LAKE GENEVA
LAKE MANAGEMENT DISTRICT PLAN

2016–2025

Prepared for
Lake Geneva Property Owners Association

Prepared by
Herrera Environmental Consultants, Inc.

HERRERA

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LAKE MANAGEMENT DISTRICT PLAN

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Prepared for
Lake Geneva Property Owners Association
King County, Washington

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1. INTRODUCTION

Lake Geneva is a nearly 30-acre lake within the 179-acre Lake Geneva watershed. The entire watershed lies within unincorporated King County. Most of the lakeshore is residential development, but a significant portion of the southeast shore of the lake is Lake Geneva Park, which is managed by King County. The lake has several state-listed aquatic noxious weeds, high water episodes due to lake outlet maintenance issues, and has recently experienced a decline in water clarity due to increased phosphorus input and algae growth. Many property owners on Lake Geneva want a comprehensive Lake Management Plan and a reliable funding source to address lake issues.

Past management of Lake Geneva has been limited to infrequent plant surveys, water quality monitoring, and some aquatic plant control activities. There has not been an overall plan in place for management of the lake.

Desiring a more thorough and comprehensive approach to lake management, the Lake Geneva Property Owners' Association (LGPOA) received a grant from the King County Flood District Flood Reduction Fund to form a Lake Management District (LMD). An LMD is a special purpose district created by local property owners to finance improvements and maintenance activities on lakes (RCW 36.61.010). The LGPOA is currently working with King County to form an LMD during 2015, intending to begin the LMD in 2016.

The Washington State Legislature created RCW 36.61 because the environmental, recreational, and aesthetic values of many of the state's lakes are threatened by eutrophication and other deterioration, and existing governmental authorities are unable to adequately improve and maintain the quality of the state's lakes. The purpose of RCW Chapter 36.61 is to establish a governmental mechanism by which property owners can embark on a program of lake or beach improvement and maintenance for their and the general public's benefit, health, and welfare.

The goals of the Lake Geneva Management District include:

- Create a funding mechanism to fund management actions on Lake Geneva
- Collect predetermined fees from the Lake Management District for a set amount of time
- Develop a Lake Management Plan

This report covers the current physical and biological conditions of the lake and the known history of lake ecology and management. It contains Lake Geneva's Management Plan, which outlines the lake's management goals and objectives for the next 10 years, and a budget for accomplishing these goals.

2. EXISTING CONDITIONS

2.1. Watershed Characteristics

2.1.1. Drainage Area and Land Use

Lake Geneva watershed is 179 acres, which is small at only six times the lake area of 29.3 acres. The lake is in the Duwamish/Green Water Resource Inventory Area (WRIA) 9, within unincorporated King County. Stormwater from within Lake Geneva watershed flows into Lake Geneva, and influences the level of the lake during times of peak precipitation (Figure 1).

The majority of land use within Lake Geneva watershed includes single-family residences comprising 59.4 percent of the watershed area, followed by vacant land at 15.8 percent (Table 1). Other land uses within the watershed include right-of-way, parks, mobile homes, Lakeland Community Club, and industrial land uses (Table 1) (Figure 2).

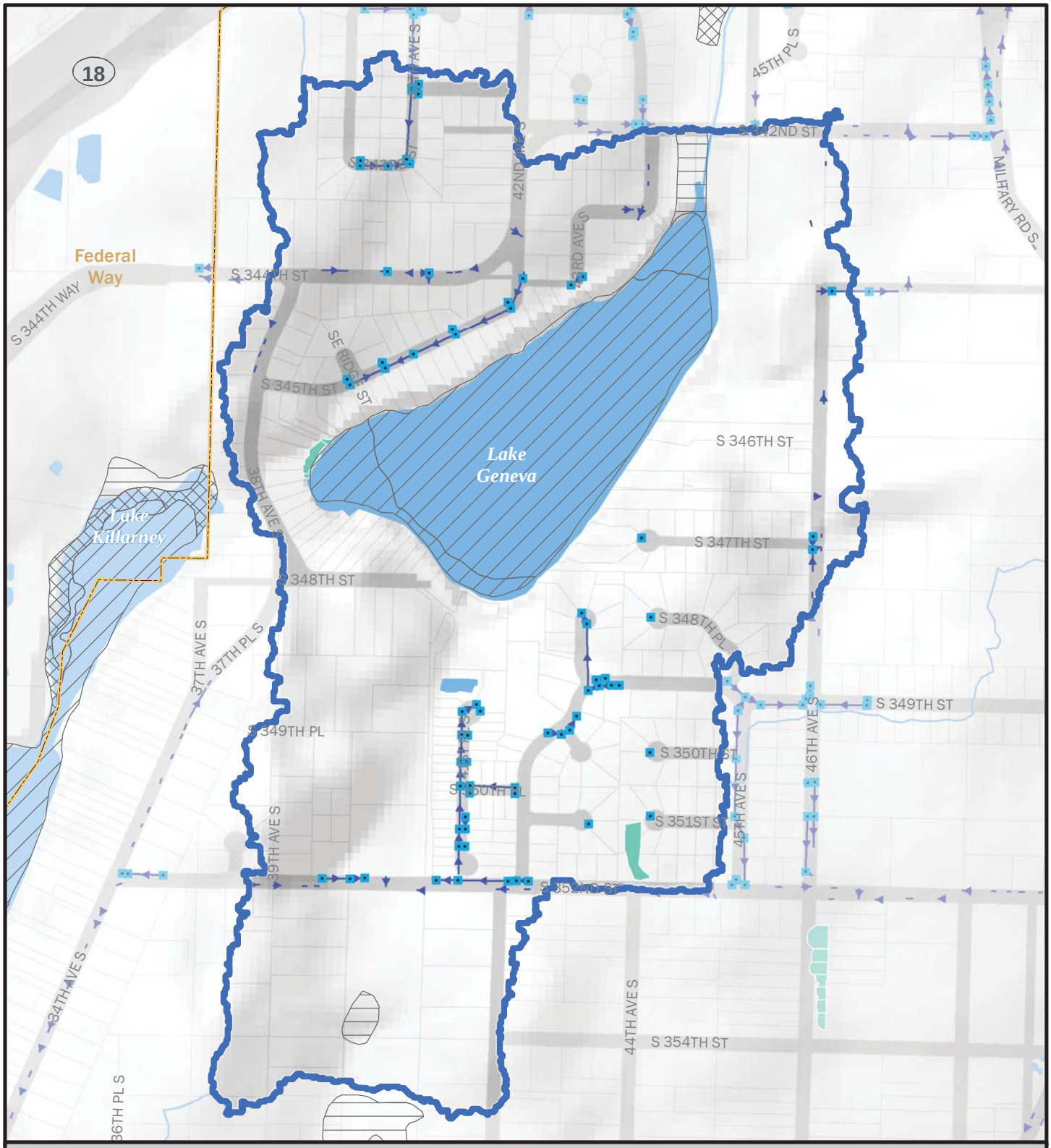
Table 1. Land Use Types Within the Lake Geneva Watershed, King County, Washington.

Land Use Type	Area (Acres)	Percent
Single-family residence	106.2	59.4
Mobile home	4.1	2.3
Park	12.6	7.1
Lakeland Community Club	2.4	1.3
Industrial	1.9	1.1
Vacant (SF)	28.3	15.8
Right-of-way	23.2	13.0
Total	178.7	100.0

2.1.2. Stream and Wetland Characteristics

Lake Geneva is the headwaters of an unnamed stream (Figure 1). The unnamed creek flows from Lake Geneva to Mill Creek, which flows to the Green River, then the Duwamish River, and then into Puget Sound. There are no streams that flow into Lake Geneva.

The National Wetland Inventory shows one small freshwater forested wetland at the southern end of the watershed. The King County wetland inventory shows two additional wetlands; a wetland along the western side of Lake Geneva and a wetland in the southern end of the watershed near South 351st Street (Figure 1).



Legend

- Stormwater pipe
- Catchbasin
- Parcel
- City limit
- Watershed
- Stream

Wetland Type (NWI)

- Lake
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Wetland (King County)

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Figure 1.
Stormwater Infrastructure, Stream, and Wetlands Within Lake Geneva Watershed, King County, Washington.

N

0 300 600 1,200 Feet

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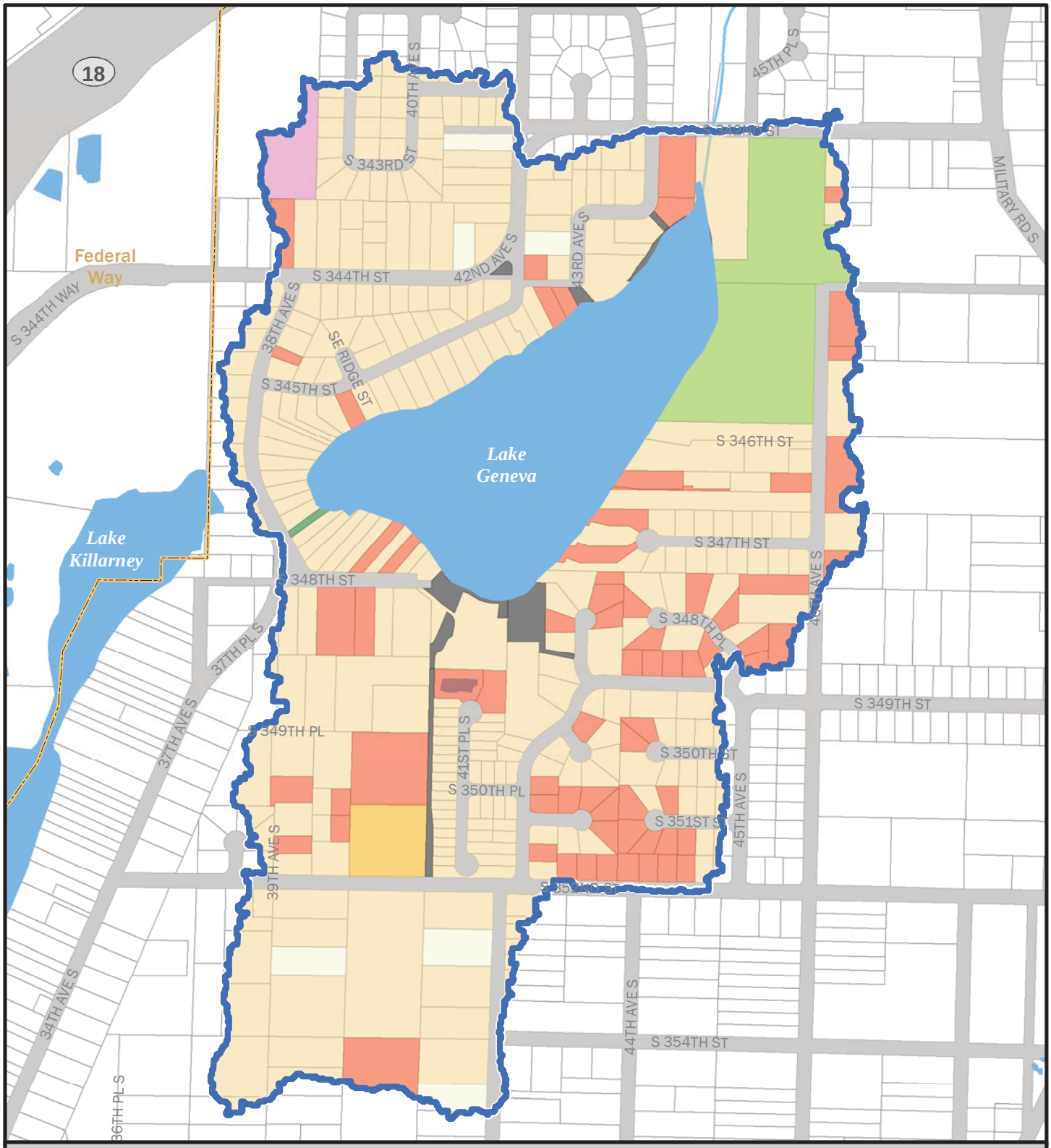

Legend

- Watershed
- Stream
- City limit

Land Use

- Single family residence
- Mobile home
- Vacant (SF)
- KC Park
- WDFW
- Club
- Industrial
- Undesignated

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Figure 2.
Land Use for Lake Geneva Watershed, King County, Washington.

N

0 300 600 1,200 Feet

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MRLC, NLCD (2011)

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2.1.3. Non-Point Nutrient Sources

Most of the non-point nutrient sources to Lake Geneva generate from stormwater runoff within the Lake Geneva watershed. Nutrients from landscaping, gardening, pets, septic systems, and waterfowl also contribute. These non-point nutrients affect phosphorus within the lake. Lake Geneva is typically mesotrophic, meaning that the biological productivity within the lake is moderate (King County 2014a). When a lake becomes eutrophic (high biological productivity), lake issues such as algal blooms and fish kills can occur. Lake Geneva watershed is within the Lakehaven Utility District, and the majority of houses within the watershed are connected to the sewer system (King County iMAP 2014).

2.1.4. Water Rights

There are no water rights or claims issued for Lake Geneva. A past water right for Lake Geneva was cancelled in 1988. Here, the permittee concurred with the decision to cancel the water right. This water right's stated use was to water the lawn and flower beds as needed (personal communication with Arlene Harris, February 11, 2015).

2.2. Lake Geneva

2.2.1. Physical Characteristics

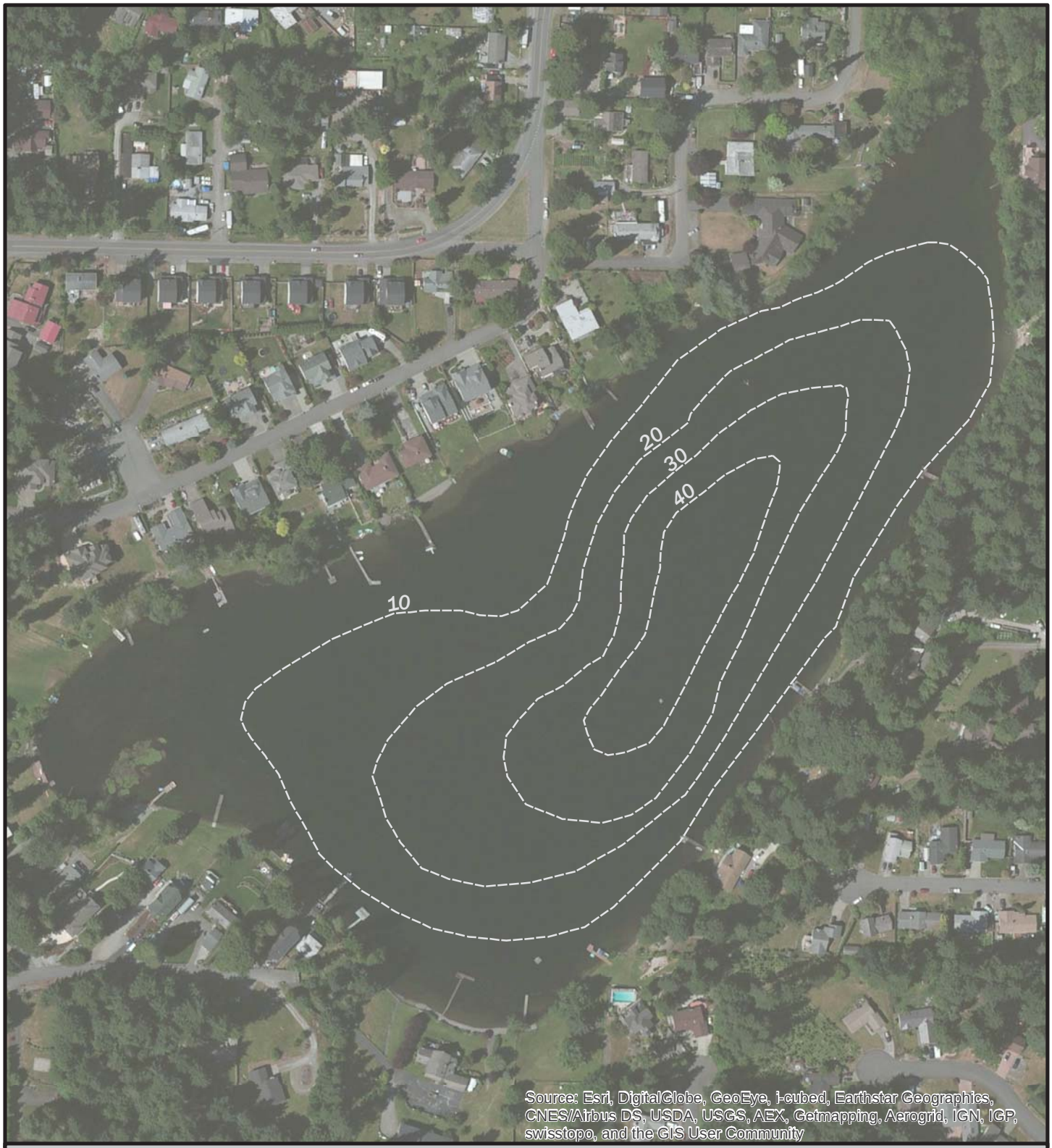
The first bathymetric map of Lake Geneva is believed to be from a 1946 survey of the lake by the Washington Department of Game (WDG 1946). An updated bathymetric map is next seen in a 1994 figure, as part of an aquatic plant mapping project for 36 King County lakes (King County 1994). It is unknown if any bathymetric mapping of Lake Geneva has occurred since 1994. The 1994 bathymetry is shown in Figure 3.

Lake Geneva has a surface area of 29 acres, an average depth of 19 feet, and a maximum depth of 46 feet. Other physical lake characteristics are listed in Table 2.

Table 2. Physical Characteristics of Lake Geneva, King County, Washington.

Characteristic	Unit of Measurement
Surface Area	29.3 acres
Volume	510 acre-feet[a]
Maximum Depth	46 feet[a]
Average Depth	19 feet[a]
Lake Altitude	390 feet
Shoreline Length	1.04 miles
Watershed Area	178.7 acres

[a] Bortleson et al. 1976.



Legend

Bathymetry

18228

Figure 3.
Lake Geneva Bathymetry,
King County, Washington.

N

0 125 250 500 Feet

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ESRI, Aerial (2011)

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2.2.2. Lake Level and Precipitation

The lake level and amount of precipitation at Lake Geneva has been monitored by a volunteer lake resident daily since 1994, as part of the King County Lake Stewardship Program (King County 2014b). Lake level has been observed at a lake staff gauge installed by King County on the resident's dock and precipitation has been observed at a rain gauge installed on the resident's property. Lake level and precipitation data are available for 13 years from October 1, 1994, through November 30, 2008, with a 1-year gap from October 1, 1997, through October 6, 1998 (King County 2014a). Daily lake level and precipitation monitoring was reestablished on February 12, 2014, and data were compiled through September 30, 2014, which is the end of water year 2014 (October 2013 through September 2014).

Weekly lake level and precipitation data for water year 2014 are presented in Figure 4 (King County 2015a). Lake level gradually decreased from a maximum of 108 centimeters (cm) in March 2014 to a minimum of 42 cm in September 2014. This pattern is similar to historical observations made in water years 1995 through 2007 (Figure 5) that typically show a rapid increase in lake level due to high precipitation from approximately October to January each year. Extreme lake levels recorded at Lake Geneva include a minimum level of 18 cm on October 13, 1994, and a maximum level of 139 cm on January 3, 1997. Examination of lake level data in Figure 5 indicates there has been no apparent long-term trend in lake levels since records began in 1994.

High lake levels are caused by high inflow rates that may be exacerbated by flow obstructions in the lake outlet channel. Lake levels over 120 cm submerge the surface of fixed docks on Lake Geneva (J. Galland and D. Leibilie, personal communication). High lake levels do not impact most of the docks on the lake because they are floating docks. Lake levels over 120 cm were measured in 1996 and 2005, but not in the remaining 12 years with lake level data (Figure 5).

2.2.3. Shoreline Characteristics

Lake Geneva comprises 1.04 miles of shoreline. The majority of shoreline use includes single-family residences (60.6 percent). Lake Geneva Park comprises 14 percent of the total watershed area. Additional shoreline use includes vacant land, the WDFW boat launch, and undesignated properties (Table 3) (Figure 6).

Table 3. Shoreline Use for Lake Geneva, King County, Washington.

Land Use Type	Shoreline Length (ft.)	Percent
Single-family residence	3,355.6	60.6
Vacant	788.7	14.2
Undesignated	580.8	10.5
Lake Geneva Park (King County)	773.7	14.0
WDFW Boat Launch	38.5	0.7
Total	5,498.7	100.0

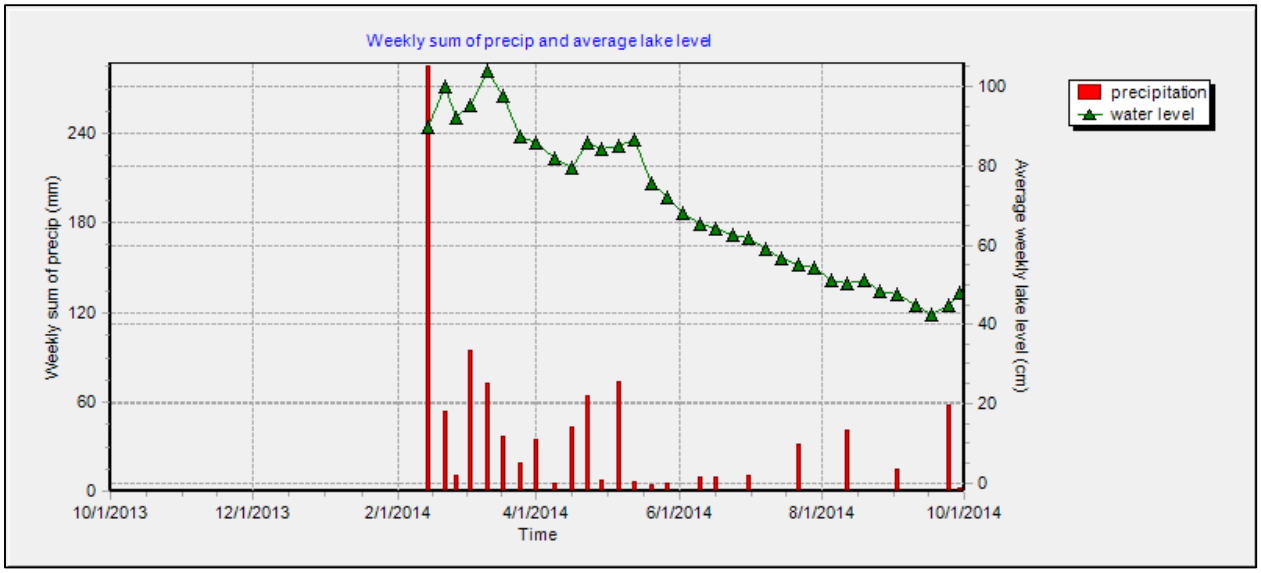


Figure 4. Weekly Lake Level and Weekly Precipitation for Lake Geneva in 2014 (King County 2015).

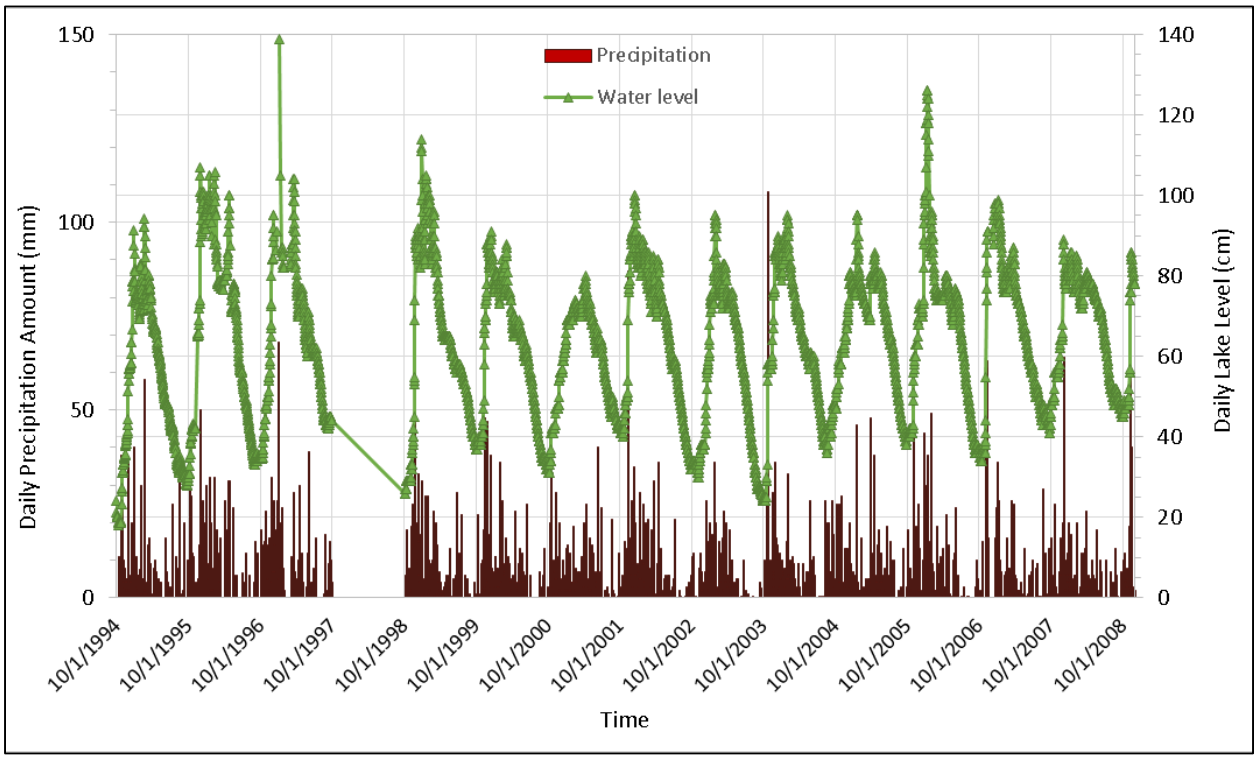
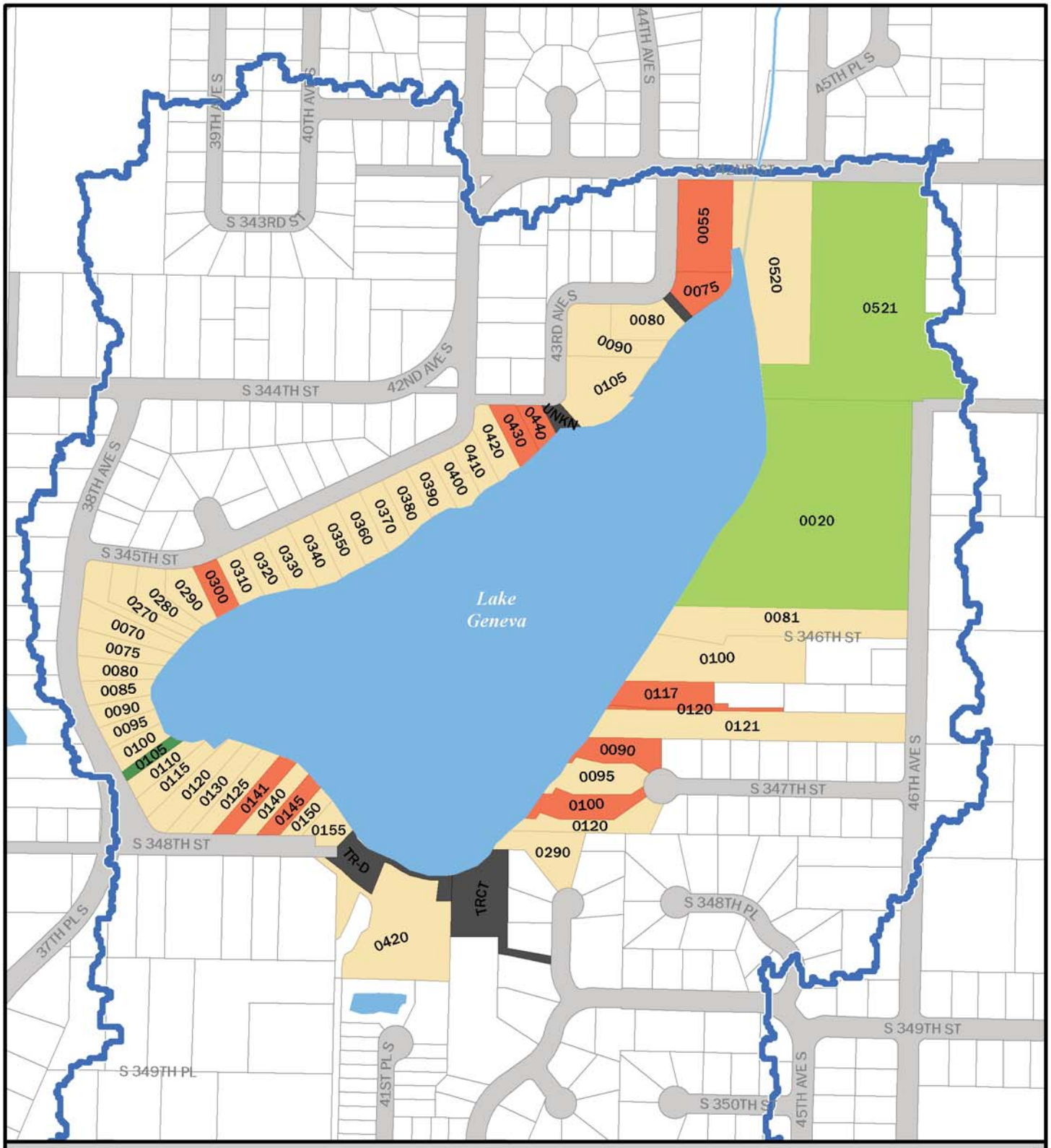


Figure 5. Daily Lake level and Daily Precipitation for Lake Geneva in 1994-2008.



Legend

- Single family residence
- Vacant (SF)
- KC Park
- WDFW
- Undesignated
- Watershed
- Stream

18228

Figure 6.
Lakeside Land Use for Lake Geneva, King County, Washington.

N

0 200 400 800 Feet

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King County, Parcels (2014)

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2.2.4. Beneficial Uses

Numerous beneficial uses are provided by Lake Geneva to local residents, and fish and wildlife. These include swimming, boating, fishing, wildlife viewing, fish habitat, bird habitat, park use, boat launch use, and wetland and creek habitat (Table 4).

Table 4. Beneficial Uses of Lake Geneva, King County, Washington.

Use	Location
Swimming	Entire lake
Boating	Entire lake
Fishing	Entire lake
Wildlife viewing	Entire lake and surrounding shoreline
Fish habitat	Entire lake
Bird habitat	Entire lake and surrounding shoreline
Park Use	King County's Lake Geneva Park
Boat launch	WDFW Boat Launch
Wetland habitat	Along edges of lake and near lake outlet (Figure 1)
Creek habitat	At lake outlet.

2.3. Fish and Wildlife

The Washington Department of Fish and Wildlife (WDFW) has not performed surveys for warm water fish within Lake Geneva. Daniel Garrett, WDFW's lead warm water fisheries biologist in the region, has estimated that it is likely that yellow perch (*Perca flavescens*) make up 60 to 70 percent of the year-round fish biomass within the lake, with smaller populations of pumpkinseed sunfish (*Lepomis gibbosus*), bluegill (*Lepomis macrochirus*), and largemouth bass (*Micropterus salmoides*). These populations would be consistent with other lakes within the region (personal communication with Daniel Garrett, December 17, 2014). The lake is annually stocked with rainbow trout (*Oncorhynchus mykiss*) a few weeks before the opening day of fishing. No Pacific salmon species are known to occur in the lake (WDFW 2014a).

The Audubon Society's Christmas Bird Count is the most comprehensive bird survey recently completed near Lake Geneva. The Rainier Audubon Society coordinates the Christmas Bird Count for the Kent/Auburn area. In the 2014 Rainier Christmas Bird Count, 120 species were identified (Rainier Audubon Society 2015) (Table 5). American crow was most abundant, followed by Canada goose, American widgeon, and mallard.

Data from the WDFW Priority Habitat and Species (PHS) lists a sighting of the common loon, a state sensitive species, at the lake in 1994. The PHS data also lists the lake as a site for waterfowl concentrations, citing it as a lowland lake which may provide a food base for piscivorous and herbivorous waterfowl in winter, including western grebes, mergansers, cormorants, coots, and Canada geese (WDFW 2014b). Residents of Lake Geneva have had several additional wildlife sightings, including swans (likely trumpeter swans) and muskrats.

Table 5. Rainier Audubon 2014 Christmas Bird Count.

Species	Count	Species	Count	Species	Count
Sora	1	Green Heron	2	American Crow	5,066
Cackling Goose	561	Bald Eagle	22	Common Raven	8
Canada Goose	1,907	Northern Harrier	3	Black-capped Chickadee	466
Trumpeter Swan	62	Sharp-shinned Hawk	4	Chestnut-backed Chickadee	155
Wood Duck	11	Cooper's Hawk	17	Bushtit	221
Gadwall	39	Red-tailed Hawk	75	Red-breasted Nuthatch	44
Eurasian Widgeon	5	American Kestrel	6	Brown Creeper	21
American Widgeon	1,611	Merlin	2	Bewick's Wren	55
Mallard	1,549	Peregrine Falcon	2	Pacific Wren	43
Green-winged Teal	600	Virginia Rail	19	Marsh Wren	39
Northern Shoveler	134	American Coot	829	American Dipper	1
Northern Pintail	1,131	Killdeer	19	Golden-crowned Kinglet	313
Canvasback	1	Spotted Sandpiper	1	Ruby-crowned Kinglet	187
Redhead	34	Wilson’s Snipe	2	Hermit Thrush	1
Ring-necked Duck	428	Mew Gull	51	American Robin	1,012
Greater Scaup	2	Ring-billed Gull	3	Varied Thrush	43
Lesser Scaup	61	Western Gull	25	European Starling	1,466
Harlequin Duck	8	Glaucous-winged Gull	402	Orange-crowned warbler	4
Surf Scoter	114	Pigeon Guillemot	7	Yellow-rumped warbler	12
White-winged Scoter	20	Rhinoceros Auklet	1	Townsend’s Warbler	5
Black Scoter	8	Rock Pigeon	662	Spotted Towhee	158
Dunlin	95	Herring Gull	2	Savannah Sparrow	1
Bufflehead	771	Band-tailed Pigeon	8	Fox Sparrow	110
Common Goldeneye	128	Mourning Dove	14	Song Sparrow	420
Barrow’s Goldeneye	66	Eurasian Collared Dove	100	Lincoln’s Sparrow	7
Hooded Merganser	109	Barn Owl	3	White-throated Sparrow	3
Common Merganser	110	Western Screech-Owl	3	White-crowned Sparrow	49
Red-breasted Merganser	57	Great Horned Owl	2	Golden-crowned Sparrow	160
Ruddy Duck	65	Thayer’s Gull	2	Dark-eyed Junco	757
California Quail	3	Red-shouldered Hawk	1	Red-winged Blackbird	302
Red-throated Loon	12	Northern Saw-whet Owl	2	Evening Grosbeak	7
Pacific Loon	1	Anna’s Hummingbird	63	Brewer’s Blackbird	100
Common Loon	7	Belted Kingfisher	14	Pine Siskin	703
Pied-billed Grebe	73	Red-breasted Sapsucker	10	Purple Finch	14
Horned Grebe	180	Downy Woodpecker	30	House Finch	220
Red-necked Grebe	29	Hairy Woodpecker	7	Red Crossbill	50
Western Grebe	6	Northern Flicker	188	American Goldfinch	82
Brandt’s Cormorant	2	Pileated Woodpecker	11	House Sparrow	148
Double-breasted Cormorant	194	Hutton’s Vireo	4		
Pelagic Cormorant	3	Steller’s Jay	151		
Great Blue Heron	51	Western Scrub Jay	15		
				Total Species	**120**

2.4. Lake Water Quality Characteristics

Water quality monitoring of Lake Geneva was conducted from 1979 to 2008, discontinued in 2009, and resumed in 2014 (King County 2014a). Monitoring frequency and parameters tested became more consistent in 1994 upon establishment of the King County Lake Stewardship Program. This program consists of monitoring conducted by volunteer lake residents, while King County provides training, coordination, laboratory analysis, and data reporting. Jerry Galland is the current volunteer monitor for Lake Geneva. The collected data were compiled and evaluated for this LMD plan. Methods and results of this evaluation are presented in Appendix A.

Lakes are classified into one of four trophic states based on increasing amounts of algae and nutrients: oligotrophic (low productivity), mesotrophic (intermediate productivity), eutrophic (high productivity), and hypereutrophic (very high productivity). Carlson's trophic state index is commonly used to determine the trophic state based on summer (May through October) average values of Secchi depth, chlorophyll *a*, and total phosphorus in the surface layer (epilimnion) of a lake. The three trophic state indices were calculated by King County (2015a) and are presented for each year in Figure 7. These results indicate that Lake Geneva is a mesotrophic lake with indices ranging from 42 to 47, neatly falling within the defined mesotrophic limits of 40 to 50. Although trend analysis was not performed on the trophic state indices, it is possible that trophic conditions have recently deteriorated because chlorophyll *a* and Secchi depth indices were higher in 2014 than all previous years of measurement.

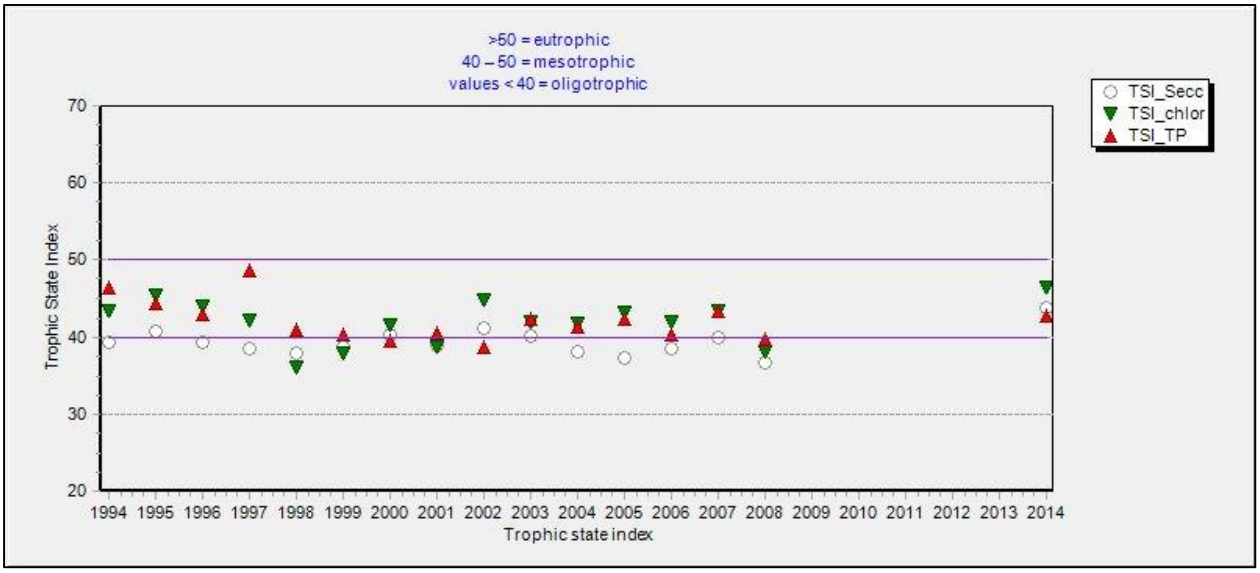


Figure 7. Trophic State Indices of Secchi Depth, Chlorophyll, and Total Phosphorus for Lake Geneva, Summer (May-October), 1994-2014 (King County 2015a).

Water quality data were analyzed for statistically significant temporal trends using two tests (Helsel and Hirsch 1992). A Mann Kendall trend test was used to test for significant trends from 1994 through 2008 when data were collected at a consistent frequency. A Mann Whitney U test was used to test for significant differences between 2014 and 1994 through 2008. Both

tests were conducted at a significance level of 5 percent ($\alpha = 0.05$), where trends are significant if the p value is less than 0.05.

Secchi depth is a measure of water transparency, which is affected by the amount and size of algae and other particles in the water. Over the summer period of record, Secchi depth ranged from 1.6 to 6.7 meters; the minimum measurement was observed in October 2014. Secchi depth was significantly poorer in 2014 than 1994 to 2008 ($p = 0.0002$), but there was no trend from 1994 to 2008 ($p = 0.16$). The recent decrease in Secchi depth indicates there was a concurrent increase in the amount of floating algae (phytoplankton) in the lake.

Chlorophyll *a* is a common measure of phytoplankton biomass. Over the summer period of record, chlorophyll *a* at 1-meter depth ranged from less than 0.5 to 32 µg/L; the maximum measurement was observed in October 2014. However, trend tests showed that chlorophyll *a* was not significantly different in in 2014 than 1994 to 2008 ($p = 0.15$), and there was no significant trend from 1994 to 2008 ($p = 0.84$).

Total phosphorus is typically the most limiting nutrient for freshwater phytoplankton and typically corresponds well with chlorophyll *a* and Secchi depth. Over the summer period of record, total phosphorus at 1-meter depth ranged from less than 1 to 127 µg/L; again, the maximum concentration was measured in October 2014. Trend tests showed that total phosphorus was not significantly different in 2014 than 1994 to 2008 ($p = 0.27$), but there was a significant decreasing trend from 1994 to 2008 ($p = 0.003$). Thus, the recent significant decrease in Secchi depth and apparent increase in chlorophyll *a* are not explained by a concurrent increase in total phosphorus concentrations near the surface of Lake Geneva.

