, both TP and chl concentrations have returned to eutrophic levels in the lake (Tetra Tech, Inc., 2022). Like the aquatic plants, the phytoplankton production in the lake has returned to high levels of organic production, which could lead to HAB events in the future; unless management actions are taken to inactivate the phosphorus in the lake water and sediment to reduce the generation of phytoplankton and specifically cyanobacteria. The target for long-term beneficial use preservation of the lake is to reduce the average TP concentration to 18 µg/L, which will result in average chl concentrations of 6 to 8 µg/L. At those concentrations the lake would not be expected to have significant HAB events.

Clarity

Water clarity, or transparency, as measured with a Secchi disk, ranged from 0.8 to 1.8 m at the mid-lake and north lake stations, and 0.8 to 1.7 m at the south end of the lake in 2021. In the summer, water clarity was generally consistent across all stations, although there were no measurements collected in August. Spring and fall measurements of water clarity varied slightly between dates and sites. The minimum Secchi disk depth (0.8 m) was observed at all lake stations in September and maximum Secchi disk depths were observed in May at all stations (Tetra Tech, Inc., 2022). The higher level of water clarity in May corresponded with lower observed chl concentrations. Water clarity was significantly lower in 2020 and

2021 when compared to the high clarity in 2019 due to the low-dose alum treatment and corresponding reduction in algal production. In 2021, water clarity was similar but slightly lower than in 2020, which had an average water clarity of 1.4 m. Water clarity in both 2020 and 2021 was lower than in 2018, which had clarity over 2 m in June before dropping to around 1.6 m in July and less than 1 m throughout August (Tetra Tech, Inc., 2022). In 2021, as in other years, lower clarity was an indication of increased algae production.

4.3.3 AQUATIC PLANTS PRESENT IN LONG LAKE

The following aquatic plants were identified in Long Lake during surveys conducted in 2021:

- Fragrant water lily (*Nymphaea odorata*) – invasive non-native
- Brazilian Elodea (*Egeria densa)* – invasive non-native
- Curlyleaf pondweed (*Potamogeton crispus*) – invasive non-native
- Swollen bladderwort (*Utricularia inflata*) – non-native
- Spatterdock (*Nuphar polysepala*) – native
- Coontail (*Ceratophyllum demersum*) – native
- Common cattail (*Typha latifolia*) – native
- Hardstem bulrush (*Scirpus acutus*) - native
- Whitestem pondweed (*Potamogeton praelongus)* – native
- Sago pondweed (*Potamogeton pectinatus*) – native
- Slender leaved pondweed (*Potamogeton filiformis*) – native
- Flat-stem pondweed (*Potamogeton zosteriformis*) – native
- Guadalupe water-nymph (*Najas guadalupensis*) - native
- Reedgrass (*Sparganium sp.*) - native
- Watershield (*Brasenia schreberi*) – native

The following additional aquatic plants were identified during the 1997 IAVMP by WATER Environmental Services, Inc. but were not observed during the 2021 surveys of Long lake:

- Small (Berchtold's) pondweed (*Potamogeton berchtoldii/pusillus*) – native
- Big-leaf pondweed (*Potamogeton amplifolious*) - native
- Common elodea (*Elodea canadensis*) – native
- Nitella (macroalgae, Charales) (*Nitella spp.*) – native
- Purple loosestrife (*Lythrum salicaria*) – non-native
- Yellow iris (*Iris pseudocorus*) – non-native
- Burreed (*Sparganium* spp.) – native
- Rush (*Juncus* spp.) – non-native

The freshwater emergent invasive non-native aquatic plants within Long Lake are dense and are gradually trapping sediment and organic matter within the littoral area, transitioning it to terrestrial habitat. This is reducing the amount of aquatic habitat in the littoral area of the lake and is adversely impacting the regional fishery. In shoreline areas, cattails and bulrush are present. Purple loosestrife, as well as yellow flag iris may be present on some private property along the shoreline.

4.3.4 RARE PLANTS IN LONG LAKE

According to the Washington Department of Natural Resources Natural Heritage Program GIS dataset of rare plants and high-quality ecosystems, there are no current observed occurrences of rare plants in Long Lake (WA DNR, 2022).

4.3.5 ALGAE PROBLEMS IN LONG LAKE

Long Lake has a history of excess algal production. Late summer and fall algal blooms have occurred regularly in Long Lake since before the 1970s, although the frequency and intensity of blooms varies year to year. Algal blooms reduce water clarity and limit primary contact recreation and the use of non-motorized boats. Both green and blue-green algae (cyanobacteria) have been observed in Long Lake. In 2021 there were no sustained cyanobacteria warnings issued by Kitsap Public Health District. Citizens reported several surface blooms during the summer of 2021, but the blooms were a mix of algae species and not exclusively or dominated by cyanobacteria. In July 2020, Kitsap Public Health District issues a cyanobacteria warning for Long Lake and there were several blooms reported during the summer of 2020.

In 2019, a low-dose alum treatment was conducted to remove phosphorus from the water column and to inactivate the release of phosphorus from the lake sediments to reduce algal production. Despite the lower dose (5 mg Al/L compared to the 2007 dose of 17.5 mg Al/L), there was a significant increase in water clarity following the 2019 treatment due to the reduction in algal production, and Long Lake did not experience a toxic bloom, which had occurred each year for the previous four years.

4.3.6 SHORELINE USE OF LONG LAKE

Commented [BS8]: Get input from Kitsap County

Shoreline use of Long Lake is rural residential (along the west, south, and east shore), and recreational (along the north shore).

4.3.7 SEDIMENT TYPES IN LONG LAKE

The sediments of Long Lake have been historically characterized as generally consisting of loose muck and sedimentary peat over sandy clays (Entranco, 1980; WATER et. al., 1997). Sediment core testing conducted as part of the 1970s Rehabilitation Project showed depths of muck/peaty substrate varying from one to two feet overlying various sands and clays in the north end to over 20 ft near the center of the lake (WATER et. al., 1997). A lake sediment coring project conducted by Eagle Scout volunteers during the fall of 1996 supported the predominantly deep, organic lake substrate. Over the years, the lake substrate has continued to build up as sediment has been washed into the lake and the dense aquatic plants beds have further added organics and nutrients to the lake bottom as they seasonally decline and decompose.

4.3.8 WATER USES IN VICINITY OF LONG LAKE

Long Lake is not believed to be a primary drinking water source for lake residents. However, 23 lake residents have active legal water rights to use Long Lake as a source of water for domestic use or irrigation. These water rights range from quantities of 0.01-0.1 cubic feet per second (cfs) and annual quantities of 0.5-6.0 acre-feet, several permits around Long Lake do not list an annual quantity. Between the residents there is a combined total of 0.36 cfs and 16.5 acre-feet per year of water (Ecology, 2022b). Details on the active certificates for these water rights are provided in Appendix A.

4.3.9 FISH IN LONG LAKE

According to WDFW, fish in Long Lake include resident coastal cutthroat trout (*Oncorhynchus clarkii*), largemouth bass (*Micropterus salmoides*), and black crappie (*Pomoxis nigromaculatus*). WDFW has historically stocked the lake with rainbow trout (*Oncorhynchus mykiss*) for recreational fishing but this has not occurred since 2001 (WDFW, 2022a). According to WDFW Priority Habitat and Species Program, coho salmon (*Oncorhynchus kisutch*) also occur in Salmonberry Creek and therefore migrate through Long Lake and its outlet, Curley Creek. This is also true for winter steelhead and chum who occur and spawn in Salmonberry Creek (WDFW, 2022a).

4.3.10 WETLANDS ADJOINING LONG LAKE

According to the U.S. Fish and Wildlife Service National Wetland Inventory, there are freshwater emergent wetlands along the southern shore of Long Lake and a small pond. At the outlet of the lake, Curley Creek, there is a freshwater forested/shrub wetland (Figure 4-2) (USFWS, 2022). In addition, the lake itself is classified as a lacustrine limnetic environment with the lake having an unconsolidated bed that is permanently flooded (Code L1AB/UBH).

4.3.11 WATERFOWL USE OF LONG LAKE

Commented [BS9]: Need input from Kitsap County

The forested watershed and Long Lake provide habitat to a variety of raptors and waterfowl that includes bald eagles, osprey, and various duck species (WATER Environmental Services, Inc., 1997).

4.3.12 WILDLIFE USE OF LONG LAKE

Commented [BS10]: Need input from Kitsap County

Beavers and otters have been observed using Long Lake for habitat and foraging, and turtles have been observed.

4.3.13 ENDANGERED SPECIES IN LONG LAKE

According to WDFW Priority Habitat and Species Program, there are no endangered species in Long Lake.

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5.0 BENEFICIAL USES AND IDENTIFIED PROBLEMS

Long Lake is a multi-use resource, supporting a variety of human and wildlife uses. Beneficial uses are derived from the federal Clean Water Act to define uses of the lake that should be protected against water quality degradation. The state defines designated uses and they include, for example, water supply, power generation, recreation, boating etc. The beneficial uses identified for Long Lake are summarized below with a short description of how they are impacted by invasive plants:

- Primary contact recreation
  - Swimming occurs at private residences and at the public swimming beach at the county owned Long Lake Park (**Error! Reference source not found.**).
  - Dense growth of aquatic plants in nearshore areas makes swimming unpleasant, cumbersome, and potentially unsafe, as limbs may get tangled in plant growth.
  - Accumulated muck and organic sediments make swimming and wading unpleasant and potentially unsafe.
- Boating
  - The whole lake is open to motorized and non-motorized boats.
  - Boaters access the lake from a WDFW public boat launch along the western shore of the lake just north of Salmonberry Creek (Figure 5-1).
  - Boating access also occurs from private docks around the lake as well as from a small launch at the County Park at the north end.
  - There are also designated water ski and jet ski courses in the south end of the lake (**Error! Reference source not found.**).
  - Aquatic plants impede navigation by motorized and non-motorized boats and watercraft by entangling boat props and paddles.
- Other recreation - Fishing
  - There is a well-utilized public fishing pier situated at the north end along the Curley Creek outlet embayment (Figure 5-1).
  - The lake can be accessed by lake residents and the community from the Long Lake County Park at the north end of the lake.
  - The lake supports a substantial warmwater fishery heavily used by anglers.
  - Fishing lines get tangled in dense mats of invasive aquatic plants and quality can be reduced if fish habitat is impacted.
- Aesthetic values/Property values
  - Decaying aquatic plants reduce water clarity and generate unpleasant odors.
  - Dense coverage of aquatic plants limits the aesthetic quality of the lake.
- Aquatic habitat
  - Invasive nuisance weeds reduce native biodiversity and habitat diversity for aquatic species.
  - Invasive aquatic weeds can provide more habitat and shelter for predatory fish (e.g., largemouth bass) that feed on juvenile salmonids.
- Fish migration, resident fish spawning and rearing (see Section 4.2.9)
  - Dense growth of aquatic plants negatively impacts fish habitat.
  - Water quality is degraded in areas of dense growth is known to cause changes in temperature, pH and dissolved oxygen negatively impacting these species (Frodge et al. 1990).