Compared to surface water samples, average total phosphorus concentrations were higher in the mid-depth water samples and much higher in the bottom water samples. The maximum total phosphorus concentration observed in the lake was 630 µg/L for the bottom water sample collected in August 2014. This measurement, combined with the high chlorophyll to total phosphorus ratio observed in the surface water samples in 2014, suggests that phytoplankton may have obtained more phosphorus from the bottom waters (hypolimnion) in 2014 than in previous years. The high total phosphorus concentrations observed in the bottom waters are likely due primarily to the release of phosphorus bound to iron in deep sediments under anoxic (no oxygen) conditions. Hypolimnion phosphorus concentrations vary from year to year depending on microbial respiration and dissolved oxygen depletion rates. Dissolved oxygen was not measured in Lake Geneva to verify this condition.

In summary, Lake Geneva has good water quality, but has shown recent signs of degradation with less transparency and more algae. Release of phosphorus from lake sediments, which likely originated from a legacy of watershed contribution, appears to be fueling the increased algae growth in the lake during the summer. Control of watershed phosphorus sources is important to prevent further deterioration. Continued degradation will likely result in increased algae blooms, which may include species of blue-green algae (also known as cyanobacteria) that produce toxins and can result in closure of the lake to all contact recreation (see Appendix A).

2.5. Aquatic Plant Community Characteristics

The Lake Geneva aquatic plant community consists of a mix of native, invasive, and noxious species. Native plants are species that naturally occur within an area, and have many benefits, including providing shelter and food for fish and waterfowl. Native plant species also can play a role in preventing establishment of invasive plants since they occupy the habitat that invasive species need. Invasive plants are species that cause serious damage to natural resources by displacing the existing plant community and growing to nuisance levels that affect other beneficial uses of the lake environment. Invasive plants can be native or nonnative species. Besides their impact on human use and aesthetic enjoyment, invasive species can lead to reduced food and habitat for fish and wildlife, changes in water quality, clogged waterways, bank erosion, and other issues. Noxious weeds are nonnative, invasive species that cause serious harm to the surrounding ecosystem, natural resources, and economy. Noxious weeds are regulated in Washington and throughout the US. The term "invasive species" encompasses noxious weeds and other troublesome plant species that may not be regulated.

2.5.1. Aquatic Plant Surveys

There are five recorded aquatic plant surveys for Lake Geneva (Table 6) (Appendix B). Although the methods and extent of the surveys varied widely between the years, the data indicate a plant community that has changed dramatically since the early 1970s. According to notes from water quality monitoring on July 20, 1973, no submersed aquatic plants were observed (King County 1973). The first recorded aquatic plant survey of Lake Geneva was on August 8, 1979. This survey was part of an aquatic plant mapping project in King County, conducted by the Municipality of Metropolitan Seattle (Metro). Six aquatic plant species were observed, including four submerged species and two floating species. Common waterweed (*Elodea canadensis*) was the most dominant species, estimated to cover 6 acres of the lake bottom, which was nearly two-thirds of the total area with aquatic plants (Metro 1979).

The next survey occurred on August 9, 1994, as part of an aquatic plant mapping project for 36 King County lakes. Seventeen plant species were identified during that survey, including eight emergent species, two floating species, and seven submerged species. Floating plants covered 3.4 acres, and submergent species covered 6.8 acres. Percent plant cover was recorded in ranges of 0 to 25 percent, 25 to 75 percent cover, and 75 to 100 percent cover (Walton 1996).

The lake was surveyed again on September 18, 1999 (Walton 2000). This survey was part of a larger King County survey to identify eight key weed species throughout lakes in King County. Only two of the eight species were identified on Lake Geneva: purple loosestrife (*Lythrum salicaria*) and reed canarygrass (*Phalaris arundinacea*). The coverage for both species was classified as low, at 0 to 25 percent cover. Likely many other aquatic plant species were present at the time of the 1999 survey, but they were not recorded.

Table 6. Historical and Current Plant Species in Lake Geneva, King County, Washington.

Plant Species	Plant Class	Plant Type	Survey Date				
			1979	1994	1999	2004	2014
Cattail (*Typha latifolia*)	Emergent	Native		X			X
Marsh cinquefoil (*Potentilla palustris*)	Emergent	Native		X			
Purple loosestrife (*Lythrum salicaria)*	Emergent	Invasive			X		X
Reed canarygrass (*Phalaris arundinacea*)	Emergent	Invasive			X		
Rush species (*Juncus* sp.)	Emergent	Native		X			
Yellow flag iris (*Iris pseudacorus*)	Emergent	Invasive		X		X	X
Fragrant water lily (*Nymphaea odorata*)	Rooted floating-leaved plant	Invasive	X			X	X
Yellow pond lily (*Nuphar lutea*)	Rooted floating-leaved plant	Native	X	X			
Berchtold's pondweed (*Potamogeton berchtoldii*)	Submerged macrophyte	Native	X	X			
Bladderwort species (*Utricularia* sp.)	Submerged macrophyte	Native/ Invasive		X			
Common waterweed (*Elodea canadensis*)	Submerged macrophyte	Native	X	X			X
Curly leaf pondweed (*Potamogeton crispus*)	Submerged macrophyte	Invasive					X
Coontail (*Ceratophyllum demersum*)	Submerged macrophyte	Native		X			
Eurasian watermilfoil (*Myriophyllum spicatum*)	Submerged macrophyte	Invasive				X	
Big leaf pondweed (*Potamogeton amplifolius*)	Submerged macrophyte	Native	X	X			X
Slender waternymph (*Najas flexilis*)	Submerged macrophyte	Native	X				
Slender-leaved pondweed (*Potamogeton filiformis*)	Submerged macrophyte	Native					X
Nuttall's waterweed (*Elodea nuttallii*)	Submerged macrophyte	Native					X
Stonewort species (*Nitella* sp.)	Submerged macroalgae	Native		X			

Another survey for aquatic weeds was performed in 2004 during development of the Lake Geneva Integrated Aquatic Vegetation Management Plan (IAVMP). Three invasive plant species were identified during that survey: one submerged species, Eurasian watermilfoil

(*Myriophyllum spicatum*); and two emergent species, fragrant water lily (*Nymphaea odorata*) and yellow flag iris (*Iris pseudacorus*) (King County 2004). This was the first documented occurrence of a submerged invasive species.

The most recent complete (invasive plus native species) survey of aquatic plants for Lake Geneva took place on September 8, 2014, by Herrera scientists for this LMD plan. The survey was conducted by boat using an underwater viewer, rake sampler, global positioning system (GPS), and identification manuals (Ecology 2001 and others). The primary purpose of the survey was to map the floating and submerged plant species and to locate Eurasian watermilfoil or other invasive submerged plant species. The overall density of submerged plant community was mapped using three cover categories: high density (greater than 75 percent cover), medium density (50 to 75 percent cover), and low density (less than 25 percent cover). Invasive emergent plant species locations were also noted.

A map showing the results from the 2014 aquatic plant survey is presented as Figure 8. The total acreage of submerged plant cover was much higher in 2014 (18.5 acres) than in 1979 (7.8 acres) or 1994 (6.8 acres) (Table 7). The dominant submerged species were slender-leaved pondweed *(Potamogeton filiformis)* and common waterweed *(Elodea canadensis*). Three other submerged species were present in low abundance: big leaf pondweed (*Potamogeton amplifolius*), Nuttall's waterweed (*Elodea nuttallii*), and curly leaf pondweed (*Potamogeton crispus*). Of these five submerged species, only common waterweed and big leaf pondweed had been observed in previous surveys (Table 6). Curly leaf pondweed is a common nonnative, invasive plant found across the US. Fortunately, only a small patch was observed on the southwest shore (Figure 8), and no Eurasian watermilfoil or other invasive submerged plants were observed.

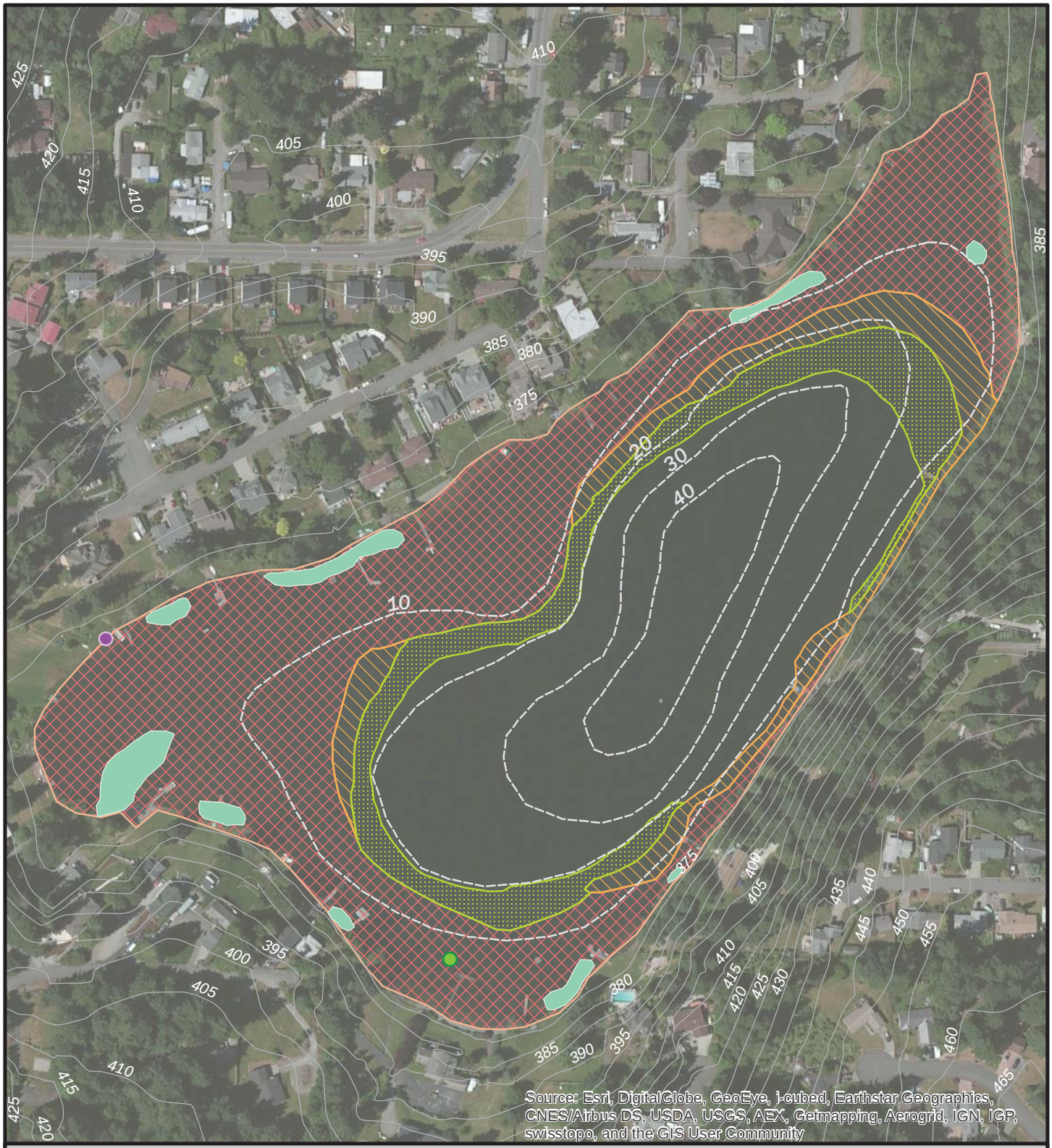
Table 7. Acres of Plant Coverage on Lake Geneva from Past Surveys.

Plant Type	Acres of Cover		
	1979 Survey	1994 Survey	2014 Survey
Submerged	7.8	6.8	18.5[a]
Floating-leaved	2.0	3.4	0.74

[a] Includes 13.7 acres of high density (> 75% cover), 2.0 acres of medium density (25% to 75% cover), and 2.8 acres of low density (< 25% cover).

The majority of submerged macrophytes were in the high density category (75 percent to 100 percent cover) versus a low density category (less than 25 percent cover) noted in previous surveys. Thus, submerged aquatic plant cover and density was much higher in 2014 than in 1979 or 1994.

As in past surveys, fragrant water lily (*Nymphaea odorata*) was observed in patches along the shoreline, with the largest patch located adjacent to the boat launch. The water lily coverage was much lower in 2014 (0.74 acres) than in 1979 (2.0 acres) or 1994 (3.4 acres). The native yellow pond lily (*Nuphar lutea*) was observed in previous years, but not in 2014.



Legend

Vegetation

- High density of submerged vegetation (75% - 100% cover)
- Medium density of submerged vegetation (25% - 75% cover)
- Low density of submerged vegetation (0% - 25% cover)
- Fragrant water lily

18228

- Approximate location of purple loosestrife
- Approximate location of curly leaf pondweed
- 10-ft bathymetry
- 5-ft contour

Figure 8.
2014 Aquatic Plant Distribution for Lake Geneva, King County, Washington.

N

0 125 250 500 Feet

HERRERA

ESRI, Aerial (2011)

K:\Projects\Y2014\14-05827-000\Project\Report\plant_zones.mxd (3/4/2015)

Purple loosestrife (*Lythrum salicaria*) was the only invasive emergent plant observed in the 2014 survey, at only one location on the northwest shore (Figure 8). However, yellow flag iris (*Iris pseudacorus*)is another invasive emergent plant historically present, and, according to lake residents, is present at multiple locations along the shore of Lake Geneva.

2.5.2. Aquatic Plant Management

Very little information is available on the management of aquatic weeds at Lake Geneva. The following information was primarily obtained from communication with lake residents.

In 2004, fragrant water lily patches on Lake Geneva were treated with herbicide (glyphosate) (King County 2005). This was paid for by funds from the LGPOA. In 2005, the LGPOA was awarded a $17,000 grant by King County for aquatic plant control, and SCUBA divers hand removed Eurasian watermilfoil (King County 2005). In the summer of 2007, herbicide treatments occurred to control Eurasian watermilfoil, potamogeton species, fragrant water lily, yellow flag iris, and purple loosestrife. This treatment was performed by Aquatechnex, LLC, and the results were summarized by the Washington State Department of Ecology (Ecology) (Ecology 2007). An additional treatment of fragrant water lily was completed in 2010 by Northwest Aquatic Management, LLC.

2.5.3. Noxious Weeds

Lake Geneva has a history of aquatic and emergent noxious weeds. Lake Geneva has been identified as a lake that is vulnerable to future aquatic plant infestations, due to its location and boat access (EnviroVision 2002, Tamayo and Olden 2014). Many noxious weeds are known to occur in King County that could spread to Lake Geneva (Table 8).

The Revised Code of Washington (RCW) Chapter 17.10 gives the authority to the state and the counties to regulate noxious weeds. Washington State noxious weeds are designated by the Washington State Noxious Weed Control Board, and are classified based on the species' level of distribution throughout the state. There are three categories of noxious weeds: Class A (extremely limited distribution throughout the entire state), Class B (extremely limited distribution throughout some of the state, while more heavily distributed in other parts), and Class C (widespread throughout the state).

Class A Noxious Weeds:

These weeds have extremely limited presence in Washington, yet they could cause serious problems if they spread. Eradication of these species is required everywhere they are found throughout Washington.

Class B Noxious Weeds:

Class B weeds have limited distribution throughout parts of the state, but are widespread in other parts of the state. In areas where the distribution is limited, eradication is required. In areas where Class B weeds are widespread, control of the weeds is decided by each county, but the primary goal is to contain weeds where they are already widespread and to prevent them from spreading further.

Class C Noxious Weeds:

Class C Noxious weeds have a widespread distribution throughout the state. Individual counties decide whether to enforce control of Class C weeds.

Table 8. Noxious Weeds that Could Occur on Lake Geneva, King County, Washington.

Name	Growth Form	Noxious Weed Class	Required for Control in King County?	Known to Occur in King County?
Garden loosestrife (*Lysimachia vulgaris*)	Emergent	B	Yes	Yes
Common reed (*Phragmites australis*)	Emergent	B	Yes	Yes
Hairy willowherb (*Epilobium hirsutum*)	Emergent	C	Yes	Yes
Knotweed species (*Polygonum* spp.)	Emergent	B	No	Yes
Purple loosestrife (*Lythrum salicaria*)	Emergent	B	Yes	Yes
Reed canarygrass (*Phalaris arundinacea*)	Emergent	C	No	Yes
Yellow flag iris (*Iris pseudacorus*)	Emergent	C	No	Yes
Floating primrose-willow (*Ludwigia peploides*)	Floating Mat	A	Yes	Yes
Parrotfeather (*Myriophyllum aquaticum*)	Floating Mat	B	Yes	Yes
Water primrose (*Ludwigia hexapetala*)	Floating Mat	B	Yes	Yes
Fragrant water lily (*Nymphaea odorata*)	Floating Leaf	C	No	Yes
Yellow floating heart (*Nymphoides peltata*)	Floating Leaf	B	Yes	Yes
Brazilian elodea (*Egeria densa*)	Submerged	B	Yes	Yes
Eurasian watermilfoil (*Myriophyllum spicatum*)	Submerged	B	No	Yes
Hydrilla (*Hydrilla verticillata*)	Submerged	A	Yes	Yes
Curly-leaf pondweed (*Potamogeton crispus*)	Submerged	C	No	Yes

3. Lake Management Alternatives and Recommendations

3.1. Goals of the Lake Management Plan

Residents of Lake Geneva met at a public meeting hosted by the Lake Geneva Property Owners' Association on January 19, 2015. Many issues were discussed at the meeting, including plant infestations, outlet maintenance, and water quality. Residents were asked to follow up with further comments after the meeting. The issues raised by lake residents were used to identify the following key goals to accomplish over the duration of the LMD period:

1. Maintain the lake outlet
2. Preserve existing lake water quality
3. Preserve public health
4. Prevent future invasive aquatic plant infestations
5. Manage existing invasive aquatic plant infestations
6. Manage excessive lake debris
7. Educate and involve the Lake Geneva community
8. Manage the LMD

There are actions that are required to meet each goal, and there are various alternatives that can be used to complete each action. The following sections describe the actions needed to accomplish each goal, and the alternatives that may accomplish each action. Recommendations are given based on the effectiveness, cost, and feasibility of each alternative. Table 9 presents a summary of the goals, actions, alternatives, and costs. Actions may be performed by the Lake Geneva Advisory Committee (LGAC), King County (KC), or a hired contractor.

3.2. Maintain the Lake Outlet

Residents report a large amount of vegetative growth within the outlet channel of Lake Geneva. Excess vegetation in the outlet channel impedes the flow of water out of the lake, and during times of heavy precipitation this causes water levels to rise above a level comfortable to residents. The primary concern of high water levels is submergence of fixed docks in the lake. The surface of these docks corresponds to a lake level of approximately 120 cm. Therefore, a lake management goal is to maintain the lake outlet as needed to prevent lake levels from exceeding 120 cm during the wet winter months.

Table 9. Summary of Alternative Actions and Costs to Meet Goals of Lake Geneva LMD.

Goal	Action	Alternative	Cost Assumptions	All Actions		Recommended Actions	
				First-Year Cost[a]	10-Year Cost[b]	Recommended (Yes/No)	Associated Annual Costs
Goal 1: Maintain Lake Outlet	1.1 – Clear vegetation to maintain unobstructed flow out lake outlet	1.1a – Annual maintenance by volunteers	LGAC or KC organizes volunteers at no cost.	–	–	No	–
		1.1b – Maintenance by King County to include removal of excess vegetation and trash from outlet channel as part of regular flood control program, with property access permissions and HPA permit from WDFW	King County maintains flow through outlet as needed as per RCW 90.24 and within KC budget. Includes permitting and assumes no contaminated sediment removal.	–	–	Yes	–
Goal 2: Preserve Current Lake Water Quality	2.1 – Monitor lake quality	2.1a – Monitor lake quality through King County Lake Stewardship Program	Monitoring bi-monthly from May through October by volunteers. Cost includes coordination with King County at no cost to LMD.	–	–	Yes	–
	2.2 – Educate lake and watershed property owners on best management practices to minimize nutrient inputs	2.2a – Email existing materials to lake and watershed property owners	KC emails materials produced by King County, Department of Ecology, and others as part of Alternative 7.3a.	See 7.3a	See 7.3a	Yes	See 7.3a
		2.2b – Presentation by expert at bi-annual meetings based on subject interest and expert availability	KC and LGAC identify experts for meeting presentations as part of Alternative 7.2a.	See 7.2a	See 7.2a	Yes	See 7.2a

Table 9 (continued). Summary of Alternative Actions and Costs to Meet Goals of Lake Geneva LMD.

Goal	Action	Alternative	Cost Assumptions	All Actions		Recommended Actions	
				First-Year Cost[a]	10-Year Cost[b]	Recommended (Yes/No)	Associated Annual Costs
Goal 3: Preserve Public Health Status	3.1 – Prevent toxic algae blooms	3.1a – Educate lake and watershed residents on reducing phosphorus inputs, and lake residents on identifying toxic algae blooms by emailing existing educational materials	KC emails educational materials produced by King County, Department of Ecology, and others as part of Alternative 7.3a.	See 7.3a	See 7.3a	Yes	See 7.3a
		3.1b – Have expert attend bi-annual meeting to give presentation on phosphorus control and algae bloom identification	KC and LGAC identify experts for meeting presentations as part of Alternative 7.2a.	See 7.2a	See 7.2a	Yes	See 7.2a
	3.2 – Manage Canada geese	3.2a – Educate lake residents on geese deterrence methods	KC or LGAC identify expert to volunteer presentation, and emails existing educational materials at no cost.	$0	$0	No	$0
		3.2b – Contract with USDA Wildlife Services to educate residents on barrier installation and to implement control using scare tactics and lethal methods as necessary.	Based on estimate from USDA Wildlife Services of $4,000 over 10 years and 10% contingency/inflation.	$3,300	$4,400	Yes	$440

Table 9 (continued). Summary of Alternative Actions and Costs to Meet Goals of Lake Geneva LMD.

Goal	Action	Alternative	Cost Assumptions	All Actions		Recommended Actions	
				First-Year Cost[a]	10-Year Cost[b]	Recommended (Yes/No)	Associated Annual Costs
Goal 4: Prevent Future Invasive Aquatic Plant Infestations	4.1 – Annual survey of invasive aquatic plants	4.1a – King County conducts invasive aquatic plant survey by boat once each year in late summer	One 8-hour day of surveying by two King County staff, plus 5 hours for reporting and discussions with LGAC at $90/hour.	$1,890	$25,325	No	–
		4.1b – Contractor conducts invasive aquatic plant survey by boat once each year in late summer	Contractor proposal for boat survey of Lake Geneva plus 10% contingency, 3% inflation.	$1,100	$12,610	Yes	$1,261
	4.2 – Educate the public to identify invasive species and prevent the spread	4.2a – Email existing invasive species materials to LMD residents	KC emails educational materials produced by King County, Department of Ecology, and others as part of Alternative 7.3a.	–	–	Yes	–
		4.2b – Have expert attend bi-annual meeting to give presentation	KC Noxious Weed Control Program or other experts give presentations on prevention as part of Alternative 7.2a.	–	–	Yes	–
		4.2c – Install one interpretive sign at WDFW boat launch and King County park	Use existing sign templates from King County or Department of Ecology. Estimated $200/sign including shipping, and installation by volunteers	$200	$200	No	–

Table 9 (continued). Summary of Alternative Actions and Costs to Meet Goals of Lake Geneva LMD.

Goal	Action	Alternative	Cost Assumptions	All Actions		Recommended Actions	
				First-Year Cost[a]	10-Year Cost[b]	Recommended (Yes/No)	Associated Annual Costs
Goal 5: Manage Current Invasive Aquatic Plant Infestations and Debris)	5.1 – Management of purple loosestrife and yellow flag iris	5.1a – Management of purple loosestrife and yellow flag iris by contractor to include treatment in 4 years (Years 2, 4, 6, and 9)	Annual costs from contractor for permit ($500), two treatments ($1,800), post-treatment survey ($800), report ($500), miscellaneous fees/meetings ($500); plus 10% contingency, 3% inflation, and excluding initial survey from Alternative 4.1b.	$4,510	$19,799	Yes	$1,980
		5.1b – Management of purple loosestrife and yellow flag iris from shoreline by volunteers	Volunteers or residents dig out weeds on their own at no cost.	–	–	No	–
	5.2 – Management of cattails to prevent further spread	5.2a – Management of new cattail growth by contractor to include 1 treatment/year of 0.1 acres on four occasions (Years 2, 4, 6, and 9)	Annual cost from contractor conducted with management of fragrant water lily as per 5.3b with additional fee of $400/treatment plus 10% contingency, 3% inflation.	$440	$1,932	Yes	$193
	5.3 – Management of fragrant water lily	5.3a – Eradication of fragrant water lily by contractor to include 2 treatments/year in 4 years (Years 2, 4, 6, and 9)	Annual costs from contractor for permit ($500), two treatments ($2,300), post-treatment survey ($800), report ($500), miscellaneous fees/meetings ($500); plus 10% contingency, 3% inflation and excluding initial survey from Alternative 4.1b.	$5,060	$22,213	No	–

Table 9 (continued). Summary of Alternative Actions and Costs to Meet Goals of Lake Geneva LMD.

Goal	Action	Alternative	Cost Assumptions	All Actions		Recommended Actions	
				First-Year Cost[a]	10-Year Cost[b]	Recommended (Yes/No)	Associated Annual Costs
Goal 5: Manage Current Invasive Aquatic Plant Infestations and Debris (continued)	5.3 – Management of fragrant water lily (continued)	5.3b – Management of fragrant water lily by contractor to include 1 treatment/year of 0.35 acres on four occasions (2, 4, 6, and 9)	Annual costs from contractor for permit ($500), 1 treatment ($900), post-treatment survey ($800), report ($500), miscellaneous fees/meetings ($250); plus 10% contingency and excluding initial survey from Alternative 4.1b.	$3,245	$14,246	Yes	$1,425
	5.4 – Management of dense stands of native pondweeds in high use areas	5.4a – Residents and volunteers pull plants from lake with weed rakes several times each summer	LGAC buys, maintains, and tracks 3 weed rakes for public use at $110 each.	$330	$330	Yes	$33
		5.3b – Management of native pondweeds reaching the lake surface to include 1 treatment/year of 0.35 acres on four occasions (2, 4, 6, and 9) in conjunction with fragrant water lily treatment	Annual costs from contractor for treatment ($900), post-treatment survey ($800), report ($500), miscellaneous fees/meetings ($250); plus 10% contingency. Excludes initial survey from Alternative 4.1b, and permit and miscellaneous fee from Alternative 5.3b.	$2,420	$10,954	Yes	$1,095

Table 9 (continued). Summary of Alternative Actions and Costs to Meet Goals of Lake Geneva LMD.

Goal	Action	Alternative	Cost Assumptions	All Actions		Recommended Actions	
				First-Year Cost[a]	10-Year Cost[b]	Recommended (Yes/No)	Associated Annual Costs
Goal 6: Manage Aquatic Debris	6.1 – Management of fragrant water lily mat	6.1a – Removal of one large mat by contractor on one occasion	Estimate of 48 person hours at $100/hour, $200 for equipment and disposal, $500 for permitting, and 15% for contingency/inflation.	$6,325	$6,325	Yes	$633
		6.1b – Removal on one large mat by volunteers on four occasions to be determined	LGAC and KC identify volunteers, method, and disposal at no cost.	–	–	No	–
	6.2 – Management of mud on lake bottom to improve wading aesthetics	6.2a – Place 6 inches of sand/gravel on mud by contractor	Cover 10 sites at 10 x 50 feet each with 185 yards of sand at $40/yard, installation at 24 hours at $100/hour, $1,000 for permitting, and 10% contingency/inflation.	$10,780	$10,780	No	–

Table 9 (continued). Summary of Alternative Actions and Costs to Meet Goals of Lake Geneva LMD.

Goal	Action	Alternative	Cost Assumptions	All Actions		Recommended Actions	
				First-Year Cost[a]	10-Year Cost[b]	Recommended (Yes/No)	Associated Annual Costs
Goal 7: Educate and Involve the Lake Geneva Community	7.1 – Annual LMD newsletter	7.1a – Distribute electronically to all LMD residents	King County emails brief summary of annual report for 10 hours at $90/hour, 3% inflation	$900	$10,000	No, distribute report only	–
		7.1b – Mail hard copy to all lake residents	Written, produced, and mailed by King County.	$1,200	$12,000	No	–
	7.2 – Bi-annual public meetings with lake residents	7.2a – Presentations by experts on subjects of interest by lake residents	KC and LGAC finds volunteer presenters to attend one meeting/year, and KC attends and presents at other bi-annual meeting only for 13 hours at $90/hour, 3% inflation, and additional 11 hours in Year 10	$1,160	$14,928	Yes	$1,430
	7.3 – Email education materials to all residents lake and watershed residents	7.3a – Distribute electronic educational materials by email to residents about events and best management practices	King County and LGAC compiles and emails existing materials of interest to all lake and watershed resident for 10 hours/year at $90/hour, 3% inflation.	$900	$10,317	Yes	$1,032

Table 9 (continued). Summary of Alternative Actions and Costs to Meet Goals of Lake Geneva LMD.

Goal	Action	Alternative	Cost Assumptions	All Actions		Recommended Actions	
				First-Year Cost[a]	10-Year Cost[b]	Recommended (Yes/No)	Associated Annual Costs
Goal 8: Management of LMD	8.1 – King County Management	8.1a – King County manages LMD funds and contracts	Estimated 20 hours/year at $90/hour for contractor procurement and fund management, 3% inflation, and additional 33 hours for first year	$4,800	$25,118	Yes	$2,512
	8.2 – Annual LMD Report	8.2a – King County staff prepares annual LMD report with assistance from LGAC	Estimated 40 hours for first year report and final year report, and 20 hours annually for other years at $90/hour, 3% inflation.	$3,600	$24,910	Yes	$2,491
		8.2b – LGAC writes report without assistance	Estimated 40 hours for initial report and final year report. 20 hours annually for other years at no cost by volunteers.	–	–	No	–
	8.3 – Development of the LMD	8.3a -King County assists with the development of the LMD	Costs incurred by King County at no cost to LMD.	–	–	Yes	–
						Total Annual Cost =	**$1,4500**

[a] Costs for first year may not occur during Year 1 of LMD. Funds may need time to accumulate.

[b] Includes 3 percent annual inflation at 1.34 times first-year cost where applicable.

LGAC = Lake Geneva Advisory committee; KC = King county; HPA = Hydraulic Project Approval.

Historically, lake outlet maintenance has consisted of occasional clearing of loose debris by lake residents, but this maintenance has been difficult to coordinate and implement regularly. Neither sediment or soil have been removed from the outlet channel in the past and their removal is not anticipated to be needed in the future.

Future maintenance of the lake outlet should consist of the removal of excess debris, trash, and invasive plant species growing within the stream channel to maintain flows that keep the lake at the desired level. This work can be done by lakeside residents, a contractor, or King County. King County DNRP Water and Land Resources Division Stormwater Services Section agreed to take responsibility of outlet maintenance as part of stormwater management and flood control efforts (personal communication with John Taylor, June 9 and August 3, 2015). Therefore, it is recommended that the work be performed by King County at no cost to the LMD. Permission by property owners must be acquired. Maintenance of the outlet should occur before the wet season begins in the fall when vegetation growth is high. Maintenance should not occur during flooding events due to the danger posed to workers during removal and the potential for flooding downstream.

3.3. Preserve Existing Lake Water Quality

Water quality conditions in Lake Geneva are good based on the moderate amount of algae and nutrients but have shown signs of recent degradation. A lake management goal is to preserve the current lake water quality by monitoring its condition and educating residents to reduce inputs of phosphorus from the watershed, as described below. Restoration of lake water quality is not included in this plan because it is a complicated and expensive process best performed only if preservation of water quality is unsuccessful.

3.3.1. Water Quality Monitoring

Lake Geneva is currently monitored by a lake resident (Jerry Galland) through the King County Lake Stewardship Program. This program joins King County staff with volunteer lake monitors to track long-term water quality trends in small King County lakes. Monitoring on Lake Geneva began in the 1980s, and occurred regularly from 1994 through 2008. Monitoring was discontinued in 2009 due to budget cuts, but began again in 2014 with funding from King County Surface Water Management fees (King County 2015a).

The current lake monitoring program should be continued at no cost to the LMD. The collected data should be evaluated annually to determine the lake's trophic status as part of the King County LMD management (see Section 3.9). The water quality preservation goal developed for this plan is to maintain mesotrophic status and not exceed all three following limits for average summer (May through October) values:

1. Secchi depth transparency shall exceed 2.0 meters (trophic state index of 50)
2. Chlorophyll *a* concentration at 1-meter depth shall not exceed 7.2 µg/L (trophic state index of 50)
3. Total phosphorus concentration at 1-meter depth shall not exceed 24 µg/L (trophic state index of 50)

Lake Geneva should also be regularly surveyed by volunteer lake residents for algae scum accumulation on shore, particularly during the late summer months. If present, scum samples should be collected and tested through the Washington State Toxic Algae Program to evaluate the potential public health threat, at no cost to the LMD. If the tested scum samples exceed state guidelines, then King County will post warning signs not to swim or conduct other forms of recreation on the lake depending on the level of toxicity observed. The lake will remain closed to recreational activity until toxin concentrations drop to low levels on several consecutive occasions.

3.3.2. Water Quality Education

Many lake and watershed residents do not understand how their daily activities affect the water quality of Lake Geneva. Education of residents has been effective elsewhere, and there are numerous sources and a wide range of information readily available. The lake management goal is to educate lake and watershed residents on how to reduce phosphorus in stormwater runoff to prevent algae blooms in the lake. This can be achieved by distributing educational information to residents via email and inviting experts to speak at LMD meetings. Educational materials and methods are described below in Section 3.8, *Community Education and Involvement*.

Water quality education materials are available from the following websites:

- US Environmental Protection Agency – Clean Lakes
  http://water.epa.gov/type/lakes/index.cfm
- US Environmental Protection Agency – Nonpoint Source Pollution
  http://water.epa.gov/polwaste/nps/
- Washington State Department of Ecology – Lake Information
  http://www.ecy.wa.gov/programs/wq/plants/lakeinfo.html
- Washington State Department of Ecology – Water Quality/Nonpoint Pollution
  http://www.ecy.wa.gov/programs/wq/nonpoint/index.html
- King County – Stormwater Services
  http://www.kingcounty.gov/environment/waterandland/stormwater.aspx

Potential lake water quality experts to present information at meetings are presented in Section 3.8, *Community Education and Involvement*. Additional research may be conducted by LMD volunteers to obtain additional education materials and expert presenters. Water quality education costs are included in the goal to educate and involve the Lake Geneva community (see Section 3.8).

3.4. Public Health Protection

A lake management goal is to protect the public health of lake users by preventing toxic algae blooms and controlling sources of fecal coliform bacteria from Canada geese.

3.4.1. Toxic Algae Bloom Prevention

Although the algae in Lake Geneva is not excessive, lake residents have observed algae blooms that form surface scums approximately once or twice a year. Lake Geneva has never been tested to determine if the algae scum consists of blue-green algae (cyanobacteria) or contains high levels of cyanotoxins, which are sometimes produced only by specific cyanobacteria species.

The lake management action to prevent algae blooms in the lake is to educate lake and watershed residents on the public health threat of toxic algae, and how to reduce phosphorus in stormwater runoff, as described in Sections 3.8 and 3.3, respectively. Costs for this education are covered by the goal to educate and involve the Lake Geneva community (see Section 3.8).

Ecology established the Freshwater Algae Control Program in 2005 (Ecology 2015). This program contains excellent information about toxic cyanobacteria. It also provides an algae identification and toxicity testing service at no cost to lake residents or the LMD. King County participates in sample collection and testing, and provides recommendations to Seattle – King County Health about the need for recreational use restrictions and posting of signs to protect public health.

A lake management action is to contact the King County Lake Stewardship Program (Section 3.8, *Community Education and Involvement*) if an algae scum is present on the lake and exhibits characteristics of blue-green algae. Ecology has a program that provides free testing for suspected toxic algae blooms. Education of residents on how to identify a toxic algae bloom, and how to collect a sample, is recommended for the safety of residents (see Section 3.8).

3.4.2. Waterfowl Management

Canada geese have become a problem at Lake Geneva. Throughout King County, populations of Canada geese in urban areas continue to increase. These urban areas provide dependable food and water, have hunting prohibitions, and lack predators.

Waterfowl often use lakes, lawns, and docks as part of their habitat. Canada geese are among the most prominent waterfowl in western Washington, and can also create the most problems. There are two groups of Canada geese in the state: migrating geese and resident, or non-migrating, geese. Resident geese can be present at lakes year-round. While many people enjoy the wildlife viewing that Canada geese provide, their presence can also cause water quality and human health issues (WDFW 2014c).

Geese eat plants growing along lakeshores necessary for erosion control and ground cover. Their droppings can increase nutrient levels in lakes, which can lead to algae blooms and potentially fish kills. Goose droppings also contain parasites irritating to humans and can cause health problems. Most often these parasites cause swimmer's itch (WDFW 2014c).

Several actions can be taken to limit goose activity at Lake Geneva. A combination of these actions will likely yield the most effective management for Canada geese. These actions include education, installation of barriers, scare tactics, and lethal control (WDFW 2014c).

Hiring an expert from United States Department of Agriculture (USDA) Wildlife Services (Wildlife Services) to deal with the control is recommended and, with lethal control, required.

3.4.2.1. Control Provided by Wildlife Services

Wildlife Services often deal with goose control on small lakes around the Puget Sound Region. Wildlife Services uses a combination of lethal and non-lethal tactics to control geese. They rely mainly on scare tactics and egg treatment, and use lethal control sparingly (personal communication with Aaron Loucks, January 29, 2015).

Scare tactics are the primary tool for Wildlife Services to dissuade geese from inhabiting an area. Wildlife Services primarily uses dogs to scare geese, as well as other noise-making devices. Scare tactics can become less effective over time, as geese learn to ignore them. Wildlife Services uses scare tactics heavily over the first few years of control and then occasionally as maintenance in the following years (personal communication with Aaron Loucks, January 29, 2015).

Egg treatment involves the destruction of Canada geese eggs. There are several methods, including oiling, puncturing, and egg addling. All egg destruction methods leave the eggs intact because geese will lay additional eggs if their eggs have been destroyed. Oiling is the most often used method, and involves coating the eggs with a layer of 100 percent food-grade corn oil. This prevents the development of the egg by blocking the pores in the egg's shell (Wildlife Services 2011).

Finally, lethal control is an option to get rid of extremely troublesome geese. This is a last resort that should only be used once all the other tactics have been tried, and there remains a legitimate concern over lake and human health. Canada geese are protected under state and federal law, and the hunting of geese for lethal control is regulated. Permits are issued by the US Fish and Wildlife Service, and the only agency permitted for lethal removal is Wildlife Services (WDFW 2014c).

3.4.2.2. Education and Action of Residents

Education of the public is important to prevent attracting geese to Lake Geneva. Education may include informative signs at public locations and emails to lake residents informing them to not feed the geese. Feeding wildlife is not only harmful to the animal, it attracts more wildlife than the area can naturally sustain. Lake Geneva lakeside residents can be educated on how lawns can attract geese and how to make these areas less attractive. The Wildlife Services provide educational presentations to the public on geese control.

One of the most simple and effective techniques is for lakeside residents to alter their landscape to make it more difficult for geese to access the shoreline. Barriers between open water and open spaces can deter Canada geese. Geese are attracted to open spaces with easy access to water and where predators could be easily visible. Installing plants just 3-feet tall along the shoreline can help lake residents deter geese while maintaining a view. In addition to plants, other barriers can be installed to deter geese. Fences made of wire, netting,

plastic, monofilament, or electric wire that are between 2- and 3-feet tall can be an extremely effective barrier (WDFW 2014c).

There are scare tactics that residents can use to keep geese off of their lawns and docks. These methods may include flags or streamers (such as shiny Mylar tape) attached on a pole to the shoreline or docks. The movement and reflection of these flags will scare geese. Scarecrows are also effective, particularly if they are in bright colors with large eyes and limbs that can move in the wind. Flags, streamers, and scarecrows should be moved regularly to prevent geese from getting used to them (WDFW 2014c).

It is recommended that Wildlife Services be hired to control the Canada goose population and educate the lakeside residents. The timing of this event is not critical, and can be done when enough LMD funds have accumulated. Education costs are included in the costs for Wildlife Services to control Canada geese.

3.5. Invasive Aquatic Plant Infestation Prevention

The prevention of future invasive aquatic plant infestations is a goal for Lake Geneva. It has been identified as a lake with a potential for infestations of Eurasian watermilfoil, because of its urban location and well-used boat access (EnviroVision 2002, Tamayo and Olden 2014). Due to the lake's history of milfoil infestation, and its recognition as a lake vulnerable to further infestation by aquatic plants, detection of new populations of invasive species is critical. To detect new invasive species populations early and prevent widespread infestations, regular professional surveys and education of lakeside residents is recommended. All new invasive plant populations observed should be eradicated immediately.

3.5.1. Aquatic Plant Surveys

Future invasive aquatic plant infestations can be detected early by annual plant surveys. These surveys should be completed by contractors in conjunction with treatments for the invasive plant infestations. Annual surveys are necessary to find and control plants while the populations are still small. King County also performs invasive plant surveys, but at a higher cost (see Table 9).