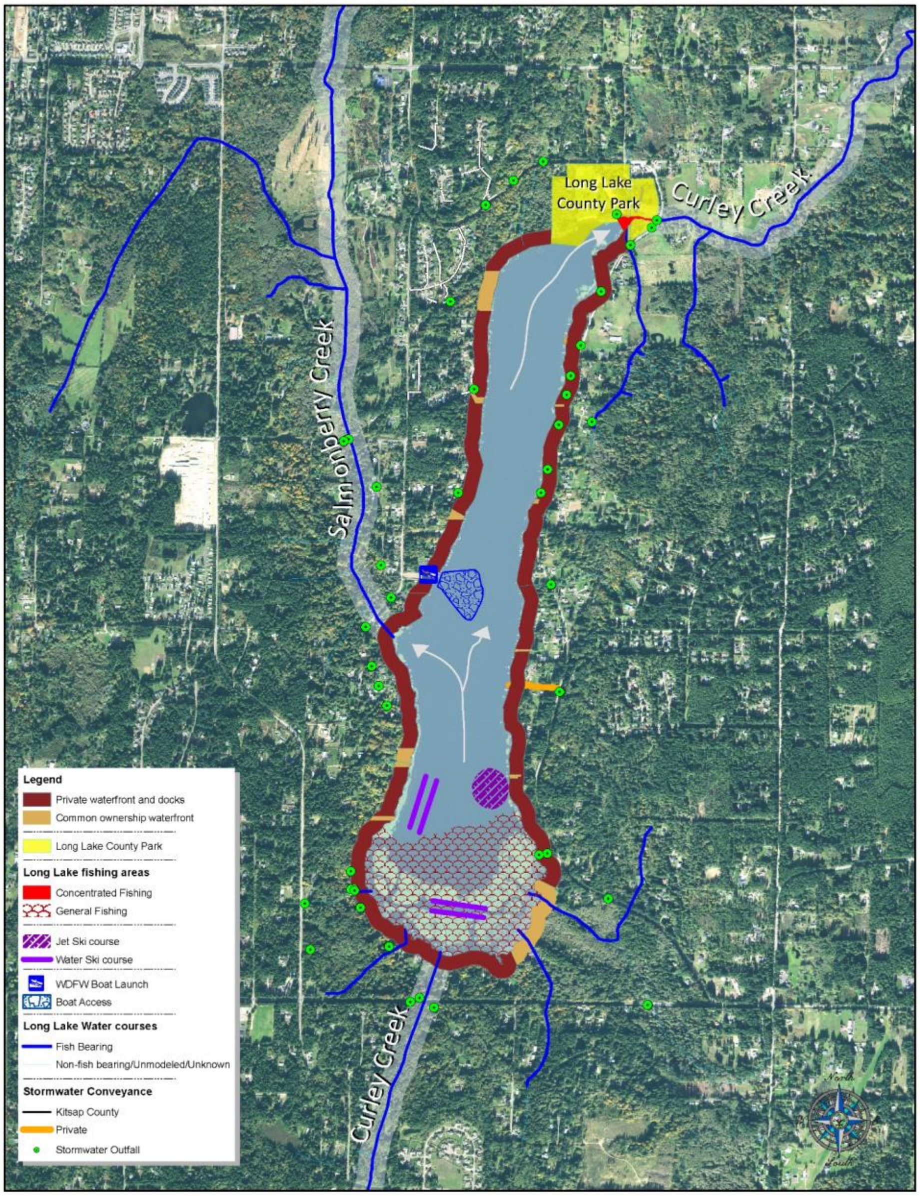

Figure 5-1. Beneficial use areas in Long Lake, Kitsap County

6.0 AQUATIC PLANT COMMUNITY

Tetra Tech conducted aquatic plant surveys of Long Lake in June and September 2021. During the surveys, an aquatic weed rake was tossed at various locations and depths throughout the lake to determine the presence, species, and percent coverage of aquatic plants at each location. The results of each aquatic weed rake toss were recorded on a map of the lake. Photos of the shoreline were taken throughout the survey to document the presence and extent of aquatic plants on the surface of the lake. Aquatic plants that were submersed, floating-rooted or floating were mapped. Aquatic plant survey methods in 2021 were consistent with methods used by Tetra Tech from 2018 – 2020. An aquatic plant survey was also conducted by citizen volunteers on May 22, 2021. A map that summarizes the aquatic plant distribution and density in Long Lake in 2021 is shown in Figure 6-1.

6.1 2021 PLANT DISTRIBUTION AND DENSITY

The 2021 aquatic plant surveys indicated that there was dense growth of aquatic vegetation throughout the lake, particularly in the southern and northern ends of the lake where both emergent and submersed plant species had expanded in density and area. The survey identified the following species:

- **Fragrant water lily (*Nymphaea odorata*) – invasive non-native**
- **Brazilian Elodea (*Egeria densa)* – invasive non-native**
- **Curlyleaf pondweed (*Potamogeton crispus*) – invasive non-native**
- Swollen bladderwort (*Utricularia inflata*) – non-native
- Spatterdock (*Nuphar polysepala*) – native
- Coontail (*Ceratophyllum demersum*) – native
- Common cattail (*Typha latifolia*) – native
- Hardstem bulrush (*Scirpus acutus*) - native
- Whitestem pondweed (*Potamogeton praelongus)* – native
- Sago pondweed (*Potamogeton pectinatus*) – native
- Slender leaved pondweed (*Potamogeton filiformis*) – native
- Flat-stem pondweed (*Potamogeton zosteriformis*) – native
- Guadalupe water-nymph (*Najas guadalupensis*) - native
- Reedgrass (*Sparganium* spp.) - native
- Watershield (*Brasenia schreberi*) – native

During the May 2021 survey, citizens indicated that the ski course and waterways in the south end of the lake appeared to have been cleared by lake residents with only sporadic small areas of various plants in those areas between the lilies. However, they noted that in the southeast corner of the lake, the lilies had not been maintained and the waterways that were previously created were beginning to fill back in as the lilies continued to expand. The citizens also noted in their survey that whitestem pondweed was abundant and was observed within the majority of the littoral area with only an occasional spot where it was not present. Specific areas that the citizens indicated to have heavy growth of whitestem pondweed included along the west shoreline and in the northern end of the lake. The citizens also indicated heavy growth of Brazilian elodea outside of the large swath of lilies in the southwest portion of the lake. This heavy growth has also been observed to be increasing by Tetra Tech and specifically noted in the spring of 2019 and every year since. Tetra Tech has observed that lake depth along the northern edge and further to the north of the large swath of lilies has been getting shallower, enabling the increase in Brazilian elodea density. This is an indication that the southern lily community is contributing to the reduction of lake water volume by direct organic over-production and is enhancing production of other plants like whitestem pondweed and Brazilian elodea.

In 2021, more native species of aquatic plants were observed in Long Lake compared to previous years. This increased diversity is beneficial for overall lake habitat and ecology. However, there was also an increase in overall aquatic plant biomass which appears to be accelerating the eutrophication process or lake aging. The emergent vegetation in the littoral areas of the lake is growing in biomass, and diversity, indicating that the lake is aging or becoming more productive over time, as well as becoming shallower. It appears that lake depth is decreasing in most locations due to sedimentation from organic material from rooted aquatic plant vegetation. Tetra Tech observed in the spring of 2021 that aquatic plant growth had accelerated relative to the normal seasonal patterns and was approximately 6 to 12 weeks ahead of the normal seasonal growth. This was due to the increase in solar radiation as well as unusually high water temperatures in the spring and early summer of 2021.

Even with the increase in overall plant biomass and diversity, three of the four non-native, invasive aquatic plant species have been reduced in both density and coverage. Eurasian watermilfoil was not observed in the spring nor fall 2021 plant surveys. Curlyleaf pondweed has been reduced in density but still was observed in scattered patches within the shallow shoreline littoral area. While Brazilian elodea remains the dominant submersed plant, its distribution and density has fluctuated greatly since 2006 due to management efforts. In particular, populations along the east and west shoreline littoral areas have been greatly reduced and replaced by native plants.

Fragrant Waterlily has significantly expanded in density and coverage resulting in accelerated lake aging and sediment accumulation to the point of creating wetland islands in the southern area, as was observed in 2020. Over time, these wetland areas could become dry land due to the sediment build-up due to excessive plant growth. The unchecked growth of this species is expected to greatly accelerate eutrophication of the lake and reduce the lake's open water area if management actions are not taken to control this plant. The lake will require significant management actions in the southern end and littoral shoreline habitat to reduce the aging process and maintain the lake's ecological status and human beneficial uses.

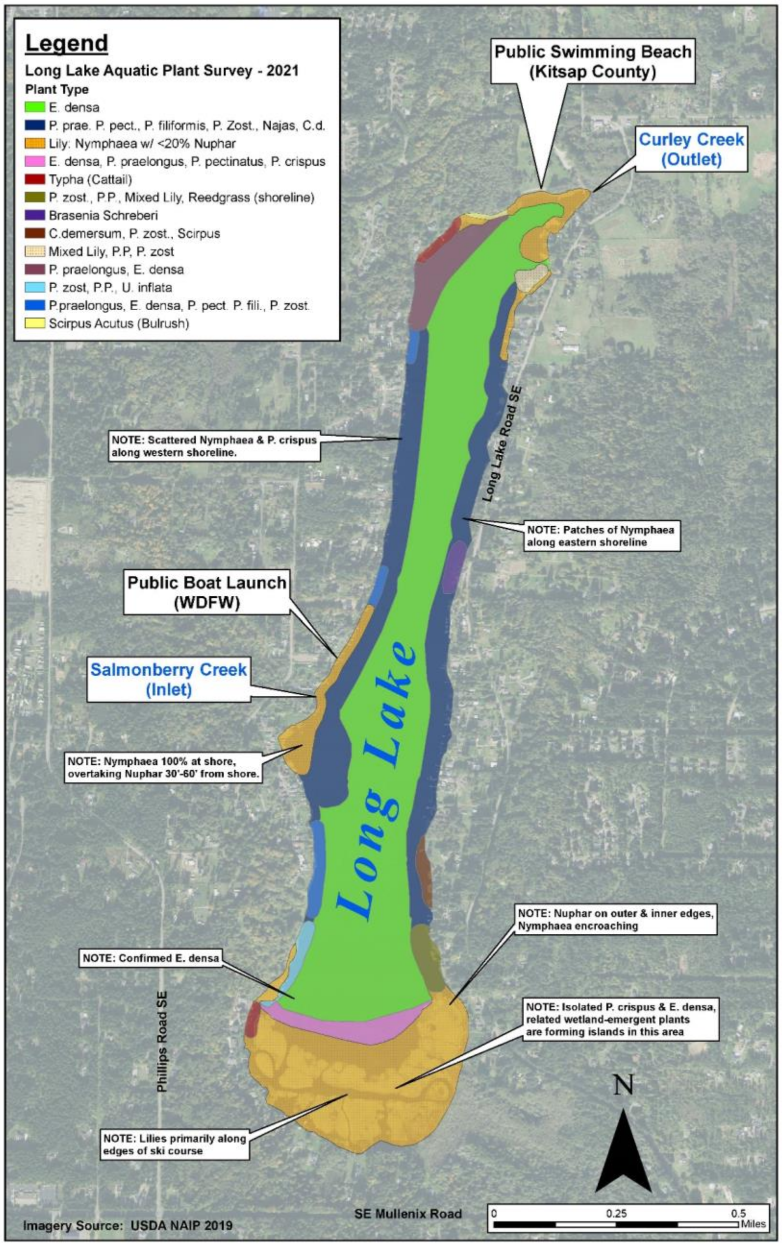

Figure 6-1. Distribution and density of aquatic plants in Long Lake in 2021

6.1.1 NOXIOUS WEED SPECIES

The 2021 plant surveys, conducted in May and September, identified three non-native, noxious weed species: Curlyleaf pondweed, Brazilian elodea (Figure 6-2), and fragrant waterlily (Figure 6-3). The approximate acreages of each of these noxious plants are shown in Table 6-1. Brazilian elodea is designated as a Class B noxious weed by the WA State Noxious Weed Board (NWCB, 2022). Class B noxious weeds are widespread in some areas but not in all areas. The State or County Noxious Weed Control boards have the option to designate a plant for mandatory control of Class B plants. The Kitsap County Noxious Weed Control Board has identified Brazilian elodea as a noxious weed of concern. Curlyleaf pondweed and fragrant waterlily are designated as Class C noxious weeds (NWCB, 2022). Class C weeds are already widespread, so control is typically not mandatory. Kitsap County has listed Fragrant waterlily on its top 12 noxious weeds of concern and has been chosen as a high priority weed in the County (Kitsap County Noxious Weed List).

Table 6-1. Approximate acreages of noxious weeds in Long Lake (2021)

Scientific Name	Common Name	Acreage
Potamogeton crispus	Curlyleaf pondweed	Scattered locations throughout roughly 15 acres
Egeria densa	Brazilian elodea	225
Nymphaea odorata	fragrant waterlily	80

Figure 6-2. Brazilian elodea growing in Long Lake, May 2021

Figure 6-3. Fragrant water lily growing in southern end of Long Lake, September 2021

6.2 TARGETED PLANT DESCRIPTIONS

6.2.1 PLANTS TARGETED FOR CONTROL IN LONG LAKE

Under this Plan, curly leaf pondweed (*Potamogeton crispus*), Brazilian elodea (*Egeria densa*), and fragrant water lily (*Nymphaea odorata*) will be targeted for control. These plants are described below.

Curly leaf pondweed

In Washington State, curly leaf pondweed is designated as a class C noxious weed. It was introduced to the United States from Europe in the 1800s. The leaves of the plant grow up to 3 inches long and have distinctive crinkled edges (Figure 6-4). Curly leaf pondweed grows in lakes, ponds, and slow-moving streams. It can grow in water as shallow as 1 ft and as deep as 15 ft. It can tolerate low light conditions but prefers cooler temperatures. Like Eurasian watermilfoil, it can grow even in low water temperatures during winter months. Though curly leaf produces flowers and seeds, it primarily spreads through asexual rhizomatic growth (Figure 6-4). It is very invasive and can rapidly grow into dense mats, inhibiting recreation and out-competing native species (Rutgers, 2014).

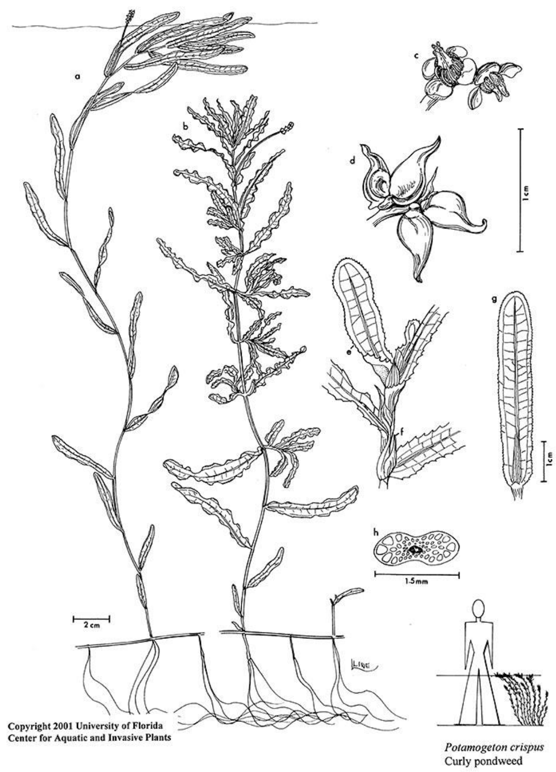

Figure 6-4. Curly leaf pondweed

Brazilian elodea

In Washington State, Brazilian elodea is designated as a Class B noxious weed and is notorious for its aggressive growth potential. Brazilian elodea is also on the Washington State quarantine list and it is prohibited to transport, buy, sell, offer for sale, or distribute this plant or parts of the plant into or within the state of Washington. Brazilian elodea belongs to the family Hydrocharitaceae, which also includes freshwater genera: *Elodea, Hydrilla,* and *Vallisneria*. Brazilian elodea is an ornamental aquatic plant that is used primarily for fish aquariums. Brazilian elodea can grow in still and flowing waters such as lakes, ponds, streams, and ditches. Infestations can form dense mats that shade out other native plants, inhibit water flow and impede recreational activities. It is a submersed plant that grows underwater but sometimes is free floating and forms dense masses near the water's surface. Leaves typically occur in whorls of 4-6 but 8-12 where stems or flowers occur (Figure 6-5). The leaves are minutely serrated, linear and bright green. Brazilian elodea have male and female flowers on separate plants (Figure 6-5). So far introduced populations only have male flowers that are white, have 3 petals and are on threadlike stems (Figure 6-5). Brazilian elodea can reproduce by roots and plant fragments. Informational sources: NWCB, 2022.

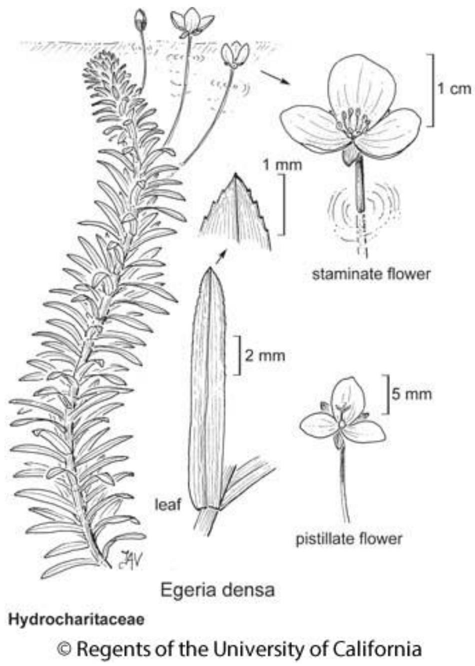

Figure 6-5. Brazilian elodea

Fragrant water lily

In Washington State, fragrant water lily is designated as a class C noxious weed. Fragrant water lily is native in the eastern United States and was likely introduced in Washington State in the late 1800s. It is favored as a decorative aquatic plant due to the large white or pink flowers that grow on lily pads on the water surface (Figure 6-6). The lily pad leaves grow from underwater stalks, which extend to the lake surface (Figure 6-6). It can grow up to depths of 10 feet in slow-moving waters with silty sediments. Fragrant water lily spreads through horizontally branching rhizomes, seed dispersal, and rhizome fragmentation. It is capable of aggressive growth and substantially altering ambient water quality conditions. Over years, the decay of the plant leads to a build-up of organic matter. Information sources: Frodge et al., 1990; NWCB, 2022.

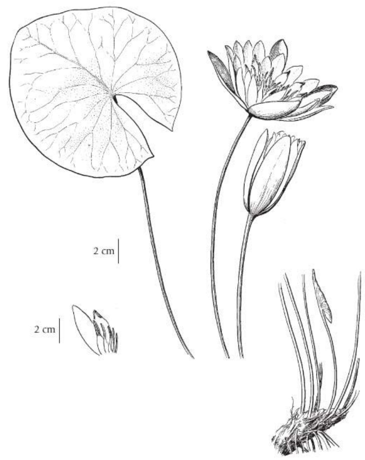

Figure 6-6. Fragrant water lily. *Source:* E-Flora BC, 2021

6.2.2 SPECIES IDENTIFIED AS A POTENTIAL THREAT TO LONG LAKE

The plant that is likely the highest risk for re-introduction and re-establishment in Long Lake is Eurasian watermilfoil. Eurasian watermilfoil was not observed in either the May or September 2021 aquatic plant surveys in Long Lake, however, small groupings of isolated plants had been identified in Long Lake during surveys conducted in 2018 – 2020. Eurasian watermilfoil was first observed in Long Lake during the surveys conducted for the 1996 IAVMP. Given the historic presence and overall prevalence of Eurasian watermilfoil in the region, the likelihood of re-introduction and re-establishment in Long Lake is moderate. Recent management activities, summarized in Section 7.0, directed at control of Eurasian watermilfoil appear to have been successful.

Long Lake may also be at risk for infestation of other aquatic invasive species including the New Zealand mudsnail which has been found in several locations in Washington including Lake Washington, the Chehalis River, Capitol Lake in Olympia, the Lower Columbia River estuary, the Snohomish estuary, as well as a few stream locations in King County (WDFW, 2022c; WISC, 2022).

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7.0 PAST MANAGEMENT EFFORTS

7.1 NON-CHEMICAL CONTROL EFFORTS

A summary of the available information on previous non-chemical efforts to control aquatic plants in Long Lake is provided in Table 7-1. There has been a long history of aquatic plant management in Long Lake going back to the late 1970s. The information presented in Table 7-1 was pulled from multiple studies and reports but may not be completely comprehensive.

Table 7-1. Summary of non-chemical control methods previously employed in Long Lake

Non-Chemical Control Method	Used in Long Lake?	Additional Information
Manual Control Methods		
Diver or shoreline hand pulling/raking	Yes	Lake residents and shoreline property owners have made individual efforts to cut and rake submersed plants and hand-pull or cut fragrant waterlily along their shorelines and around docks. These efforts require repeated work and are usually limited to small areas within docks and swimming areas and in boating lanes to private docks.
Bottom barriers	No	No bottom barriers have been installed to impede plant growth.
Diver dredging	No	No diver dredging has been conducted in Long Lake.
Environmental Manipulation Methods		
Water level drawdown	Yes	In 1979 there was a partial six-foot drawdown of the lake level. The drawdown project appeared to have only short-term benefits for aquatic plant control (Jacoby et al., 1982).
Mechanical Methods		
Mechanical cutting and/or harvesting and/or rotovation	Yes	Large-scale mechanical harvesting was conducted in 1988, 1989, and 1990 and had no effect on the dominance of Brazilian elodea or was proven largely unsuccessful for long-term weed control (WATER et al., 1997).
Dredging	Yes	Small-scale dredging of the north end/outlet (5% of lake bottom) was implemented in 1978 and was largely unsuccessful for long-term weed control (WATER et al., 1997).
Biological Control Methods		
Biological control methods, such as triploid grass carp	No	No biological control methods have been implemented in Long Lake.

7.2 CHEMICAL CONTROL METHODS

A summary of the available information on previous chemical control methods implemented in Long Lake is provided in Table 7-2. The information summarized in Table 7-2 was gathered mostly from reports written by Tetra Tech during two long-term studies conducted in 2006 – 2010 as well as 2018 – 2022. It is unknown if herbicides or other chemical control methods were used during 2011 – 2017 in between the two studies or prior to 2006.