There are other invasive aquatic species than those known to occur in Lake Geneva; many are found in other areas of King County (Table 8). These invasive aquatic species can be extremely destructive, and may be difficult to identify; therefore, surveys by professionals are important for early detection.

3.5.2. Education of Lakeside Residents and Visitors

The most effective prevention strategy for aquatic plant control is education of the lakeside residents and visitors. Every lakeside resident should receive a copy of a noxious weed identification brochure, such as *Guide to Aquatic Water Weeds in King County*. The King County Noxious Weed Control Board and Ecology provide free materials that can be easily emailed to lakeside residents (Appendix C). King County also provides free presentations to the public on the identification and control of noxious weeds. However, this service would not

be free to the LMD because this service is considered to be part of LMD management and King County must recover all costs associated with the LMD management (personal communication with Sally Abella, June 9, 2015). Alternative experts that may present invasive plant information at no cost to Lake Geneva residents include Jennifer Parsons with Ecology and aquatic plant control contractors identified on Ecology's lake information website. These free presentations should be provided to lakeside residents approximately once every 2 years.

Information given to lake visitors will also help spread awareness of invasive species. Signs posted at the boat launch and Lake Geneva Park can inform visitors about how to prevent the spread of noxious weeds (Appendix D). Residents can also hand out information to boaters at the boat launch on heavy use days, such as the opening day of fishing.

3.5.3. Immediate Eradication of New Populations

The most effective way to control invasive species is to eliminate a new population as soon as it is observed. This prevents widespread infestations throughout the lake, which become expensive to control.

New populations of emergent species, such as purple loosestrife or yellow flag iris, can be dug out by residents, or removed by a contractor if residents do not wish to remove the plant themselves. Any aquatic invasive species, such as milfoil, should be hand removed by a contracted SCUBA dive team. It is assumed that new populations will be identified in small areas totaling 1,000 square feet or less in size because plant surveys will be conducted on an annual basis. Actions and funds planned for managing existing invasive species populations would need to be reduced to cover additional costs for eradicating small populations of new invasive plant species (see Section 3.6.2).

3.6. Current Invasive Aquatic Plant Infestation Control

It is a goal to control the current aquatic plant infestations on the lake. Current invasive aquatic plants on Lake Geneva include purple loosestrife, yellow flag iris, and fragrant water lily. There are also aggressive native plants, including cattails and pondweeds that are encroaching on recreational and high-use areas. These aquatic plants limit the recreational enjoyment of many lake residents and visitors, and have detrimental effects on the ecology of the lake.

3.6.1. Plant Control Options

There are many methods of controlling invasive plant species. Often the best strategy for controlling invasive plant populations is using multiple control options, a method called Integrated Pest Management (IPM). IPM considers population size, plant location, and the cost of treatment to develop an approach for dealing with invasive species in the most effective manner. Different control options include manual removal, mechanical removal, chemical removal, biological removal, and cultural removal.

The recommended methods for the Lake Geneva Management Plan were chosen primarily based on cost effectiveness and feasibility. The most cost-effective methods for controlling

invasive aquatic plants are manual control by lakeside residents of small patches or areas around their docks and using herbicides for larger infestations. It was assumed in development of the cost estimates that the primary control technique will be herbicides. The detailed information on control options provided in the next sections was obtained from Ecology (Ecology 2014).

3.6.1.1. Manual Control

There are several methods for manually removing invasive plant species. Permits may be required for any manual control method that takes place in the lake. WDFW requires a Hydraulic Project Approval (HPA) for all activities that take place in the water, including removal of aquatic plants. King County may require additional permits.

3.6.1.1.1. Hand-Pulling or Digging

Hand-pulling or digging invasive species is an effective way of dealing with small plant populations. This could be accomplished with small emergent plant populations that occur on the lakeshore. When plants are hand pulled or dug out, it is extremely important to remove the entire root. It is also important to prevent the spread of seeds during removal by cutting flower heads off and placing them carefully in a garbage bag before pulling or digging out the rest of the plant.

Advantages:

- This method can be performed by lake residents or volunteers and is therefore cost effective.
- The equipment is affordable.
- This method is environmentally safe, and desirable plants are easily avoided.

Disadvantages:

- This method is not effective for large areas.
- Some plants can be difficult to remove by hand, and some plants can become more aggressive if not properly removed by hand.
- Hand-pulling and digging disturbs soil and can cause erosion, which can be detrimental to lakeshores.

3.6.1.1.2. Cutting

Cutting terrestrial plants to the ground can be an effective way of preventing annual growth without disturbing soil by digging or disturbing the environment, or by adding herbicides. Plants that are cut down routinely cannot photosynthesize, which will deprive the plant of nutrients. It will also allow surrounding plants to grow taller and out-compete the invasive plant. This can be an effective method for grasses like reed canarygrass and common reed. It should not be used for plants that can reproduce from fragments, such as knotweed species.

Advantages:

- This method can be done by lake residents or volunteers and is cost-effective.
- The equipment is affordable.
- This method is environmentally safe, and desirable plants are easily avoided.

Disadvantages:

- This method must be repeated several times in a growing season to be effective.
- This method is not recommended for plants that reproduce from fragments, such as Eurasian watermilfoil and Japanese knotweed.

3.6.1.1.3. Raking

Raking is a method of removing aquatic plants. This can be done from the shore, a dock, or a boat. This method can be done with volunteers, and can be an effective way of clearing troublesome plants from near swimming areas. This method involves bringing vegetation to shore using a rake. Rakes can be tied to ropes and thrown to achieve a greater depth or distance from shore. This method does not remove all plant roots, and plants will regrow in removal areas within a season. This method should not be done with plant species in small, isolated patches within the lake, since this method produces plant fragments that could produce other plants in weed-free areas of the lake.

Advantages:

- This method can be done by lake residents or volunteers and is cost-effective.
- The equipment is affordable.
- This method is environmentally safe, and desirable plants are easily avoided.
- This method can be effective for large areas if there are enough workers.

Disadvantages:

- Plant roots will not be removed.
- Plant fragments will be created, and can start new populations elsewhere in the lake.
- Raking may need to occur several times in one season to be effective.
- A large amount of plant material will be generated, and it will need a place to dry out on shore or be hauled away to a disposal facility.

3.6.1.1.4. Diver Pulling

Diver pulling is a removal method for small populations of submerged aquatic plants where the entire removal of the plant is necessary. This method may be used if small infestations of Eurasian watermilfoil, Brazilian elodea (*Egeria densa*), or other new invasives are detected within the lake. Divers can be much more precise than rakes to remove the entire plant and root system, and to not create plant fragments. Divers can also remove the roots of floating

leaved aquatic plants, such as fragrant water lily, which are difficult to control from above water.

Advantages:

- Diving allows for the removal of the entire plant at a depth deeper than raking or hand-pulling can accomplish.
- This method is environmentally safe, and desirable plants are easily avoided.
- This method can eradicate an invasive species if caught early enough.

Disadvantages:

- Diver removal is the most expensive manual removal option.
- Diver removal is not cost-effective for large populations.

3.6.1.2. Chemical Control

3.6.1.2.1. Herbicide for Terrestrial Plants

Many herbicide treatments are available for terrestrial emergent plants, such as purple loosestrife, garden loosestrife (*Lysimachia vulgaris*), yellow flag iris, and knotweeds. Herbicide treatment may be preferable to hand-pulling or digging in cases where the populations are too large to effectively remove by hand, or where digging may cause soil erosion on the lakeshore. A variety of application methods can be used on emergent plants, including spraying, injections, and spreading or painting the herbicide on the plant by hand. Only herbicides approved for aquatic use should be used in lakeshore treatments. These herbicides are designed not to have a negative impact on the aquatic environment, including fish.

Advantages:

- Herbicides can effectively remove large or small plant populations.
- Herbicide application can be cost effective.
- Herbicide kills the entire plant, and usually only small follow-up treatments are needed in subsequent years.

Disadvantages:

- Herbicide can damage non-targeted plants.
- Some herbicides take a long time (weeks to months) to kill a plant.
- Herbicide treatment requires a licensed herbicide applicator and obtaining permits from Ecology.
- Some lake residents may not condone use of herbicides.

3.6.1.2.2. Aquatic Herbicide

Aquatic herbicides may be used where populations of aquatic plants are too big to control by hand. These situations should be considered carefully, because usually large populations of aquatic species require a large amount of herbicide to treat completely. While herbicide treatment may effectively control the desired target, other native plants may also be harmed. Maintaining native plants while controlling invasive plants is essential, because the native plants can help prevent invasive plants from re-establishing. The sudden death of many plants by herbicide causes a massive input of nutrients to the lake all at once, which almost always leads to an algae bloom. While the algae dies down and the native plants bounce back after a while, herbicide treatment to a lake can cause the entire system to be out of balance for a while.

Advantages:

- Aquatic herbicides can remove large populations of invasive species.
- Herbicide application can be cost effective.
- Herbicide applied in lakes can eradicate the entire invasive plant population.

Disadvantages:

- Herbicide applied to lakes can kill more than just the targeted plant species.
- Massive algae blooms and fish kills can occur after the plants die off.
- Some aquatic herbicides have water use restrictions, including where there is swimming, potable use, and fishing.
- Some herbicides take a long time (weeks to months) to kill a plant.
- Herbicide treatment requires a licensed herbicide applicator and obtaining permits from Ecology.
- Some lake residents may not condone the use of herbicides.

3.6.1.3. Mechanical Control

3.6.1.3.1. Dredging or Suction Harvesting

A dredging device or suction harvester will suck up plants, ensuring removal of root fragments. Divers operate a hose attached to a dredge to suck up the entire plant from the sediment. The suction hose dredges up the plant, as well as sediment and water. The contents of the hose are deposited onto a fine screen that holds the plants while filtering out the water and sediment. Usually the sediment and water is returned to the lake, behind an area sectioned off from the rest of the lake by a sediment curtain. After the sediment behind the curtain settles, the curtain is removed. Plant material remains in the screen and is not returned to the water. Dredging or suction harvesting will require permits, including an HPA from WDFW, a Section 404 permit from the US Army Corps of Engineers, and additional local permits.

Advantages:

- Dredging can be a selective technique for removing large populations of invasive species.
- Dredging can remove plants from difficult to reach areas, such as under docks.
- Dredging can be used for large aquatic plant populations where herbicide control is not an option.

Disadvantages:

- Diver dredging is expensive.
- Dredging disturbs sediments within the lake, which can release nutrients and toxins buried in the sediment.
- Dredging requires the acquisition of federal, state, and local permits and may take years to obtain.
- Plants growing in rocky soils and hard sediments may have their roots broken by the suction, making the removal less permanent.

3.6.1.3.2. Mechanical Harvester

A mechanical harvester is similar to a lawn mower positioned on a barge. This machine can mow aquatic plants and bring them onto the boat. This method will not remove plant roots, but will harvest a large amount of plants in a small amount of time. Similar to the raking method, these plants can grow back within a few weeks, thus requiring multiple harvesting events over the course of a growing season. Harvesters must be cleaned before entering the lake, as they are often hired to mow lakes with invasive populations, and fragments of these plants can cause infestations in other lakes.

Advantages:

- This method quickly removes large amounts of plants from the lake.
- Habitat for fish can be maintained if plants are not cut too short.
- Harvesting can target areas of the lake.

Disadvantages:

- Plants grow back, and may need to be harvested multiple times within a season.
- A large amount of plant material will be generated, and it will need a place to dry out on shore or be hauled away to a disposal facility.
- Harvesting may not be suitable for lakes with bottom obstructions (stumps and logs)
- Harvesters may produce plant fragments that remain in the lake.
- Harvesters brought in from other lakes must be thoroughly cleaned and inspected to ensure that exotic species are not introduced.

3.6.1.4. Biological Control

Biological control is the introduction of animals to control invasive species. These species can directly or indirectly control invasive species. Several animal species control invasive plants and could be introduced to Lake Geneva. In these cases, the introduced species would feed on the invasive plants. These are methods that can dramatically alter an ecosystem's food chain, and therefore should be carefully evaluated.

3.6.1.4.1. Grass Carp

Grass carp are vegetarian fish that have a primary diet of aquatic plants. Grass carp placed in lakes to control vegetation are sterile, and eat a wide variety of aquatic plants, including native vegetation. Studies examining the control of weeds by grass carp are varied, with results ranging from no improvement, to control of the desired species, to total elimination of all vegetation. Due to the difficulties in determining the appropriate number of grass carp to stock and the variable results observed in lakes around the country, this is not a preferred control technique and may be difficult to permit. Permits are needed to stock grass carp in a lake.

Advantages:

- This method can be cheaper than other lake-wide control options and may last longer.
- Herbicide is not needed.

Disadvantages:

- It may take several years to achieve the desired result.
- Grass carp may eliminate other species before the target plant species, or eat all plant species if overstocked.
- Grass carp may cause increased turbidity or algal blooms.
- The outlet to the lake must be screened and regularly maintained to prevent the grass carp from moving to other lakes and streams.
- A fish stocking permit and an HPA from WDFW must be obtained.

3.6.1.4.2. Loosestrife Beetles and Weevils

Loosestrife beetles (*Galerucella calmariensis* and *Galerucella pusilla*) adults and larvae feed heavily on purple loosestrife's leaves, stems and buds, which impacts plant growth and reproduction. The loosestrife root weevil (*Hylobius transversovittatus*) adults feed on plant foliage, while the larvae feed within the roots. The loosestrife seed weevil (*Nanophyes marmoratus*) adults and larvae damage purple loosestrife plants by feeding on unopened flower buds. These methods often take many years to make an impact, and are only effective on large populations that can't be treated by hand or with chemicals. Loosestrife beetles and weevils rarely completely eliminate the plant, just decrease the population.

Advantages:

- This method is fairly inexpensive when used over a large area.
- Herbicide is not needed.
- Can be used to specifically target purple loosestrife.

Disadvantages:

- It may take several years to achieve the desired result.
- The treatment is not practical for small populations of plants.
- The entire population is rarely eliminated and usually parts of the plant persist.
- Only controls purple loosestrife plants.

3.6.1.5. Cultural Control

Cultural control involves changing the environment to alter the growth of the plant. These methods are environmentally safe, but require significant effort in implementing them, and maintenance to be effective. Sometimes covers must remain in place for several years to get the desired result.

3.6.1.5.1. Bottom Barriers

A bottom barrier is placed on the bottom of the lake, over the sediment. The barriers can be made of burlap, plastic, or synthetic material. The barriers compress the plants while blocking light. Properly installed barriers can entirely eliminate weeds within an area, but will kill native species as well as invasive species. Barriers must be secured thoroughly while allowing gas created by decomposing plant material to escape. Bottom barriers can be ideal for swimming areas and in front of houses.

Advantages:

- The installation of a bottom barrier immediately creates open water in swimming areas and around docks.
- Bottom barriers can control 100 percent of the covered plants, if installed correctly.
- Materials are easily obtainable and can be installed by divers and homeowners.

Disadvantages:

- Bottom barriers must be properly installed and regularly maintained, or plants may grow on top, around, or through the barrier.
- Fishing gear, propellers, and anchors can damage or dislodge barriers.
- Improperly installed barriers can create hazards for boaters and swimmers.
- Bottom barriers may affect spawning and feeding at the lake bottom.
- This method is not selective for several species of plants living together. This method will control all plants that the barrier covers.

3.6.1.5.2. Terrestrial Covers

Cardboard, plastic, landscape fabric, and mulch can act similarly to a bottom barrier, but are used on land. Undesirable plant species can be mowed, and then covered with the barrier material. The barrier is then typically covered in at least 1 foot of mulch. These methods compress the plants while blocking light, resulting in total death of the plant. These methods are only effective if plants cannot grow through or around the barriers. This method is good for small patches of problem plants.

Advantages:

- This method is environmentally friendly and does not cause erosion.
- This method can be done inexpensively with volunteers.

Disadvantages:

- It may take several years to achieve the desired result.
- The area of cover will be unattractive.
- This method requires maintenance to ensure proper results.

3.6.2. Management of Current Invasive Aquatic Species

3.6.2.1. Purple Loosestrife and Yellow Flag Iris

Purple loosestrife and yellow flag iris are present on the shoreline of Lake Geneva. During the 2014 aquatic plant survey, one purple loosestrife plant was spotted, and no yellow flag iris plants were identified. This is likely because most of the blooms from the plants had disappeared by the time the survey took place in September, making them difficult to spot from a boat. However, many residents reported seeing both species on the lakeshore. It is estimated that the population size of each plant is less than 0.1 acre.

The management objective for purple loosestrife and yellow flag iris is to eradicate these species completely from Lake Geneva. Purple loosestrife is a King County Class B noxious weed, requiring removal within King County. Partial removal was considered for yellow flag iris. However, eradication of both species is recommended over partial removal because the population is small and easily removable. While these weeds are not present on all properties, they can spread rapidly and impact many lakeside properties.

Several methods are used to treat purple loosestrife and yellow flag iris, depending on the size of the population. To remove these plants completely, herbicide is often used. Herbicide application near water bodies requires a permit from Ecology. Management of these plants with herbicide requires a license and is therefore most often done by an outside contractor. Lakeside residents can manually remove the plants without a permit, or reduce the spread of the plants by removing the flowers before the plants go to seed. Sometimes beetles are used for biological control to diminish purple loosestrife, but typically only in large populations (King County 2015b).

It is recommended that a contractor control the entire population of purple loosestrife and yellow flag iris along the shoreline using herbicide. It is recommended that these plants be fully treated every few years. Annual plant surveys and reports by lakeside residents will be used to identify and locate remaining plants. A cost estimate of $4,510 per year (plus 3 percent annual inflation) in Years 2, 4, 6, and 9 has been assumed for control of up to 0.1 acre each of purple loosestrife and yellow flag iris (Table 9). The timing of these treatments is spread out over several years to allow LMD funds to accumulate.

3.6.2.2. Cattails

Cattails are an aggressive native species. They can grow rapidly along lakeshores and inhibit use of the shoreline and access to the lake. There are several dense stands of native cattails around the lake.

The management objective for cattails is to control up to 0.1 acre of this species in select high use areas and to prevent their further spread. These targeted areas will include the boat launch area and the lake outlet.

There are several methods for controlling native cattails, but herbicide application provides the greatest control and is the most cost-effective option. Therefore, it is recommended that control will be achieved through herbicide applications by a contractor. Herbicide application near water bodies requires a permit from Ecology. Management of these plants with herbicide requires a license and is therefore most often done by an outside contractor. A cost estimate of $440 per year (plus 3 percent annual inflation) in Years 2, 4, 6, and 9 is assumed for control of up to 0.1 acre of cattail (Table 9). The timing of these treatments is spread out over several years to allow LMD funds to accumulate.

3.6.2.3. Fragrant Water Lily

Fragrant water lily is present in several large mats throughout the lake. Mapping during the 2014 aquatic plant survey showed approximately 1 acre of fragrant water lily. Much of the fragrant water lily growth is on the western side of the lake, near the boat launch. These fragrant water lilies have become a nuisance to residents and visitors recreating on the lake.

The management objective for the fragrant water lily is to eradicate the lilies from near the boat launch area, and prevent the population from growing beyond 1 acre. While fragrant water lily is present in many parts of the lake, eradication of this species is not recommended. This is mainly due to the high cost of complete eradication of these lilies from the lake.

Herbicides are the most effective control technique for these plants. Management of these plants with herbicide requires a license and is therefore most often done by an outside contractor. Herbicide application near water bodies requires a permit from Ecology, and it is recommended that control will be achieved through herbicide applications by a contractor. A cost estimate of $3,245 per year (plus 3 percent annual inflation) in Years 2, 4, 6, and 9 has been assumed for control of up to 1 acre of fragrant water lily (Table 9). The timing of these treatments is spread out over several years to allow LMD funds to accumulate.

3.6.2.4. Pondweeds

The most dominant species in Lake Geneva is slender-leaved pondweed, a native submerged plant. This plant is growing at nuisance levels in many areas of the lake that have a depth of less than 15 feet, particularly in the northern and western portions of the lake. However, there are few aquatic plants lakeside of the King County park. Pondweed growth appeared to increase dramatically in 2015 compared to amounts observed during the most recent survey conducted in September 2014. The plants had grown to the lake surface and were covered with extensive filamentous algae by July 2015 in a large area covering approximately 0.35 acres located in the northwest portion of the lake (personal communication with Larry Gross on July 26, 2015).

Control of native species may be necessary in some areas to support the beneficial uses of the lake, including swimming and boating. But removal of native species should be done sparingly, because of the many benefits of native plants. Extensive removal of the native plants could cause negative impacts on fish, which rely on native aquatic plants for shelter and food (personal communication with Daniel Garrett, December 17, 2014).

The management objective for native pondweeds is to reduce plant matter to enhance recreational activities on the lake in high-use areas.

There are many methods for controlling nuisance aquatic plants. These methods include mechanical harvesting, herbicide treatments, and manual removal. Mechanical harvesting is an expensive process and must be repeated several times per year. Herbicide treatment of native plants on a large scale destroys native ecology of the lake and can cause algal blooms. Manual removal is often done on a volunteer basis, and is very cost effective.

One recommended action is for the LMD to purchase aquatic weed rakes that can be used by the general community to clear out areas in front of docks and around swimming areas. The rakes may also be used to remove pondweeds that impair boating in other areas of the lake. Various rake styles are available with a range of pole lengths, rake widths, and tine lengths. It is recommended that the LMD purchase two styles of aquatic weed rakes at a cost of approximately $330. Interested residents may conduct weed raking themselves, or hire a student or laborer to remove excess pondweeds.

An additional recommended action is for the LMD to contract herbicide treatment of the small area of pondweeds that have reached the lake surface. Herbicides are the most cost-effective control technique for these plants covering areas too large to rake. Management of these plants with herbicide requires a license and is therefore most often done by an outside contractor. Herbicide application near water bodies requires a permit from Ecology, and it is recommended that this control will be achieved through herbicide applications by a contractor in conjunction with water lily control. A cost estimate of $2,420 per year (plus 3 percent annual inflation) in Years 2, 4, 6, and 9 has been assumed for control of up to 0.5 acres of fragrant water lily (Table 9). The timing of these treatments is to occur with fragrant water lily control to reduce permitting and reporting costs.

3.7. Aquatic Debris Management

A lake management goal is to reduce the debris in the lake. Lakeside residents have noted the negative effects of debris, including floating root mats from fragrant water lilies and the accumulation of muck and decomposing plants on the bottom of the lake.

3.7.1. Management of Decomposing Water Lily Root Mats

There are several reported water lily root mats in the lake. Previous treatments of fragrant water lily on the lake have caused the root mats to decompose and rise to the surface. These root mats inhibit boating and swimming. The main water lily root mats are near the boat launch area, but there are smaller root mats elsewhere in the lake.

The management objective is to remove the decomposing root mats from the lake. Mats can be removed by lakeside resident volunteers, or by a contractor. It is recommended that contractors be hired to remove the root mats from the lake.

In the cost estimate provided in Table 9, it was assumed that a contractor will be hired to obtain permits and remove the floating mats and that it will be done once for a cost of $6,325 in Year 7.

3.7.2. Management of Lake Bottom Mud

Lakeside residents have observed an increase in siltation and the accumulation of mud in some areas of the lake. Lake bottom mud may impair the aesthetic quality of wading in shallow waters of the lake, and an excessive accumulation of mud over time may decrease water depth sufficiently to impair swimming in some areas. Inflow of silt and nutrients from the shoreline and watershed is the primary source of mud in the lake. The continued accumulation of mud in the lake should be addressed by implementing best management practices along the shoreline and in the watershed as described for management of water quality.

Management of existing mud problems may be addressed by either removal of the mud or covering the mud with coarse material (sand/gravel). Mud removal (sediment dredging) is very expensive due to high dewatering and disposal costs. Mud covering (sediment capping) may be performed by individual lakeside residents as needed.

Sediment capping requires preparation of Joint Aquatic Resource Permit Application (JARPA) to comply with various local, state, and federal environmental regulations (ORIA 2015). Initial coordination with individual agencies is recommended to adequately address application requirements. Mitigation for filling wetlands will likely be required for permit compliance, and may include but not be limited to native vegetation enhancement. If less than 25 cubic yards of materials are placed in the lake, then sediment capping may qualify under a nationwide permit for minor discharge. If the activity is not covered by a nationwide permit then an individual permit may be necessary and require more information such as an alternatives analysis and a State Environmental Policy Act checklist.

Applying a 6-inch cap over 1,350 square feet of lake bottom would require 25 cubic yards of gravelly sand. This amount (1,350 square feet) approximately would equate to application along 67 feet of shoreline out to a distance of about 20 feet from shore. Materials would cost approximately $900 delivered, and application using a bobcat would cost approximately $1,100. Mitigation may cost as much as the capping materials and application. Permitting would cost approximately $200 for the permits and approximately $5,000 for preparation of applications by a professional consultant.

Management of lake bottom mud is not recommended for the Lake Geneva LMD because prevention of mud accumulation is addressed by water quality management. Management of existing mud problems for individual lakeside residents also is not recommended due to the high cost, and the differing needs of, and benefits to, individual residents. This is an action a group of residents may want to consider addressing as a group to defray costs.

3.8. Community Education and Involvement

Community education and involvement will be a key component to accomplishing the goals of the Lake Management Plan. Many aspects of education are described in sections above, but there are additional forms of education that the LMD can provide.

3.8.1. Annual Distribution of LMD Newsletter

The LMD Advisory Committee could partner with King County to produce and distribute an annual newsletter to the lakeside residents. These newsletters would include a report of the current status of lake quality and plant surveys, and services paid for by the LMD. Rather than prepare a separate newsletter, the annual report may be sent electronically to lakeside residents, and one hard copy of the annual report may be made available for review by residents that are not able to receive email.

3.8.2. Biannual Public Meetings with Lakeside Residents

Meetings will occur twice a year for lakeside residents. At these meetings, upcoming events will be discussed, and experts will present material to the public about lake issues. In subsequent years, informed residents can continue these presentations. Examples of local experts are found in Table 10.

Table 10. Experts to Contact for Educational Presentations.			
Subject Matter	**Expert**	**Agency**	**Contact Information**
Aquatic Weeds	Ben Peterson, Aquatic Weed Specialist	King County Noxious Weed Control Program	206-477-4724 ben.peterson@kingcounty.gov
Aquatic Weeds	Jenifer Parsons	Washington Department of Ecology	509-457-7136 jenp461@ecy.wa.gov
Water Quality	Sally Abella	King County Science and Technical Support	206-477-4605 sally.abella@kingcounty.gov
State Algae Control Program	Lizbeth Seebacher	Washington Department of Ecology	360-407-6938 lizbeth.seebacher@ecy.wa.gov
Lake Geneva Fish	Daniel Garrett, Warmwater Fisheries Biologist	Washington Department of Fish and Wildlife	425-775-1311 Ext. 101 daniel.garrett@dfw.wa.gov
Canada Goose Control	Aaron Loucks, Wildlife Biologist	USDA Wildlife Services	425-686-0679

3.8.3. Distribution of Educational Materials to Lakeside and Watershed Residents

King County and the LMD Advisory Committee will distribute educational materials to lakeside residents via email. There are many free publications by King County, Ecology, and other agencies, that cover important lake quality topics. Education material may cover identification and prevention of aquatic plants, landscaping techniques for lakeshores, or ways to reduce nutrient input to lakes. Examples of educational materials can be found in Appendix C.

It is recommended that King County and the LMD Advisory Committee also distribute educational materials to watershed residents. Free publications or links to them should be sent to inform residents that explain how they can prevent nonpoint source pollution and further degradation of lake water quality. Website links are provided in Section 3.3.2, *Water Quality Education* and example materials are provided in Appendix C.

3.9. LMD Management

The successful management of the LMD is one of the goals in the Lake Management Plan. The success of LMD management involves several actions: the establishment of the LMD, the involvement of King County to manage and allocate the monetary resources of the fund, the information about the actions of the LMD provided to lakeside residents, and the management of a contingency fund used to cover unexpected costs.

The establishment of the LMD involves the LGPOA, lakeside residents, consultants, and King County. A plan must be developed and accepted by the County to form an LMD.

King County must manage the funding and allocation of monetary resources within the LMD. This includes collecting annual assessments from the residents of the LMD and distributing money to contractors hired to perform work for the LMD.

Management of the LMD will also include the production of an annual report distributed to lakeside residents. This will allow the funders of the LMD to know what management activities have been performed each year. The annual report shall include summaries of water quality monitoring results in comparison to goals, and management actions performed by contractors and residents in the past year.

Finally, LMD management will include updating the goals and actions as lake conditions and users' needs change over the 10-year period. Specific goals, priorities, and actions may be revised by the LMD advisory committee based on input from lake residents, King County, and others. These revisions will be documented in the annual reports and discussed at the biannual meetings.

4. Lake Management District Allocation and Cost

The Lake Management District will fund the recommended actions needed to meet the goals of the Lake Management Plan. An advisory committee will be formed to advise the County on the desired allocation of funds. A representative from King County will collect and administer funds to carry out the goals of the Lake Management Plan.

4.1. Recommended Actions

The actions recommended to meet the lake management goals are based on the input of lakeside residents and financial feasibility. Goals were developed from citizen feedback, which was received at the January 19, 2015, meeting, and in subsequent emails from lakeside residents following the meeting. See Table 9 for a breakdown in goals, actions, alternatives, and costs.

4.2. LMD Funds

On behalf of the LMD, King County will collect funds from all lakeside parcels, including vacant lots, King County's Lake Geneva Park, and the WDFW boat launch. See Figure 6 for a map of lakeshore properties and land use designation. Four parcels on the lake are not taxed (undesignated on Figure 6). These parcels would not contribute to funding the LMD. Table 11 indicates the proposed cost per parcel type.

Table 11. Proposed Annual Cost for LMD Per Parcel for Lake Geneva.

Parcel Designation	Number of Parcels	Annual Cost Per Parcel	Total Revenue per Parcel Designation
Single Family	42	$145	$6,090
Vacant Lot	11	$45	$495
WDFW	1	$4,345	$4,345
King County	2	$1,785	$3,570
		Total:	**$14,500**

The LMD is planning to operate on an average annual budget of $11,211. See Table 12 for the cost breakdown for each year.

4.3. LMD Advisory Committee

The Lake Geneva Advisory Committee (LGAC) will be formed to represent the property owners on Lake Geneva. These positions will be selected from property owners within the LMD. The LGAC will advise the County Council on actions the LMD wishes to take. The County will be responsible for collection and administration of all funds.

Table 12. Estimated Annual Costs for Implementation of the Lake Geneva Management Plan.

Lake Management Goal/Action	Responsibility	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Goal Totals	Percent of Total
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025		
1.1 Maintain Lake Outlet	King County	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	0%
2.1 Monitor Lake Quality	Volunteers	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	0%
2.2 Nutrient Education[a]	King County	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	0%
3.1 Toxic Bloom Education[a]	King County	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	0%
3.2 Manage Canada Geese	USDA	$0	$0	$3,300	$550	$550	$0	$0	$0	$0	$0	$4,400	3%
4.1 Annual Plant Survey	Contractor	$1,100	$1,133	$1,167	$1,202	$1,238	$1,275	$1,313	$1,353	$1,393	$1,435	$12,610	9%
4.2 Invasive Species Education[a]	King County	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	0%
5.1 Manage Purple Loosestrife and Yellow Flag Iris	Contractor		$4,510		$4,781		$5,051			$5,457		$19,799	14%
5.2 Manage Cattails	Contractor		$440		$466		$493			$532		$1,932	1%
5.3 Manage Water Lily	Contractor		$3,245		$3,440		$3,634			$3,926		$14,246	10%
5.4 Manage Pondweeds	Volunteers	$330	$2,420		$2,565		$2,710			$2,928		$10,954	8%
6.1 Remove Water Lily Mat	Contractor							$6,325				$6,325	4%
7.2 Bi-annual Meetings	King County	$1,160	$1,195	$1,231	$1,268	$1,306	$1,345	$1,385	$1,427	$1,469	$2,514	$14,298	10%
7.3 E-mail Education Materials	King County	$900	$927	$955	$983	$1,013	$1,043	$1,075	$1,107	$1,140	$1,174	$10,317	7%
8.1 King County Management	King County	$4,800	$2,000	$2,060	$2,122	$2,185	$2,251	$2,319	$2,388	$2,460	$2,534	$25,118	17%
8.2 Annual LMD Report	King County	$3,600	$1,854	$1,910	$1,967	$2,026	$2,087	$2,149	$2,214	$2,280	$4,824	$24,910	17%
8.3 King County LMD Formation	King County	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	0%
Estimated Annual Expenditures		**$11,890**	**$17,724**	**$10,622**	**$19,344**	**$8,318**	**$19,890**	**$14,566**	**$8,488**	**$21,587**	**$12,481**	**$144,909**	100%
Annual Assessment Income		**$14,500**	**$14,500**	**$14,500**	**$14,500**	**$14,500**	**$14,500**	**$14,500**	**$14,500**	**$14,500**	**$14,500**	**$145,000**	100%
Cumulative Fund Balance		$2,610	($614)	$3,264	($1,579)	$4,603	($787)	($853)	$5,158	($1,929)	$91	**$91**	0%

All costs include 10% contingency and 3% annual inflation

[a] Costs included in Actions 7.2 and 7.3.

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APPENDIX A

Water Quality Data Analysis

LAKE GENEVA WATER QUALITY DATA ANALYSIS

Herrera Environmental Consultants compiled and evaluated existing water quality monitoring data for Lake Geneva for preparation of a Lake Management District Plan. The data evaluation methods are described, and the results are presented in graphs and summarized.

Methods

Water quality monitoring data for Lake Geneva were downloaded from King County's website (King County 2015). Volunteer monitoring of Lake Geneva began in the 1980s and continued from 1994 through 2008. It was discontinued in 2009, but resumed in 2014. Monitoring frequency and parameters became consistent in 1994 upon establishment of the King County Lake Stewardship Program. This program comprises Level I and II monitoring conducted by volunteer lake residents, while King County provides training, coordination, laboratory analysis, and data reporting.

Level I monitoring was conducted daily throughout the year since 1994 for precipitation and lake level, and weekly for lake surface temperature and Secchi depth. Level II monitoring was conducted twice monthly from May through October since 1994 for Secchi depth, and water samples were collected at 1-meter depth for analysis of temperature, total phosphorus, total nitrogen, and chlorophyll *a*. Since 1996, water samples were also collected on two occasion each summer (typically in May and August) at mid-depth (approximately 7 meters) and near the lake bottom (approximately 13 meters) for analysis of temperature, total phosphorus, total nitrogen, and chlorophyll *a* (mid-depth only). Starting in 2006, the surface (1 meter) and bottom (13 meter) samples were also analyzed for three dissolved nutrients: orthophosphate phosphorus, nitrate+nitrite nitrogen, and ammonia nitrogen.

The collected data were compiled in a database consisting of separate Excel spreadsheets for the daily precipitation/level data, weekly temperature/Secchi depth data, 1-meter data, and depth profile data. Data were plotted on graphs to show seasonal trends in 2014, and annual trends over the period of record based on the average (mean) and range of values for each summer period (May through October). Water quality criteria and indices were included on the graphs for comparison to the observed lake values.

Lakes are classified into one of four trophic states based on increasing amounts of algae and nutrients: oligotrophic (low productivity), mesotrophic (intermediate productivity), eutrophic (high productivity), and hypereutrophic (very high productivity). Carlson's trophic state index is commonly used to determine the trophic state based on summer (May through October) average values of Secchi depth, chlorophyll *a*, and total phosphorus in the epilimnion (surface layer) of a lake. The trophic state indices and criteria used in the evaluation are presented in Table A-1.

Table A-1. Trophic State Indices and Criteria for Lakes.				
Trophic Class	**Trophic State Index**	**Secchi Depth (meters)[a]**	**Chlorophyll *a* (ug/L)[a]**	**Total Phosphorus (ug/L)[a]**
Oligotrophic	< 40	> 4	< 2.6	< 12
Mesotrophic	40 to 50	2 to 4	2.6 to 7.2	12 to 24
Eutrophic	50 to 60	0.5 to 1	7.2 to 20.1	24 to 48
Hypereutrophic	> 70	< 0.5	> 56	> 96

[a] Summer mean value for epilimnion.

Water quality data were analyzed for statistically significant temporal trends using two tests (Helsel and Hirsch 1992). A Mann Kendall trend test was used to test for significant trends from 1994 through 2008 when data were collected at a consistent frequency. A Mann Whitney U test was used to test for significant differences between 2014 and 1994 through 2008. Both tests were conducted at a significance level of 5 percent ($\alpha = 0.05$) where trends are significant if the p value is less than 0.05.

Results

Water quality monitoring data for Lake Geneva are summarized separately for each measured parameter.

Lake Level and Precipitation

In 2014, lake level gradually decreased from 108 centimeters (cm) in March to 42 cm in September, representing a drop of 66 cm (2.2 feet) (Figure A-1). The lake level pattern in 2014 was similar to previous years that typically show a rapid increase in response to precipitation from October to January (Figure A-2). Over the summer period of record, lake level exhibited a wider range from 18 to 139 centimeters for an overall range of 112 cm (3.7 feet). Although water level data were not tested for long-term trends, none are apparent in the collected data (Figure A-2).

High lake levels are caused by high inflow rates that may be exacerbated by flow obstructions in the lake outlet channel. High lake levels over 120 cm submerge the surface of fixed docks on Lake Geneva (J. Galland and D. Leibilie, personal communication). High lake levels do not affect most of the docks on the lake because they are floating docks. High lake levels over 120 cm were observed in 1996 and 2005, but not in the remaining 12 years with lake level data (Figure A-2).

Water Temperature

In 2014, surface (1-meter depth) water temperature exhibited a typical unimodal pattern, increasing from a low of 16 °C in May to a maximum of 25 °C in August, and then decreasing to a low of 17 °C in October (Figure A-3). Over the summer period of record, surface water temperature exhibited a wider range from 9 to 27 °C (Figure A-4). Summer surface water temperatures typically exceeded the 16 °C criterion established by the Washington State Surface Water Standards (WAC 173-201A) as a 7-day average maximum for protection of summer salmonid (salmon and trout) habitat. No long-term trends were identified by the statistical tests of the surface temperature data.

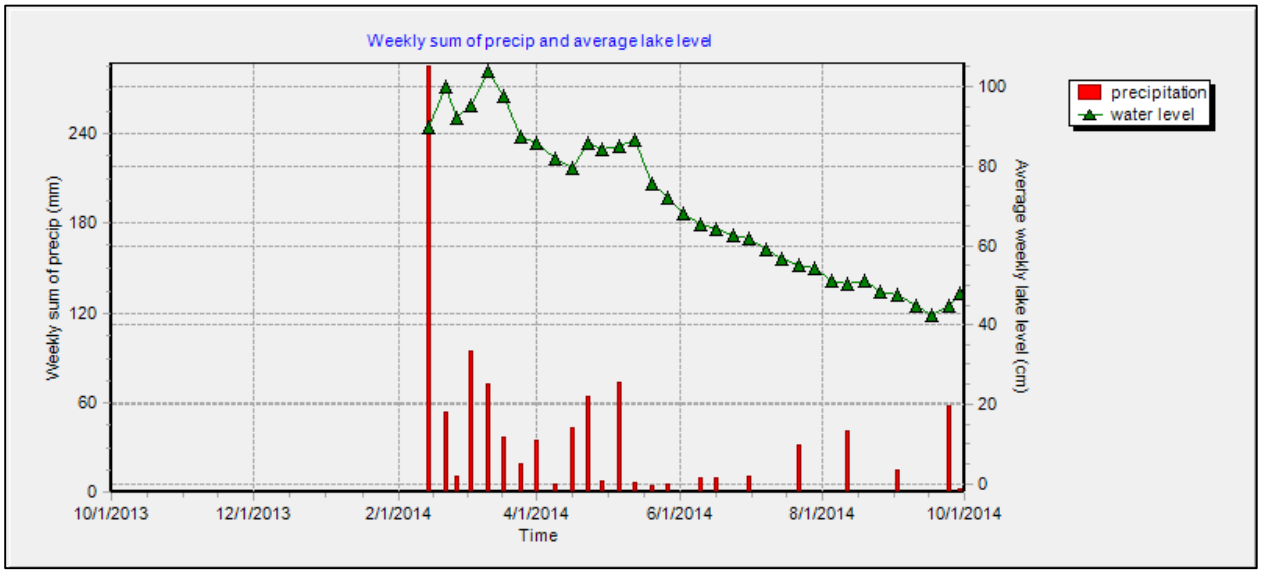


Figure A-1. Weekly Lake Level and Total Precipitation at Lake Geneva for 2014 (King County 2015).

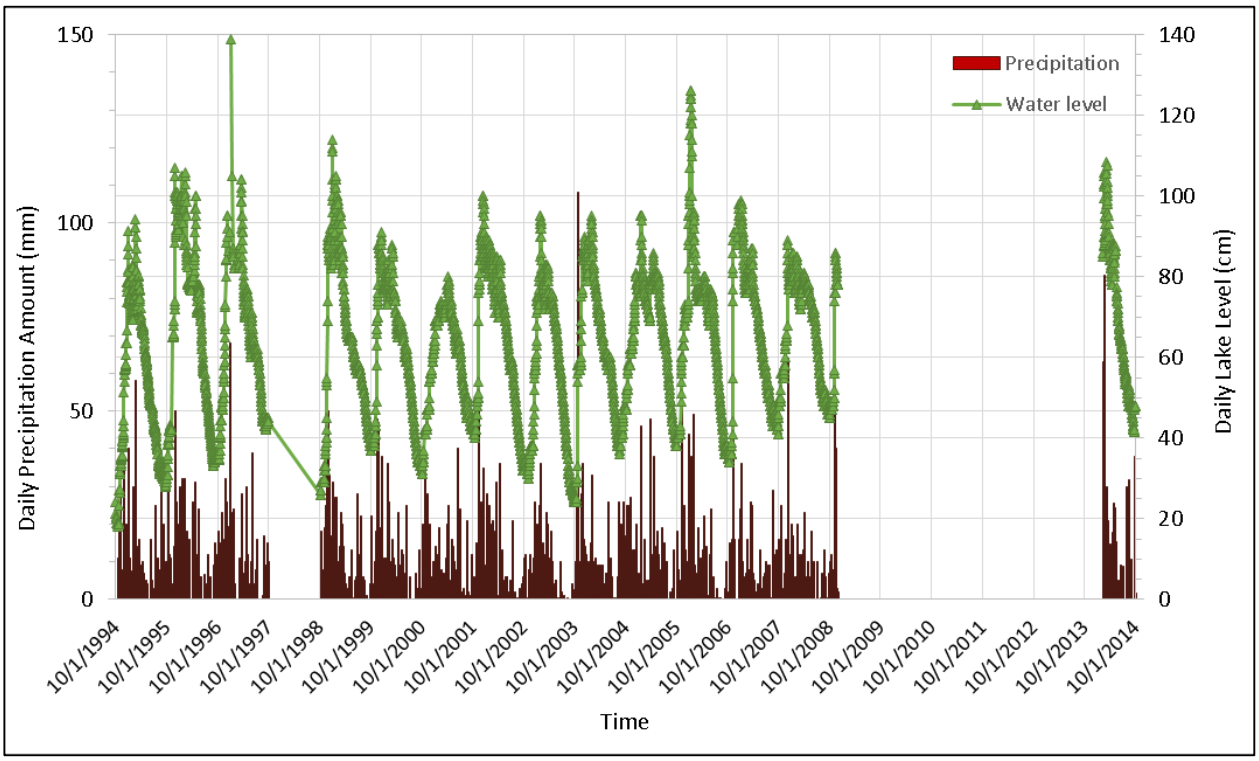


Figure A-2. Daily Lake Level and Total Precipitation at Lake Geneva, 1994-2014.

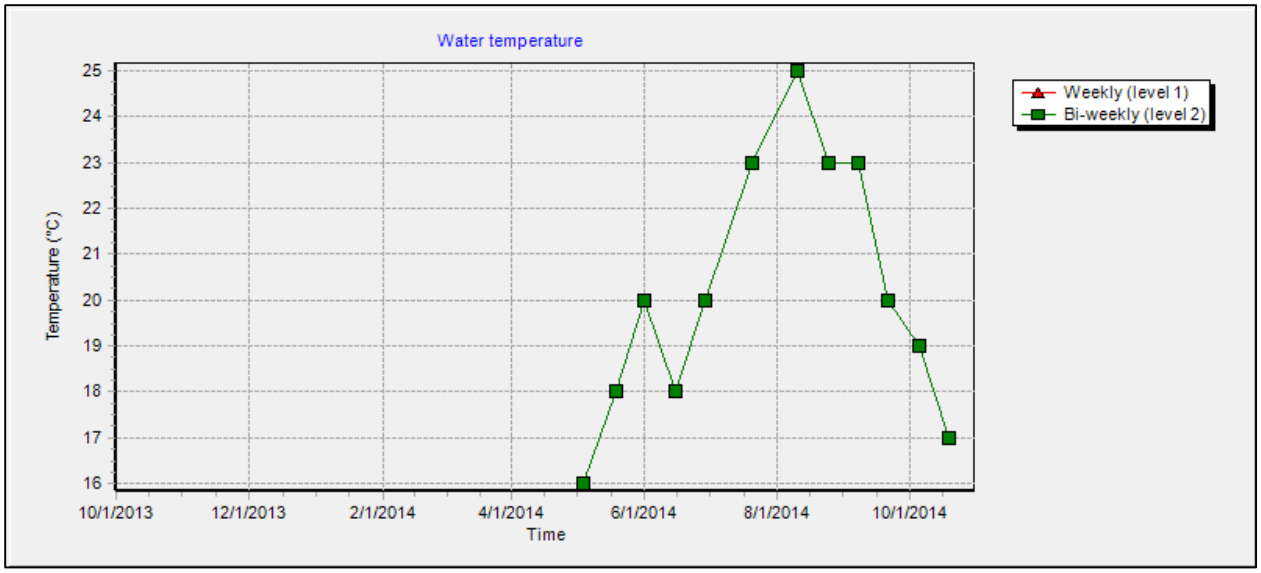


Figure A-3. Water Temperature in Lake Geneva for 2014 (King County 2015).

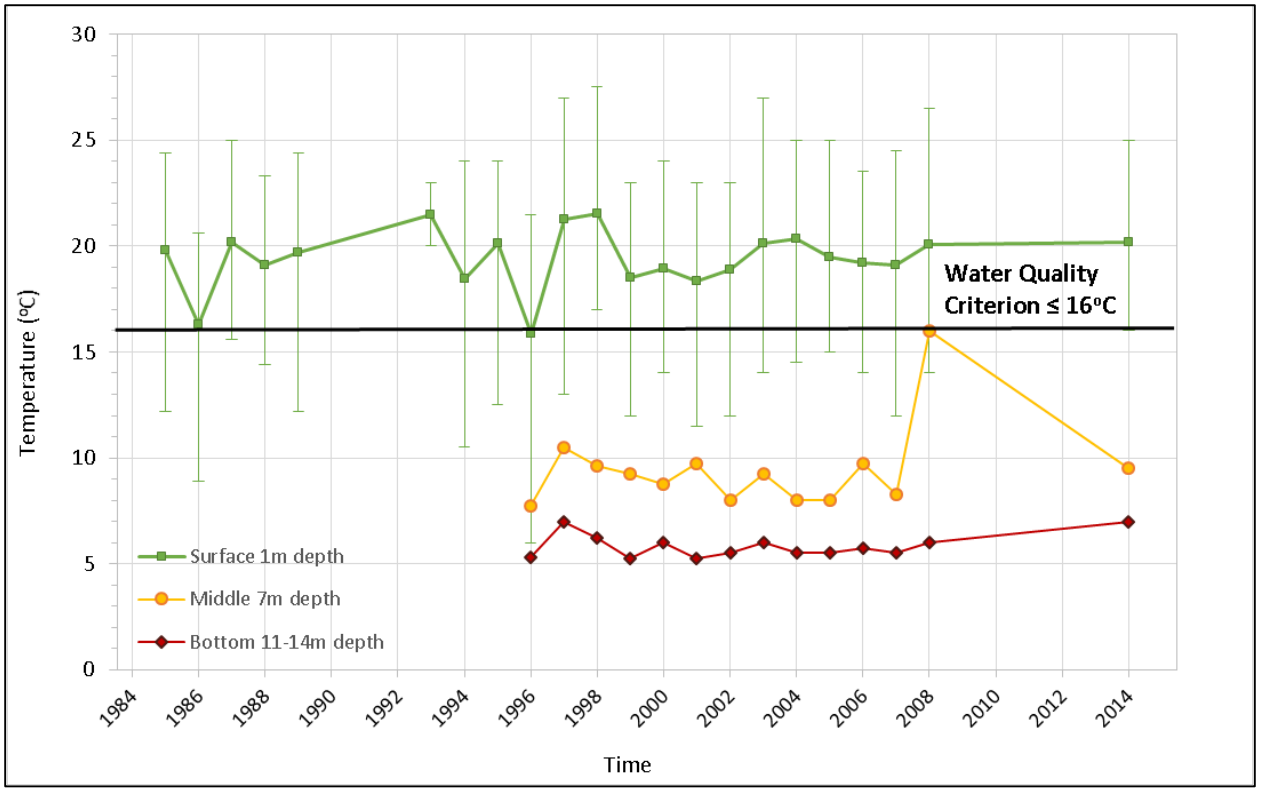


Figure A-4. Water Temperature Mean/Range in Lake Geneva, Summer (May-October), 1985-2014.

Figure A-4 also presents the average mid-depth and bottom depth temperatures measured in May and August since 1996. These results show that average mid-depth temperatures were approximately 5 to 10 °C lower than surface temperatures, and temperatures decreased another 3 C at the lake bottom. These results indicate that the lake exhibited strong thermal stratification during the summer to form three layers: epilimnion (surface), metalimnion (middle), and hypolimnion (lower), and the three depth samples were collected from each of these layers.

Strong summer stratification occurs because of the small and deep lake shape, and is often good for water quality because it reduces the availability of high nutrients in the hypolimnion for algae growth in the epilimnion. However, strong stratification often results in low dissolved oxygen concentrations in the hypolimnion, which was not measured but is indicated to have occurred based on the high nutrient concentrations observed. This results in "trout squeeze," where cold water fish habitat is restricted to the metalimnion because the epilimnion is too warm and the hypolimnion does not have sufficient oxygen.

Secchi Depth Transparency

Secchi depth is a measure of water transparency, which is affected by the amount and size of algae and other particles in the water, and is used to determine the trophic state of lakes along with chlorophyll *a* and total phosphorus. Trophic state thresholds for Secchi depth commonly include less than 2 meters for eutrophic lakes and greater than 4 meters for oligotrophic lakes.

In 2014, summer Secchi depth decreased from 4 meters in May to 2 meters in October 2014 (Figure A-5), indicating there was a gradual accumulation of floating algae (phytoplankton) in the lake. However, this seasonal pattern was not consistently observed in previous years.

Over the summer period of record, Secchi depth ranged from 1.6 to 6.7 meters where the minimum measurement was observed in October 2014 (Figure A-6). The average summer Secchi depth was in the mesotrophic range (2 to 4 meters) in 2014, but typically in the oligotrophic range (greater than 4 meters) for the previous years. Trend tests showed that Secchi depth was significantly lower in 2014 than 1994 to 2008 ($p = 0.0002$), but there was no trend from 1994 to 2008 ($p = 0.16$). The recent decrease in Secchi depth indicates there has been a concurrent increase in phytoplankton growth, as discussed below for chlorophyll *a*.

Chlorophyll

Chlorophyll *a* is a convenient and common measure of phytoplankton biomass. However, it is present in highly varied amounts among phytoplankton species and growth stages, and rarely relates well to other measures of phytoplankton biomass such as cell biovolume. It typically relates well with Secchi depth transparency unless there are large amounts of suspended inorganic particles causing turbidity in a lake. The summer mean concentration of chlorophyll *a* is used to determine the trophic state of lakes. Common thresholds include less than 2.6 micrograms per liter (µg/L) for oligotrophic lakes and greater than 7.2 µg/L for eutrophic lakes.

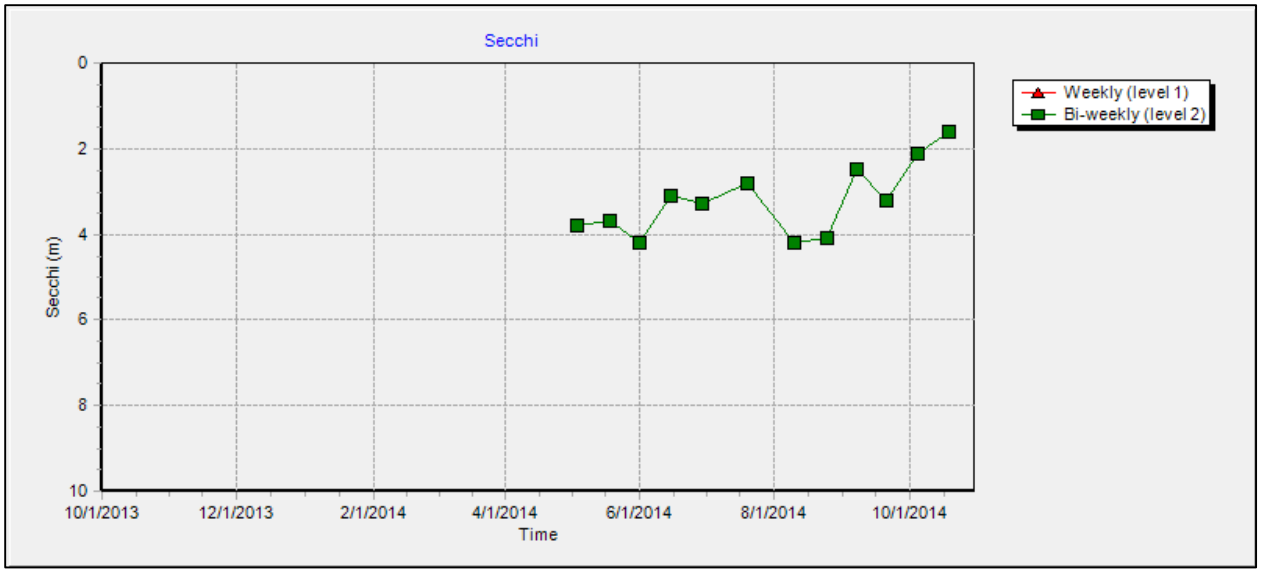


Figure A-5. Secchi Depth Transparency in Lake Geneva for 2014 (King County 2015).

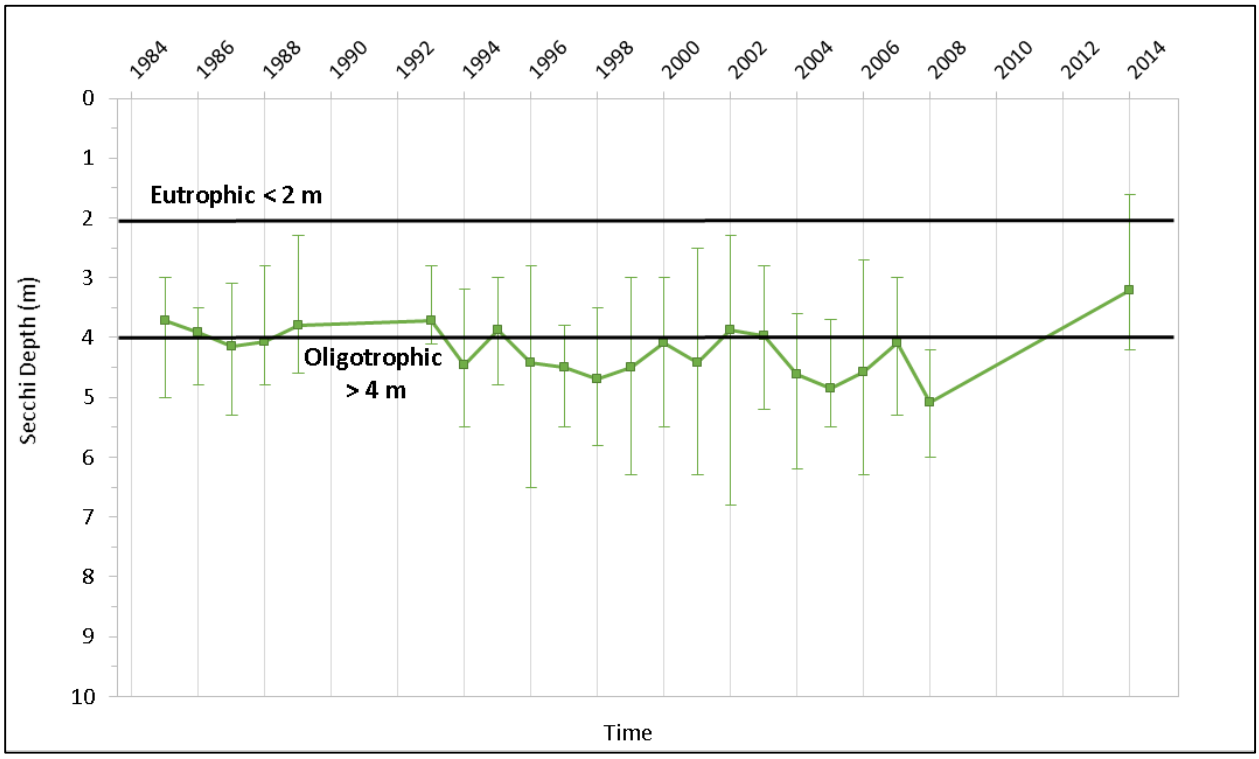


Figure A-6. Secchi Depth Transparency Mean/Range in Lake Geneva, Summer (May-October), 1985-2014.

In 2014, the concentration of chlorophyll *a* at 1-meter depth was moderate at approximately 6 ug/L in May, remained low at 2 to 4 µg/L in June through August, and then increased to a maximum of 32 µg/L in October (Figure A-7). Although this seasonal pattern has not been consistently observed in Lake Geneva, it is commonly observed in these types of lakes due to moderate amounts of diatoms in the spring, low amounts of green and other types of algae in the summer, and high amounts of blue-green algae (cyanobacteria) in the fall. Fall "blooms" typically occur in response to an increased supply of phosphorus from the hypolimnion as thermal stratification deteriorates, a process known as destratification.

Over the summer period of record, chlorophyll *a* ranged from less than 0.5 to 32 µg/L, where the maximum measurement was observed in October 2014 (Figure A-8). The average summer chlorophyll *a* concentration in 2014 (8.3 µg/L) slightly exceeded the eutrophic threshold (7.2 µg/L), and was typically in the mesotrophic range (12 to 24 µg/L) for the previous years. Trend tests showed that chlorophyll *a* was not significantly different in 2014 than 1994 to 2008 ($p = 0.15$), and there was no significant trend from 1994 to 2008 ($p = 0.84$).

Average chlorophyll *a* concentrations were higher for the mid-depth than surface samples (Figure A-8). Comparison of individual profile sample concentrations shows that the mid-depth value was typically much higher than the surface value in August but not in May. This vertical pattern in phytoplankton is commonly observed in stratified lakes due to the higher phosphorus supply and sufficient light for more phytoplankton growth in the metalimnion. Cyanobacteria are well adapted to these conditions and have the additional advantage of maintaining their position in the metalimnion by controlling their buoyancy, but their actual presence in the metalimnion of Lake Geneva is unknown.

Phosphorus

Total phosphorus is also used to determine the trophic state of lakes because phosphorus is typically the most limiting nutrient for freshwater phytoplankton and relates well with chlorophyll *a* and Secchi depth. The summer mean concentration of total phosphorus is used to determine the trophic state of lakes. Common thresholds include less than 12 µg/L for oligotrophic lakes and greater than 24 µg/L for eutrophic lakes.

In 2014, the total phosphorus concentration at 1-meter depth decreased from approximately 60 µg/L in May to approximately 40 µg/L in June through August, and then increased to a maximum of 72 µg/L in October (Figure A-9). This pattern follows that observed for chlorophyll *a*, but has not been consistently observed in Lake Geneva. The decrease in May is likely due to the settling of phosphorus in phytoplankton, and the increase in October is likely due to the initial stage of destratification when phosphorus-rich bottom waters mixes with surface waters in the lake.

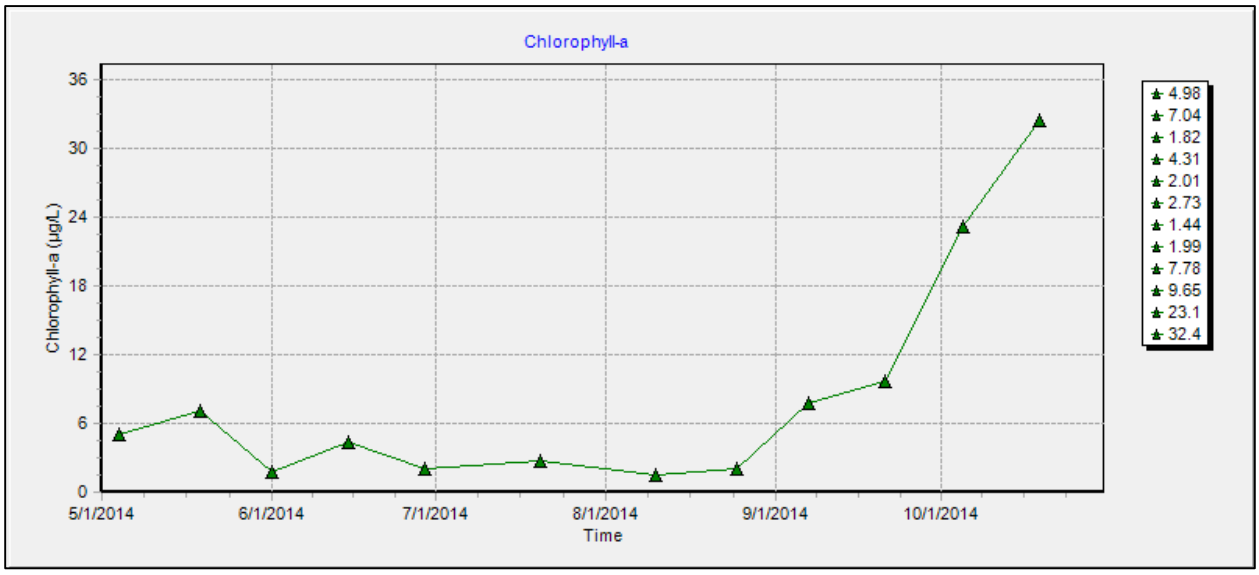


Figure A-7. Chlorophyll *a* at 1-Meter Depth in Lake Geneva for 2014 (King County 2015).

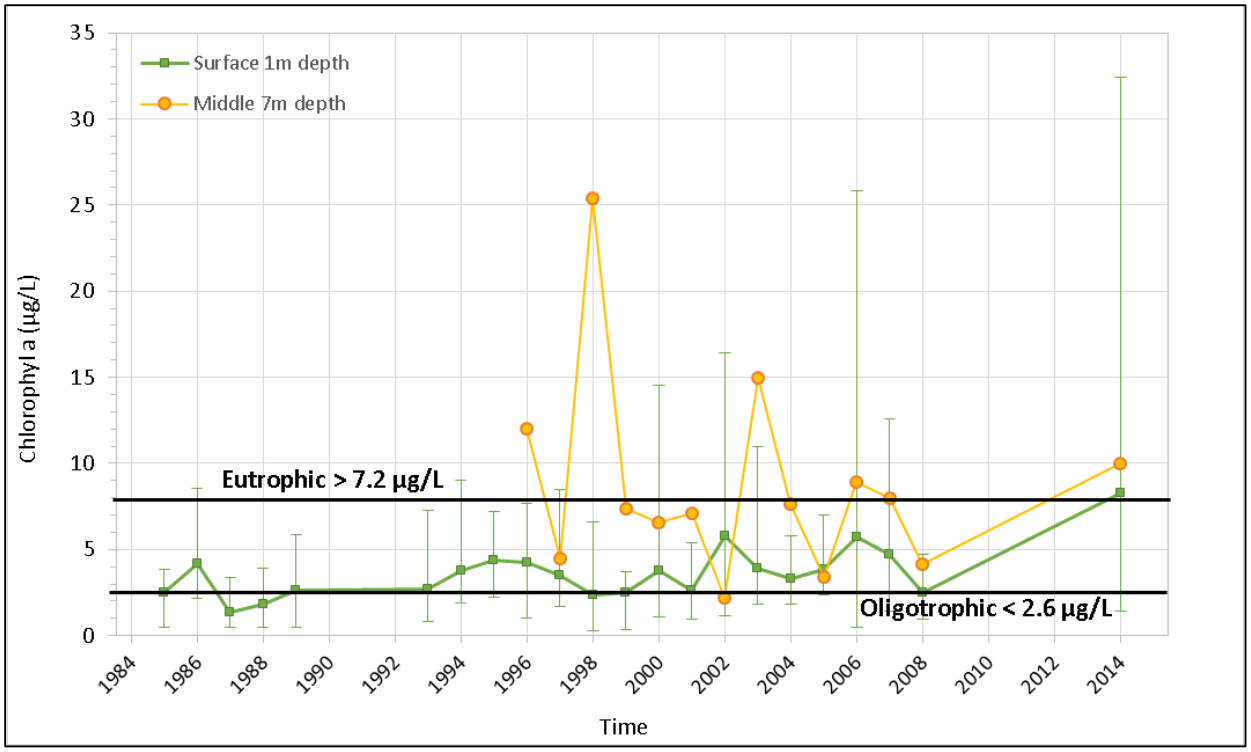


Figure A-8. Chlorophyll Mean/Range in Lake Geneva, Summer (May-October), 1985-2014.

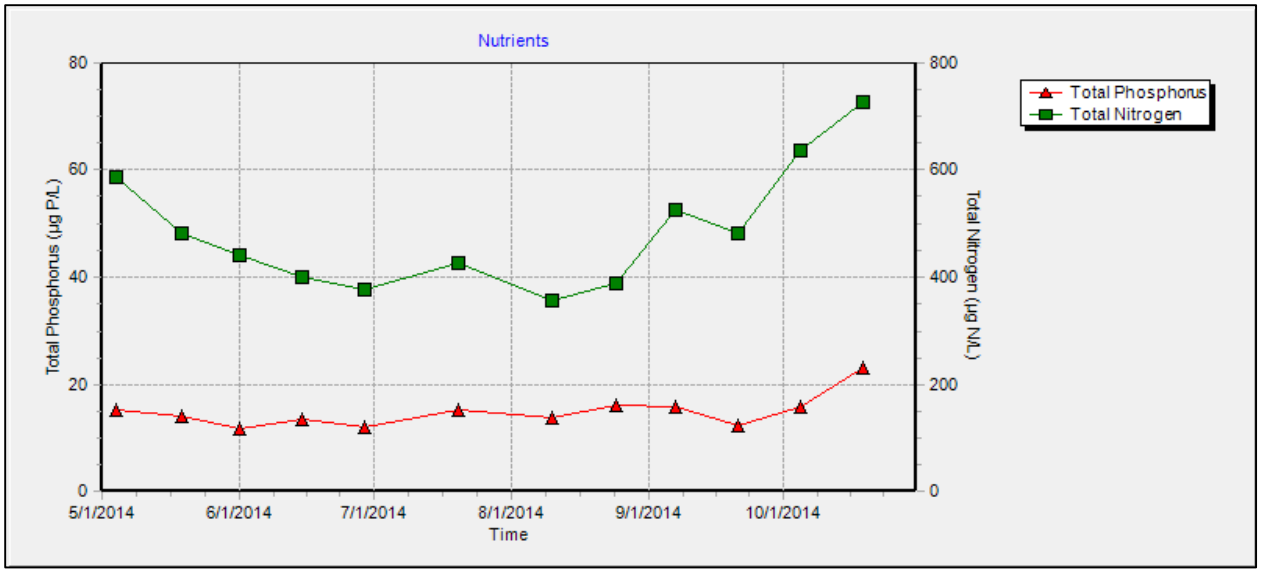


Figure A-9. Total Phosphorus and Nitrogen at 1-meter depth in Lake Geneva for 2014 (King County 2015).

Over the summer period of record, total phosphorus ranged from less than 1 to 127 µg/L, where the maximum measurement was observed in October 2014 (Figure A-10). The average summer total phosphorus concentration in 2014 (15 µg/L) was well below the eutrophic threshold (24 µg/L), and was typically in the mesotrophic range (12 to 24 µg/L) for the previous years. Trend tests showed that total phosphorus was not significantly different in 2014 than 1994 to 2008 ($p = 0.27$), but there was a significant decreasing trend from 1994 to 2008 ($p = 0.003$). Thus, the recent increase in chlorophyll *a* is not explained by a concurrent increase in total phosphorus concentrations near the surface of Lake Geneva.

Compared to surface water samples, average total phosphorus concentrations were higher in the mid-depth water samples and much higher in the bottom water samples (Figure A-10). The maximum total phosphorus concentration observed in the lake was 630 ug/L for the bottom water sample collected in August 2014. This observation, combined with the high chlorophyll to total phosphorus ratio observed in the surface water samples in 2014, suggests that phytoplankton may have obtained more phosphorus from the hypolimnion in 2014 than in previous years. This may be explained by an increase in cyanobacteria because they migrate vertically up into surface waters after obtaining phosphorus from bottom waters during early stages of growth (known as luxury uptake), but this cannot be determined without analysis of trends in phytoplankton composition.

The high total phosphorus concentrations observed in the bottom waters are likely due primarily to the release of phosphorus bound to iron in deep sediments under anoxic (no oxygen) conditions. Hypolimnion phosphorus concentrations likely vary from year to year depending on microbial respiration and dissolved oxygen depletion rates.

Orthophosphate phosphorus is a measure of dissolved phosphorus immediately available for phytoplankton uptake. Orthophosphate phosphorus is not presented in graphs, but the limited data collected at 1-meter depth shows it was low in May and August (0.5 to 2 µg/L). In bottom water samples, orthophosphate phosphorus concentrations were high in May (16 to

96 µg/L) and increased in August (29 to 446 µg/L). These results indicate that dissolved phosphorus was readily consumed by phytoplankton in surface waters and produced in bottom waters during the summer months.

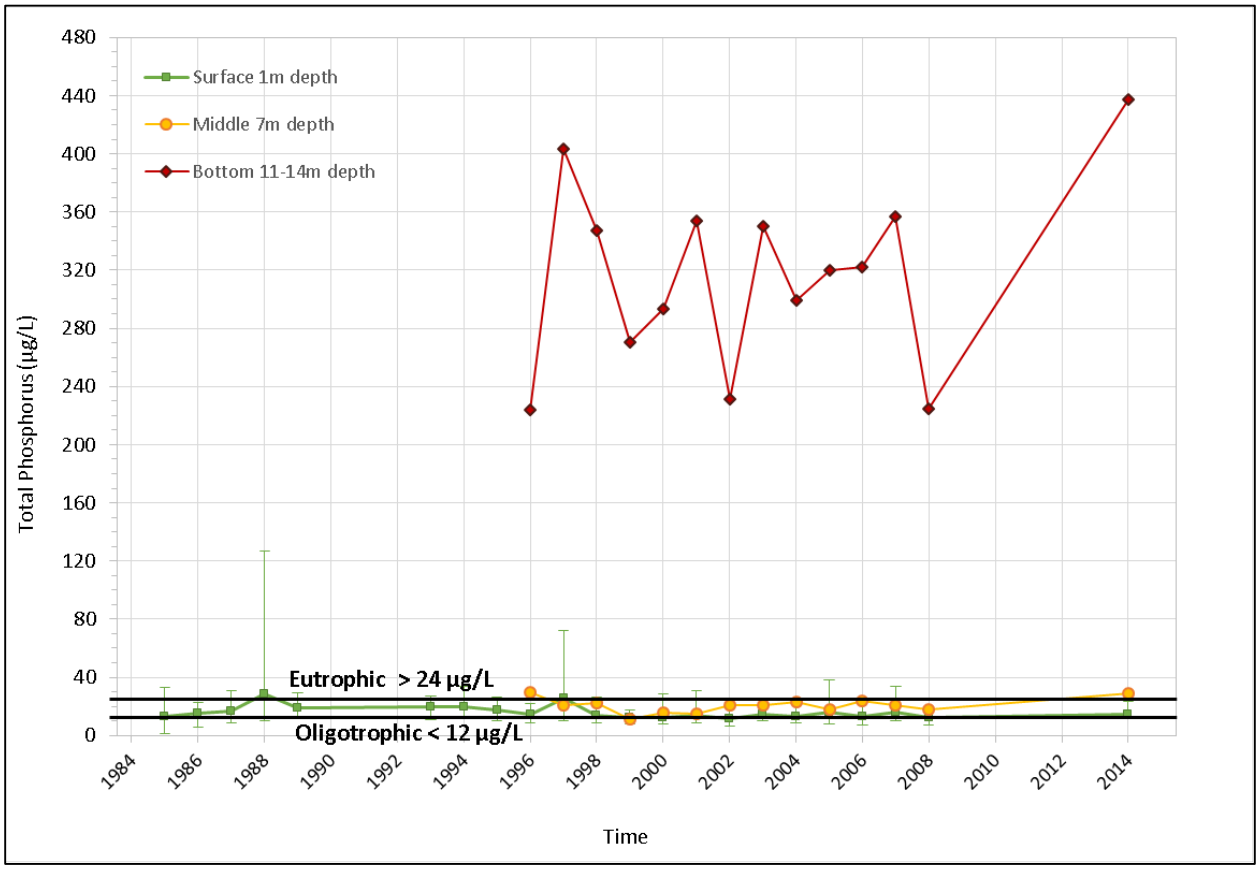


Figure A-10. Total Phosphorus Mean/Range in Lake Geneva, Summer (May-October), 1985-2014.

Nitrogen

Total nitrogen is a measure of both organic nitrogen and dissolved inorganic nitrogen, which comprises nitrate+nitrite and ammonia nitrogen. Total nitrogen can be the most limiting nutrient for freshwater phytoplankton when total phosphorus in high, which can occur in hypertrophic lakes from inputs of human or animal waste. Total nitrogen is not commonly used to determine trophic state.

The total nitrogen concentration at 1-meter depth followed patterns similar to those observed for total phosphorus in 2014 (Figure A-9) and previous years (compare Figures A-10 and A-11). Trend tests showed that total nitrogen was not significantly different in 2014 than 1994 to 2008 ($p = 0.21$), and there was no significant change from 1994 to 2008 ($p = 0.26$).

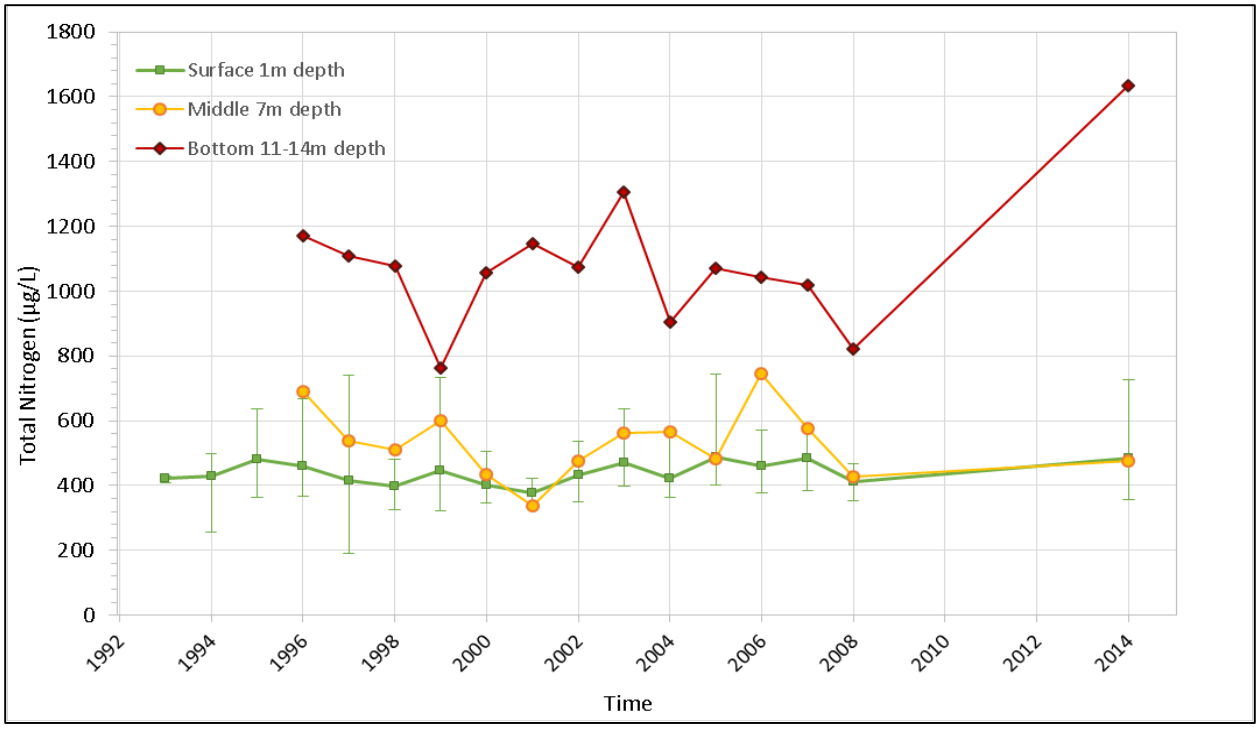


Figure A-11. Total Nitrogen Mean/Range in Lake Geneva, Summer (May-October), 1993-2014.

Compared to surface water samples, average total nitrogen concentrations were typically higher in the mid-depth water samples and much higher in the bottom water samples (Figure A-11). The maximum total nitrogen concentration observed in the lake was 1,850 µg/L for the bottom water sample collected in August 2014. As for phosphorus, high total nitrogen concentrations are commonly observed in bottom water samples from lakes due to high rates of microbial activity.

Nitrate+nitrite nitrogen is a measure of two dissolved inorganic forms of nitrogen readily used by phytoplankton and microbes in lakes, but this parameter represents just nitrate nitrogen in surface waters when oxygen is present. Nitrate nitrogen is not presented in graphs, but the limited data collected at 1-meter depth shows it ranged from 20 to 95 µg/L in May and was not detected in August. In bottom water samples, nitrate nitrogen was typically present at higher concentrations (up to 442 µg/L) in May, and was not detected in August. These results indicate that nitrate nitrogen was readily consumed by phytoplankton and other microbes during the summer months.

Ammonia nitrogen is another form of dissolved inorganic nitrogen readily used by phytoplankton and other microbes in lakes. The limited data collected shows that ammonia nitrogen concentrations were typically low at 1-meter depth in May and August (less than 25 µg/L), but were high in bottom water samples in May (45 to 553 µg/L) that substantially increased in August (663 to 1,540 µg/L). These results reflect the high demand for ammonia by phytoplankton in surface waters and the high ammonia production by microbes in the bottom waters, which commonly occurs in stratified lakes during the summer.

Nitrogen to Phosphorus Ratio

The total nitrogen to total phosphorus ratio by weight (total N:P) is often used to evaluate which of the two nutrients limit phytoplankton growth. Phosphorus is typically the primary limiting nutrient in lakes, and nitrogen is the primary limiting nutrient in marine waters. A recent review of nutrient limitation literature concluded that while phosphorus appears to control phytoplankton growth in oligotrophic lakes over the long term (years), most lakes appear to be limited over the short term (months) by both phosphorus and nitrogen (co-limitation), and possibly by other resources such as iron (Sterner 2008). One study concluded that nutrient limitation depends on both nutrient concentrations and their ratio (Guildford and Hecky 2000). Based on nutrient relationships observed in 221 lakes, they found that phosphorus-deficient growth occurred consistently at total N:P ratios greater than 22, nitrogen-deficient growth occurred consistently at total N:P ratios less than 9, and co-limitation by phosphorus and nitrogen is assumed to occur between these limits.

Total N:P ratios for Lake Geneva are presented in Figure A-12. Surface and mid-depth samples consistently exhibited phosphorus limitation with average N:P ratios greater than 22. Trend tests of 1-meter-depth data showed that total N:P ratio was not significantly different in 2014 from 1994 to 2008 ($p = 0.88$), but there was a significant increasing trend from 1994 to 2008 ($p = 0.004$). The low total N:P ratios in bottom waters were due to the high total phosphorus concentrations. Phytoplankton were not limited by either nutrient in bottom waters due to the high supply of both nutrients.

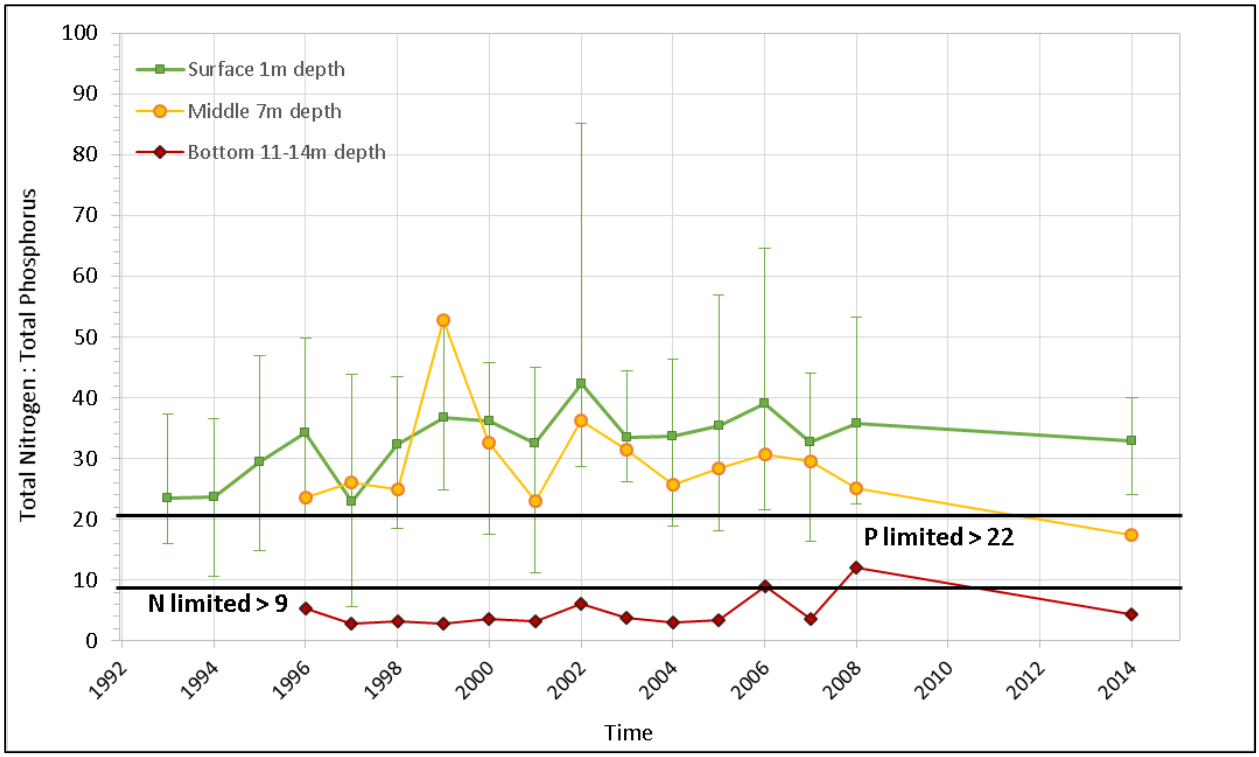


Figure A-12. Total Nitrogen to Phosphorus Ratio Mean/Range in Lake Geneva, Summer (May-October), 1993-2014.