Table 7-2. Summary of chemical control methods previously employed in Long Lake

Chemical Control Method	Used in Long Lake?	Additional Information
Aluminum sulfate (Alum) Treatments	Yes	Alum has been applied to Long Lake several times over the past 50 years to inactivate sediment phosphorus release and strip phosphorus from the water column. Years in which alum has been applied to Long Lake include: • **1980 – 5.5 mg Al/L**; highly effective for first four years and maintained modest water quality improvement on average for seven years • **1991 – 5.5 mg Al/L**; effective again for the first four years following treatment • **2006 – 2.5 mg Al/L**; low dose treatment to achieve short-term control • **2007 – 17.5 mg Al/L**; high dose treatment to achieve long-term control, effective for first four years (monitoring stopped after 2010) • **2019 – 5 mg Al/L**; low dose treatment to strip water column
Algaecides	No	Algaecides have not been applied to Long Lake.
Herbicides	Yes	There has been a long history of herbicide use in Long Lake. Below is a summary of known herbicide use in the past 20 years: • **2006 –** High use zones around boat-launch area and to the south, as well as along the eastern shore were treated with fluridone targeting Brazilian elodea and endemic pondweeds that interfered with recreation as well a Eurasian watermilfoil • **2007 –** Narrow treatment band along most of eastern shoreline with smaller bands near boat-launch area and in the northwest corner of the lake; herbicide unknown; Eurasian watermilfoil nearly eliminated • **2008 –** A wider treatment band along most of the eastern shoreline with an expanded treatment area along the western shoreline stretching further out on each side of the boat-launch area; herbicide unknown; species diversity expanded greatly by fall 2008 • **2009 –** Smaller treatment bands along both eastern and western shorelines targeting a reduced amount of acreage due to a reduction in Brazilian elodea and nuisance plant density and an increase in diversity; herbicide unknown • **2010 –** Treatment confined to narrower and shorter strips along the east shoreline and at the northeast end of the lake; herbicide unknown. No treatment on the west side of the lake. • **2018 –** Late growth season treatment of 25% of the shallow littoral area targeting fragrant waterlily, Brazilian elodea and Eurasian watermilfoil, also included treatment of excessively dense beds of native pondweeds. Herbicides used included diquat dibromide and glyphosate. Treatments appeared to have 30% carryover effectiveness of fragrant waterlily and 60% carryover effectiveness on nuisance pondweed. • **2019 –** No herbicide treatments due to delayed timing of potential treatments and concern in a massive release of phosphorus and subsequent potentially toxic algae bloom • **2020 –** Treatment areas included 16.6 acres in the littoral areas along the east and west banks targeting Eurasian

Chemical Control Method	Used in Long Lake?	Additional Information
		watermilfoil, Brazilian elodea, and nuisance pondweeds. Herbicide used was fluridone. • **2021 –** Treatment areas along western shoreline and in the southern end of the lake. Endothall and diquat were applied to 10.3 acres targeting dense growth of native pondweeds and Brazilian elodea, followed by two applications of fluridone to same 10.3 acres. Fragrant waterlily expansion was targeted with application of Imazamox and an adjuvant to 13 acres. • **2022 –** Treatment areas along the northern shoreline of approximately 7 acres and along the southern shoreline of approximately 10 acres. Imazamox used in these areas for fragrant waterlily control. Sonar One and PAK27 applied to approximately 3 acres along Salmonberry Creek Bay shoreline and in 7 acres along eastern shoreline.

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8.0 AQUATIC PLANT CONTROL ALTERNATIVES

8.1 AQUATIC PLANT CONTROL ALTERNATIVES CONSIDERED FOR LONG LAKE

Table 8-1 provides a summary of aquatic plant control alternatives that were considered for Long Lake. The types of controls are divided into the following categories: chemical, manual, bottom barrier, mechanical, dredging, and biological methods. One or more control method is commonly employed in an integrated approach, depending on several factors such as the target plant species, density of its growth, presence of desirable native plants, and location in the waterbody. Additional information on potential aquatic herbicides is summarized in Table 8-2. A summary of potential health and environmental risks of herbicides that could potentially be used at Long Lake is included in Table 8-3. And lastly, the control strategies considered for the Long Lake IAVMP and presented to the steering committee are provided in Section 8.3 and summarized in Table 8-4 through Table 8-6.

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Table 8-1. Summary of aquatic plant control alternatives considered for Long Lake

Type of Control	Method	Description	Advantages	Disadvantages	Cost[1]	Target Plants
None	No Action	No management strategy implemented to control and reduce aquatic plant growth	• No Cost	• No plant control • Does not maintain or improve beneficial uses	$0	None
Chemical	Aquatic Herbicides (for more details regarding potential herbicides see Section 8.2). **Cannot be done without permit and may only be performed by licensed applicator using Ecology-approved aquatic herbicides.	Chemicals applied directly to plants or lake sediments to inhibit or restrict plant growth or to kill existing plants	• Cost effective • High level of control • Specific herbicides for specific situations • Easily adaptable	• Some herbicides have ecological impacts and concerns • Potential damage to non-target plants • Permit required with annual reporting through the life of the permit	$800 to $2,000 per acre	All plants
Manual	Hand-pulling	Plants are removed by hand (must remove roots)	• No equipment costs except collection bins and proper disposal • Can be done by trained volunteers or lake residents	• Small infestations only • Time consuming • Must capture all pieces of the plant and root system • Limited depth of removal	Market labor cost for contractor	Generally, submersed, some loosely rooted emergent plants

Type of Control	Method	Description	Advantages	Disadvantages	Cost[1]	Target Plants
Manual, cont.	Diver Assisted Suction Harvesting (DASH)	Extraction of plants using a diver, suction tube, a unique set of pumps mounted on a boat and a bagging or filtration system	• Entire plant and root system removed • Target specific species • Eradication possible with small and moderate infestations • Plants can be removed around submerged obstacles (i.e., logs)	• High costs • Slow – 0.25 to 0.5 acres removed per day depending on species & density • Must capture all pieces of the plant and root system for proper disposal • As sediments are disturbed, harder to distinguish target species	$45K to $88K per acre for fragrant water lily; may be less for other species	All plants except shoreline/riparian (e.g., reed canary grass)
	Raking	Plants are raked from the shore, dock, or boat using a rake attached to a rope or long pole; requires multiple times per year	• Low equipment cost • Easy for homeowners to implement	• Effective for control in small areas only • Plant regrowth and drift • Safety • Generates fragments that spread distribution • Affects non-target plants	Market labor cost for contractor	Shallow-rooted plants where no Eurasian watermilfoil (or other noxious weed) is present to prevent fragmentation and further spread
	Cutting	Plants are cut by hand from shore, dock or boat using cutting implement; stems, flower and seed may be cut and removed from lake; requires multiple times per year	• Low equipment cost • Easy for homeowners to implement • Can selectively cut target plants	• Effective for control in small areas only • Plant regrowth and drift • Safety • Possibly generates fragments that spread distribution	Market labor cost for contractor	All plants, but easier with floating or emergent species

Type of Control	Method	Description	Advantages	Disadvantages	Cost[1]	Target Plants
Bottom Barrier	Burlap	Burlap material installed on the lake bottom anchored by burlap covered sandbags or rocks. Compresses existing plants while blocking light to prevent further growth (similar to shading weeds in a garden)	• Very effective for rooted plants in small areas around docks • Can be installed by homeowners • Gas permeable	• Moderate costs • Must be monitored and plants growing on top of barriers removed by hand-pulling • Decompose every 4 years • Permitting difficult for large areas; installation under WDFW pamphlet limited to 50% or less of property per year for lake residents • Non-biodegradable materials must be removed after two years unless approved by WDFW	$22,000 per acre (assumes material and diver install needed due to depth) Costs for homeowner installation in shallow areas would be cost of barrier material	All Plants
	Geotextiles/Plastic	Geotextile fabric or plastic installed on the lake bottom anchored by burlap covered sandbags or rocks. Compresses existing plants while blocking light to prevent further growth	• Very effective for rooted plants in small areas around docks • Can be installed by homeowners	• High costs • Must be removed every year or every 2 years if not 100% biodegradable, including weights used to keep in place • Not gas permeable • Not sustainable	$28,000 per acre (assumes material and diver install needed due to depth)	All Plants

Type of Control	Method	Description	Advantages	Disadvantages	Cost[1]	Target Plants
Mechanical	Harvesters	Plants are cut several feet beneath the water surface and collected using a large barge-mounted machine, typically outfitted with a conveyor. Harvested plants are disposed off-site.	• Collects plants • Clears boating and swimming lanes easily	• High costs • Fragment drift if not properly collected • Depth limitations • Difficult to maneuver around submersed obstacles (e.g., logs) • Plant Regrowth • Increase the distribution and density of plants that spread by fragments	$150,000 to 250,000 initial purchase $33,000 to $100,000 annual operations depending on area	All plants
	Rotovation	Aquatic rotovators have underwater rototiller-like blades to uproot aquatic plants	• Clears boating and swimming lanes easily • Disrupts rhizomes and additional plant growth	• Floating plant material must be gathered • Plant regrowth and fragment spread • Only feasible if submersed logs not significant	$200,000 to $275,000 initial $40,000 to $100,000 annual operations Additional costs for plant retrieval $20,000 to $30,000	All plants
	Weed Cutters	Plants are cut several feet beneath the water surface using a hand-held machine or tool with no plant collection	• Low Costs • Could be implemented by homeowner • Clears boating and swimming lanes	• No plant collection • Plant and fragment drift • Depth limitation • Plant regrowth • Increase the distribution and density of plants that spread by fragments	$200 initial (hand-cutters) Market labor cost for contractor for frequent cutting	Submersed or emergent

Type of Control	Method	Description	Advantages	Disadvantages	Cost[1]	Target Plants
Dredging	Mechanical Dredging	Sediment and plant material from the lake bottom are removed using large dredging equipment (e.g., backhoe)	• Deepens lake • Removes sediment, plants, nutrients, roots, and seeds from the system	• Very high costs • Sediment disposal • Permitting • Requires trucks for offsite disposal • Inefficient removal as water-saturated sediment will require multiple pulls • Disturbs lake bottom and all plants and organisms • Release of sediment nutrients that can contribute to algae blooms	$200 to $400 per cubic yard $1.2M to $2M per acre (including sediment disposal)	All plants
	Hydraulic Dredging	Sediment and plant material from the lake bottom are removed using large dredging equipment	• Deepens lake • Removes sediment, plants, nutrients, roots, and seeds from the system • Removes slurry and transfers offsite via a closed system pipe (reduced turbidity)	• Very high costs • Sediment disposal • Permitting • Cannot be used in areas with large, submersed objects (e.g., rocks and logs) • Removes a significant amount of water • Requires large disposal and dewatering area	$165 to $200 per cubic yard $800,000 to $1.0M per acre (including sediment disposal)	All plants

[1]Cost estimates are based on best professional judgement and information from recent relevant projects in WA. Costs presented here are indented to illustrate a range or estimate and is not intended to represent all potential expenses as these can vary widely for some control approaches, for example, travel time, disposal fees, permitting, or monitoring requirements.

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8.2 DETAILS ON CHEMICAL CONTROL OPTIONS

A summary of potential herbicides that could be used for chemical treatment of target plants in Long Lake is provided below in Table 8-2. Table 8-2 also provides a summary of associated use restrictions and treatment limitations for each potential herbicide.

To be approved for use in water, herbicides must first go through an extensive review by the United States Environmental Protection Agency. In addition, Ecology conducts an additional review which examines many factors including ". . . target efficacy, non-target effects, human health and ecological hazard or risk, short- and long-term toxicity, potential effects to endangered plant and animal species as well as their habitats, label restrictions, mitigation requirements, the need for post-treatment monitoring, and other key factors." (Ecology, 2017). A summary of the various human health and environmental risks from Ecology's review is provided in

Table 8-3. The table is an attempt to highlight the key findings, but for further details, the full text may be viewed online[1,2]. It should be noted that for some products, Ecology has imposed restrictions/advisories (e.g., swimming) beyond those listed on the label developed as part of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).