Trophic State Index

The three trophic state indices were calculated by King County (2015) and are presented for each year in Figure A-13. These results show that Lake Geneva is a mesotrophic lake with indices ranging from 42 to 47 versus mesotrophic limits of 40 to 50. Historically, some indices (particularly Secchi depth) dropped into the oligotrophic class for most years from 1994 to 2008. Although trend analysis was not performed on the trophic state indices, these results show that the chlorophyll *a* and Secchi depth indices were higher in 2014 than all previous years of measurement.

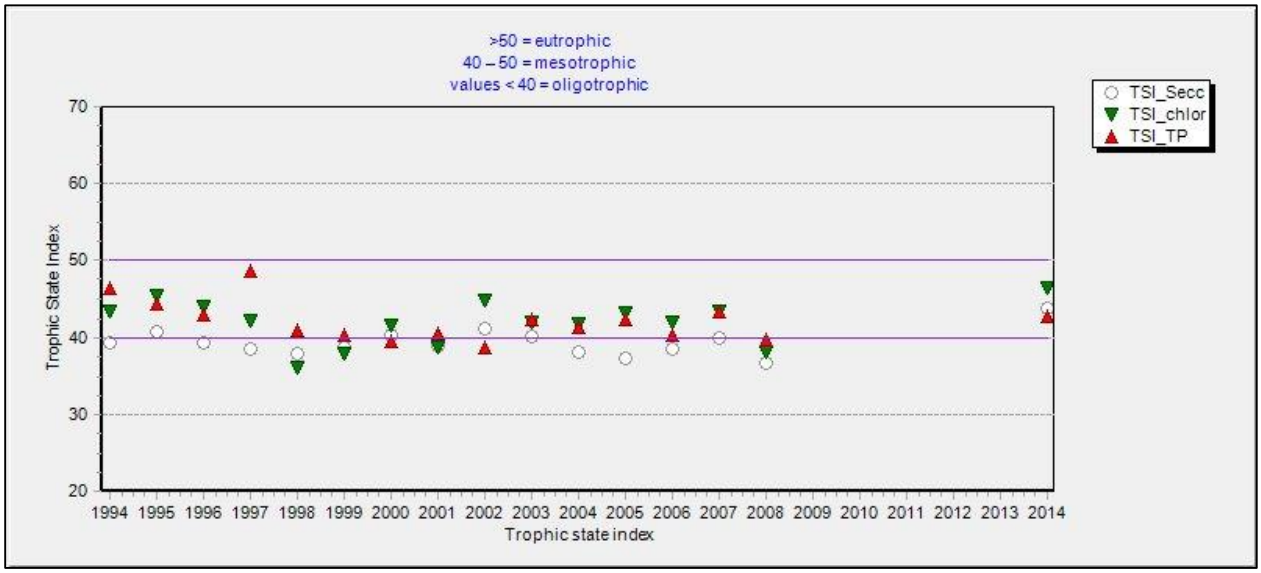


Figure A-13. Trophic State Indices of Secchi Depth, Chlorophyll, and Total Phosphorus for Lake Geneva, Summer (May-October), 1994–2014 (King County 2015).

REFERENCES

King County 2015. King County Small Lakes Information and Data – Lake Geneva. King County, Seattle, Washington. Information and data obtained from the following website in January 2015: http://green2.kingcounty.gov/SmallLakes/LakePage.aspx?SiteID=13.

Helsel, D.R. and R.M. Hirsch. 1992. Statistical Methods in Water Resources. US Geological Survey, Water Resources Division, Reston, Virginia. Elsevier Science Publishing Company, Inc., New York, New York.

APPENDIX B

Previous Vegetation Monitoring Reports

Aquatic Plants in Selected Waters of King County

Distribution and Community Composition of Macrophytes

METRO

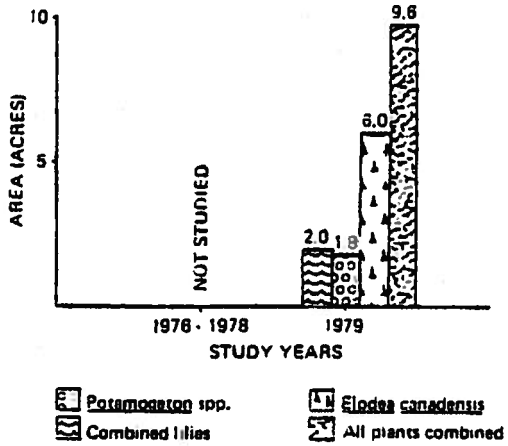
WATER QUALITY DIVISION
1979

Municipality of Metropolitan Seattle

LAKE GENEVA

Survey date:
August 8, 1979

SPECIES LIST
- Elodea canadensis (water weed)
- Najas flexilis (water nymph)
- Nuphar variegatum (yellow waterlily)
- Nymphaea odorata (fragrant white waterlily)
- Potamogeton amplifolius (large-leaved pondweed)
- Potamogeton berchtoldii (Berchtold's pondweed)



DENSITY: Light. Some moderate to dense. No previous information.

TOTAL LAKE AREA 26 ACRES
MAXIMUM POTENTIAL MACROPHYTE COVERAGE 14.4 ACRES

Fig. 9. Histogram of areal coverages of macrophytes in Lake Geneva, 1976-1979.

The dominant plants in this lake were Nymphaea odorata, Potamogeton amplifolius, and Elodea canadensis. The density of submersed plants was generally light with a moderate to dense patch of P. amplifolius at the west end. The lake bottom was generally silty along most of the shoreline. The southeast side lake-bottom was silt but with many submerged logs and branches. The entire lake has good exposure to the sun except the southeast side which is shaded by nearshore fir trees. Plants generally occurred around the entire lake shore except for the southeast part.

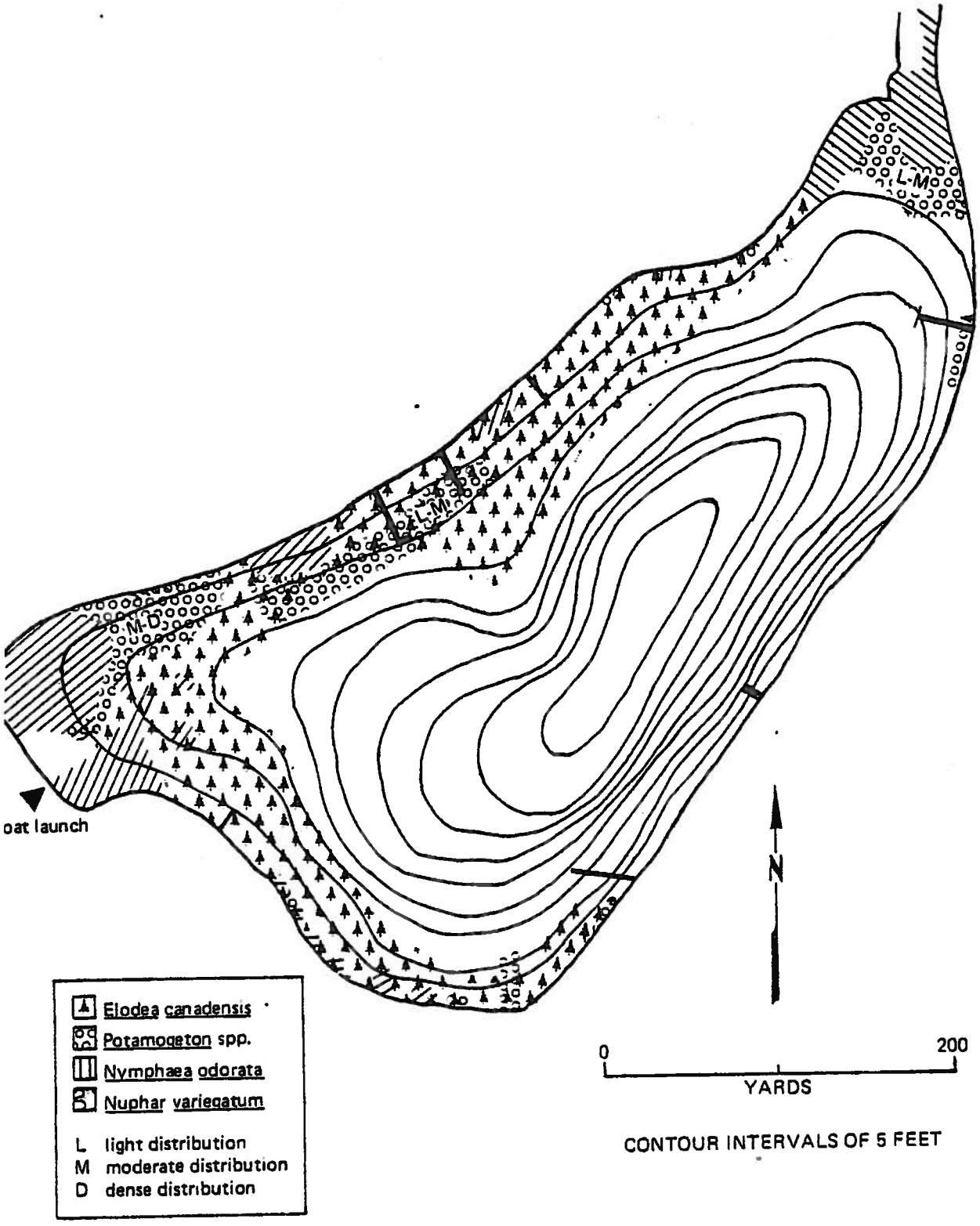


Fig. 10. Contour map showing areal distributions and densities of macrophytes as shown by 1979 survey.

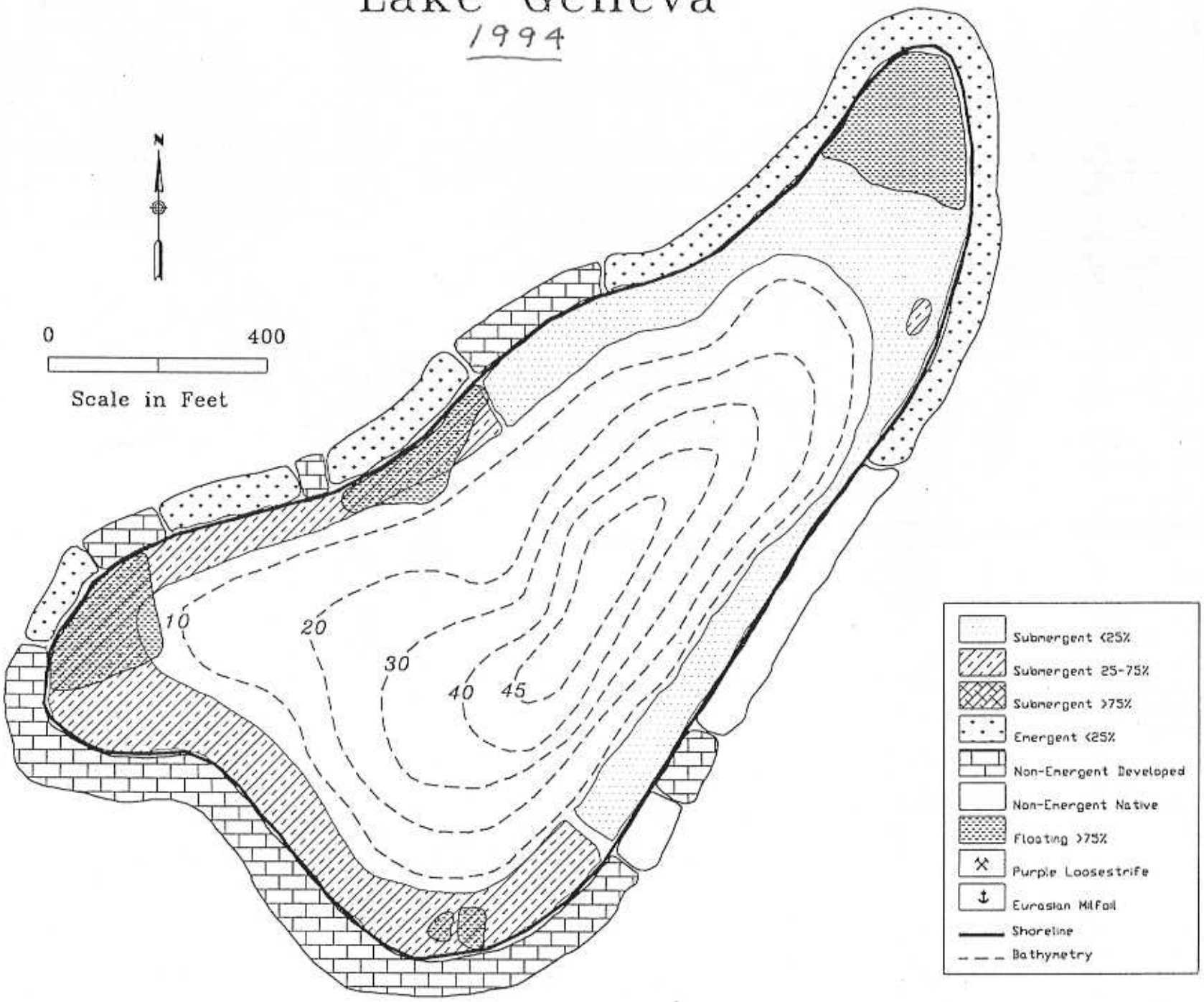
Lake Species List

28-Sep-94

Lake Name	Sample Date	Species Name	Common Name	Community Type
Geneva	8/9/94	Cerataphyllum demersum	Coontail	Emergent
Geneva	8/9/94	Elodea canadensis	Water Weed	Submergent
Geneva	8/9/94	Iris pseudacorus	Yellow Iris	Emergent
Geneva	8/9/94	Juncus sp.	Rush	Emergent
Geneva	8/9/94	Nitella sp.	Stonewort	Submergent
Geneva	8/9/94	Nuphar variegatum	Yellow Pondlily	Floating
Geneva	8/9/94	Nyphaea odorata	Fragrant White Pondlily	Floating
Geneva	8/9/94	Potamogeton amplifolius	Large Leafed Pondweed	Submergent
Geneva	8/9/94	Potamogeton berchtoldii	Berchtold's Pondweed	Submergent
Geneva	8/9/94	Potentilla palustris		Emergent
Geneva	8/9/94	Spiraea douglasii	Hardhack	Emergent
Geneva	8/9/94	Typha latifolia	Cat Tail	Emergent
Geneva	8/9/94	Utricularia sp.	Bladder Wort	Submergent

Lake Geneva

1994



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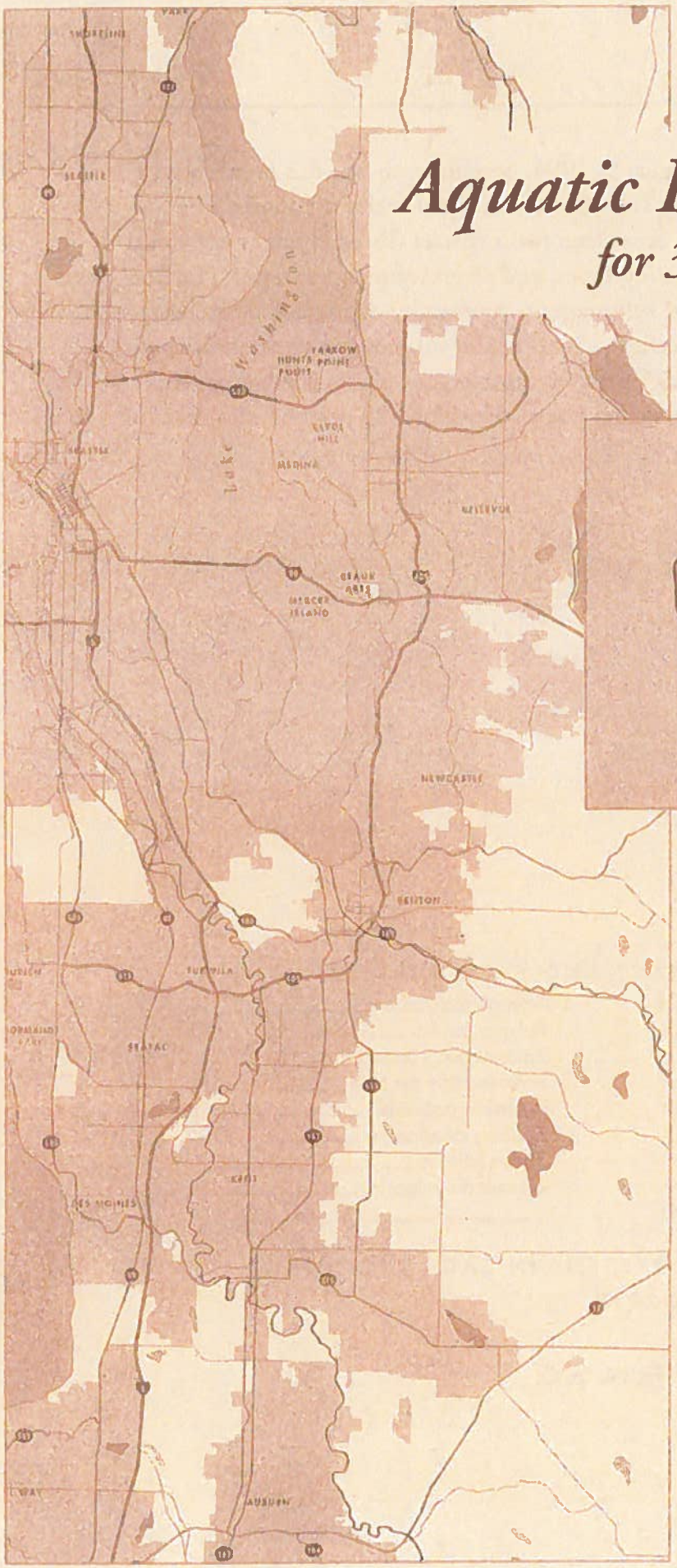


Aquatic Plant Mapping
for 36 King County Lakes

December 1996

King County
Surface Water
Management
Everyone lives downstream

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

18228

Geneva

Lake Geneva was surveyed on August 9, 1994. Secchi depth was 4.2 meters with good water clarity. The survey team was assisted by Lake Geneva resident Delores Pounds. The weather during the survey was partly sunny. Seventeen plant species (listed below) were identified including eight emergent types, two floating types, and seven submergent types. The floating plant coverage totaled 3.4 acres while the submergent community comprised 6.8 acres. Percent cover was generally less than 25 percent for floating and submergent communities with only several sections having between 25 and 75 percent. Submergent plant coverage generally diminished after three meters. Emergent vegetation was also less than 25 percent with most of the shoreline developed for residential uses.

SPECIES PRESENT AND THEIR ABBREVIATIONS

Ceratophyllum demersum ..... Cd	Nymphaea odorata ..... No
Chara sp. ..... Cs	Polygonum sp. ..... Pm
Elodea canadensis ..... Ec	Potamogeton amplifolius ..... Pa
Iris pseudacorus ..... Ip	Potamogeton pusillus ..... Pb
Juncus sp. ..... Ju	Potentilla palustris ..... Pp
Ludwigia palustris ..... Lp	Spiraea douglasii ..... Sd
Najas flexilis ..... Nf	Typha latifolia ..... Tl
Nitella sp. ..... Ni	Utricularia vulgaris. ..... Uv
Nuphar lutea ..... Nl	.....

SPECIES PRESENT IN EACH SECTION

1 ..... Sd, Ip, Pp, Tl, No, Pa, Pb, Ec, Uv, Cd, Nf

2 ..... Ip, Tl, Sd, Pp, Pa

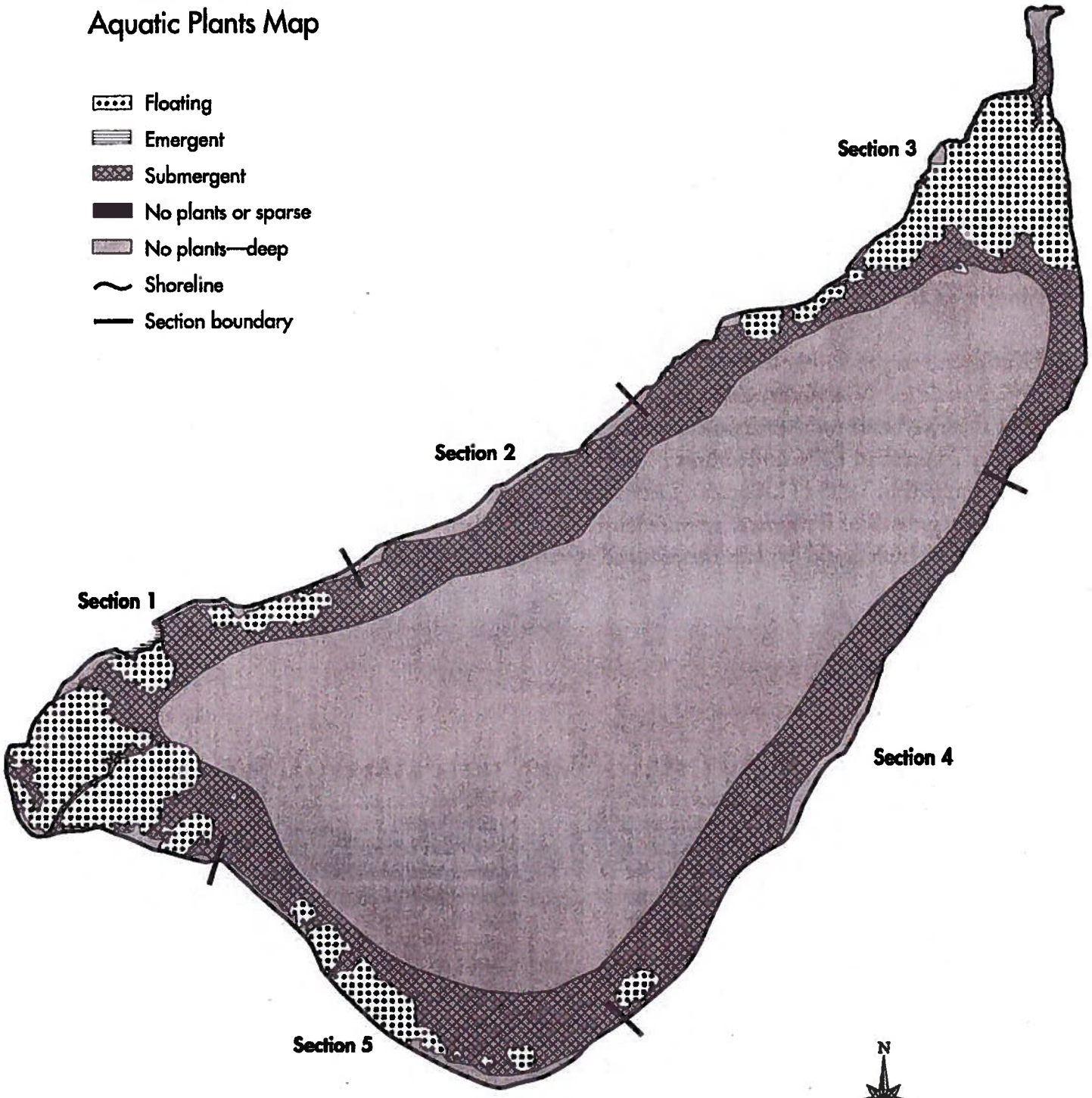
3 ..... Tl, Ip, Sd, Pp, Ju, No, Nl, Uv, Ec, Pa, Ni, Lp, Cs

4 ..... Ip, Pp, Ju, Pa

5 ..... Sd, Ju, No, Pa, Pb, Ec, Ni

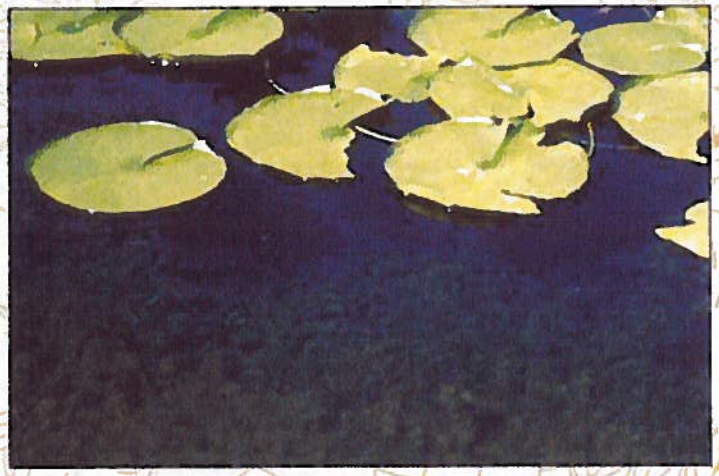
Geneva

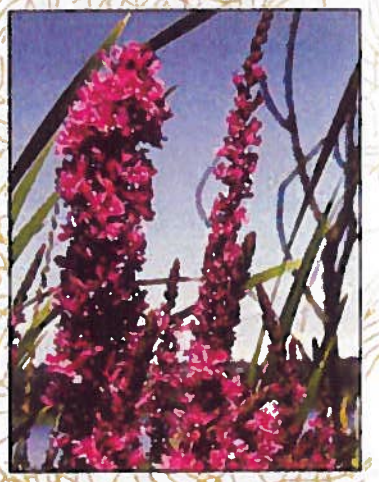
Aquatic Plants Map



Lake Area: *27.9 acres*
Mean Depth: *19 feet*
Maximum Depth: *46 feet*

Waterweeds:
A Report on Volunteer Survey Results for Fifteen King County Lakes





FINAL REPORT
for the Washington State Department of Ecology

February 2000

King County
Department of Natural Resources

18228

Summary

This report presents the results of the 1998-1999 waterweeds volunteer survey program. Through the waterweeds project, a pilot aquatic weed volunteer monitoring and education program was developed.

Through this program, volunteers were successfully trained to identify and survey their lakes for eight target weed species. These weeds included *Cabomba caroliniana* (fanwort), *Egeria densa* (Brazilian elodea), *Eichhornia crassipes* (water hyacinth), *Hydrilla verticillata* (hydrilla), *Lythrum salicaria* (purple loosestrife), *Myriophyllum aquaticum* (parrotfeather milfoil), *Myriophyllum spicatum* (Eurasian watermilfoil), and *Phalaris arundinacea* (reed canary grass).

During 1998 and 1999, fifteen King County lakes participated in the survey project. Using weed identification cards, lake maps, and other tools, volunteers successfully mapped the weeds in their lakes, recording this information on field sheets and accompanying lake maps.

At each lake, volunteers typically found only two or three weed species. These species were limited to *L. salicaria*, *M. spicatum*, and *P. arundinacea*. Based on previous surveys, all three of these weeds can be commonly found in King County lakes. No new infestations were reported of less frequently occurring species like *E. densa*, *H. verticillata*, or *M. aquaticum*.

By focusing on a few species of concerns, volunteers can recognize target weed species and map their location. In turn, this location information can be used to prioritize weed control efforts by lake groups, local agencies, and weed boards.

Project Description

Through the waterweeds project, a pilot aquatic weed volunteer monitoring and education program was developed. Volunteer lake monitors were trained to identify eight aquatic weeds of concern in Washington. As part of the project, identification materials for the eight target weeds were created. These materials included laminated cards with color photographs of the plant on the front side and background and identification information on the back side. These materials were used in the training program to develop plant identification and surveying skills among volunteer monitors.

During summer workshops, volunteer monitors were trained in plant survey and identification techniques. Staff followed up with on-site training, which ensured volunteers were properly identifying plants in the field and correctly implementing survey techniques.

After training, volunteers completed weed surveys at their respective lakes in 1998 and 1999. Through these surveys, volunteers were able to document the extent of weed coverage at their lakes as well as survey for new infestations of the target weeds.

Project Purpose

Using volunteers to regularly survey and map aquatic plants provides an opportunity to track waterweeds in lakes which may not otherwise by monitored. Volunteers' surveys can record the types and amounts of plants in our lakes over time. Regular monitoring, in turn, can help with early the detection of waterweeds, saving time and money when weed control efforts are warranted. Additionally, survey information collected by volunteers can be used to develop integrated vegetation management plans for long-term plant eradication or control.

Weed Classification

In Washington State, the management of noxious weeds is governed by RCW 17.10. This law defines a noxious weed as "any plant which when established is highly destructive, competitive, or difficult to control by cultural or chemical practices." Each year, the Washington Noxious Weed Control Board adopts a weed list for control (Washington State Department of Agriculture, 1999). Similarly, local boards like King County's Noxious Weed Board, adopt county weed lists that target statewide and regional species of concern (King County, 1999).

Both state and local weed lists categorize species into three major classes: A, B, and C. Class A weeds are non-native species with limited distribution in Washington. For Class A weeds, preventing new infestations and eradicating existing infestations is the highest priority. Moreover, the weed law requires affected property owners to eradicate Class A species.

Class B weeds are non-native species which are limited in distribution to portions of Washington state. These species are designated for control in regions where they have

areas remains a high priority. In regions where a Class B species are already established, control is decided on a local level, with containment as the main goal.

Class C weeds are non-native species that have become widespread in the state. Control of these species is designated at the local level with control programs typically established to emphasize containment, partial control, and education.

For this project, eight aquatic weed species were targeted. These species included *Cabomba caroliniana* (Class B statewide and locally), *Egeria densa* (Class B statewide, weed of concern locally), *Eichhornia crassipes* (not listed), *Hydrilla verticillata* (Class A statewide and locally), *Lythrum salicaria* (Class B statewide and locally), *Myriophyllum aquaticum* (Class B statewide and locally), *Myriophyllum spicatum* (Class B statewide, weed of concern locally), and *Phalaris arundinacea* (Class C statewide, weed of concern locally).

Volunteer Recruitment

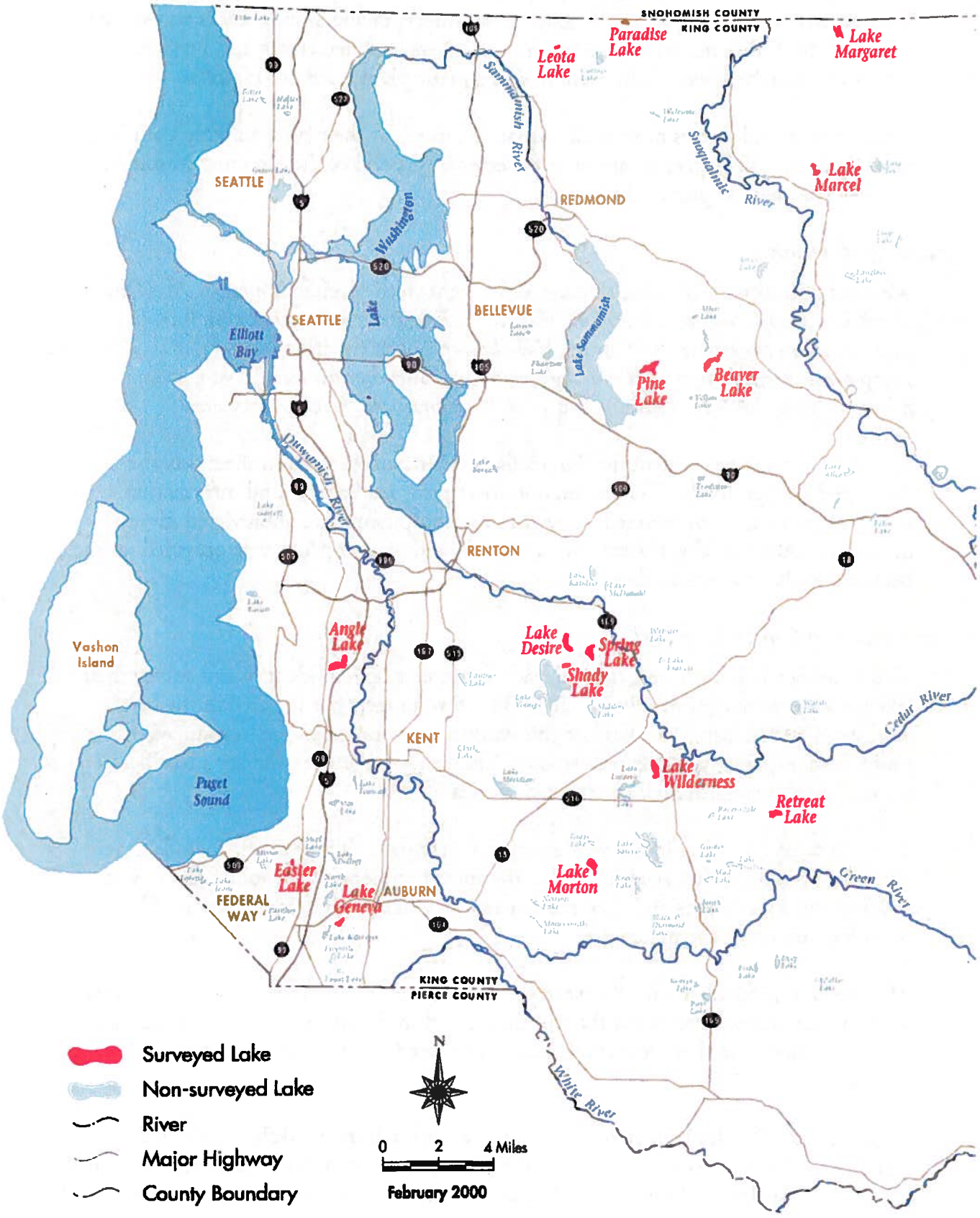
Volunteers were enlisted through the King County Lake Stewardship Program by direct contact and by advertisement in the Program's quarterly newsletter, the Lake Steward. Fifteen lakes (Figure 1) and thirty-two volunteers participated in the waterweeds project during 1998 and 1999. Surveyed lakes and participating volunteers are highlighted in Table 1.

Table 1: 1998 and 1999 Waterweed Survey Participants.

Lake	1998 Volunteers	1999 Volunteers
Angle	Ed and Jeannie Montry	Ed and Jeannie Montry
Beaver	Acar Bill, Ray Petit	Acar Bill, Ray Petit
Desire	Ed and Min Merrill	Ed and Min Merrill
Easter	No survey	M. Tiffany
Geneva	No survey	Sue and Tom Jones
Leota	David Mangles	David Mangles, Rick Sampson
Marcel	Henry Hatem, Chuck Willis	Henry Hatem, Chuck Willis
Margaret	Douglas Johnston	Douglas Johnston
Morton	Richard Balash, Robert Wagner	Richard Balash, Robert Wagner
Paradise	Kay Doolittle	Kay Doolittle
Pine	Kate Bradley, Holly Delaney	Kate Bradley, Holly Delaney, Ilene Stahl
Retreat	Todd and Janice Hammerstrom	Todd and Janice Hammerstrom
Shady	Roberta Dewitt, Beverly Giberson	Nancy and Terry Golden
Spring	Caren Adams, Ted Barnes, Elaine Cruikshank, Ellon Jarvis, Linda O'Brien	Caren Adams, Ted Barnes, Kathy Walker
Wilderness	Roger King , John Vasboe	Roger King , John Vasboe

Figure 1

Locations of 1999 Surveyed Lakes



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Training Materials and Methods

This section details the training materials developed for the waterweed program, training workshop content, and methods used by volunteers to survey their lakes for waterweeds. Training material developed specifically for volunteers included weed cards and survey instructions. Other materials used by the volunteers included lake maps, herbarium specimens, historical weed information, and aquatic plant reference materials.

After training, volunteers proceeded to map the weeds at their lake, marking their locations on a map. Volunteer's maps were collected at the end of the mapping season and the data compiled as part of this report.

Training Materials

Weed identification cards were developed for eight weed species (Appendix A). These weeds included *Cabomba caroliniana* (fanwort), *Egeria densa* (Brazilian elodea), *Eichhornia crassipes* (water hyacinth), *Hydrilla verticillata* (hydrilla), *Lythrum salicaria* (purple loosestrife), *Myriophyllum aquaticum* (parrotfeather milfoil), *Myriophyllum spicatum* (Eurasian watermilfoil), and *Phalaris arundinacea* (reed canary grass).

In addition to the weed identification cards, a laminated instruction sheet was also developed (Appendix B). The instruction sheet provided background information, survey objectives, recommended survey timing, equipment, and abbreviated survey procedures. Additionally, a weed coverage guide and mapping key were provided on the backside of the instruction sheet.

Workshops and Onsite Training

Two training workshops were held to teach volunteers how to identify and survey their lake for waterweeds (Appendix C). In 1998, 25 volunteers participated in the first workshop, representing 13 lakes. At this workshop, volunteers were introduced to the problems associated with noxious weeds. Volunteers also learned the key identification features associated with each target weed species.

To teach weed identification, several mediums were used. These media include slides, identification cards, live material, and herbarium specimens. The volunteers viewed slides of the target weeds and then participated in a hands-on demonstration of key plant features using live material.

After becoming familiar with the weed species targeted, survey methods were reviewed with the volunteers. Following the workshop, staff made onsite visits and worked with volunteers to ensure they were comfortable with weed identification and survey techniques.

In July 1999, 20 volunteers participated in a second training workshop. This workshop was designed as a refresher course for 1998 particpants and training opportunity for new volunteers. At this workshop, two additional lakes and seven new volunteers were added to the waterweeds program.

Equipment and Maps

To participate in the weed survey, volunteers were required to own or have access to a boat, safety equipment, anchor, clipboard, garden rake, rope, homemade viewing scope, pencils, and a large plastic bag or cooler. Staff provided a lake map, permanent markers, field sheets, and identification cards to all volunteers.

Lake maps were developed from digital aerial photographs, which were overlain with parcel and stream features. Lake maps were laminated to waterproof them, which allowed volunteers to write directly on their surface with permanent markers.

Methods

Using a boat, volunteers conducted shoreline weed surveys by circumnavigating their lake. On the lake map, volunteers broke the lake shoreline into distinct areas or sections. Sections were distinguished based on plant community, level of development, and the shape of the lake. Each shoreline section was defined as the area between two chosen fixed shoreline points. These fixed shoreline points typically included public launch sites, parks, and distinct shoreline features such as homes, docks, and geologic elements.

As volunteers circumnavigated the lake shoreline, they mapped weed locations onto the lake map. Volunteers marked weed location onto the laminated field maps using permanent markers. Different symbols were used to represent each weed species.

Volunteers also qualitatively characterized each shoreline section by weed species present and relative percent coverage of weed type. This weed coverage was recorded on the field sheet (Appendix D). Three categories of percent cover were used to describe the aquatic plant coverage (Figure 2). These categories included light (0-25% coverage), medium (25-75% coverage), and heavy (75-100% coverage).

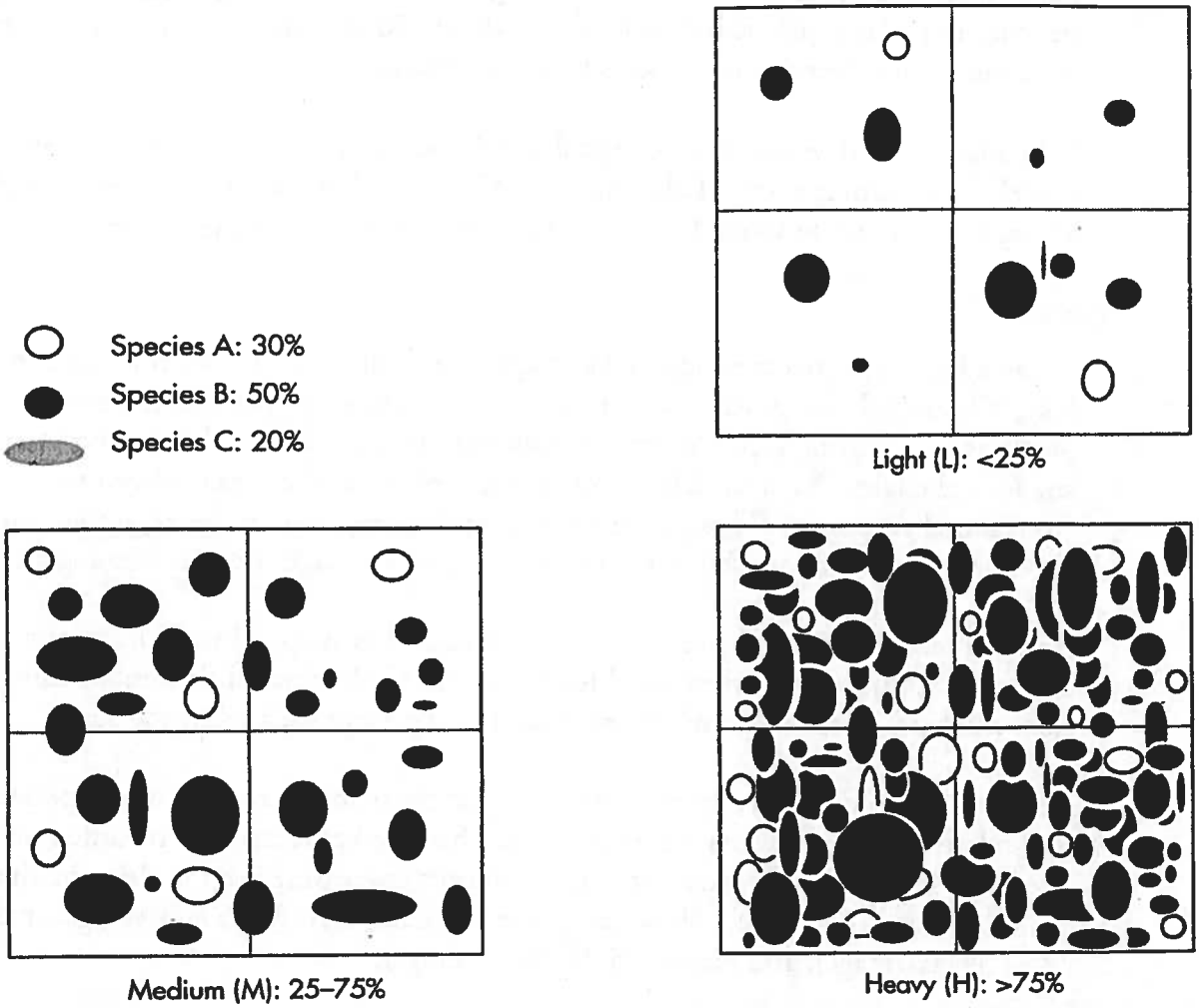
To aid volunteers in locating the target weeds, three plant groupings were also used. These groupings included emergent (shoreline plants), floating (freely or rooted) and submergent (underwater). The eight waterweed species by plant group are listed in Table 2.

Table 2: Waterweed species by Plant Group

Plant Group	Latin Name	Common Name
Emergent	*Lythrum salicaria*	purple loosestrife
Emergent	*Phalaris arundinacea*	reed canary grass
Floating	*Eichhornia crassipes*	water hyacinth
Submergent	*Cabomba caroliniana*	fanwort
Submergent	*Egeria densa*	Brazilian elodea
Submergent	*Hydrilla verticillata*	hydrilla
Submergent	*Myriophyllum aquaticum*	parrotfeather milfoil
Submergent	*Myriophyllum spicatum*	Eurasian watermilfoil

Figure 2

Percent Cover Categories



Volunteers easily characterized the emergent and floating weeds by visual observation of the lake shoreline and adjacent water surface. Submergent weeds were identified through visual observation aided by using a viewing scope or by dragging a garden rake along the lake bottom. The latter technique allowed plant specimens to be brought to the surface for closer viewing.

Volunteers repeated this qualitative survey procedure for each shoreline section as they circumnavigated the lake. For plant samples that could not be identified in the field, additional samples were obtained and marked for later identification. These samples were numbered and recorded on the field sheets by designated number. Staff assisted volunteers with the identification of unknown plant specimens. Volunteers' field notes were updated with the proper identification information after samples were properly identified.

Volunteers were asked to complete their weed surveys in August when total plant numbers are near or at their peak. Most volunteers were able to complete their surveys during this month or early in September.

Survey Results

Fifteen lakes participated in the waterweeds survey project during 1998 and 1999. Table 3 lists the survey results for participating lakes. Only three of the eight weeds species were found at participating lakes. These species included *Lythrum salicaria*, *Myriophyllum spicatum*, and *Phalaris arundinacea*. The most frequently occurring weed species was *P. arundinacea* which was found on 12 of the 15 surveyed lakes. *L. salicaria* was reported on five lakes while *M. spicatum* was found on four lakes.

Table 3: 1998 and 1999 Waterweeds Survey Results

Lake	1998 Weeds**	1999 Weeds**
Angle	Pd	Pd
Beaver	Pd, Ls	Pd, Ls
Desire	Ls, Ms	Ls, Ms
Easter	No survey	None
Geneva	No survey	Pd
Leota	Pd	Pd
Marcel	Pd	Pd
Margaret	Pd	Pd
Morton	Pd	Pd
Paradise	Ls	Ls, Pd
Pine	Pd, Ls	Pd, Ls
Retreat	None	Pd
Shady	Ls, Ms	Ms, Pd, Ls removed
Spring	Ls, Ms, Pd	Ls, Ms, Pd
Wilderness*	Ms	Ms removed

*Wilderness was treated with fluridone to eradicate Ms during 1998.
**Key to weed species: Ls-*Lythrum salicaria*; Ms-*Myriophyllum spicatum*, and Pd-*Phalaris arundinacea*.

Lake Geneva

Lake Geneva was surveyed by Sue and Tom Jones on September 18, 1999. Sky conditions were sunny.

At Lake Geneva, two weed species were found: *Lythrum salicaria* (Ls, Purple loosestrife) and *Phalaris arundinacea* (Pd, reed canary grass). The 1999 location of these weeds is illustrated in Figure 7 . In the five lake sections surveyed, coverage of these weed species was identified as light (Table 8).

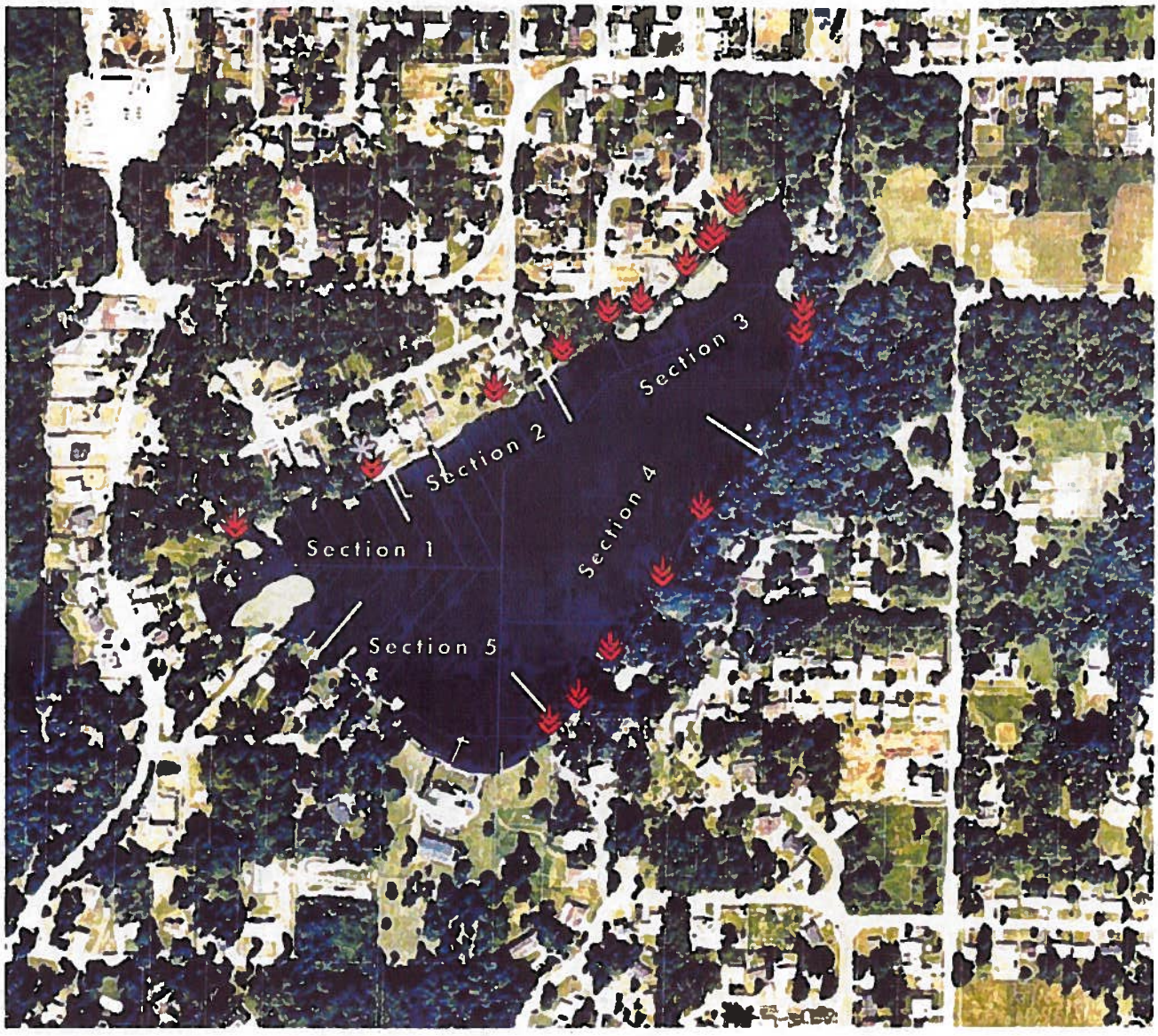
Table 8: Lake Geneva 1999 Waterweeds Survey Results

Section	1998 Species	1998 Coverage	1999 Species	1999 Coverage
1	no survey		Ls Pd	light light
2	no survey		Pd	light
3	no survey		Pd	light
4	no survey		Pd	light
5	no survey		Pd	light

Figure 7

Lake Geneva

Waterweed Volunteer Survey Map 1999



Lythrum salicaria
(Purple Loosestrife)

Phalaris arundinacea
(Reed Canary Grass)

Stream

Section boundary

Parcel boundary

N

0 100 200 300 feet

February 2000

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Key Findings

Local lake residents are most likely to be familiar with the status of water quality or the composition of flora and fauna found at their lake. This familiarity lends residents the ability to observe changes at their lakes more readily then would be expected by a casual visitor, making lake residents very valuable observers of change.

Through the waterweeds program, volunteers were successfully trained to identify and survey their lakes for target weed species. By focusing on a few species of concerns, volunteers recognized these species and mapped their location. In turn, this location information can then be used to prioritize weed control efforts by lake groups, local agencies, and weed boards.

With the 1998 and 1999 surveys, volunteers confirmed the presence of weed species identified in previous surveys (King County, 1996), mapped weeds in lakes which had no previous survey information (Easter, Leota, Marcel, and Paradise), and identified the presence of new weeds which were not recorded in past surveys.

At lakes Angle, Geneva, Margaret, Morton Pine, Retreat, and Spring, *Phalaris arundinacea* was newly identified. While *Lythrum salicaria* was identified for the first time at lakes Beaver, Paradise, and Shady. Because of the volunteer surveys, small infestations of *L. salicaria* were identified and removed at Beaver and Shady lakes, preventing further spread.

Timely detection of new weeds has played an important role in early infestation grant awards from the Washington State Department of Ecology's (Ecology) Aquatic Weed Mmanagement Fund. Specifically, several *Myriophyllum spicatum* early infestation projects were initiated across the state after citizen monitors sent plant samples to Ecology for identification. Similarly, the waterweeds program provides opportunity for early detection and subsequent early infestation funding to address new weed infestations.

Overall, volunteers are important participants in the detection of potentially invasive weed species. Trained volunteers can detect new weeds and alert their local lakes program or weed board. New introductions as well as small infestations can usually be controlled quickly before becoming problematic. Additionally, control costs can be kept to the minimum and limited weed funding stretched further.

Recommendations

The waterweeds program provides a valuable assessment of weed problems at King County lakes. Through the pilot project, training materials have been developed and tested at fifteen lakes. As staff funding allows, these materials can be used to continue the support of the waterweeds survey program in King County lakes.

In 2000, the waterweeds program should support the removal of noxious weeds identified at participating lakes with particular emphasis on *Lythrum salicaria* removal. At lakes Beaver, Paradise, Pine, and Spring, *L. salicaria* can likely be eradicated with moderate effort while at Lake Desire more extensive efforts are needed to ensure control and eventual eradication occurs. To accomplish *L. salicaria* removal, the WLR Lake Stewardship Program should partner with King County Noxious Weed Board (KCNWB) to ensure that volunteers and their lake communities are supported in their weed removal efforts.

In the future, the weed identification cards should be expanded to include other aquatic or emergent species of concerns including *Lysimachia vulgaris* and *Ludwigia hexapetala.* Over time, the weed cards can be updated and other new species added as appropriate.

Finally, volunteers and their lake neighbors should develop or enhance existing native shoreline buffers. These buffers will discourage *L. salicaria* and *Phalaris arundinacea* from becoming established or returning once removed from affected shoreline areas.

References

King County, 1996. Aquatic Plant Mapping for 36 King County Lakes. Department of Public Works, Surface Water Management Division.

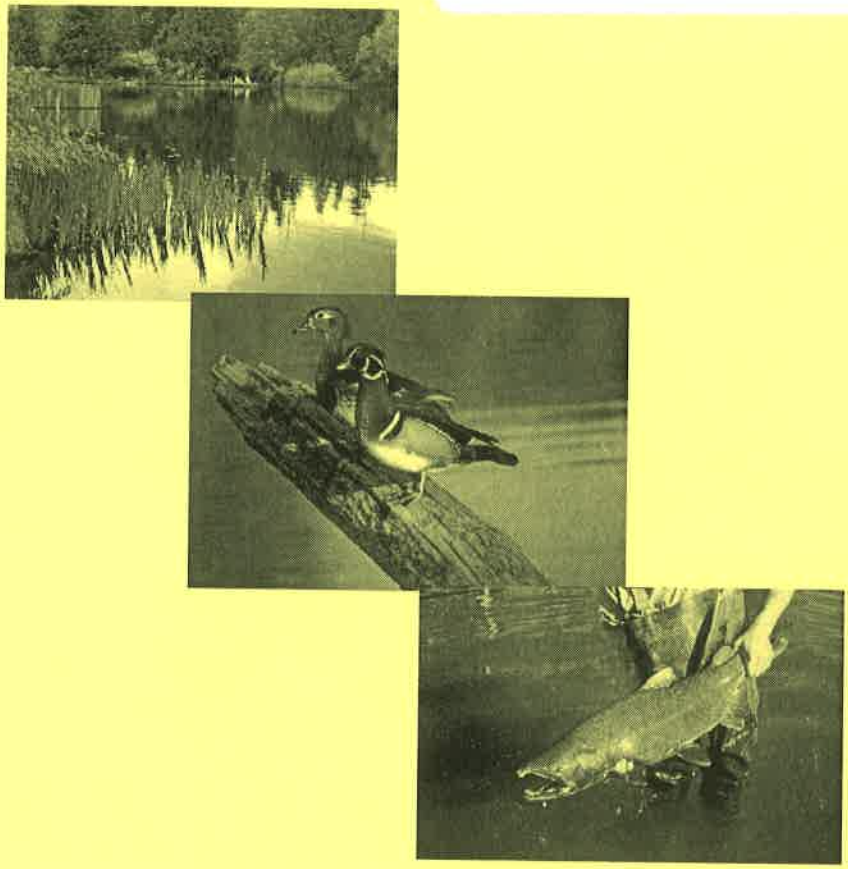
King County, 1999. 1999 King County Noxious Weed List. Department of Natural Resources, Water and Lake Resource Division.

Washington State Department of Agriculture, 1999. 1999 Washington State Noxious Weed List. Department of Natural Resources, Water and Lake Resource Division.

King County Lake Monitoring Report

A Lake Stewardship Program

Volunteer Lake Monitoring Results for the Water Year 2001



December 2002

King County

King County Lake Monitoring Report

Volunteer Lake Monitoring Results for Water Year 2000–2001

December 2002

King County

Department of
Natural Resources and Parks
Water and Land Resources Division
Lake Stewardship Program
King Street Center
201 South Jackson, Suite 600
Seattle, WA 98104
(206) 296-6519 TTY Relay: 711
www.metrokc.gov/dnr

Text will be made available in large print, Braille, or audiotape as requested.
TTY Relay: 711
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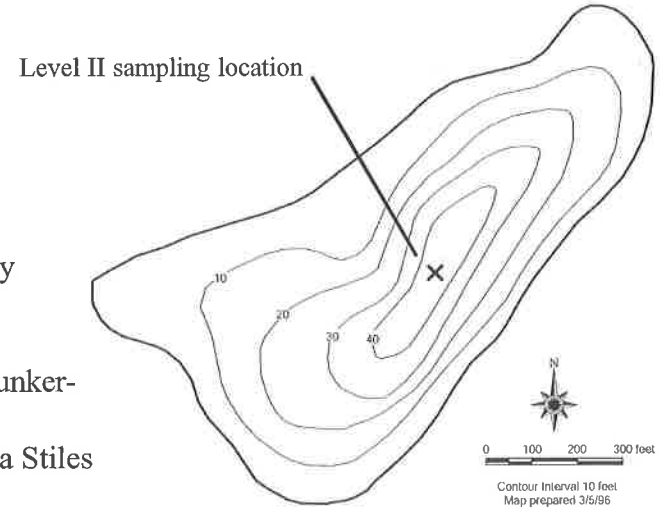
Overview

Volunteer monitoring began at Lake Geneva in the 1980s and continued through 2001, with a four-year hiatus in the early 1990s. The data collected suggest that this lake is moderate to low in primary productivity (threshold oligotrophic) with good to excellent water quality. Since the lake surface makes up nearly 13% of the drainage area, direct precipitation is important, in addition to stormwater runoff and groundwater inputs. There are no significant wetlands in the basin. Current land use appears to be mostly as rural residential/small farms, but is becoming more suburban in character. Increased algal productivity through human impacts is likely to occur, and good management practices are encouraged to avoid creating future problems.

Lake Geneva has a public access boat ramp, and residents have funded efforts to control water lilies in the past. A close eye should be kept on aquatic plants growing nearshore to catch early infestations of Eurasian milfoil or other noxious weeds.

Lake Characteristics

Surface area:	29 acres
Watershed area:	224 acres
Max depth:	46 ft
Mean depth:	19 ft
Location:	0.2 mi east of Federal Way

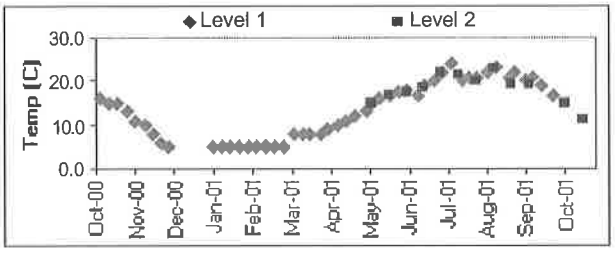


Volunteers

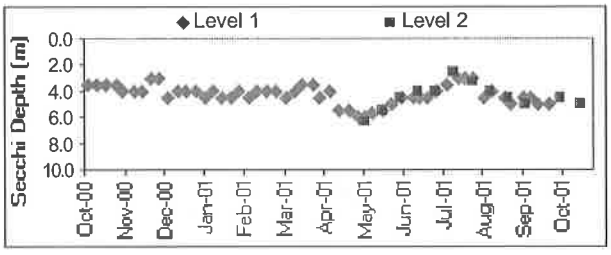
Level I :	Thomas Jones and Sue Yunker-Jones
Level II:	Bruce Harpham and Laura Stiles

Level II samples collected: 12/13

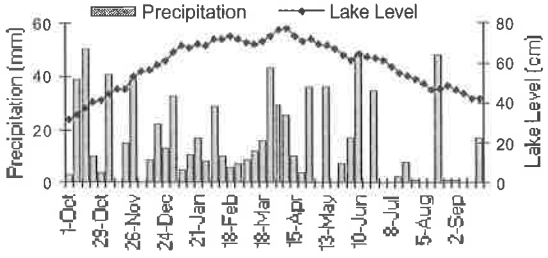
Lake Temperature



Secchi Depth

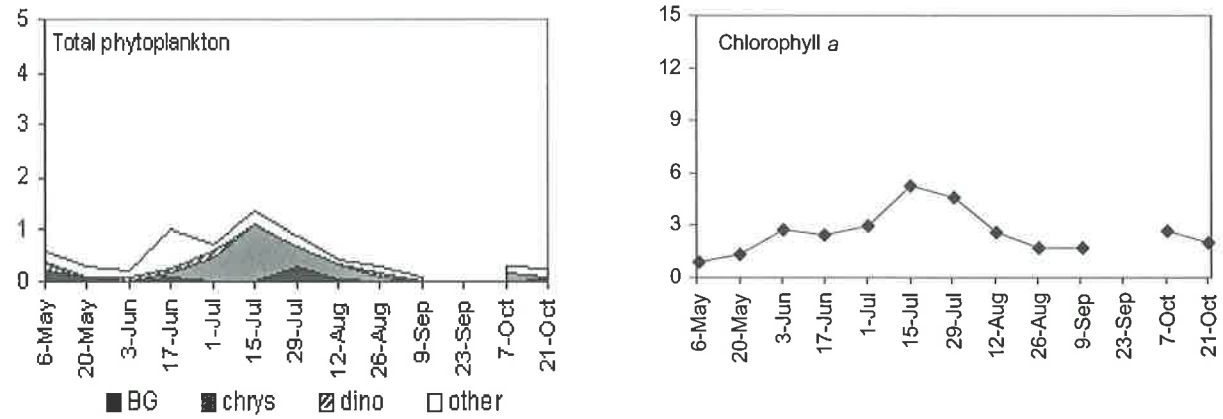


Lake Level and Precipitation



Secchi transparency ranged between 2.5 and 6.3m through the year. Water levels were consistent with the general pattern of an autumn low stand. Annual water temperatures ranged between 5 and 24 degrees Celsius, with a dip in the summer in response to cool July air temperatures.

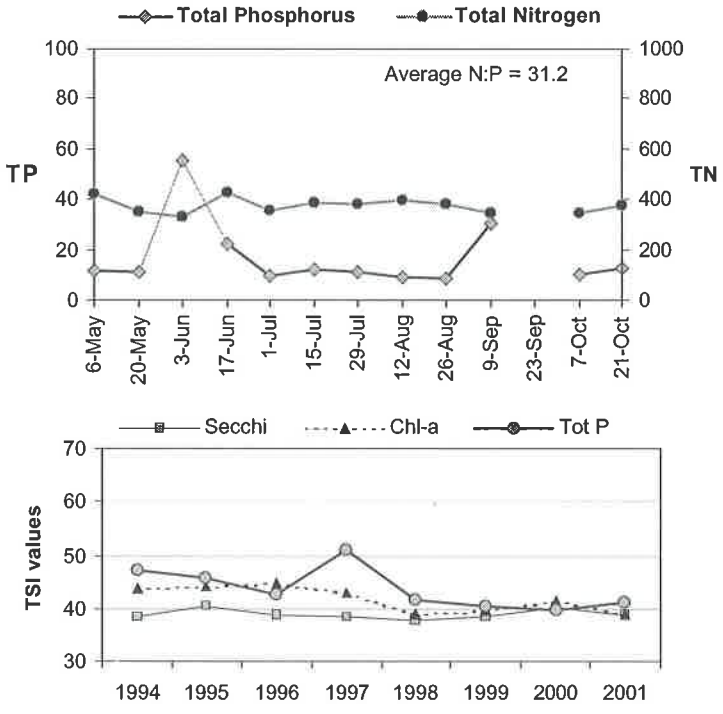
Phytoplankton (mm 3/L) and Chlorophyll *a* Concentrations (µg/L)



Phytoplankton populations were low through the sampling season, with two peaks. The first peak was in June, made by the chlorophyte *Botryococcus,* the second was made by the Chrysophyte *Gloeobotrys*. The bluegreens *Anabaena* and *Aphanizomenon* made smaller populations, as well as the chrysophytes *Dinobryon* and *Synura*. Chlorophyll content tracked the pattern of the phytoplankton populations reasonably well through the season.

Phytoplankton Chart:
BG = Bluegreen; **chrys** = Chrysophytes; **dino** = Dinoflagellates

Nutrient Analysis and TSI Ratings



Total phosphorus and total nitrogen remained in fairly constant proportion to each other through the sampling period, aside from two dates with exceptionally high Total P (see chart). Excluding those dates, the N:P ratio ranged from 19 to 45. In 2001, the three TSI indicators were very close to each other, on the threshold between oligotrophy and mesotrophy, similar to the last three years of the record.

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AquaTechnex

"Advancing the Science of Lake Management"

Regional Eurasian Milfoil Control Plan for King County

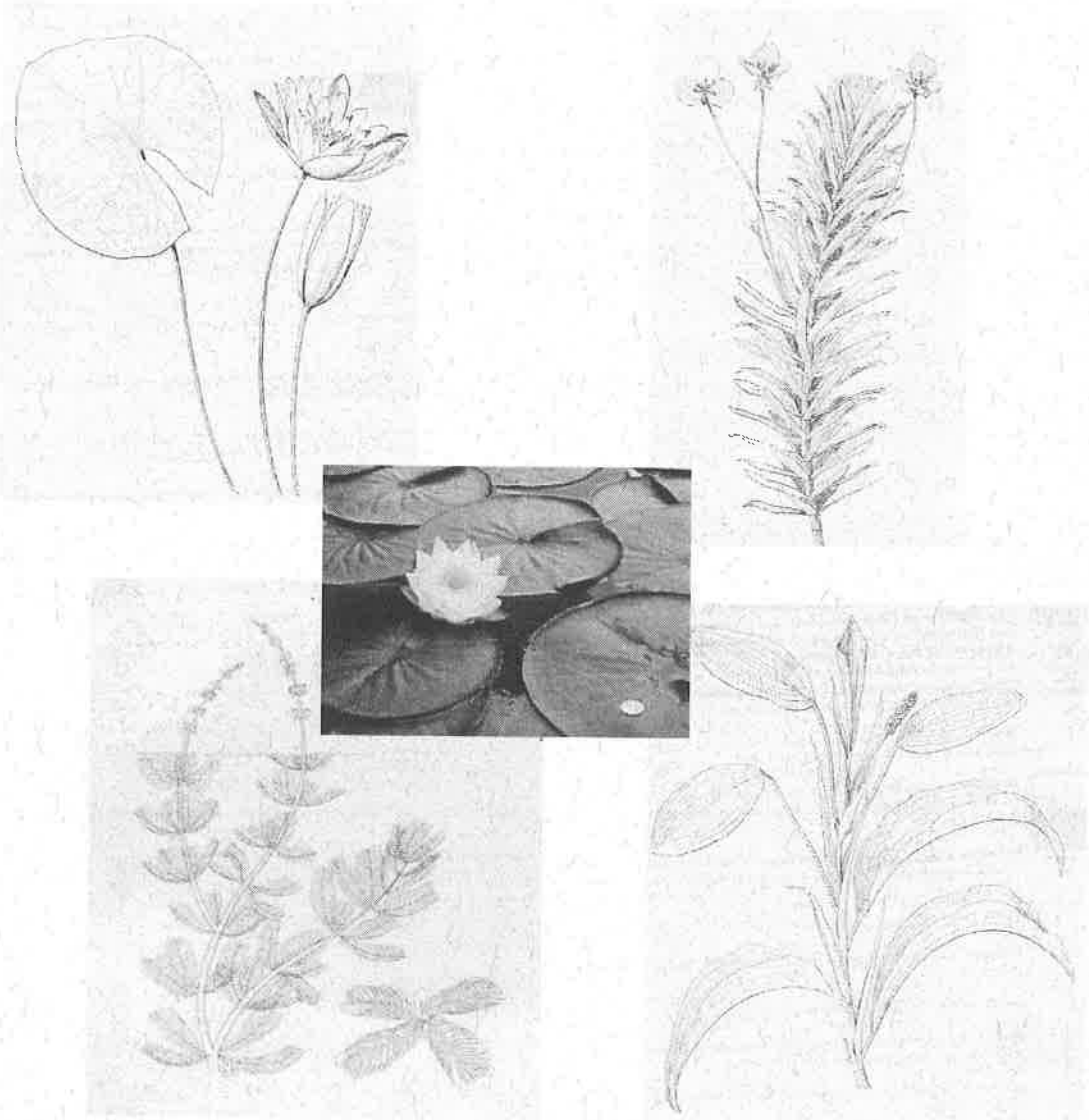
prepared for:

King County WRLD

prepared by:

Envirovision Corporation and Aquatechnex, LLC

Regional Eurasian Milfoil Control Plan for King County



Prepared By:
Envirovision Corporation
and
AquaTechnex, LLC

Prepared For:
King County WRLD

December 2002

INTRODUCTION

King County is located in Western Washington along the eastern shores of the Puget Sound. A diverse mix of large urban areas, suburban cities, rural areas, farmland, timberland, and alpine wilderness exists within the County. Elevation changes from sea level to nearly 8,000 foot peaks in the Cascade Mountains along the eastern border of the County. The landscape was largely shaped during the last glacial period in North America when glaciers carved the landscape creating many lakes. Most of the lakes are within or in close proximity to urban areas and are under pressure from urbanization. They are also an important recreational and ecological resource to residents of the region. Since the early 1980s, the value of these lakes for use by people, fish, and wildlife has been greatly impacted by the introduction of invasive (noxious) plants, especially Eurasian milfoil (*Myriophyllum spicatum).*

The US Congress Office of Technology Assessment has recognized Eurasian milfoil as a "harmful non-indigenous species." Eurasian milfoil is also on the State of Washington's Noxious Weed List. This list includes those plants that are exotic, invasive, and are known to cause detrimental impacts to the state's resources including the environment. The dense weed beds formed by the plant can be a menace to swimmers and can greatly impede boaters. Extensive Eurasian milfoil beds have also been shown to degrade water quality and aquatic habitat. Dense plant beds absorb sunlight resulting in water temperatures that are elevated, often beyond levels that are safe for trout and salmon species. Dissolved oxygen levels can also be severely depressed under these mats (Frodge et al., 1991). Dense aquatic beds can also affect predator/prey relationships among fish. For example, dense milfoil beds may concentrate young salmon at the outside edges of the plant bed where they are more susceptible to predation. Finally, aquatic plant, invertebrate, and fish species diversity also declines when a monoculture of an exotic like Eurasian milfoil replaces more beneficial native aquatic plants (Madsen et al., 1988).

Eurasian milfoil spreads by fragmentation. Viable fragments break off from the plant and then float to other parts of the lake where they can sink to the bottom and start new plants. Eurasian milfoil often spreads to other waterbodies when plant fragments "hitchhike" on birds, boats, and trailers. Boat trailers are considered the principal carrier of this weed.

PURPOSE AND NEED

Statewide concern over the impacts of Eurasian milfoil and other invasive, non-native plants, resulted in the establishment of the Aquatic Weeds Program at the Washington State Department of Ecology (Ecology). This program is funded through a tax on boat trailers. The money generated is used to fund both planning and implementation efforts for the control of aquatic plants. However, when a noxious weed is widespread within a waterbody an Integrated Aquatic Vegetation Management Plan (IAVMP) must be submitted and approved by Ecology before an application can be submitted for implementation. Because plan development can be expensive, Ecology also offers grant funding up to $40,000 total project cost to develop integrated plans. The requirements for submittal of an IAVMP are very specific, they include; a problem statement, list of management goals, public involvement, a description and discussion of lake and watershed characteristics, a discussion of beneficial uses, an aquatic plant survey, a discussion and site-specific evaluation of control techniques, and finally an action plan. A long term program for prevention of future aquatic plant problems, cost estimates and a plan for implementing and funding the work set out by the IAVMP are also necessary components for insuring project success.

Since the Aquatic Weeds Program was established, several lakes in King County have produced and implemented plans for control of aquatic plants. One of the problems with the existing lake-by-lake control efforts is that the investment which local groups make in eradicating this weed from their lakes is often threatened by remaining infestations in nearby lakes since the primary mode of spread is by boat trailers. As contaminated lakes are in close proximity to reclaimed lakes, it normally does not take long before a reintroduction occurs.

In 1999, King County recognized the benefits of developing a regional plan that would provide a more efficient and focused approach for combating the spread of Eurasian milfoil. King County applied for and received a grant to develop this "Regional Eurasian milfoil Control Plan". This document will allow King County to focus their efforts in controlling Eurasian milfoil. It provides basic lake and watershed information, milfoil survey results from 38 King County lakes, and examples of plant control goals for different levels of infestation. It also describes available control strategies that are approved to meet selected goals. This plan can be used to meet a number of the planning elements required for completion of an IAVMP.

Using the information provided on specific lake characteristics and the existing level of infestation by Eurasian milfoil, a problem statement, management goals and applicable control strategies can be selected. Refinement of the Problem Statement and Goals and selection of the preferred Control Strategy through a documented Public Involvement process will need to be done on a lake specific basis before implementation of a plan can begin. These steps will also allow specific lakes or groups of lakes to qualify for implementation grants from Ecology.

SURVEY METHODS

Aquatechnex, a consulting firm that specializes in aquatic plant control, conducted the lake surveys. The first step was to develop a list of lakes to survey for this project. A meeting was held with King County staff to select the lakes and discuss the scope of the surveys. The County presented a list of lakes that had public access sites; a subset of these lakes were selected for survey based on available budget and priorities. The budget for field work was capped at approximately $10,000.00 with a cost per field crew day of approximately $800.00. The County then developed a prioritized list. Although budget limitations were exceeded, the field crew continued until all 38 of the lakes on the priority list were surveyed. A boat survey method was selected as the most efficient means of conducting the surveys.

The first step in the process was to obtain copies of bathymetric maps for each of the survey lakes. Most of these were available in the Washington Lakes Reconnaissance Data report (Bortelson et al. 1976). Lake Washington and Lake Sammamish are not included in this volume, bathymetry for these two lakes was obtained from Garmen's (Global Positioning System) GPS mapping software. The bathymetry for each lake was reviewed to determine a probable littoral zone. Since Eurasian Milfoil will grow within the littoral region of each lake, the bathymetry maps helped focus the survey effort for each lake. Aerial images were also obtained. The King County GIS Department provided high resolution aerial imagery in digital format for use on this project. An image of each lake was printed and placed in a survey folder with the corresponding bathymetric map for the lake.

Each of the lakes to be surveyed were highlighted on a map of the County for logistical planning purposes. The size of the lakes and proximity to each other were used to estimate the time necessary to

complete each of these and a daily survey schedule was developed. At that point, the survey teams began field observations and data collection.

Each survey team was equipped with polarized viewing glasses, an underwater viewing tube, snorkel and dive equipment and a differential GPS receiver and data logger. Different sized boats were used depending on the size of the lake, the type of access and the need for electric motors. (King County granted permission to use gas powered vessels on lakes with regulations prohibiting them. Our team utilized electric vessels wherever practical to limit impacts to lake residents).

Prior to each survey effort, the team would develop protocols for the lake or lakes that were scheduled for survey. The bathymetric map was used to define the littoral area that could support Eurasian Milfoil growth and survey coverage was developed based on the amount of area that had to be covered. Some lakes drop off rapidly from the shoreline to deep water habitats. In those cases the littoral area requiring survey would be predicatively narrow. Other lakes might have littoral areas that extend to some distance off shore and additional coverage would be necessary.

On arriving at each lake, surveyors assessed water clarity and the actual extent of the littoral zone. Water clarity plays a role in the depth of the littoral zone and on the ability of the survey team to see aquatic vegetation. This information was utilized to check the assumptions made regarding the littoral zone and to refine the survey as necessary.

The boat team then surveyed all areas of the lake that might support Eurasian Milfoil populations. A Garmin DGPS with topographic maps display was used to plot the location of the vessel and ensure coverage by monitoring the path of the survey craft. When Eurasian Milfoil was discovered, the team would determine the extent of each patch. Single plants were marked as a point with the DGPS equipment. Larger plant communities were mapped as polygons, mapping the outside edge of the plant bed. Field notes and sketch maps were also created by the team to support the GPS data.

At the end of each day, the GPS data was downloaded into mapping software. When work on an individual lake was partially completed, an endpoint was recorded on the paper maps and a waypoint was collected with the Garmin GPS unit to serve as a starting point for the next visit to that location.

Data collected were used to develop maps for each lake in ArcView GIS mapping software. These maps are provided in Appendix A.

LAKE SURVEY RESULTS .....

Thirty eight lakes in King County were surveyed for the presence of Eurasian milfoil. These 38 water bodies were chosen in a collaborative process with King County staff. They included the major water bodies in the County, and include most of the lakes with a boat ramp or public access site. For other lakes, contact staff at Ecology's Aquatic Weeds Program to request a survey or accurate identification of plants found by citizens. Since lakes can be invaded at any time by milfoil, some of the information in this report may already be out of date.

Survey maps are presented in Appendix A along with information on general lake characteristics, some history of aquatic plant control efforts, and the existing level of infestation at the time of the survey. More detailed information on the characteristics of each lake and its watershed will be required to develop a lake-specific IAVMP. A list of Resources and Contacts is included as Appendix D.

Four levels of infestation have been defined for the purpose of this plan: milfoil free, pioneering colonies present, moderately infested, and heavily infested. Each level of infestation is described below with a list of which of the 38 lakes fell within this category.

MILFOIL FREE

Milfoil free lakes are defined as those for which no milfoil was observed during surveys. These lakes have the potential to be impacted by future introductions due to their location and boat access. Monitoring and preventative activities are appropriate for these lakes. The following 23 lakes in King County are classified as milfoil free as of this inspection.

Lake Alice
Beaver Lake (Green R.)
Dolloff Lake
Lake Geneva
Langlois Lake
Marcel Lake
Pine Lake
Trout Lake
Angle Lake
Boren Lake
Fenwick Lake
Lake Jeane
Lorene Lake
Morton Lake
Pipe Lake
Walker Lake
Beaver Lake (Sammamish R.)
Cottage Lake
Fivemile Lake
Lake Killarney
Lucerne Lake
North Lake
Star Lake

Four of these lakes (Pipe, Killarney, Lucerne, and Star) had Eurasian watermilfoil infestations at one time and were treated with fluridone. Another lake (Dolloff) also had a small amount of milfoil at one time. There has been no reported or permitted treatment of this lake (K. Hamel, Pers. Comm.). Also, although Fenwich Lake does not have milfoil, it does have Brazilian waterweed, a different noxious plant.

PIONEERING COLONIES/EARLY INFESTATIONS

The presence of pioneering colonies of Eurasian milfoil indicate that the weed has very recently been introduced to the lake and is not yet distributed widely. It is critical to focus on pioneering infestations as soon as they are discovered. Eurasian milfoil will auto-fragment in the fall. These fragments disperse by both the wind and currents in the lake, rapidly spreading the infestation.

There are a number of ways to define a pioneering infestation. For funding purposes, Ecology generally defines an early infestation as three acres or less of the noxious weed in the lake. However, this is somewhat dependent upon history and lake size. If there is a question about whether or not a lake qualifies as an early infestation, contact Ecology's Aquatic Weeds Program staff to make this determination. The following 5 lakes in King County fell into this category:

Lake Neilson (Holm)
Shadow Lake
Shady Lake
Lake Wilderness
Steel Lake

Shady Lake was identified as having a high population of milfoil in a survey in 1994 (K. Hamel, Pers. Comm.) and there has been no reported treatment. Lake Wilderness previously had a heavy infestation but was chemically treated and milfoil free until recently. Steel Lake has been treated since this survey and may now be milfoil free.

MODERATE INFESTATION

Lakes with moderate infestations have Eurasian Milfoil colonies in 30 to 60 percent of the littoral zone. The following 3 lakes in King County are classified as moderately infested:

Phantom Lake
Lake Desire
Spring Lake

HEAVY INFESTATION

Lakes that are heavily infested with Eurasian milfoil have dense beds of this plant dominating the littoral zone. Eurasian milfoil generally fills the littoral zone in 5 or 6 years after introduction. The following lakes in King County are classified as heavily infested:

Bass Lake
Lake Meridian
Lake Sawyer
Lake Union
Lake Twelve
Lake Sammamish
Lake Washington

DEVELOPING AN IAVMP

The following sections of this plan provide guidance on developing an acceptable IAVMP for controlling milfoil in each of these King County lakes. The information on the existing level of infestation should be used to select from a list of appropriate management goals, and that goal will affect the selection of control strategies. Using the information provided in this report, a local agency or homeowners association should be able to develop an IAVMP appropriate to the level of infestation and recreational activities in a specific lake.

PROBLEM STATEMENT

Numerous King County lakes are infested with Eurasian milfoil, while others are threatened by infestation due to their proximity to infested lakes and boater access. The existing lake-by-lake efforts to control or eliminate this plant are inefficient and expensive. It is beneficial to the County and to lake users to have a regional plan for controlling existing plant populations and the spread of new infestations. The plan must acknowledge that the appropriate strategy for a given lake is dependent upon the level of infestation, specific lake characteristics, and community needs. Therefore, the plan must be flexible enough to allow implementation of a variety of control strategies across a wide variety of situations.

MILFOIL MANAGEMENT GOALS

The management of Eurasian milfoil within the County is the desired outcome of this planning effort. As such, it is critical for the user to understand the types of control that can be achieved, and the tools that are available to manage this invasive weed. There are four basic strategies or goals to consider: prevention, suppression, control and eradication. The decision about which of these is most appropriate for a given lake is dependent upon the lake characteristics and the existing level of infestation.