[1] The 2017 Final Supplemental Environmental Impact Statement: Final Supplemental Environmental Impact Statement for the State of Washington Aquatic Plant and Algae Management

[2] 2000 Final Supplemental Environmental Impact Statement for Aquatic Plant management - https://apps.ecology.wa.gov/publications/SummaryPages/0010040.html

Table 8-2. A summary of potential herbicide options for treating target plants in Long Lake

Herbicide[1]	Description	Target Plants	Use Restrictions and Treatment Limitations
2, 4-D Ester	Systemic herbicide that targets broadleaf (dicots) plants	Curlyleaf Pondweed Brazilian Elodea Fragrant waterlily	Swimming restriction during treatment and for 24-hours post treatment (in the treated area). Salmon, Steelhead and Bull Trout timing window Do not use in salmon-bearing waters
Endothall (dipotassium salt)	Selective contact herbicide; damages plants at site of contact but does not impact roots or tubers	Curlyleaf Pondweed Brazilian Elodea	Swimming restriction during treatment and for 24-hours post treatment (in the treated area). Do not apply within 400 ft of an outlet stream if there is an outflow. Salmon and Steelhead, Bull trout timing window Check label for water use restrictions
Florpyrauxifen-benzyl (ProcellaCOR)[2]	Relatively fast-acting selective systemic herbicide	Curlyleaf pondweed (some evidence of control but not currently labeled for use on curlyleaf pondweed)	None, No fish timing window
Fluridone	**Slow-acting systemic herbicide, may be applied as pellet or liquid. Moves from submersed foliage to roots or emergent foliage**	**Curlyleaf Pondweed** **Brazilian Elodea** **Fragrant waterlily**	**Unless operating under a Fluridone Vegetation Management Plan (Appendix C of Permit), Ecology further limits fluridone application to no more than 50% of littoral zone in lakes up to 50 acres and no more than 40% of the littoral zone in lakes from 50-500 acres** **No fish timing window**
Glyphosate	Non-selective broad-spectrum herbicide. Applied as a liquid to leaves. Good applicator can be somewhat selective to remove target plants by focusing spray/application	Fragrant waterlily	None, no fish timing window
Imazamox	**Broad spectrum systemic herbicide. Requires use of Ecology-approved adjuvant for emergent, floating or shoreline target species**	**Fragrant waterlily** **Curlyleaf pondweed**	**None, No fish timing window**

Herbicide[1]	Description	Target Plants	Use Restrictions and Treatment Limitations
Sodium Carbonate Peroxyhydrate (sodium percarbonate) [3]	**Selective and broad-spectrum algaecide. Applied in granular form. Creates a powerful oxidation reaction when applied to water.**	**Filamentous algae** **Reduce DO demand from organic decay**	**Do not treat plants growing on the shore** **No fish timing window**
Triclopyr	Triclopyr TEA registered for aquatic use. Can be applied as liquid or granular form. Fast-acting systemic, selective herbicide. Most commonly used for Eurasian watermilfoil control.	Fragrant waterlily	Swimming advisory during treatment and for 12-hours post-treatment in treated area Aerial applications not allowed No fish timing window

[1] Products recommended for use in Long Lake are in **Bold Print**

[2] Florpyrauxifen-benzyl is currently only available within the United States under the product name ProcellaCOR.

[3]Currently sold within the United States under the produce names Phycomycin, GreenClean, PAK 27, and EcoBlast.

Table 8-3. Summary of potential health and environmental risks of herbicide application

Note: The information provided in this table was compiled from the Supplemental Environmental Impact Statement for State of Washington Aquatic Plant and Algae Management (Ecology, 2017) and does not represent the opinions of Kitsap County, Tetra Tech, or ESA.

Human Health Risks	Environmental Risks
2, 4-D Ester	
In 2015, the International Agency for Research on Cancer (IARC), classified 2,4-D as "possibly carcinogenic to humans" based on inadequate evidence in humans and limited evidence in experimental animals. There is strong evidence that 2,4-D induces oxidative stress, a mechanism that also occurs in humans, and moderate evidence that 2,4-D causes immunosuppression, based on both in vivo and in vitro studies. However, epidemiological studies did not find consistent increases in risk of cancers in relation to 2,4-D exposure (IARC, 2015 in Ecology, 2017).	2,4-D Ester has shown acute toxicity to fish, particularly to rainbow trout fry and fathead minnow fingerlings (CSI 2001 in Ecology, 2017). However, field studies have indicated that the use of 2,4-D BEE granular pellets has no direct impact on fish populations (Shearer and Halter, 1980), presumably due to the insolubility of these granular materials. Thus, as long as label specifications are followed, field data have indicated that use of 2,4-D aquatic use products should be safe to aquatic biota at label-specified use rates (Ecology, 2017).
Endothall (dipotassium salt)	
The main adverse health effect of endothall appears to be associated with irritation potential. Endothall falls under FIFRA (Federal Insecticide, Fungicide and Rodenticide Act) Toxicity Category I as causing severe irreversible eye damage. Irritation effects to the gastrointestinal tract were also noted in some animals in the mid and high dose test groups in the endothall sub-chronic and chronic oral dosing and feeding studies. Label directed use of the endothall products for aquatic weed control, and dilution and degradation of the chemical following application, reduces the potential for overexposure (Ecology, 2001)	It is recommended that exposure of wild fisheries to endothall should be avoided, although toxicity testing have suggested that the most common forms of endothall, including the dipotassium and mono salts, will not cause acute or chronic harm to non-target aquatic animals when label specifications are followed (Ecology, 2017).
Florpyrauxifen-benzyl (ProcellaCOR)	
Based on the current understanding of available environmental fate, chemistry, toxicological, and other data, there is little to no cause for concern to human health or ecotoxicity for acute, chronic, or subchronic exposures to ProcellaCOR™ formulations (Ecology, 2017).	ProcellaCOR™ has undergone extensive ecotoxicological testing. No toxicity was observed for avian, fish, or other species exposed to the herbicide in acute and long-term studies (Ecology, 2017).
Fluridone	
Fluridone has been found to be non-teratogenic, mutagenic, or carcinogenic to humans (Ecology, 2000). There are no label restrictions against drinking, swimming, or fishing in water treated with fluridone (Ecology, 2017).	Fluridone is not expected to have adverse effects on fish or aquatic invertebrates based on a range of aquatic species tested (Hamelink et al. 1986 in Ecology, 2017).
Glyphosate	
Glyphosate is classified as "probably carcinogenic" to humans by the IARC based on evidence in experimental animals. However, the levels of anticipated glyphosate exposure experienced by humans, through current use patterns, are not expected to be carcinogenic (IARC/WHO, 2016 in Ecology, 2017).	Glyphosate shows relatively low toxicity to birds and mammals but can impact animals at high doses (Evans and Batty, 1986; Nature Conservancy, 2001 in Ecology, 2017). Glyphosate could present a potential hazard to non-target, native plant species or terrestrial plants through the use of contaminated irrigation water. Overapplication of glyphosate can result in oxygen depletion and potential fish kills.

Human Health Risks	Environmental Risks
	.
Imazamox	
Imazamox targets an enzyme found only in plants and microorganisms, and therefore does not present a human health risk. Standard toxicity studies involving oral, dermal, ocular, or inhalation exposure have reported no remarkable signs of toxicity. No signs of carcinogenicity have been reported in mammals, and Imazamox is classified as "not likely to be a human carcinogen" by the EPA (USDA, 2010).	Extensive toxicity testing (as summarized by Durkin (2010), Schumacher (2014), and Ecology (2012) show that imazamox is practically non-toxic to fish, birds, mammals, and invertebrates, including insects such as honey bees (taken from Ecology, 2017). Imazamox could present a potential hazard to non-target, native plant species (e.g., cattail, pondweeds, bulrushes) or terrestrial plants through the use of contaminated irrigation water.
Sodium Carbonate Peroxyhydrate (sodium percarbonate)	
Sodium percarbonate has been shown to have low acute toxicity to mammals via oral and/or dermal routes. Existing data show that sodium percarbonate causes a localized, slight irritating effect on skin (HERA 2002). When people are exposed to sodium percarbonate, neither hydrogen peroxide nor sodium carbonate is systemically available due to degradation and neutralization in the body. The properties of sodium percarbonate resemble those of hydrogen peroxide and it can be concluded that there is no concern for possible genotoxicity or carcinogenicity of sodium percarbonate (Ecology, 2017). Human exposure to sodium percarbonate can cause skin irritation and eye irritation is accidental eye exposure occurs.	Based on available data, the use of sodium percarbonate in lake and ponds is expected to have little to not adverse effect on the aquatic ecosystem (HERA, 2002). Sodium percarbonate rapidly dissolves in water and dissociates into sodium (essentially non-toxic), carbonate (will be neutralized over time to bicarbonate) and hydrogen peroxide (degrades in aquatic environments).
Triclopyr	
An overview of the toxicology information indicates that triclopyr shows only a low degree of systemic toxicity based on findings from a variety of acute, subchronic, and chronic toxicology studies. The main adverse health effect appears to be associated with eye contact with concentrated triclopyr which can result in severe eye irritation and damage (Ecology, 2017).	Toxicity studies indicate that triclopyr and its products used as aquatic herbicides do not pose a significant acute or chronic risk to wild birds or terrestrial mammals. Most species of fish are tolerant of triclopyr TEA and it is considered to have very low toxicity to environmentally relevant fish and aquatic invertebrates (Ecology, 2004).

[1] Products recommended for use in Long Lake are in **Bold Print**

8.3 CONTROL STRATEGIES CONSIDERED FOR PROBLEM PLANTS

Prior to identifying aquatic plant control strategies, the steering committee identified the plant species targeted for control and developed attainable management goals for each targeted species. The steering committee determined that plant control would be focused on the currently present invasive species but understood that nuisance native pondweeds may need to be controlled in the future. The management goals developed by the steering committee for each targeted plant species are:

- **Curlyleaf Pondweed – Eradication**
    - Eradicate the current small infestation and continue monitoring efforts to identify any new infestations within the lake.
- **Brazilian Elodea – Control**
    - Reduce coverage and density throughout the lake to promote native plant growth and increase native plant diversity.
- **Fragrant Waterlily – Control**
    - Significantly reduce current fragrant waterlily coverage and slow lake aging.
    - Educate landowners and lake residents on available, effective control options that they can implement near their shorelines to complement and support the overall community plan.

A suite of control strategies and/or prevention strategies was developed that would help the community reach the above goals. These strategies are summarized in Tables 8-4 through 8-7. The tables also provide preliminary estimated costs for each plant management approach. Tetra Tech, based on their technical expertise and experience, provided a recommendation to the steering committee as to whether the community should consider each suite of control options for each targeted plant species.

The tables were presented to the community steering committee and their feedback was used to help narrow down the suite of control options which was recommended to the greater community. (See Section 9.0).

Table 8-4. Management options at a glance: curlyleaf pondweed (*Potamogeton crispus*)

Management Goal	Control Strategy	Preliminary Costs and Assumptions	Estimated 5-Year Cost[1]	Further Consideration/ Recommendation
Eradicate remaining small infestations within the lake	**Manual, includes annual surveying (diver hand-pulling)**	• **$12-20K for 3-5 days for entire lake survey and hand-pulling** • **Currently scattered throughout roughly 15 acres – majority within south end of lake and along eastern shoreline** • **Annual surveys should be conducted for at least 5 years post eradication**	**$60K - $80K**	**Recommended for further consideration**
	Chemical, Fluridone, 2, 4-D, or Florpyrauxifen-benzyl (some evidence of control but not currently labeled for use on curlyleaf pondweed	• $800 - $1,500 per acre, as needed; • Currently scattered throughout roughly 15 acres – majority within south end of lake and along eastern shoreline • Annual surveys should be conducted until eradications and at least 5 years post eradication	$12K - $22.5K (if needed)	Not recommended for further consideration for curlyleaf pondweed only - based on low density and random coverage; should be an option to pursue in future if coverage expands. Chemical treatment for other targeted plant species will have beneficial impacts in areas where curlyleaf pondweed is present
Status Quo	No Action	• $0 • Most likely will spread to cover a larger area and other parts of the lake	$0	Not recommended

NOTES:
[1]Costs are estimated for first five years of control. Continued control work is necessary beyond five years.