EXECUTIVE SUMMARY

Eurasian watermilfoil *(Myriophyllum spicatum)* is a submersed aquatic noxious weed that proliferates to form dense mats of vegetation in the littoral zone of lakes and reservoirs. It reproduces by fragmentation, and is often spread as fragments "hitchhike" on boat trailers from one lake to another. *M. spicatum* can degrade the ecological integrity of a water body in just a few growing seasons. Dense stands of milfoil crowd out native aquatic animals. *M. spicatum* can also reduce dissolved oxygen – first by inhibiting water mixing in areas where it grows, and then as oxygen is consumed by bacteria during decomposition of dead plant material. Decomposition of *M. spicatum* also adds nutrients to the water that could contribute to increased algal growth and related water quality problems. Further, dense mats of *M. spicatum* can increase the water temperature by absorbing sunlight, create mosquito breeding areas, and negatively affect recreational activities such as swimming, fishing, and boating.

Lake Geneva, in the middle Green River watershed in King County, Washington, is moderately infested with *M. spicatum*. Members of the Lake Geneva Homeowners' Association realized the potential gravity of the aquatic weed problem and initiated a partnership with staff from the King County Department of Natural Resources and Parks to apply for an Aquatic Weeds Management Fund grant through the Washington Department of Ecology (Ecology). If awarded, grant money will fund initial eradication efforts, including several years of follow-up survey and control. Since complete eradication is very difficult to achieve, and reintroduction is very likely, the community is organizing a management structure and the funding mechanisms necessary to implement ongoing monitoring and spot control.

Two other noxious weed species with expanding infestations at Lake Geneva threaten to degrade the ecological and recreational benefits of the system as well. Fragrant water lily *(Nymphaea odorata)* is rapidly expanding beyond a pioneering level of infestation, and yellow flag iris *(Iris pseudacorus)* is already established around the shoreline. Immediate control measures are also needed to protect the regionally significant resource areas of Lake Geneva and its Class 1 system from all three of these invasive aquatic noxious weeds.

This *Integrated Aquatic Vegetation Management Plan* (IAVMP) is a planning document developed to ensure that the applicant and the community have considered the best available information about the waterbody and the watershed prior to initiating control efforts. Members of the Lake Geneva Homeowners' Association and King County staff worked in partnership to develop this IAVMP for Lake Geneva. To tackle the difficult task of generating community concern and action for an environmental issue, a core group of residents formed a steering committee, which included two King County staff members. Through their work, the Steering Committee was able to educate the wider community about the problem, inspire them to contribute feedback about potential treatment options, and explore ongoing community-based funding mechanisms. The community ultimately agreed upon an integrated treatment strategy, which includes an initial chemical treatment with a systemic aquatic herbicide, followed by a combination of manual, mechanical, and cultural control methods to maintain the outcome afterwards. This plan presents lake and watershed characteristics, details of the aquatic weed problems at Lake Geneva, the process for gaining community involvement,

discussion of control alternatives, and recommendations for initial and ongoing control of noxious aquatic weeds threatening Lake Geneva.

PROBLEM STATEMENT

Lake Geneva is located between Auburn and Federal Way in unincorporated King County. Lake Geneva is within the Mill Creek sub-basin of the Green River watershed. There are several small lakes in this area with several city and county parks which provide diverse recreational opportunities for people of the region. These lakes are all popular boating, fishing, birding, and swimming destinations.

Due to prolific growth of several species of dense, invasive aquatic noxious weeds, Lake Geneva is in danger of losing its aesthetic beauty, its wildlife habitat, and its recreational attributes. If left untreated, the worst of these weeds, Eurasian water milfoil *(Myriophyllum spicatum)* will blanket the lake in a short time, preventing most recreational uses and eliminating badly needed wildlife habitat. There will be long-term financial and recreational loss and the loss of conservation areas, all affecting watershed residents and other members of the public who use the lake. Increasing development in the area is likely to increase the number of people using the lake in coming years, which accelerates the magnitude of the loss of beneficial uses to the community.

The shallow shoreline area provides an excellent habitat for aquatic plants. Recently, aggressive, non-native Eurasian water milfoil (milfoil) has invaded the lake and is colonizing the near-shore aquatic habitat. The dense submerged growth of milfoil has begun to cause deterioration in the quality of the lake and its value to the community. The boat launch area has dense patches of milfoil, which can spread to other lakes by fragments on boat trailers. The other nearby lakes are threatened with new introductions of milfoil if Lake Geneva is not controlled because of the high probability of transport by boat trailers to these nearby systems.

Milfoil is the most significant submerged invasive threat, but other noxious weeds also invaded Lake Geneva. These include fragrant water lily *(Nymphaea odorata)*, and yellow flag iris *(Iris pseudacorus)*. All of these species are considered noxious weeds as listed in WAC 16-750. None of the native aquatic plants in this system are a management issue at this time. The native plants provide important benefits to the aquatic system and are not impeding any of the recreational uses of the lake. Removing the noxious invaders will halt the degradation of the system and allow the dynamic natural equilibrium to be maintained.

Unfortunately, these invasive plants concentrate in the near-shore zone which is also that portion of the lake that is valued and utilized most by lake residents and visitors. Dense weed growth poses a threat to swimmers, and the portion of the lake where people can fish is shrinking. Both milfoil and fragrant water lilies foul fishing gear, motors, and oars. It is no longer possible to troll through large portions of the lake.

As a group, these invasive plants:

- Pose a safety hazard to swimmers and boaters by entanglement

- Snag fishing lines and hooks, eventually preventing shoreline fishing
- Crowd out native plants, creating monocultures lacking in biodiversity
- Significantly reduce fish and wildlife habitat, thereby weakening the local ecosystem as well as degrading wildlife and wildlife viewing opportunities
- Pose a threat to adjoining ecosystems

MANAGEMENT GOALS

The overarching management goal is to control noxious aquatic weeds in Lake Geneva in a manner that allows sustainable native plant and animal communities to thrive, maintains acceptable water quality conditions, and facilitates recreational enjoyment of the lake.

There are four main strategies to ensure success in meeting this goal:

1. Involve the community in each phase of management process;
2. Use the best available science to identify and understand likely effects of management actions on aquatic and terrestrial ecosystems prior to implementation;
3. Review the effectiveness of management actions;
4. Adjust the management strategy as necessary to achieve the overall goal.

Specific details related to the implementation of management objectives are covered in subsequent sections of this plan.

Lake Geneva Aquatic Weed Control

Presented by King County for the LPGOA

July 14, 2005

The problem:

The lake is infested with two noxious aquatic weeds: fragrant water lily and Eurasian milfoil. Both plants are ecologically detrimental, and create a nuisance (and possibly a safety hazard) for residents and recreational users.

The lake has widespread lily growth with dense areas by the outlet and boat ramp. Lilies were sprayed with herbicide (glyphosate) last year using community funds, but have returned this year, which is to be expected (unfortunately).

As of 2004 the milfoil infestation was moderate. Sufficient funds were not available to treat milfoil with herbicide in 2004, so the infestation has undoubtedly expanded since last year.

The Solution:

The Lake Geneva Property Owners' Association (LGPOA) was awarded a $17,000 grant from King County to control aquatic weeds. The grant was intended to fund community education about aquatic weeds and other lake issues and an initial herbicide treatment to control weeds.

Permitting Issues

- Applying herbicide to aquatic plants requires a National Pollution Discharge Elimination System (NPDES) permit, a federal permit issued through the WA State Dept. of Agriculture.
- In 2005, only government agencies can obtain NPDES permits. The agency can do the work or sponsor an applicator to apply herbicide.
- If King County obtains a permit and sponsors an applicator, King County needs to manage the contract with the applicator. Managing the contract implies that contractor would invoice King County and King County would then pay the contractor.
- Normally, grant money awarded to a community group cannot be used to pay King County or its debts (i.e. to the contractor) even if those debts were incurred by King County operating as a middle-man for the community.
- King County management has given permission to the Lake Stewardship Program to procure a contract (and permit) and to use money earmarked for the LGPOA grant to pay the contractor directly for the herbicide application and associated work.
- The King County contract procurement process takes a minimum of 4-weeks.
- Whether or not herbicides are used, a King County Clearing and Grading permit from the Department of Development and Environmental Services *may* be necessary (processing time 2-3 weeks minimum). Necessity of the permit will be determined by July 21, 2005.

King County contact:

Michael Murphy
King County DNRP, Lake Stewardship Program
Phone: 206-296-8008
Email: michael.murphy@metrokc.gov

Fragrant water lily control options: 1-2 years of herbicide treatment, followed by 2-3 years of manual control.

Option	Cost	Pros	Cons
Herbicide treatment	$1250	• Effective • Immediate results (2-3 weeks) • Effective at any time lily pads are green (late August OK)	• $$ for herbicide (but grant will pay)
Mechanical control	??	• No herbicides into lake	• Impractical given size of infestation • Need to dispose of material
Wait to treat until 2006	$0	• No $$ or effort required	• Detrimental to ecology, aesthetics, and recreation

Eurasian milfoil control options:

A single, well-timed herbicide treatment could control milfoil enough to allow returning weeds to be pulled by hand. Initial removal by hand (w/ diver vacuuming) will not eradicate, but will clear lake and prevent further spread.

Option	Cost	Pros	Cons
Herbicide treatment, including pre-treatment survey and post-treatment monitoring	$12,000	• Effective • Immediate results (2-3 weeks) • More likely to eradicate than other methods	• Permitting and contract process will delay treatment to less effective date • Expensive (but grant will pay)
Diver-vacuum dredging	$1000/day (Est. 4-6 days)	• No herbicides into lake • NPDES permits unnecessary • Prevents further spread • Returns "beneficial uses"	• Is not an eradication technique; plants will return • May require annual removal efforts to maintain control
Wait to treat until 2006	$0	• No $$ or effort required	• Detrimental to ecology, aesthetics, and recreation • Availability of grant $$ uncertain

APPENDIX C

Educational Materials

Lakeside Landscaping and Water Quality

natural Lawn care

For Western Washington

18228

Hey, Neighbor!

Maybe you're asking, what's a salmon doing on the lawn? I'm here to say that your lawn and my stream are connected. If you use too much water or too many chemicals, it may hurt me and my fish friends. So try a "natural" approach to lawn care. You can have a healthy, good-looking lawn – and be a good neighbor, too!

Going natural:

healthy lawns that are easy on the environment

Going natural may mean you need to accept a lighter green color, a few weeds, and mowing a little higher than you're used to. But you'll have a healthy, good-looking lawn that's easier on the environment. And that's a good deal for fish and everybody.

Why make a change?

Your lawn can be a great place to hang out, but depending on how you care for it, your lawn can also be part of big environmental problems.

Lawn and garden watering make up more than 40% of our summer water use. That's when supplies are lowest and when salmon, wildlife and people need it most. It's also when rates are highest.

Much of this water is wasted through overwatering–a practice which invites lawn disease. So water wisely–and help out your lawn, your wallet and the fish.

Scientists testing our urban streams found 23 pesticides used by homeowners. Rainwater can wash bug and weed killers from our lawns into streams or lakes. Scientists are worried about the effects of these chemicals on birds and fish. Rain can also wash fertilizers from lawns into local waters. The fertilizers feed algae that choke out fish and other water dwellers.

Pesticides may not be so great for you and your kids either. In a science journal review of 98 health studies related to the use of weed and bug killers, half the studies found an increased cancer risk. And safe disposal of pesticides costs you, the ratepayer, big bucks.

Grass clippings are overloading our compost facilities, when they could supply at least 1/4 of your lawn's fertilizer needs. It's called "grasscycling" – just leave the clippings on the lawn. This saves you time and money and helps prevent the growing problem of overloaded compost facilities. And if you use less fertilizer, there's less chance of it washing off into our streams.

Natural lawn care works! Fortunately, the natural lawn care practices outlined in this booklet make it easy to reduce the use of hazardous products while saving time, water, money and helping to preserve our Northwest environment.

Six Steps to Natural Lawn Care

Healthy lawns grow on healthy soil. Using proper soil preparation and lawn maintenance practices will help to build healthy soil and vigorous, deep-rooted lawns. These lawns are more resistant to disease, tolerate some insect and drought damage, and will out-compete many weeds. The practices recommended here can help make lawns healthier for our families, protect beneficial soil organisms, and protect our environment too.

Mulching mowers

For clean mowing that leaves no visible clippings, consider buying a "mulching" mower. This mower will chop clippings finely and blow them down into the lawn so they disappear and won't be tracked into your house. Check the spring issues of Consumer Reports for current ratings of mulching mowers. The rechargeable electric mulching mowers are quiet, clean, and grasscycle very well.

1 Mow high, mow often, and leave the clippings.

Set mowing heights up to about 2 inches for most lawns (1 inch on bentgrass lawns) to develop deeper roots and crowd out weeds.

Remove only one-third of the grass length at each mowing. Try to mow weekly in spring. Cutting too much at once stresses the grass.

Leave the clippings on the lawn. "Grasscycling" provides free fertilizer (at least 1/4 of your lawn's needs), helps lawns grow greener and denser, and doesn't cause thatch buildup.

You can grasscycle with your existing mower. For best results, keep the blade sharp, mow when the grass is dry, and mow a little more often in the spring. Clippings left scattered on the surface will break down quickly. If there are clumps, mow again to break them up. Push mowers work great for grasscycling.

Fertilizer: How much is enough?

WSU recommends that home lawns receive 3 to 4 pounds of nitrogen (in a balanced fertilizer) per 1,000 square feet of lawn each year. Grasscycling can supply at least one-quarter of that. Split the rest between May and September applications. Avoid fertilizing in the early spring because it makes lawns grow too fast (unless your lawn needs help recovering from disease or insect damage). Wait until May.

2 Fertilize moderately in May and September with a "natural organic" or "slow-release" fertilizer.

These fertilizers release nutrients to feed the lawn slowly, and less is wasted through leaching or runoff into our streams. "Quick-release" fertilizers are 100 percent water soluble and wash into streams easily. Instead, look for the words "natural organic" or "slow-release" on the bag.

Healthy lawns are a medium green color, depending on the variety of grass. The darkest green turf, which many people strive for, is not in fact the healthiest turf. Overfertilized lawns are more prone to disease, thatch buildup, and drought damage.

With slow-release or organic fertilizers, you can fertilize just twice a year, in mid- to late May and again in early September. If you choose to fertilize only once, the fall application is most important.

Soils west of the Cascades are often low in calcium. Apply lime in the spring or fall if a soil test shows a calcium deficiency or acid soil conditions (pH less than 5). Call WSU/King County Cooperative Extension (206-205-3100) for information on soil testing and their Home Lawns bulletin.

Remember, grasscycling returns valuable nutrients to the soil every time you mow!

3 Water deeply, to moisten the root zone, but infrequently.

Grasses do better when the whole root zone is wetted and then partially dries out between waterings. Avoid frequent shallow watering; that causes shallow rooting. Overwatering can promote lawn disease, leach nutrients from the soil, and waste water.

Aerate the lawn if water won't penetrate because of soil compaction or thatch buildup. Dethatching will also help if there is heavy thatch buildup.

Water about one inch per week during July and August. Use less in late spring or early fall–let the weather be your guide. Water slowly, or start and stop, so the water penetrates rather than puddling or running off. Sandy soils will need lighter, more frequent watering because they can't hold much water. Water early or late, not in the heat of the day.

Newly planted lawns may need daily watering if planted in the late spring or summer. Replant in September to avoid that chore, but be ready to water if it stops raining.

Consider letting the lawn go brown and dormant in the summer. Watering deeply but slowly, so it penetrates, once each rainless month will help support dormant lawns so they recover better in the fall. (Perennial ryegrass lawns on sandy soil will not survive if allowed to dry out completely.) Avoid heavy traffic on dormant lawns, or regularly water the play/high use areas to prevent damage. When rain returns in the fall, overseed any thin areas to thicken the lawn and help crowd out weeds.

Weather-wise watering

Watch the weather (don't water if it's going to rain). Signs of a lawn that needs more water include a duller color, and the "footprint test": grass blades stay bent in your footprint rather than popping back up. Or call your water utility for information on how to use evapotranspiration (ET) rates to match your irrigation to current weather conditions.

Poor soil: What to do?

If your soil is very poor and compacted, it may be best to improve the soil and replant.

- **Till up old lawn. If very weedy, remove the sod with a rented sod stripper, or you might spray glyphosate (Roundup) once to kill weeds.**
- **Get a soil test to find out what's missing and spread the amendments (like lime) suggested in the test results.**
- **Spread two inches of Grade A compost and till it in to a depth of 6-8 inches. Sandy or gravelly soils may need other amendments too—consult a certified landscaper or your local Cooperative Extension for help with these soils.**
- **Rake the soil level, roll with a landscape roller, water to settle for a day, and rake again.**
- **Seed with an appropriate grass mix, and water daily if the weather is hot and dry until the lawn is well established.**

Call Cooperative Extension for more information, or consider hiring a qualified professional for this big job.

4 Improve poor lawns with aeration, overseeding, and top dressing with compost. Or fix the soil and replant.

Aerate compacted soil in the spring or fall to improve root development. Use a rented power aerator for best results, or hire a professional. The soil should be moist, and making two or more passes gives better results. Rake or mow to break up the cores. The soil left will help to decompose excess thatch layers in the lawn. If your soil is deeply compacted (more than 2 inches—dig a hole to find out) find a landscape professional who has equipment that penetrates 6 to 8 inches to aerate for you.

Overseed, after raking or aerating to expose soil, with a perennial rye/fine fescue mix designed for Pacific Northwest conditions. Talk to a knowledgeable nursery-person or call Cooperative Extension for seed recommendations. A light application of "starter" fertilizer can help the seeds grow quickly and crowd out weeds. A 1/2-inch thatch layer can be beneficial, but much more than that can keep water, air, and fertilizer from reaching the roots. Rent a power dethatcher and make several passes, then overseed to thicken the lawn and crowd out weeds.

Then top dress with compost. Spread a 1/4-inch layer of compost, by scattering it with a shovel and then raking it in to fill aeration holes, cover the seed, and improve the soil.

April/May or September are the best times to aerate, overseed, and top dress, or to amend the soil and replant.

5 Think twice before using "weed and feed" or other pesticides.

These products may damage soil and lawn health and pollute our waterways. Some studies also suggest that use of pesticides may harm our health.

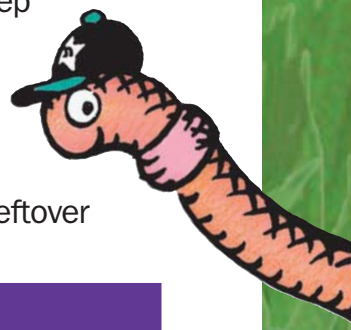
Crowd out weeds and reduce pest damage by promoting a healthy, vigorous lawn through proper fertilization, irrigation, and mowing. Improve thin areas with aeration and overseeding. A healthy turf will need far fewer pesticides.

Accept a few "weeds" in your lawn. Some, like clover, may look fine. Target the problem weeds, leave the others.

Remove problem weeds by hand in the spring and fall. Don't cover your entire lawn with weed and feed just to kill a few dandelions. Pincer-type long handled weed pullers are available at many garden stores. They work well in moist soil, with no stooping. Pull dandelions when they're young (for best results get as much root as possible).

Or spot-spray problem weeds with the proper herbicide at the right time of year. Identify the weed to make sure you are using the correct product.

Read the label carefully before using any pesticide (including weed and feed). Be sure to follow all label warnings, wear proper protective clothing, and keep children and pets off the lawn for at least as long as the label specifies. Call the Hazards Line at 206-296-4692 for information on safe disposal of leftover



What about crane flies?

European crane flies can be a problem on wet lawns. Crane fly larvae feed on grass roots and crowns in fall, warm winters, and early spring. Many larvae are eaten by birds in fall and winter. This can bring populations below damaging levels.

<u>You cannot control crane flies by applying pesticides in the late spring or summer.</u> The insecticides often used for control are toxic to birds and aquatic life. Count larval populations in the early spring before choosing any control method. For a free brochure on crane fly control, call 206-633-0224 or email: info@lawnandgardenhotline.org. A healthy lawn can tolerate some crane fly damage. Overseed and fertilize in May to help fill in any damaged areas.

6 Consider alternatives to lawns for steep slopes, shady areas, or near streams and lakes.

Leave a buffer of natural vegetation along streams and lakes to filter pollutants and protect fish and wildlife. These buffers should include shrubs and trees to shade the stream, and groundcovers of native plants or low-maintenance grasses that are left unmowed and wild. Avoid use of pesticides or soluble fertilizers near streams, ditches, wetlands, or shorelines.

Grass grows best on well-drained soil in full sun or partial shade. Steep slopes are hard to mow and water. Call WSU/King County Cooperative Extension (206-205-3100) for information on alternative plants or grasses that do well in shady, steep, or wet sites. Ask for Fact Sheet #77, "Groundcovers."

For more information, call 206-633-0224 or email: info@lawnandgardenhotline.org

To find out more about less-toxic ways to manage pests, visit www.govlink.org/hazwaste/house

To find out more about grasscycling, composting, water conservation and natural lawn care visit www.seattle.gov/util/services/yard

This guide was developed and produced by **Seattle Public Utilities, King County Water and Land Resources Division, and the Local Hazardous Waste Management Program in King County,** based on information from the scientific and professional literature, and discussions with scientists and turf professionals around the Northwest.

There is a wide range of scientific evidence, and some disagreement, about the possible effects of turf chemicals on the soil, people, pets, and the environment. The recommendations here represent the sponsoring agencies' best advice, based on the available information. We encourage you to learn more. Please contact your local landscape professional, Washington State University Cooperative Extension, or call us about our research sources.

18228

When it comes to your lawn, act naturally.

A message from local cities, counties and water utilities promoting a healthy environment

This brochure was printed on paper made from 100% recycled post-consumer waste, processed chlorine-free, certified by the Forest Stewardship Council (FSC) and manufactured with Green-e® certified wind power. Rev. 2007

King County

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Water and Land Resources Division
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Seattle, WA 98104
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dnr.metrokc.gov/wlr

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Printed on recycled paper.

A guide to creating your own native plant landscape

Going Native

King County

Department of
Natural Resources and Parks
Water and Land Resources Division

18228

Contents

Why go native?

It's up to all of us to keep our waterways clean and healthy. Native plants bring benefits to Northwest land and water resources, wildlife and people—and you can have them in your own yard!

Well–established native plants control erosion by holding the soil with their roots. They reduce flooding by slowing runoff. Trees, shrubs and groundcovers clean water by filtering out sediment and pollutants before they reach lakes and streams. Northwest fish and wildlife depend on native plants for food, shelter, and cover. Once established, native plants in the right place require little maintenance.

A naturally–cared for native landscape is healthy for kids, pets and our environment. Your yard makes a difference! This brochure, plus a little time, money and sweat, is all you need to build a great looking native plant landscape. Footnotes refer to Web sites and other resources found on the last page.

1. Make a plan

Scan the land. Assess your site conditions to determine what plants will thrive in your spot. Remember that planning is easier (and cheaper) than replanting. Consider light, moisture and soil conditions. Is the site sunny, shady or some of both? How often is the area wet? Test your soils by sticking a shovel in the ground. Is it rocky? Sandy? Mostly clay? Need dynamite?

Think about the other features of your site, too. Note power lines, existing trees, view corridors, and height restrictions. Leave space for decks, additions or water features you may want to add in years to come.

If you want to plant beside a stream or wetland, check with your local jurisdiction about possible permit requirements. If you are using only native plants and hand tools, permits may not be required.

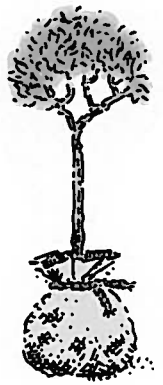
Where to plant? Put your native plant landscape in the less–traveled areas of your property to attract more wildlife. Keep your vegetable garden, perennial beds, and lawn close to the house (and hose) so they get the attention they need with fewer hassles.

2. Prepare the site

Take some lawn out. Consider replacing your lawn with natives where grass grows poorly or is losing the battle with moss. You'll save time and aggravation and your yard will look great. Unwanted lawn can be cut into easily lifted squares with a flat bladed spade or removed with a rented sod remover. Or compost your lawn in place by covering grass with heavy cardboard and a few inches of wood chips or bark.[1]

Add other features. Now is also the time to create mounds, install wildlife snags, rock piles or ponds[2] and remove any pesky invasive weeds. Weed removal is a challenge! Be sure to look at other resources to battle your problem weeds[3].

3. Pick the right plants for your spot



This brochure includes a plant list of popular and common natives, many of which can adapt to a range of sites. Narrow your choices to plants that match the sunlight, moisture and space conditions of your site. Then pick your favorites.

Each native plant performs a role in its habitat, so use each plant to its best advantage. To control erosion on the edge of a stream, plant red osier dogwood, willows, Oregon ash and vine maple. To attract hummingbirds, plant red flowering currant and orange honeysuckle.[4] And kids as well as animals enjoy huckleberries and native blackberries. To attract more wildlife, "layer" plants that grow to different heights; check out the examples of layering on page 6.[2]

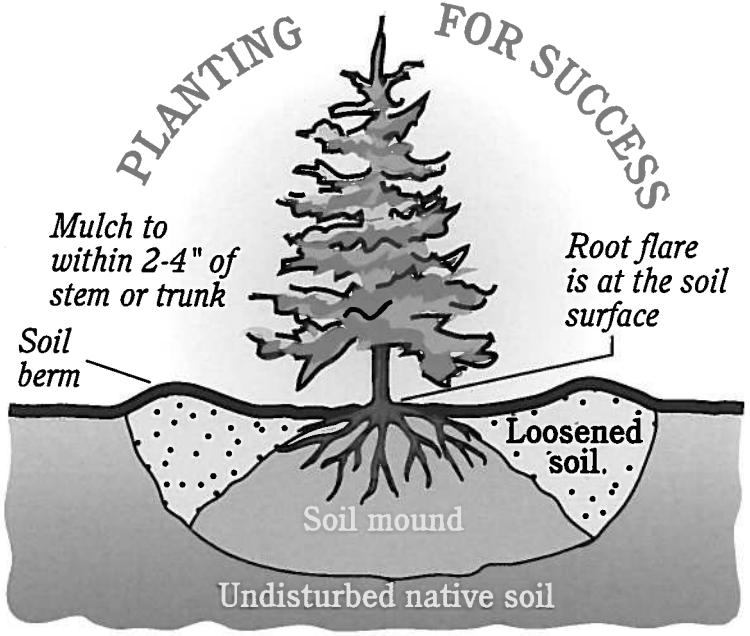
Is bigger better? Most important, choose plants that fit your spot when full-grown. Pruning large plants to fit a small area is loads of work and could harm your plant's health. Larger plants may suffer more transplant shock and higher mortality than small plants, but can survive deer browsing better and are less likely to be trampled or weed–whacked.

Start shopping. While native plants are increasingly available in nurseries, some may be a little harder to find.[5] Ask the King Conservation District (206–764–3410 or www.kingcd.org) and the Washington Native Plant Society (206–527–3210 or www.wnps.org) about their annual native plant sales. When buying, use the Latin name to get the plant you want. For example, asking for mock orange could land you the European *Philadelphus coronarius* rather than our Northwest native mock orange, *Philadelphus lewisii*. Bring the attached plant list to help.

4. Proper planting is paramount!

Help your plants put their best root forward.[6] Take the time to plant carefully. Fall or winter is the best time of year to plant. In most years, a newly installed plant's survival decreases after March as the weather gets drier and warmer. Set out your plants, still in their pots, where you want them and rearrange for the look you like. Cluster three or more shrubs of the same species for a natural look. General guidelines for plant spacing are 10–15 feet apart for trees, 5-10 feet for shrubs and 1-3 feet apart for groundcovers.

1. Take the plant out of its pot or burlap to view its root size. Keep the roots wet.
2. Dig a saucer-shaped hole 2-3 times the width of the root mass, and about as deep. Fill hole with water and let drain.
3. Build a mound of soil at the bottom of the hole.
4. Loosen bound roots and gently shake off excess potting soil (not into the planting hole).
5. Gently spread the roots evenly over the soil mound. The roots should not circle in the hole.
6. Place the plant so the root flare (where the roots join the stem) is at the soil surface.
7. Replace soil into the hole so it fills the space between the roots.
8. Water generously and add more soil to fill the hole up to the root flare. Create a soil berm around the planting hole to retain moisture.
9. Mulch!



Mulch, mulch, mulch! Tree grindings, leaves, wood chips, shredded bark, grass clippings, compost, and manure are all common mulches.[7] Spread mulch at least a couple of inches deep around your new plants (but keep the mulch a couple of inches from the plant's stem). Use mulch over weed barriers (cardboard or newspaper) if you're eager to reduce weeding. Weed barriers are temporary, though; annual additions of mulch and shading by plants helps control weeds and creates a healthy landscape in the long run.

Do fence me in. A fence can keep livestock, rodents, pets or children away from new plants. There are a variety of plant protectors available to keep your tender new shrubs from becoming a wildlife snack. Once established, most plants survive moderate munching.

5. A little maintenance goes a long way

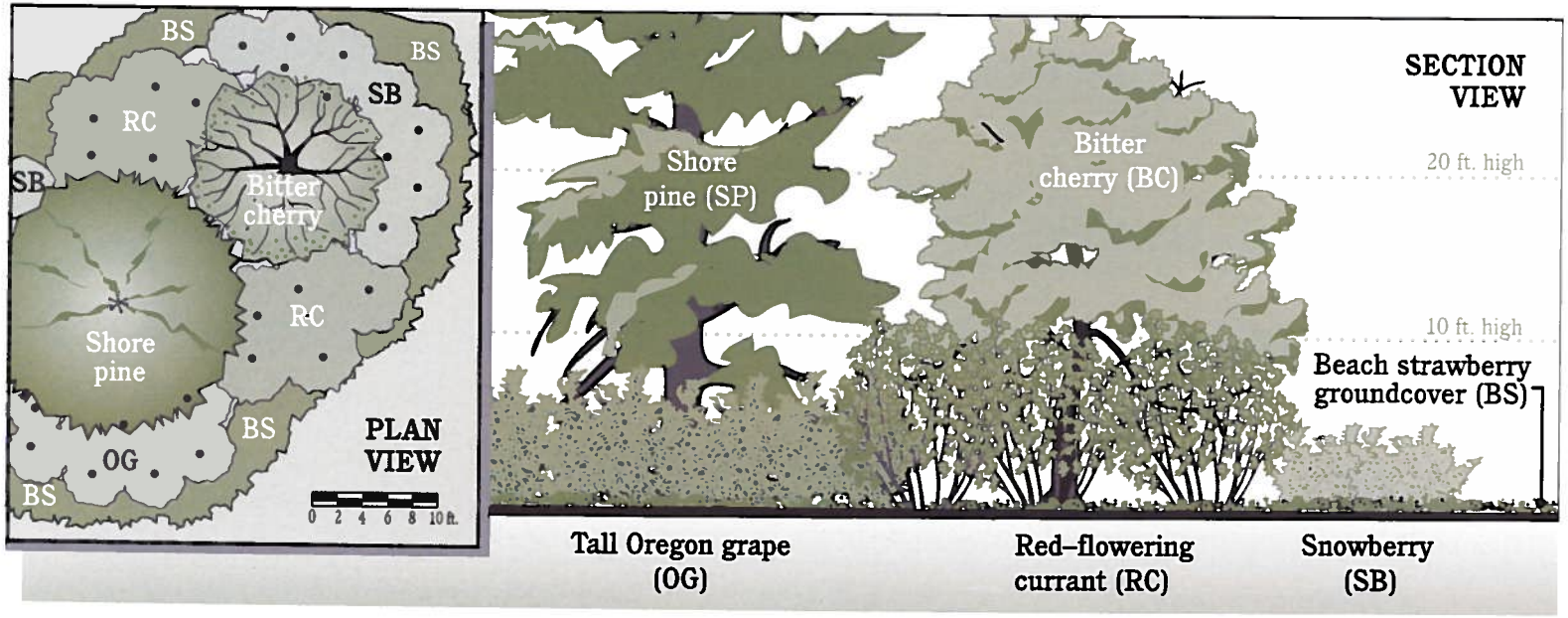
Mulch helps reduce weeding and watering, but you will still need to help your new plantings get established.[8] Water when dry during the first two growing seasons. Deep, infrequent watering is best. Let the soil nearly dry out between soakings. Many native plants will need little or no additional water after one or two growing seasons, when they develop healthy root systems. Handpull invasive plants to give your new natives a chance to grow.[3] Once a well-planned native landscape matures, it will almost care for itself.

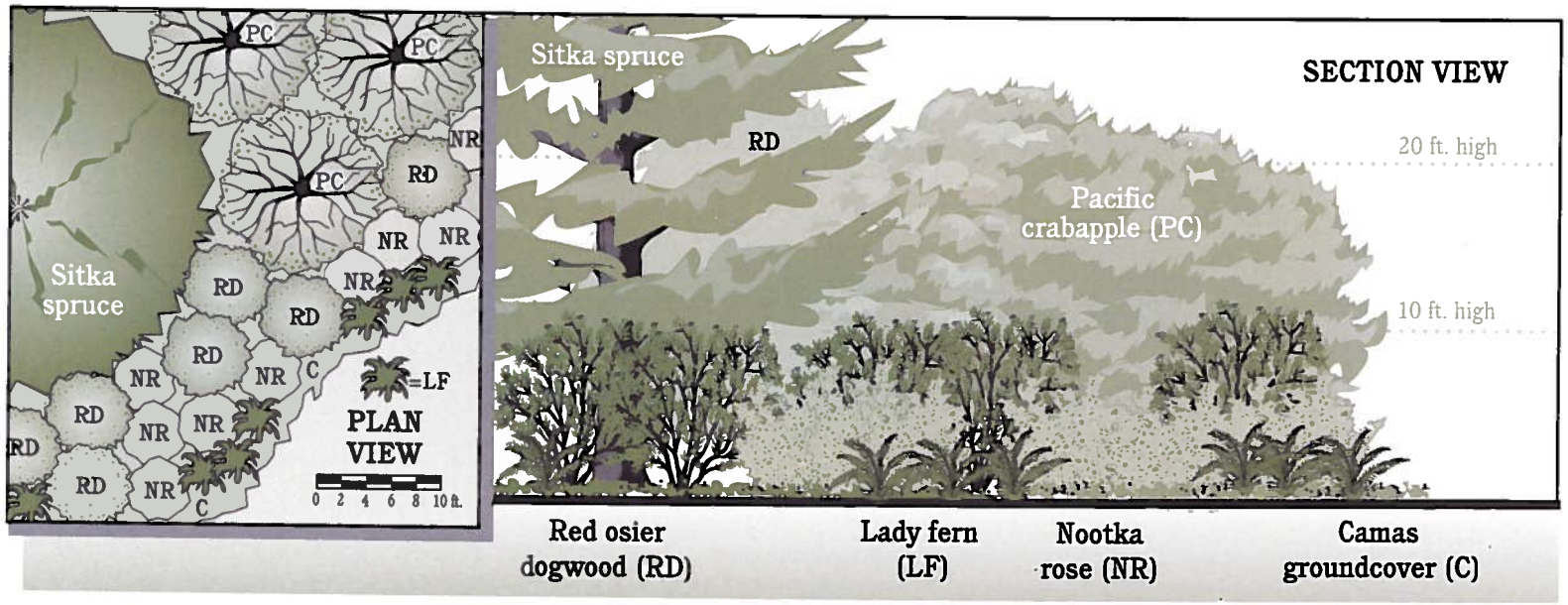
Learn more! Visit http://dnr.metrokc.gov/topics/yard-and-garden for links to native plant nurseries, resources and more. Or call 206–296–6519 and ask for information about native plant landscaping. If you are planning to restore habitat along streams or rivers, ask for the Small Habitat Restoration Program.

Appendices

- **Sample planting plans**
  The following four illustrations are intended to give you a jumping off point to get started naturescaping. Different conditions make it very difficult to present a planting plan suitable for every site. Soil alkalinity, elevation, slope and soil texture can all affect the survival of plants in your yard. Learn more, experiment and celebrate the successes.
- **Suggested native plants list**
  This list contains some of the more common and readily available native plants. We left out some notable plants, but there are plenty here to get you started. Check out our resource list at the end to learn more.