Table 8-5. Management Options at a Glance: Brazilian Elodea (*Egeria densa*)

Management Goal	Control Strategy	Preliminary Costs and Assumptions	Estimated 5-Year Cost[1]	Further Consideration/ Recommendation
Control to reduce coverage and density to promote native plant growth	**Chemical, Fluridone with PAK 27**	• **$800 - $1,500 per acre** • **Treat 25 acres each year, equivalent to 55% of current coverage over 5 years** • **PAK to control filamentous algae growth while reducing DO demand from organic decay** • **PAK 27 oxidizes sediment "goo"**	**$100K - $187.5K**	**Recommended for further consideration - current herbicide treatment has reduced density and coverage by 50% or more** **Will also have beneficial treatment for other target plant species (fragrant waterlily)**
	Manual (DASH)	• **$100 – 200K per year for 30 days of diving annually (unsure of progress achievable – need to be adaptative)** • **Highly selective – no off-target impacts allowing for reestablishment of native plants**	**$500K to $1M**	**Recommended for further consideration as non-chemical option**
	Manual – hand-pulling (divers in deep areas; landowners in shallow)	• Market labor costs for contractor (higher for divers); or volunteer/landowner in shallow areas • Must remove all plant parts and contain fragments	Unknown	Considered but not recommended due to size of current coverage, plant density, and propensity for the plant to spread by fragments
	Bottom Barriers (Individual Landowner)	• Dock and swimming areas per landowner discretion • Shoreline residences only (following WDFW Pamphlet) • Cost incurred by landowner	Unknown – costs incurred by landowner $1.00 - $3.00 ft^2 for materials	Not recommended for large scale control but could be used for control in front of individual shorelines
Status Quo	No Action	• $0	$0	Not recommended

NOTES:
[1]Costs are estimated for first five years of control. Continued control work is necessary beyond five years.

Table 8-6. Management options at a glance: Fragrant waterlily (*Nymphaea odorata*)

Management Goal	Control Strategy	Preliminary Costs and Assumptions	Estimated 5-Year Cost[1]	Further Consideration/ Recommendation
AGGRESSIVE CONTROL				
Aggressive Control: Target 75% reduction of lilies and up to 3 ft of sediment removal. Focus on south end of lake, high-use recreational areas, and where lily has significantly expanded in density and coverage.	Mechanical – Hydraulic Dredging for lily control and sediment removal	• $40M - $50M for 50 acres • One time event • Remove all plants in dredging areas • Permits are extensive and could be challenging to obtain • Dewatering and disposal costs are very high	$40M - $50M	Recommended for further discussion with steering committee; If aggressive control is management goal this suite of control strategies should be considered
	Manual (DASH)	• Post dredging cleanup of any surviving lilies and shoreline/channel maintenance • $45k - $88K/acre, as needed	$2M	
	Manual – hand-pulling or cutting (non-diver)	• Channel and shoreline maintenance • Hand cutting of flowers and seeds and removal from lake • Market labor cost for contractor; or volunteer/landowner	Unknown – costs incurred by landowner	
	Bottom Barriers (Individual Landowner)	• Dock and swimming area maintenance per landowner discretion • Shoreline residences only (following WDFW Pamphlet) • County could potentially supply materials - $10K per year • Installation cost incurred by landowner	$50K for materials	

NOTES:
[1]Costs are estimated for first five years of control. Continued control work is necessary beyond five years.

Table 8-6 continued. Management options at a glance: Fragrant waterlily (*Nymphaea odorata*)

Management Goal	Control Strategy	Preliminary Costs and Assumptions	Estimated 5-Year Cost[1]	Further Consideration/ Recommendation
		MODERATE CONTROL		
Moderate Control: Target 40 to 50% reduction of lilies. Focus on south end of lake, high-use recreational areas, and where lily has significantly expanded in density and coverage.	**Option 1 – Chemical, Imazamox**	**• 40% reduction would include treatment to approximately 30 acres • 15-acre treatment annually; whole area cannot be treated at once -likely be 2 times per year over 5 years • $25 - $40K per year, decreasing as infestation decreases**	**$125K - $200K**	**Recommended for further consideration**
	Option 2 – Mechanical, Harvester/Cutter	• $2K - $3K per day • Assume can harvest 2 acres per day and will operate 5 days - 4 times a year • Unable to operate in shallow areas or where logs are present • Not specific to invasive water lily; non-target plant impacts	$200K – $300K, for contractor Capital Cost to purchase Harvester - $150K - $200K plus O&M	Considered but not recommended based on historical harvesting results
	Option 3 - Manual (DASH)	• $1.6 - $2K per day for 800 square feet • May not be feasible given large infestation • Dependent on available contractor	$900K – $1.8M	Considered but not recommended
	Manual – hand-pulling or cutting (non-diver)	**• Channel and shoreline maintenance • Hand cutting of flowers and seeds and removal from lake • Market labor cost for contractor; or volunteer/landowner • Should be in conjunction with Option 1, 2 or 3**	**Unknown – costs incurred by landowner**	**Recommended for further consideration – combined w/Option 1**
	Bottom Barriers (Individual Landowner)	**• Dock and swimming area maintenance per landowner discretion • Follow WDFW Pamphlet • County could potentially supply materials - $10K per year • Installation cost incurred by landowner • Should be in conjunction w/ Option 1, 2, or 3**	**$50K for materials**	**Recommended for further consideration – combined w/Option 1**

NOTES:
[1]Costs are estimated for first five years of control. Continued control work is necessary beyond five years.

Table 8-7. Management options at a glance: Education Plan – All invasive plant species control

Management Goal	Control Strategy	Description	Preliminary Costs and Assumptions	Estimated 5-Year Cost[1]	Further Consideration/ Recommendation
Prevent spread of invasive species to and from Long Lake	Boat Washing Station	Boat washing station set up at public boat launch	• Initial purchase $14K to $37K • Requires potential infrastructure upgrade • Maintenance and potentially staffing • Need adequate space for washing that does not disrupt boat traffic	$50K - $1.2M	Not recommended for further consideration
	Boat Launch Education through Use of Volunteers	**Community members visit the boat launch on heavy use days and provide education about cleaning, draining and drying boat**	**• Outreach materials** **• Time for volunteer training - assumes volunteer labor** **• Printing of education materials $1.5K**	**$1.5K - $3K**	**Recommended for further consideration**
	Outreach campaign to lake residents	**Develop and implement outreach campaign for landowners to prevent introduction form their boats**	**• Multi-year outreach campaign** **• $5K - $10K**	**$5K - $10K**	**Recommended for further consideration**
	Boat Launch Signage	**Additional signage at boat launch and park – all public access points**	**• Additional sign for Clean/Drain/Dry** **• Sign costs plus installation** **• Assume $2K**	**$2K**	**Recommended for further consideration**
Landowner/Resident Invasive Plant Control	**Landowner Workshops**	**Host workshops with expert presenting control methods that individual landowners can use on property**	**• $5K per workshop** **• Assume 1 workshop annually**	**$25K**	**Recommended for further consideration**
	Outreach campaign to lake residents	**Develop and implement outreach campaign for residents to identify invasive species and control methods they can use on their property**	**• In conjunction with outreach campaign for prevention** **• County staff time or volunteer time**	**Unknown, would be in addition to prevention outreach campaign**	**Recommended for further consideration**

NOTES:
[1]Costs are estimated for first five years of control. Continued control work is necessary beyond five years.

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9.0 PROPOSED ALTERNATIVE

Successful management of invasive plants in Long Lake will require a long-term commitment as it will take several years to re-establish a sustainable lake environment with increased native plant diversity. Ongoing prevention and early detection of invasive species are also needed to prevent future establishment of invasive plants. The plan shows the first five years of implementation which are likely to be the costliest. However, ongoing investments beyond these five years will be needed to at least maintain initial success and potentially continue improvements.

9.1 INITIAL PROPOSED MANAGEMENT STRATEGY

Based on feedback from the steering committee and Tetra Tech recommendations, a potential management strategy was developed for review by the Long Lake community and is presented in Section 9.1.1 and Tables 9-1 and 9-2. The management strategy includes control options for management of all three targeted invasive plant species as well as education and outreach components.

9.1.1 DESCRIPTION OF RECOMMENDED CONTROL APPROACHES INCLUDED IN PROPOSED MANAGEMENT STRATEGY

Curlyleaf Pondweed

To achieve the desired goal of eradication of curlyleaf pondweed, the recommended control method is to conduct annual diver surveys of the entire lake and hand-pull plants when observed. Currently curlyleaf pondweed is scattered throughout roughly 15 acres mostly within the south end of the lake and along the eastern shoreline. Diver surveys and hand-pulling should be conducted in late spring or early summer prior to the formation of turions and because curlyleaf pondweed senesces earlier in the year than most other aquatic plants. Annual diver surveys and hand-pulling should be conducted for at least 5 years post eradication. After 5 years post eradication, surveys can be reduced to every 3-4 years. The estimated cost per year for this control method was $12,000 to $20,000 for 3 to 5 days of diver surveys and hand-pulling.

If the curlyleaf infestation dramatically increases, chemical treatment is an additional recommendation. Chemical treatment options for curlyleaf pondweed include fluridone, 2, 4-D or potentially florpyrauxifen-benzyl (ProcellaCOR). At the time of this plan, there has been some evidence of control of curlyleaf pondweed with applications of ProcellaCOR, however, it is not currently labeled for use on curlyleaf pondweed but may be in the furture. ProcellaCOR has a highly favorable human health and environmental toxicity profile, meaning the impacts to human and environmental health are very low.

Brazilian Elodea

In order to reduce the current coverage and density of Brazilian elodea and promote increased native plant growth, the recommended control method is chemical treatment with the herbicide fluridone in conjunction with PAK 27 (sodium carbonate peroxyhydrate). The proposed control strategy is to treat 25 acres each year, which would be equivalent to 55% of the current Brazilian elodea coverage over 5 years. The location of the 25 acres to be treated should be determined based on current conditions and effectiveness of the previous years' treatment. Either a fall or spring aquatic plant survey should be conducted each year to refine that year's 25-acre treatment area. It is recommended that PAK 27 be applied in conjunction with fluridone to help control filamentous algae growth. The PAK 27 application is also expected to reduce DO demand from organic plant decay and help to oxidize the sediments, potentially reducing the amount of sediment "goo".

Ideally, herbicides would be applied early in the season, preferably near June 15 (the earliest treatment window applicable to Long Lake without a treatment timing window modification). The applicator should apply fluridone and PAK 27 within the designated treatment area to achieve a pre-determined target concentration. Maintaining a target dosage throughout the treatment period may require multiple applications over the course of approximately 8 weeks. The estimated cost for treatment with fluridone and PAK 27 is $800 to $1,500 per acre or $20,000 to $37,500 per year for 25 acres.

Fragrant Waterlily

Based on input from the steering committee, as well as cost considerations and concerns, a moderate level of control was chosen as the most achievable management goal for fragrant waterlily in Long Lake. This management goal targets a 40 to 50% reduction of fragrant waterlily with a focus on the south end of the lake, high-use recreational areas, and where the lily has significantly expanded in density and coverage.

In order to achieve the desired management goal for fragrant waterlily, a suite of control options was recommended. These control options include:

- **Chemical Control with Imazamox** – A 40% reduction in waterlily coverage would require treatment to approximately 30 acres. It is not feasible to treat all 30 acres at once, so it was recommended that 15 to 20 acres be treated with imazamox annually, likely twice per year for the course of 5 years. Herbicide application would be focused on the south end of the lake where the lily has significantly expanded in density and coverage. High-use recreational areas would also be a priority for herbicide application. Specific treatment locations would be determined annually based on current conditions and the effectiveness of the previous year's treatment. It is recommended that a fall aquatic plant survey be conducted to refine the next year's treatment area. It is estimated that an herbicide treatment to 15 acres would cost $25,000 to $40,000 per year.

- **Manual Control** – This control strategy includes hand-pulling and cutting for channel and shoreline maintenance. Hand-pulling and cutting will be conducted by volunteers and lake residents along private waterfronts, docks and in channels as needed. Volunteers and lake residents will follow the guidelines for hand-pulling and cutting as outlined in the WDFW *Rules for Aquatic Plant Removal and Control* pamphlet. Residents are strongly encouraged to cut fragrant waterlily flowers and seeds as this control strategy has been shown to reduce waterlily infestations especially when used in conjunction with herbicide treatment. Lake residents would incur the costs associated with this control strategy, however, Kitsap County has proposed to conduct annual workshops where community members will learn how to properly identify fragrant waterlily as well as appropriate hand-pulling and cutting methods to be used.

- **Bottom Barriers** – Lake residents/landowners will be encouraged to install burlap bottom barriers following the guidelines outlined in the WDFW *Aquatic Plants and Fish* pamphlet. Placement of the bottom barriers would be on the lakebed surrounding their waterfront/shorelines areas and docks. The pamphlet limits installation to 50% of the length of the applicant's shoreline. The barriers should be installed either in the late fall, after the plants have declined, or in the early spring, before plants begin to grow rapidly. Once installed, the burlap bottom barriers will likely need to be replaced every 4 years, as they typically decompose in that amount of time. The level of control has the potential to be high in the focused areas where bottom barriers would be installed. Kitsap County is evaluating the option of purchasing and supplying the burlap material for lake residents to use. The annual cost of burlap material was estimated to be approximately $10,000. Installation costs would be incurred by the landowner and divers may be needed for installation in deeper areas. The County has also proposed to conduct annual workshops where community members can learn how to properly install barriers around their docks and along their shorelines.

Recommended Approach for Invasive Species Prevention

In addition to aquatic plant control, the steering committee recognized that invasive species prevention through outreach and education to lake users is important to not only prevent new invasive species from entering Long Lake but also to help prevent the transport of invasive species such as curlyleaf pondweed and Brazilian elodea to other lakes.

Preventing the introduction of any new species and having early recognition of species is critical to ensuring the long-term health of the lake. It also cannot be overstated that prevention of new introductions and rapid response to those introductions provide significant cost savings over controlling an invasive species once established. While this plan focuses on invasive plants, the same efforts can also help prevent the introduction of invasive animals such as zebra mussels or New Zealand mudsnails.

The primary vector by which new invasive species can be introduced to the lake is through contaminated boats coming from other lakes into Long Lake. Similarly, boats leaving Long Lake can also carry invasive species such as curlyleaf pondweed and Brazilian elodea to other nearby lakes. Cleaning, draining and drying boats when leaving any lake can help prevent the spread of invasive species. The cleaning includes removing plant fragments and debris from boats, trailers, and other equipment that was in contact with water. Draining includes cleaning any bilge water or other water remaining in the boat hull or live wells. Drying helps to kill any invasive plants or animals that may have been missed which is especially important for preventing the spread of invasive mussels and snails.

Outreach and education are the primary methods to prevent the spread of invasive species The target audience for efforts would include both external lake users as well as lake residents that take their boats to other lakes and then return to Long Lake. The following control strategies were recommended to educate lake users:

- **Boat Launch Education**: The best method of reaching external lake users is to provide education at the boat launch while launching and leaving the lake. One approach successfully used at other lakes is for community members to volunteer and provide outreach materials to lake users - especially on busy summer weekends. There are many good outreach materials developed by other jurisdictions such as Lake Whatcom that could be adapted for this purpose at a relatively low cost. This effort would require coordination and implementation by CILL. Estimated costs for boat launch education ranged from $1,500 to $3,000 and include time for volunteer training and printing of education materials.
- **Outreach and Education campaign** – To reach Long Lake residents an outreach campaign focused on Cleaning, Draining and Drying boats would be developed. Methods to reach residents would include email, social media and mailers. This effort could compliment efforts to educate landowners on invasive aquatic plant identification and control methods they can use on their property. An outreach and education campaign is estimated to cost between $5,000 and $10,000 depending on complexity and number of years and would also include county staff time and/or volunteer time.
- **Boat Launch Signage** – A passive method of reaching external lake users would be posting additional signage at the boat launch to encourage Cleaning, Draining and Drying your boat. To be effective, the sign would have to be highly visual and easy to read. This would be in addition to the numerous signs that already exist at the public WDFW boat launch. Consideration should be taken in determining how additional Clean, Drain, Dry signage can be incorporated into existing

signage, so lake users do not experience sign fatigue. Highly visible Clean, Drain, Dry signs should also be placed at all public access points including in the Long Lake County Park. It was assumed that additional signs and installation costs would be around $2,000.

Recommended approach Landowner/Resident Invasive Plant Control

The steering committee also recognized the importance of educating landowners and lake residents on available and effective control options for invasive aquatic plants that they can implement themselves to support the overall community plan. This was one of the project goals identified early on by steering committee members. It is also critical that individual landowners be able to recognize invasive species so they can quickly respond to any new invasive plant and alert Kitsap County and or Ecology. It is key that landowners be equipped with the knowledge on the most effective control methods and what methods require permits and/or the assistance of licensed professionals. The most effective strategy to achieve this project goal is through rigorous education and outreach efforts.

Based on similar work at other lakes and similar IAVMP plans the following are potentially effective outreach strategies that are recommended for Long Lake:

- **Outreach campaign** – the goals of an outreach and education campaign would be to first raise awareness of the problem, help landowners identify invasive plants, provide information on how to effectively control plants and lastly, encourage them to take control actions. Messaging and materials would need to be developed and then distributed multiple times via email, social media and mailers. This effort could complement efforts to educate Long Lake residents on Cleaning, Draining, and Drying boats and preventing the introduction or transport of invasive species. Costs for this outreach campaign would be included with the outreach campaign focused on invasive species prevention.

- **Landowner workshops** on plant control – workshops conducted in person or online have been a highly effective method used for other areas, including Lake Ballinger and throughout King County, to empower landowners to conduct invasive plant control. Workshop topics would include an introduction to each target plant and tips for identification, control methods that they can conduct on their own, and control methods that are effective but require professional assistance and/or permits. Specific to Long Lake, workshop topics would include proper installation methods for burlap bottom barriers as well as fragrant waterlily flower and seed cutting and disposal. Workshops were estimated to cost $5,000 per year.

Table 9-1. Recommended aquatic plant management strategies for Long Lake

Plant Species	Management Goal	Control Strategy	Preliminary Costs and Assumptions	Estimated 5-Year Cost[1]
Curlyleaf Pondweed	Eradicate remaining small infestations within the lake	Manual, includes annual surveying (diver hand-pulling)	• $12-20K for 3-5 days for entire lake survey and hand-pulling • Currently scattered throughout roughly 15 acres – majority within south end of lake and along eastern shoreline • Annual surveys should be conducted for at least 5 years post eradication	$60K - $80K
Brazilian Elodea	Control to reduce coverage and density to promote native plant growth	Chemical, fluridone with PAK 27	• $800 - $1,500 per acre • Treat 25 acres each year, equivalent to 55% of current coverage over 5 years • PAK 27 used to control filamentous algae growth while reducing DO demand from organic decay • PAK 27 oxidizes sediment “goo”	$100K - $187.5K
Fragrant Waterlily	**Moderate Control**: Target 40 to 50% reduction of lilies. Focus on south end of lake, high-use recreational areas, and where lily has significantly expanded in density and coverage.	Chemical, Imazamox	• 40% reduction would include treatment to approximately 30 acres • 15-acre treatment annually; whole area cannot be treated at once -likely be 2 times per year over 5 years • $25 - $40K per year, decreasing as infestation decreases	$125K - $200K
		Manual – hand-pulling or cutting (non-diver)	• Channel and shoreline maintenance • Hand cutting of flowers and seeds and removal from lake • Market labor cost for contractor; or volunteer/landowner	Unknown – costs incurred by landowner
		Bottom Barriers (Individual Landowner)	• Dock and swimming area maintenance per landowner discretion • Follow WDFW pamphlet • County could potentially supply materials - $10K per year • Installation cost incurred by landowner	$50K for materials

NOTES:
[1]Costs are estimated for first five years of control. Continued control work is necessary beyond five years.

Table 9-2. Recommended aquatic plant management strategies for Long Lake: Education Plan – All invasive plant species

Management Goal	Control Strategy	Description	Preliminary Costs and Assumptions	Estimated 5-Year Cost[1]
Prevent spread of invasive species to and from Long Lake	Boat Launch Education through Use of Volunteers	Community members visit the boat launch on heavy use days and provide education about cleaning, draining and drying boat	• Outreach materials • Time for volunteer training - assumes volunteer labor • Printing of education materials $1.5K	$1.5K - $3K
	Outreach campaign to lake residents	Develop and implement outreach campaign for landowners to prevent introduction form their boats	• Multi-year outreach campaign • $5K - $10K	$5K - $10K
	Boat Launch Signage	Additional signage at boat launch and park – all public access points	• Additional sign for Clean/Drain/Dry • Sign costs plus installation • Assume $2K	$2K
Landowner/Resident Invasive Plant Control	Landowner Workshops	Host workshops with expert presenting control methods that individual landowners can use on property	• $5K per workshop • Assume 1 workshop annually	$25K
	Outreach campaign to lake residents	Develop and implement outreach campaign for residents to identify invasive species and control methods they can use on their property	• In conjunction with outreach campaign for prevention • County staff time or volunteer time	Unknown, would be in addition to prevention outreach campaign

NOTES:
[1]Costs are estimated for first five years of control. Continued control work is necessary beyond five years.

9.1.2 COST ASSUMPTIONS FOR PROPOSED MANAGEMENT STRATEGY

Successful management of invasive plants in Long Lake will require a long-term commitment as it will take several years to re-establish a sustainable lake environment with increased native plant diversity. Ongoing prevention and early detection of invasive species are also needed to prevent future establishment of invasive plants. The proposed management strategy includes the first five years of implementation which are likely be the costliest. However, ongoing investments beyond these five years will be needed to at least maintain initial success and potentially continue improvements.

The proposed management strategy above identified control methods and cost estimates for each targeted plant. The proposed strategy was summarized in Tables 9-1 and 9-2 with preliminary cost estimates for the first five years detailed below in Table 9-3. Table 9-3 also includes estimated costs associated with planning and permitting of the proposed management strategy. Detailed descriptions of potential control methods and cost estimates for each target plant are described in Section **Error! Reference source not found. Error! Reference source not found.**.

The following assumptions were made when estimating costs for the control options:

- Cost estimates were calculated in 2022 dollars and do not include inflation.
- Estimated costs for each year of implementation were calculated using the high end of estimated ranges.
- Costs were estimated for the first five years, but continued investment will be needed beyond five years.

Table 9-3. Estimated 5-year costs[1] associated with recommended aquatic plant management strategies for Long Lake

Management Strategy	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Curlyleaf Pondweed Diver Hand-Pulling	$20K	$20K	$12K	$6K	$6K	$72,000
Brazilian Elodea Herbicide & PAK 27	$37.5K	$37.5K	$37.5K	$37.5K	$37.5K	$187,500
Lily Herbicide Treatment	$40K	$40K	$40K	$40K	$40K	$200,000
Bottom Barrier Materials	$10K	$10K	$10K	$10K	$10K	$50,000
Outreach & Education	$10K	$10K	$8K	$6K	$6K	$40,000
Project Management & Permitting	$10K	$10K	$7K	$7K	$6K	$40,000
TOTAL[2]	**$127,500**	**$127,500**	**$114,500**	**$106,500**	**$105,500**	**$589,500**

NOTES:
[1]Costs are estimated for first five years of control. Continued control work is necessary beyond five years.
[2]Costs are just for aquatic plant management strategies and control and does not cover toxic algae or nutrient management.

9.2 COMMUNITY FEEDBACK ON INITIAL MANAGEMENT SCENARIOS

To be completed after public meeting

9.3 FINAL MANAGEMENT APPROACH FOR LONG LAKE

To be completed after public meeting

9.3.1 TIMING, INTENSITY AND AREA OF CONTROL

To be completed after public meeting – most likely will include a table summarizing potential timing, intensity and area of control

9.3.2 PERMITS, LICENSES AND PERMISSIONS

Working on vegetation control in and near water and wet areas requires several permits and licenses to ensure that control work is done with minimal to no impact on the environment.

Aquatic Plants and Fish Rules for Aquatic Plant Removal and Control

- Issued by the Washington Department of Fish and Wildlife
- The pamphlet can be acquired and printed from this web site: https://wdfw.wa.gov/licenses/environmental/hpa/types/aquatic-plants
- This pamphlet covers activities that occur in “Waters of the State” including areas of standing water on the lake shore.
- This pamphlet served as the Hydraulic Project Approval (HPA) for some types of aquatic week or plant control and removal including physical and mechanical methods.
- Plant control activities vary depending if the plant is an “aquatic noxious weed” (on the state noxious weed list) or an “aquatic beneficial plant” (all native and nonnative aquatic plants except those on the state noxious weed list). Read and follow the pamphlet carefully.
- All work outside allowable work windows listed in the permit time period table requires an individual HPA permit.
- The pamphlet is specific about what weed control situations it allows, what situations required an HPA permit (see below) and what activities do not pertain
- The pamphlet does not regulate the use of grass carp or herbicide, which are regulated by other WDFW rules and Ecology, respectively

Formal Hydraulic Project Approval (HPA) Permit

- The HPA covers all other activities, including weed control work, that happen in “Waters of the State” and are not allowed under the Aquatic Plants and Fish pamphlet.
- Details of when a formal HPA is needed are in the Aquatic Plants and Fish pamphlet.
- A HPA can be applied for online at: http://wdfw.wa.gov/licensing/hpa/
- Cost is $150 and takes 45 days to process

Pesticide Applicators License with an Aquatic Endorsement

- Issued by the Washington State Department of Agriculture (WSDA)
- Requires testing and annual license fees are required
- Without re-certification credits, the license is good for five years.
- WSDA pesticide licensing web site: https://agr.wa.gov/services/licenses-permits-and-certificates

- A license is not necessary for a private landowner using the injection method to control knotweed on their own property.

Aquatic Noxious Weed Control Permit

- Issued by the Ecology and managed by WSDA
- For emergent plants (state listed noxious weeds only)
- Free permit, takes approximately one month to receive
- Apply online: https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Aquatic-pesticide-permits/Aquatic-noxious-weed-control
- Public notification (letters and/or signs) are needed and the permit involves record keeping of herbicide use and reporting back to WSDA
- Each permit has its own list of Ecology permitted herbicides and surfactants

Aquatic Plant and Algae Management General Permit

- Issued by Ecology
- Required for herbicide use on submerged and floating leaf aquatic plants (and for native plants/non noxious weeds in any aquatic situation)
- Permit costs about $700/year and takes approximately 2-6 months to receive
- Apply online: https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Aquatic-pesticide-permits/Aquatic-plant-algae-management
- Public notification is required (newspapers, signs, letters)
- Record keeping, annual reporting, and water quality testing (chemical dependent) are required
- Each permit has its own list of Ecology permitted herbicides and surfactants.

9.4 EVALUATION OF MANAGEMENT APPROACHES FOR LONG LAKE

9.4.1 POTENTIAL HEALTH AND ENVIRONMENTAL RISKS

The herbicides selected in the final recommended management approach were chosen to maximize the efficacy of treatment while minimizing risks to humans and wildlife, as well as, minimizing adverse impacts to beneficial uses of the lake. The potential health and environmental risks and the options that were selected to minimize these risks are fully addressed in section **Error! Reference source not found. Error! Reference source not found.**.

9.4.2 BALANCE OF PROPOSED APPROACH BETWEEN WATERBODY ENHANCEMENT AND ENVIRONMENTAL PROTECTION

The proposed plan will have significant long-term positive impacts for both waterbody enhancement and environmental protection. The aquatic vegetation management plan exclusively addresses the control and prevention of invasive plant species in areas where beneficial uses are currently impeded by excessive plant growth (see section **Error! Reference source not found.**). Controlling the population of invasive aquatic plants will provide significant benefits for lake recreation including boating, swimming and fishing. Additionally, removal of invasive plant species will lead to an increase in the diversity of native aquatic plants, improving the quality of aquatic habitat in Long Lake.

There could be some short-term impacts to the water quality and ecological health of the lake from management control options identified in the plan including:

- DASH and diver hand-pulling of curlyleaf pondweed may cause a short-term increase in turbidity
- Chemical control of lilies will lead to a die-off of plants that can deplete dissolved oxygen and release nutrients that can stimulate algal growth. The plan and associated herbicide permitting mitigates for these impacts by limiting the area of treatment at any one time.

- Bottom barriers exclude all plant growth and may harm the benthic organisms under the barrier. The size and coverage of barriers is limited by permits to prevent significant harm in any one area.
- All control methods will lead to temporary decreases in any aquatic vegetation. However, native plants have been shown to quickly re-colonize suitable growing areas when invasive competitors are removed.

The long-term health and environmental improvements associated with the implementation of this plan outweigh the short-term impacts listed above. Furthermore, the alternative of taking no action regarding invasive aquatic plants will lead to future impacts to both the recreational and ecological beneficial uses of the lake.

9.4.3 COMPATIBILITY WITH FISHERIES, WATERFOWL, WILDLIFE, WETLANDS, RARE PLANTS, ENDANGERED SPECIES, WATER RIGHTS, AND ECOLOGY OF WATER BODY

No endangered species or rare plants have been identified in Long Lake (see Section 4.0). The final management approach will have no adverse impact on wildlife, waterfowl, or fish known to use Long Lake. The treatment plan, by design, will reduce aquatic invasive plant coverage within the littoral zone. As a result, these areas will reduce the coverage of invasive species and allow for the re-establishment of native species, improving the ecology of the waterbody and the quality of aquatic habitat in the lake.

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10.0 MONITORING, RESPONSE, AND PREVENTION

The Long Lake IAVMP is designed to be adaptive. Throughout its implementation, aquatic plant surveys will be necessary to guide treatment planning, to assess the efficacy of completed treatments, and to inform strategies for future treatments. Each year following implementation of management control options, visual surveys of the target aquatic plants, at a minimum, should be conducted to assess efficacy. Surveys within treatment areas and non-treatment areas (to serve as control) are also recommended to assess the recovery of native plants following invasive treatment. A complete re-survey of the lake's vegetation is recommended every 2 to 4 years depending on treatment progress. These periodic surveys of the entire lake will provide a means to monitor existing infestations of aquatic plants, detect new infestations should they occur and measure the effectiveness of implemented control methods.

The Long Lake IAVMP included preventative actions as part of the final management approach. In addition to these actions already specified in the plan, any equipment used during aquatic plant surveys, control efforts or monitoring efforts should be decontaminated and cleaned following Ecology standard operating procedures for minimizing the spread of invasive species (Ecology, 2018). This includes equipment used by licensed herbicide applicators or other plant management contractors.

If any new invasive species and/or infestations are identified in Long Lake, the Long Lake Steering Committee, CILL, and Kitsap County should work cooperatively to adapt the management plan to address these infestations. Additionally, the Long Lake community and Kitsap County should continue to explore and research emerging technologies that could improve treatment efficacy and reduce implementation costs.

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11.0 FUNDING OPTIONS

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Implementation of the Long Lake IAVMP will require a long-term financial investment by the Long Lake community. There are a variety of mechanisms by which residents can raise funds for local lake management. In addition, there may be state or local grants that could reduce the financial burden.

11.1 LOCAL PROPERTY OWNER FUNDING

Commented [BS12]: The County (Jennifer/Eric) to include text on funding the Lake management district or other options.

See the Lake Roesiger IAVMP for example text

11.2 GRANT OPPORTUNITIES

Grants can help stretch local dollars and provide funding for larger cost items such as herbicide treatments or diver hand pulling. They are not a reliable source of funding for long-term or ongoing lake management activities. There are limited grant opportunities for funding the recommended actions with the most promising being the Department of Ecology's Invasive Aquatic Plants Management Grants Program.

At this time, grants of up to $75,000 are available for invasive aquatic plant control projects. A 25% ($25,000) local match for any grant funds awarded is required. Grant match may include some in-kind labor efforts. The grants are funded by a portion of boater registration fees. Grants are typically offered every year or every other year pending funding availability. According to current guidelines, an approved Integrated Aquatic Vegetation Management Plan, such as this plan, are required to be eligible for funding. Eligible public bodies that may apply include state agencies, counties, special purpose districts (including LMD's) and Tribes.

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APPENDICES

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APPENDIX A. WATER RIGHTS

A.1 WATER RIGHTS

Record Document Number	WR Doc ID	Certificate Number	Person or Organization	Priority Date Claim First Use	Purpose of Use	Instantaneous Quantity (CFS)	Annual Quantity (Acre-ft)
S1-*09833CWRIS	2276289	05046	ARRANTS J M	08/15/1950	Irrigation	0.1000	
S1-*10109CWRIS	2276347	04185	HAHN E A	02/05/1951	Irrigation	0.0500	
S1-*10589CWRIS	2276174	04419	CURRY J D	08/08/1951	Domestic Single	0.0100	
S1-*11550CWRIS	2276077	06300	BOTHELL R E	07/25/1952	Irrigation	0.0400	
S1-*11648CWRIS	2276089	05371	BLEDSOE B H	09/03/1952	Domestic Single,Irrigation	0.0200	
S1-035370CL	2263486		Burns, Gordon H		Domestic General		
S1-041663CL	2262022		Melitch, William		Domestic General		
S1-047613CL	2260114		Askey, M Louise		Domestic General		
S1-081513CL	2251437		Barnes, Clarence D		Domestic General		
S1-091216CL	2248773		Howe, Scott		Irrigation		
S1-099886CL	2246600		Rutherford, Francis C		Irrigation,Domestic General		
S1-132329CL	2238245		Price, Melvin R		Irrigation		
S1-135322CL	2237949		Bussell, Eldon R		Irrigation		
S1-158733CL	2231856		Cardinal, Richard L		Irrigation,Domestic General		
S1-20166CWRIS	2274147	S1-20166 C	FEDDOCK JOHN G	06/06/1972	Irrigation	0.0200	6.0000
S1-20372CWRIS	2273935	S1-20372 C	WHITAKER JOHN L	11/29/1972	Irrigation	0.0200	2.0000
S1-21923CWRIS	2273187	S1-21923 C	BURNS GORDON H	06/27/1974	Irrigation	0.0200	2.0000
S1-22755CWRIS	2272908	S1-22755 C	FORBES BEN A	11/05/1976	Irrigation	0.0200	2.0000
S1-22941CWRIS	2272682	S1-22941 C	FOREMAN ALICE I	08/01/1977	Domestic Single	0.0100	1.0000
S1-24528CWRIS	2272370	S1-24528 C	MOORE/NEAL	08/01/1984	Domestic Single	0.0100	1.0000
S1-25193CWRIS	2272487	S1-25193 C	NOYES RONALD & D	03/07/1988	Domestic Single	0.0100	1.0000
S1-25337CWRIS	2272509	S1-25337 C	W R HUBBARD	10/04/1988	Domestic Single	0.0200	1.0000
S1-25423CWRIS	2272210	S1-25423 C	WALTER C BRISKI	04/13/1989	Domestic Single	0.0100	0.5000
					Total	0.3600	16.5000

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