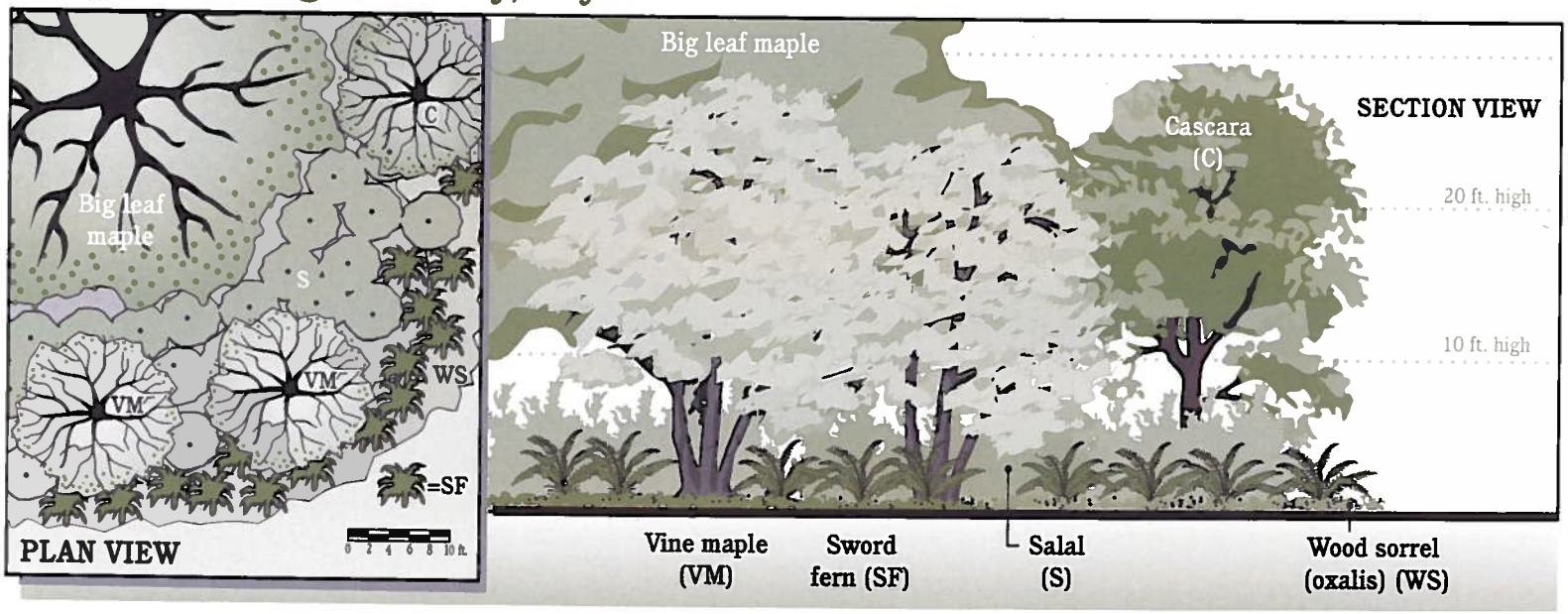
Sample Planting for Sunny, Dry Conditions

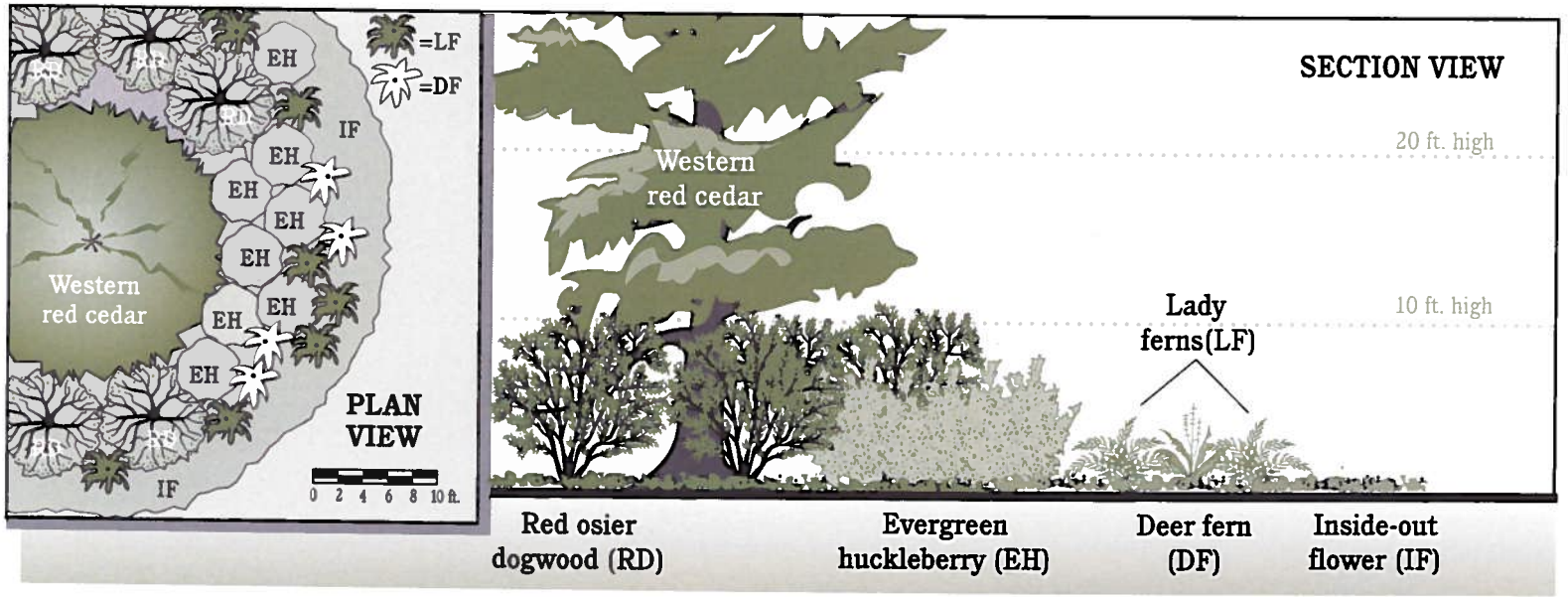




Sample Planting for Sunny, Moist Conditions

Sample Planting for Shady, Dry Conditions





Sample Planting for Shady, Moist Conditions

Native Plant List—Trees

Common name	Botanical name		Ideal growing conditions	Height	Notes
Big leaf maple	(*Acer macrophyllum*)	Deciduous	dry–moist, sun–part shade	100 ft	
Bitter cherry	(*Prunus emarginata*)	Deciduous	dry–moist, sun–part shade	30 ft	
Black cottonwood	(*Populus balsamifera*)	Deciduous	moist–wet, sun–part shade	160 ft	
Black hawthorn	(*Crataegus suksdorfii*)	Deciduous	moist–wet, sun–part shade	30 ft	
Cascara	(*Rhamnus purshiana*)	Deciduous	*dry–wet, sun–shade	30 ft	
Douglas–fir	(*Pseudotsuga menziesii*)	Evergreen	dry–moist, sun–part shade	250 ft	
Grand fir	(*Abies grandis*)	Evergreen	dry–moist, sun–shade	250 ft	
Oregon ash	(*Fraxinus latifolia*)	Deciduous	moist–wet, sun–part shade	70 ft	
Pacific crabapple	(*Malus fusca*)	Deciduous	moist–wet, sun–part shade	40 ft	
Pacific willow	(*Salix lasiandra*)	Deciduous	moist–wet, sun–part shade	40 ft	
Red alder	(*Alnus rubra*)	Deciduous	dry–wet, sun–part shade	120 ft	
Scouler's willow	(*Salix scouleriana*)	Deciduous	dry–moist, sun–part shade	30 ft	
Shore pine	(*Pinus contorta var. contorta*)	Evergreen	dry–wet, sun–part shade	50 ft	
Sitka spruce	(*Picea sitchensis*)	Evergreen	moist–wet, sun–part shade	200 ft	
Sitka willow	(*Salix sitchensis*)	Deciduous	moist–wet, sun–part shade	30 ft	
Vine maple	(*Acer circinatum*)	Deciduous	*dry–moist, sun–shade	25 ft	
Western hemlock	(*Tsuga heterophylla*)	Evergreen	moist–wet, part shade–shade	225 ft	
Western red cedar	(*Thuja plicata*)	Evergreen	moist–wet, part shade–shade	200 ft	
Western white pine	(*Pinus monticola*)	Evergreen	dry–moist, sun–part shade	130 ft	

Definitions:

Dry: *quick drying well draining soils*
Moist: *damp much of year (not standing water)*
Wet: *rarely or never dries out*

Sun: *more than 6 hours sun*
Part shade: *2-6 hours sun*
Shade: *fewer than 2 hours sun*

Deciduous: *drops leaves seasonally*

** If planted in full sun, prefers moist conditions. Dry shade is fine.*

Native Plant List—Shrubs and Ferns

Common name	Botanical name		Ideal growing conditions	Height	Notes
Beaked hazelnut	(*Corylus cornuta*)	Deciduous	dry–moist, sun–shade	20 ft	
Deer fern	(*Blechnum spicant*)	Evergreen	moist–wet, part shade–shade	2 ft	
Evergreen huckleberry	(*Vaccinium ovatum*)	Evergreen	*dry–moist, part shade–shade	10 ft	
Indian plum	(*Oemleria cerasiformis*)	Deciduous	*dry–moist, part shade–shade	15 ft	
Lady fern	(*Athyrium filix–femina*)	Deciduous	moist–wet, sun–shade	4 ft	
Mock orange	(*Philadelphus lewisii*)	Deciduous	dry–moist, sun–part shade	9 ft	
Oceanspray	(*Holodiscus discolor*)	Deciduous	dry–moist, sun–part shade	15 ft	
Oregon grape (tall)	(*Mahonia aquifolium*)	Evergreen	*dry–moist, sun–shade	5 ft	spreads easily
Pacific ninebark	(*Physocarpus capitatus*)	Deciduous	moist–wet, sun–shade	13 ft	
Pacific wax myrtle	(*Myrica californica*)	Evergreen	*dry–moist, sun–shade	15 ft	
Red elderberry	(*Sambucus racemosa*)	Deciduous	*dry–moist, sun–shade	15 ft	
Red–flowering currant	(*Ribes sanguineum*)	Deciduous	dry–moist, sun–part shade	6 ft	
Red huckleberry	(*Vaccinium parvifolium*)	Deciduous	dry–moist, part shade–shade	10 ft	
Red osier dogwood	(*Cornus sericea*)	Deciduous	moist–wet, sun–shade	15 ft	
Rosa species	(*R. nutkana, R. pisocarpa*)	Deciduous	dry–wet, sun–part shade	6 ft	spreads easily
Salal	(*Gaultheria shallon*)	Evergreen	*dry–moist, part shade–shade	5 ft	spreads easily
Salmonberry	(*Rubus spectabilis*)	Deciduous	moist–wet, sun–shade	10 ft	spreads easily
Serviceberry	(*Amelanchier alnifolia*)	Deciduous	dry–moist, sun–shade	20 ft	
Snowberry	(*Symphoricarpos albus*)	Deciduous	dry–wet, sun or part shade	5 ft	spreads easily
Sword fern	(*Polystichum munitum*)	Evergreen	dry–moist, part shade–shade	3 ft	
Thimbleberry	(*Rubus parviflorus*)	Deciduous	*dry–moist, sun–shade	8 ft	spreads easily

Definitions:

Dry: *quick drying well draining soils*
Moist: *damp much of year (not standing water)*
Wet: *rarely or never dries out*

Sun: *more than 6 hours sun*
Part shade: *2-6 hours sun*
Shade: *fewer than 2 hours sun*

Deciduous: *drops leaves seasonally*

** If planted in full sun, prefers moist conditions. Dry shade is fine.*

Native Plant List—Groundcovers and Perennials

Common name	Botanical name	Ideal growing conditions		Height	Notes
Beach strawberry	(*Fragaria chiloensis*)	Evergreen	dry–moist, sun–part shade	6 in	spreads easily
Bleeding heart	(*Dicentra formosa*)	Deciduous	dry–moist, part shade–shade	1.5 ft	spreads easily
Camas	(*Camassia quamash*)	Deciduous	*dry–moist, sun–part shade	1 ft	
Inside–out–flower	(*Vancouveria hexandra*)	Deciduous	dry–moist, part shade–shade	6 in	spreads easily
Kinnikinnick	(*Arctostaphylos uva–ursi*)	Evergreen	dry, sun	6 in	spreads easily
Western trillium	(*Trillium ovatum*)	Deciduous	moist, shade	1 ft	
Wood sorrel	(*Oxalis oregana*)	Deciduous	dry–moist, part shade–shade	6 in	spreads easily

Definitions:

Dry: *quick drying well draining soils*
Moist: *damp much of year (not standing water)*
Wet: *rarely or never dries out*

Sun: *more than 6 hours sun*
Part shade: *2-6 hours sun*
Shade: *fewer than 2 hours sun*

Deciduous: *drops leaves seasonally*
** If planted in full sun, prefers moist conditions. Dry shade is fine.*

Footnote Resources for More Information

All these and more are at:
http://dnr.metrokc.gov/wlr/pi/npresrcs.htm

1. **Shrink your Lawn!**
   http://dnr.metrokc.gov/wlr/pi/shrunklawn.htm
2. ***Landscaping for Wildlife in the Pacific Northwest.*** Russell Link. UW Press, Seattle. 1999.
3. **King County Noxious Weeds:**
   http://dnr.metrokc.gov/wlr/lands/weeds/index.htm
4. **Native Plant Information:**
   - ***Grow Your Own Native Landscape.*** Item MISC0273 WSU Cooperative Extension. Revised 1999. Order at 1–800–723–1763.
   - ***Gardening with Native Plants of the Pacific Northwest.*** 2nd edition. Arthur R. Kruckeburg. UW Press, Seattle 1996.
   - ***Plants of the Pacific Northwest Coast.*** Jim Pojar and Andy Mackinnon. Lone Pine Publishing, Vancouver, BC. 1994.
   - **WSU Native Plant Guide**
     http://gardening.wsu.edu/text/nwnative.htm
5. **Native Plant Sources:**
   - **Where to purchase native plants**
     http://dnr.metrokc.gov/wlr/pi/npnursry.htm
   - **Restoration Growers Association**—Let the King Conservation District find local native plants for you! Contact KCD at 206–296–3410 ext. 129.
6. **Plant it Right Brochure:**
   http://cru.cahe.wsu.edu/CEPublications/misc0337/misc0337.pdf
7. **Soils, Compost & Mulch Information:**
   - **Soils, compost and mulch use**
     http://www.metrokc.gov/soils/
   - **Mulch and horticulture myths**
     http://www.cfr.washington.edu/research.mulch/
8. **Natural Yard Care Booklet** (includes watering):
   http://dnr.metrokc.gov/swd/ResRecy/composting/naturalyardbooklet.shtml

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THE NATURAL LAWN & GARDEN

Healthy Landscapes for a Healthy Environment

Natural Pest, Weed & Disease Control

Spring 2012

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Why Manage Your Garden Naturally?

Insects, spiders, and other crawling or flying creatures are a vital part of healthy gardens. Most perform important jobs like pollinating flowers, recycling nutrients and eating pests. In fact, less than 1% of garden insects actually damage plants. Unfortunately, the pesticides often used to control pests and weeds are also toxic to beneficial garden life—and may harm people, pets, salmon and other wildlife as well.

Follow these Basic Steps to Natural Pest, Weed and disease Control

- **Create a healthy garden to stop pest problems before they start.** Healthy plants and soil not only resist pests and diseases, they also encourage beneficial garden life.
- **Identify pests before you spray, stomp or squash.** When you see damaged plants or what appear to be pests, use the Natural Pest Control Resources on page 10 and 11 to identify the "suspects" first. What you think is a pest may actually be a beneficial insect!
- **Give nature a chance to work.** Do not try to eliminate pests at the first sign of damage. Garden pests feed beneficial insect populations and allow them to grow.
- **Use the least toxic pest controls available.** You can often control pests by using traps or barriers, or by simply removing pests and infested plant parts. These methods do not harm beneficial garden life or the environment. If pesticides are the only way to control a problem, look for the least toxic ones and closely follow the application tips outlined on pages 6 and 7.

Start with Prevention

- **Build healthy soil to grow healthy plants.** Amend and mulch entire growing beds with compost, and fertilize moderately with natural organic or slow-release fertilizers to grow vigorous, pest-resistant plants. See the *Growing Healthy Soil* guide* for more details.
- **Plant right.** Place each plant in the sun and soil conditions it prefers. Select varieties that are known to grow well in your garden conditions and resist common pest and disease problems. See the *Choosing the Right Plants* guide* and *The Plant List* for help selecting plants ideal for each spot in your garden.
- **Give your plants some space.** Good air circulation can prevent or reduce many disease and pest problems. Space plants so they have plenty of room to grow, and remove some when they become too crowded.
- **Water wisely.** Overwatering and underwatering are two of the most common causes of plant problems. Observe plants and check soil as deep as roots grow before and after watering to make sure plants get the water they need, but not too much. You can check the soil with a trowel, shovel or a soil-coring tool. Water early in the day or use soaker hoses to prevent diseases caused by wet leaves. For more details, see the *Smart Watering* guide.*
- **Clean up.** Remove weeds, wood boards and other yard debris that can harbor pests and disease. Fallen leaves and fruit from plants like apple trees and roses with persistent diseases such as scab, rust and mildew should be put in curbside yard waste collection containers—not in home compost piles, ravines, streams or lakes.
- **Diversify and rotate annual crops.** Grow a variety of plants to prevent problems from spreading, as well as to attract pest-eating insects and birds. Do not plant the same type of annual vegetables in the same spot each year; crop rotation prevents pests and diseases from building up in the soil.

Good bug:
Lady beetle larva

Bad bug: Aphids

When is it a pest?

- **Pest** refers to an insect, animal, plant or micro-organism that causes problems in the garden.
- **Beneficials** are organisms in the air, on the ground or in the soil that do good things for your garden, like pollinating flowers, feeding on insect pests, or improving soil.
- **Some pests are also beneficials.** For example, yellow jackets are both predators of pests and painful to humans. When considering any controls, weigh a creature's damage against damage to the entire community of garden life.

Washing aphids from underside of leaf

Copper slug barrier

Protecting a crop with a floating row cover

1 What to Do If a Pest Problem Develops

Use Physical Controls First

Many pests can be kept away from plants with barriers or traps, or controlled by simply removing infested plant parts. These controls generally have no adverse impact on beneficial garden life, people or the environment.

Removal

Pests and diseased plant parts can be picked, washed or pruned out of plants to control infestations. In fact, pulling weeds is a natural pest control!

Handpicking can be effective for large pests like cabbage loopers, tomato hornworms, slugs and snails.

Pruning out infestations of tent caterpillars is effective on a small scale. Control leaf miners on beets or chard by picking infected leaves. Put infestations in curbside yard waste collection containers—not in home compost piles, which do not get hot enough to destroy pests.

Washing aphids off plants with a strong spray of water from a hose can reduce damage. Repeated washings may be required, as this process does not kill the aphids, but knocks them off the plant.

Traps

It is possible to trap enough pests like moths and slugs to keep them under control. You can also use traps for monitoring pest numbers to determine when controls may be necessary. Two simple and effective pest traps include:

Cardboard or burlap wrapped around apple tree trunks in summer and fall will fool coddling moth larvae into thinking that they have found a safe place to spin their cocoons as they crawl down the tree to pupate. Traps can be peeled away periodically to remove cocoons.

Slug traps drown slugs in beer or in a mixture of yeast and water.

Barriers

It is often practical to physically keep pests away from plants. Barriers range from 2-inch cardboard "collars" around plants for keeping cutworms away to 8-foot fences for excluding deer.

Floating row covers are lightweight fabrics that let light, air and water reach plants, while keeping pests away—they are useful for pests like rust flies on carrots, leaf miners on spinach, and root maggots on cabbage, broccoli and cauliflower.

Mesh netting keeps birds away from berries and small fruit trees.

A band of sticky material around tree trunks stops ants from climbing trees and introducing disease-carrying aphids.

Repellents

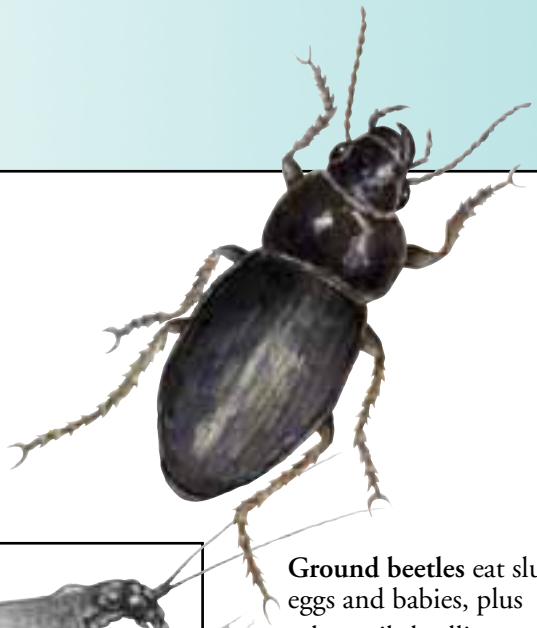
A variety of homemade and commercial preparations can be used to keep pests away from plants. Many gardeners claim repellents work, although some are not consistently effective in scientific trials.

A mixture of **raw eggs blended with water** produces a taste and odor that offend deer; some gardeners add garlic and hot pepper. Spraying this mix onto plant foliage can repel deer for several weeks, or until it is washed off by rain or sprinklers.

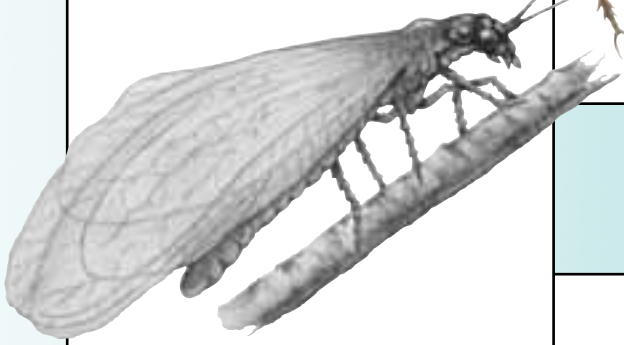
Garlic oil and extracts are used to repel a variety of insect pests, and also work as fungicides.

Meet The Beneficials!

Spraying any pesticide may kill more beneficials than pests. Think twice before you spray.

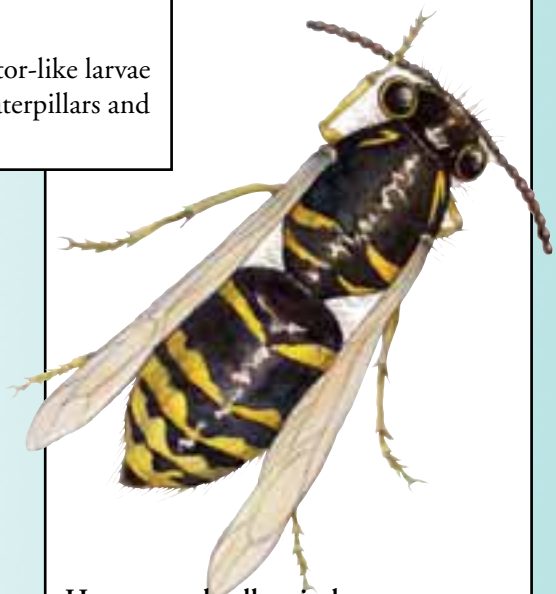


Ground beetles eat slug eggs and babies, plus other soil-dwelling pests.

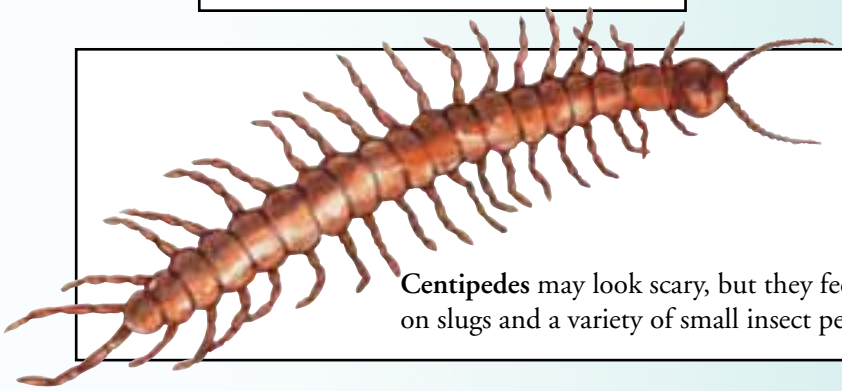


Lacewings and their alligator-like larvae eat aphids, scales, mites, caterpillars and other pests.

Lady beetle larvae and adults feed on soft-bodied insects such as aphids, mealybugs, scale insects, and spider mites as well as insect eggs.



Hornets and yellow jackets are effective predators of many garden pests. However, controls may be necessary if they pose a threat to people or pets.



Centipedes may look scary, but they feed on slugs and a variety of small insect pests.

2 Use Least-Toxic Pesticides When Physical Controls Don't Work

The pesticides listed below have a low toxicity or break down quickly into safe byproducts when exposed to sunlight or the soil. They are the least likely to have adverse effects. However, even these pesticides can be toxic to beneficial garden life, people, pets and other animals—especially fish. They should be used carefully and kept out of streams, lakes and Puget Sound. Refer to Resources on page 10.

Soaps, Oils and Minerals

- **Horticultural oils** smother mites, aphids and their eggs, scales, leaf miners, mealybugs and many other pests; they have little effect on most beneficial insects.
- **Horticultural soaps** dry out aphids, white flies, earwigs and other soft-bodied insects. They must be sprayed directly onto the pests to work, so repeated applications may be necessary. There are also soap-based fungicides and herbicides.
- **Sulfur** controls many fungal diseases such as scab, rust, leaf curl and powdery mildew without harming most animals and beneficials. For greater effectiveness, sulfur can be mixed with lime. Sulfur is also frequently combined with other materials to create more toxic fungicides.
- **Baking soda** (1 teaspoon) mixed with dishwashing liquid (a few drops) and water (1 quart) has been used by rose growers to prevent mildew. A commercial product is also available that contains potassium bicarbonate, which is similar to baking soda.
- **Iron phosphate slug baits** are less toxic than other slug baits and not as hazardous to dogs.

Botanicals

These plant-derived insecticides degrade quickly in the sun or soil. However, most are initially toxic to people, animals, fish and beneficial garden life. *Use cautiously and follow label directions closely, just as when applying synthetic pesticides.*

- **Neem oil** kills and disrupts feeding and mating of many insects, including some beneficials. Also an effective fungicide, neem oil is the botanical that is least toxic to people, animals, birds and fish.
- **Pyrethrum, ryania and sabadilla** kill many tough pests, but are also quite toxic to beneficial insects, people, fish and other animals. *These pesticides should only be used as a last resort.*

Biocontrols

- **Bacillus thuringiensis** (**Bt**) is a common, commercially available bacterium that poisons caterpillar pests, including cutworms, armyworms, tent caterpillars, cabbage loopers, and corn earworms. Bt is not toxic to people, animals, fish or insects—although it can kill caterpillars of non-pest butterflies and moths.
- **Predatory nematodes** kill a wide variety of pests, including cutworms, armyworms, root maggots, crane fly larvae, root weevil larvae and other soil-dwelling pests. Proper soil temperature and moisture are required for nematodes to be effective.
- **Beauveria bassiana** is a commercially available fungus that destroys an extensive range of pest insects.
- **Beneficial insects** like ladybugs and lacewings can be purchased and released. A healthy and diverse garden will usually have lots of them around already.
- **Compost teas** use compost organisms to help control leaf and root diseases. They are sometimes effective, and they won't harm any beneficial organisms. Call the Garden Hotline at (206) 633-0224 for more information on using compost teas and other biocontrols.

3 Use Synthetic Pesticides Only As a Last Resort

When physical and least-toxic controls fail to control a pest, other pesticides may be used as a final resort. But first, consider your pest problem. Is it the result of poor plant placement? Is it likely to recur after pesticide treatment? Keep in mind that scientists have found 23 pesticides—including four commonly used insecticides—in local streams, some at high enough levels to harm fish and what they eat.

- **Don't use services that spray insecticides or herbicides on a prescheduled plan.** Preventive sprays can disrupt natural controls, and may do more harm than good. Fungicides are an exception because they only work when applied prior to the appearance of the problem—use the least toxic fungicides, only on plants which have been infected in previous years.
- **Look for the least toxic pesticide.** Ask nursery staff for help identifying the least toxic pesticides for your pest problem. Or call the Garden Hotline at (206) 633-0224 and ask for *Grow Smart, Grow Safe—A Consumer Guide to Lawn and Garden Products*. Avoid products with warnings like "highly toxic," "causes permanent eye damage," or "may be fatal if swallowed." Choose "ready-to-use" products, which are safer to use instead of more toxic concentrates which require mixing.
- **Don't use broad-spectrum insecticides** like diazinon, chlorpyrifos (Dursban), malathion and carbaryl. These are likely to kill more of the natural enemies than the pests. Pest populations may soar and become more of a problem than before they were sprayed.
- **Avoid "weed and feed" and other pesticides that are broadcast over the entire yard.** Instead, spot apply the least toxic product, only where you have a pest or weed.
- **Buy only as much as you need.** Unused pesticides are dangerous to store or dispose, and expensive for local governments to dispose of.
- **Read and follow label directions carefully.** Only use pesticides on the plants and pests listed on the label, and apply exactly according to label directions. Be sure to wear specified protective clothing and equipment, and keep children and pets off application areas for the specified period of time on the label.
- **Apply only when and where pests are present.** Timing is critical with all pest control. Most pesticides should not be used as a preventative, except fungicidal tree sprays.
- **Dispose of unused pesticides and containers properly.** Empty containers should be disposed of in your garbage. Dispose of unused pesticides at household hazardous waste disposal sites; see the Resources List on page 11 for more information.

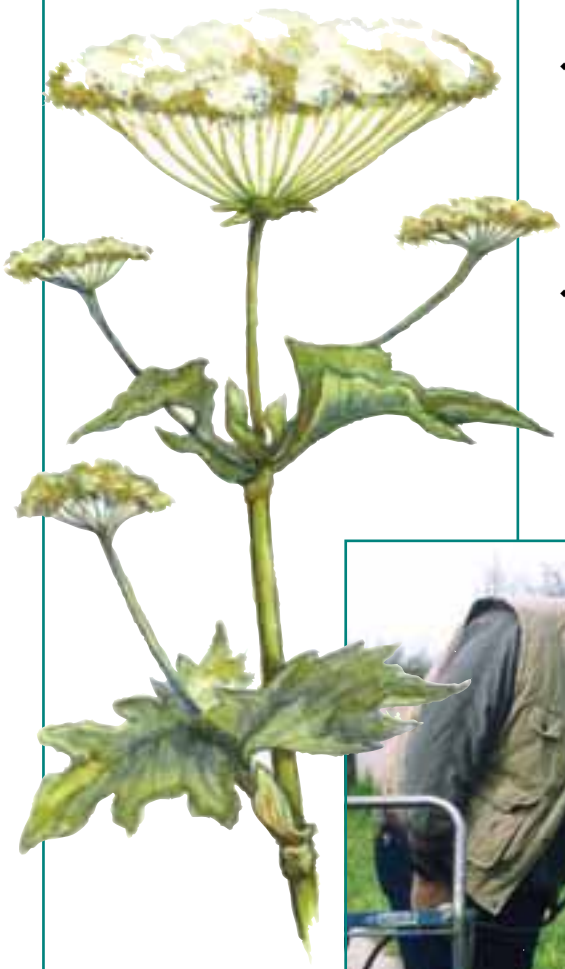
What About Weeds?

A "weed" is simply a plant in the wrong place. Some weeds compete with desirable plants, but many are merely aesthetic concerns. For instance, white clover is often considered a weed in lawns, yet it stays green when dry conditions turn lawns brown, and its roots support bacteria that transform nitrogen from the air into plant fertilizer. So clover feeds your lawn every time you mow!

- **Accept a few weeds in your lawn.** Target the problem weeds, and leave the others. Many people who see a lawn with 10-20 percent weed cover consider it healthy and good looking. For tips on maintaining a dense, healthy lawn that crowds out weeds, refer to the *Natural Lawn Care* guide.*
- **Prevention: don't give weeds a chance.** Weeds thrive in bare soil and neglected garden areas. Plant spreading ground cover to outcompete weeds, or smother them with cardboard or newspapers covered with lots of mulch. See the *Growing Healthy Soils* guide* for more information on mulches.
- **Physical control: be a control freak with problem weeds.** A single weed flower can produce thousands of seeds. To prevent future infestations, remove weeds before they go to seed. Cultivating with a hoe works well on young or shallow-rooted

Have you seen these "noxious" weeds?

There are a few non-native "noxious weeds" that property owners are required to control by Washington State law to prevent their spread. Check the noxious weed website for a list, at www.kingcounty.gov/weeds.



Giant Hogweed

Torches work on weeds in cracks or gravel

Using a weed puller

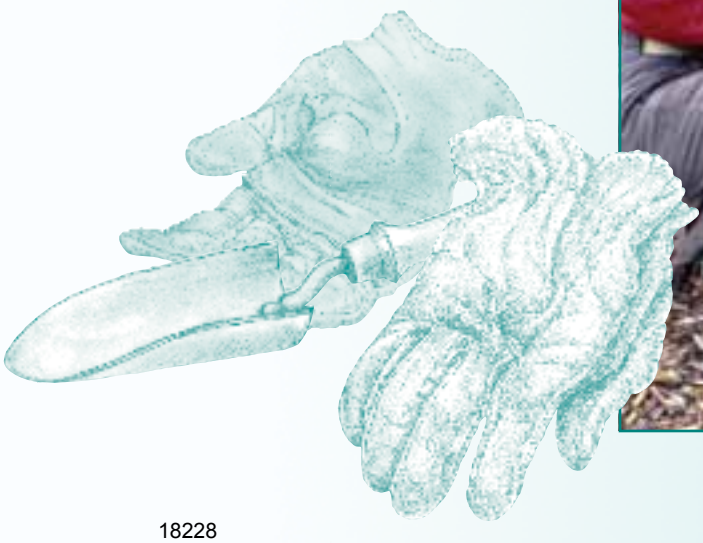
weeds in garden beds or paths. Long-handled pincer-type weed pullers work great for weeds with taproots like dandelion and thistle, especially in lawns when soil is moist. Propane weeding torches scorch and kill most weeds without damaging plants around them; repeated flame treatment may be needed for tough weeds. Be aware of fire hazards when using torches, as well as the potential to burn your feet. Spring and fall, when the ground is moist and weeds have just sprouted, is the safest and most effective time to use a torch.

Spot apply the least toxic herbicide

- **Least toxic controls: corn, soap or vinegar?** Herbicides with low toxicity to beneficial garden life, people and wildlife include corn gluten—a milling byproduct which is used as animal feed—herbicidal soaps, and vinegar (acetic acid). Corn gluten prevents the growth of weed seedlings, and actually fertilizes established plants. It is sold under several brand names. Corn gluten's effect is short-lived, so applications must be timed to coincide with seed germination and weather. Herbicidal soaps and vinegar both damage leaf cells and dry out plants. Tough weeds resist these herbicides or resprout from roots. Reapplication may be necessary. Some concentrated vinegar products can cause permanent damage if accidentally splashed into the eyes. Ready-to-use dilutions are safer.

- **The last resort: spot apply synthetic herbicides.** When extreme weed problems call for treatment with synthetic chemical herbicides, carefully apply them (only as directed on the label) directly onto weed leaves. Do not use "weed and feed" or pre-emergent products, which spread toxic herbicides all over lawns or gardens and are likely to run off into streams and Puget Sound. *If you are applying an herbicide on a regular basis, there is probably a landscape design or soil problem that needs to be addressed.*

Spreading mulch to prevent weeds



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Natural Pest Control Resources

Call the Garden Hotline at (206) 633-0224 or email help@gardenhotline.org to ask a question, or to request other guides including *Natural Lawn Care; Growing Healthy Soil; Choosing the Right Plants; Smart Watering; The Plant List; Composting at Home; Natural Pest, Weed & Disease Control*; *Grow Smart, Grow Safe;* and *How to Choose a Landscape Company*. Landscape professionals can request the series of *Pro-IPM* professional factsheets, or the report *Ecologically Sound Lawn Care*. You can also visit **www.savingwater.org** to view many of these publications online. View the *Pro-IPM* series of factsheets at **www.seattle.gov/util/proipm**

Books For Gardeners

- ***Sunset Western Garden Problem Solver.*** Photos and descriptions of many common pest, disease and weed problems, plus less-toxic ways to prevent and manage them.
- ***Rodale's Color Guide of Garden Insects.*** Photos for identifying pests and beneficial insects, with recommended organic controls for many pests.
- ***Rodale Pest and Disease Problem Solver.*** Photos and descriptions of many common pest and disease problems, plus less-toxic ways to prevent and manage them.
- ***Pests of Landscape Trees and Shrubs: An Integrated Pest Management Guide*** by Steven Dreistadt. Detailed descriptions of pests by plant type, as well as pest life cycles and controls.
- ***Pests of the Garden and Small Farm: A Grower's Guide to Using Less Pesticide*** by Mary Flint. Detailed descriptions of pests by plant type, plus pest life cycles, and controls.
- ***Common Sense Pest Control*** by Olkowski, Daar & Olkowski. Least-toxic solutions for home, garden, pets, and community.

WSU Extension Resources and Services

- **Master Gardener Clinics.** Master Gardener volunteers are available to answer questions and diagnose problems by email, or at clinics held regularly around the county. For help and clinic locations, see http://county.wsu.edu/king/gardening.
- **http://gardening.wsu.edu.** View Cooperative Extension publications on horticulture and pest management online, or link to Extension and Master Gardener programs in counties around Washington.
- **Publications.** Order many bulletins on growing plants and managing pests for a small charge at (800) 723-1763. Several authoritative books can also be ordered, including *Landscape Plant Problems: A Pictorial Diagnostic Manual*, and *Pacific NW Integrated Pest Management Manual*. Three books primarily for professionals, excellent for diagnosing plant problems by symptom (though all focused on chemical control), are *PNW Insect Management Handbook, PNW Plant Disease Management Handbook*, and *PNW Weed Management Handbook*.

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Other Resources

- **Landscape Professionals.** Many landscape and nursery professionals are skilled in environmentally friendly landscaping. Find them at **www.savingwater.org** by clicking on Lawn and Garden, or call (206) 633-0224 and ask for the brochure *How to Choose a Landscape Company.*
- **Seattle Tilth.** To learn more about organic gardening classes, get directions to demonstration gardens, or to purchase the *Maritime NW Gardening Guide,* call (206) 633-0451, or visit **www.seattletilth.org**
- **Washington Toxics Coalition.** For publications on non-toxic pest management strategies and products, call (206) 632-1545 or go to **www.watoxics.org**
- **Local Hazardous Waste Management Program website.** To learn more about safer gardening and pest control, go to **www.LHWMP.org** or see the Grow Smart Grow Safe guide at **www.GrowSmartGrowSafe.org.**
- **Seattle Public Utilities.** Pro IPM Factsheets on specific pests and other resources for public and professionals at **www.seattle.gov/util/ProIPM.**
- **University of California IPM.** For pest descriptions, photos and management options for home gardeners and landscape professionals, go to **www.ipm.ucdavis.edu/**

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- **Poison Control.** In case of pesticide poisoning, call (800) 222-1222, or just call 911.
- **Washington State Department of Agriculture.** If you have a concern about a pesticide application or want to report a violation, call WSDA at 1-877-301-4555.
- **Household Hazards Line.** For information on pesticide disposal, including the days, hours and locations of disposal facilities, call the Hazards Line at (206) 296-4692 or 1-888-ToxicEd.

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Illustrations by Wilda Boyd

18228

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Local Hazardous Waste
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Public Health

*This information originally appeared in the **2002 King County Lake Monitoring Report** and has been modified for this fact sheet.*

Algae & King County Lakes

Introduction

Algae are the basic food producers in lakes, using the energy of sunlight to change water and carbon dioxide dissolved in the water into substances that animals then use to stay alive, grow, and reproduce. The long chain of life that stretches from algae to large animals, including humans, has been studied intensively, and yet there is still much to learn.

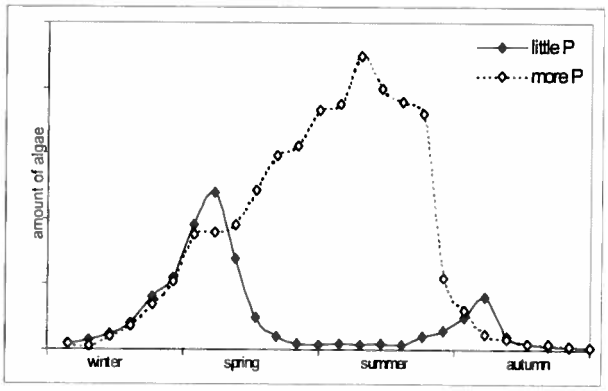
Some algae live by attaching to surfaces such as rocks, docks and large aquatic plants. Others lay on the bottom sediments, and a third group floats freely through the water column. The last group, known as "phytoplankton," often makes the biggest contribution to the volume of algae growing in lakes through the year and is the most studied of the various groups.

The interactions between phytoplankton and the environment within a lake can be quite complex and unpredictable. However, there are some generalizations that can be made about changes in populations through the year and how those relate to seasonal changes in lakes in temperate climates, such as that of the Pacific Northwest. Algae need all the same conditions as land-based plants in order to grow. In addition to the necessary elements for photosynthesis, they need a temperature range to which they are adapted, as well as appropriate concentrations of hydrogen ions (pH) and nutrients, including nitrogen, phosphorus, silica, calcium, magnesium, and iron.

The seasonal interplay between climate, water input and water circulation within a lake result in changes in water temperatures, light availability, and nutrient concentrations in the water. Changing conditions allow different algal groups to become dominant (i.e., high numbers relative to other algae) as time passes and seasons progress.

While most algae like the warmer temperatures and bright, long days of spring through fall, others can survive in cool temperatures and short days. The general patterns of phytoplankton populations through the seasons ("succession") can be summarized for lakes situated in moderate climate areas like the Pacific Northwest. There are many variations, since each lake is unique. Commonly, phosphorus plays the role of "limiting nutrient" in lakes in the Puget lowlands. A limiting nutrient is the substance necessary for growth that will be exhausted first by the growing algae. When that nutrient is essentially gone from the lake, algal growth will be limited (Fig. 1). Algal growth reaches a maximum in spring in lakes with smaller amounts of phosphorus and then drops in summer when the phosphorus has been used up in the epilimnion (upper water). In lakes with more phosphorus, the phytoplankton continue to grow into the summer, reaching maximum levels in July, August, or even September before decreasing temperatures and light begin to limit growth. Sometimes lakes with algal peaks in spring also produce a second peak in fall, when cool temperatures mix the phosphorus from the hypolimnion (lower water) of the lake upwards and enough light enters the water to stimulate the second period of growth.

Figure 1: Illustration of Typical Seasonal Abundance of Algae in Lakes



This figure shows the two general patterns that volumes of algae in a lake can make over a calendar year. The solid line illustrates a common pattern when little phosphorus is available for growth. The dotted lines illustrate what may happen with more phosphorus available.

Chlorophyll and Algae

One simple way to estimate the size of the phytoplankton population in a lake is to measure the amount of chlorophyll *a* found in a liter of water.

All algae have chlorophyll, generally contained in special organelles called chloroplasts, since this substance is necessary for photosynthesis (food production). The chlorophyll measurement is sometimes used as an analogue for the volume of phytoplankton present. There are several problems with this method, but it can be a useful tool for classifying lakes in broad terms of productivity.

Algae can have differing amounts of chlorophyll per volume of cell contents, depending on the species present as well as the time of year and the health of the cells. Sometimes quite a large volume of algae will have relatively little chlorophyll and vice versa. For example, the diatoms tend to have less chlorophyll per volume because many have large vacuoles or inclusions inside the cells, which take up space but are not chloroplasts, so do not add to the amount of chlorophyll. Other algae, such as the bluegreens, have pigments in addition to chlorophyll that are used to capture light, so the amount of chlorophyll in each cell may be commensurately less. In addition, as algae age, or senesce, they may lose chlorophyll, so older populations may have less chlorophyll than young, rapidly growing groups.

Major Groups of Phytoplankton

Algae that float in the water of lakes are diverse and come from all the major groups of algae classified by scientists. However, several groups are predominant in this area. Many have something particular about their requirements that can be used to characterize the environment of the lake in which they are found. Lakes with water colored by large amounts of humic substances from adjacent wetlands often feature different phytoplankton species than lakes with clear water, but similar amounts of phosphorus. The following is a description and discussion of the major groups and some representative species of algae that are

common in the small lakes of King County. Besides the Latin botanical names of the groups, algae are commonly distinguished by their coloration.

Cyanobacteria: Bluegreen Algae

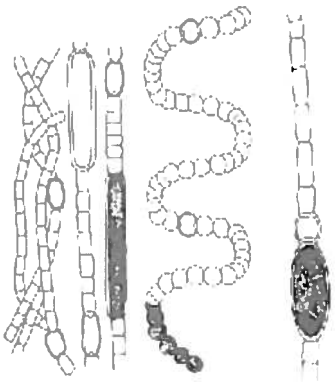
Bluegreens are simple organisms that share many features with bacteria, but produce food in the same way as plants, thus making their place in biological classifications open to argument. For this reason, some people refer to them as algae although strictly speaking it may not be appropriate. The bluegreens also share many of the environmental requirements of true algae and are important competitors for nutrients and light in the phytoplankton communities of lakes.

Bluegreens can actually be bluish-green in color, but they can also be red, brown, purple, yellow-green and olive. They always have at least a small amount of chlorophyll to complete the photosynthetic reactions, but they also can have a wide variety of other pigments that act as auxiliary light catchers for photosynthesis.

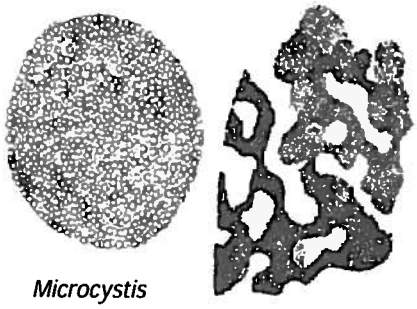
Bluegreens have become especially notorious in lake studies because several species can grow quickly in waters rich in phosphorus, which can be increased by land use changes or other human impacts. On occasion they can outnumber and exclude other naturally occurring species, leading to reduced water clarity, bad smells, and floating scums of decaying colonies, thus adding to their reputation as the algae of polluted waters. In addition, some species are known to release compounds toxic to mammals and fish. Although this is a rare occurrence, when it happens the results are often dramatic and make newspaper headlines.

Bluegreens are most often colonial, which means that the cells band together in groups rather than occur alone in nature. The two major colony forms are simple clusters of cells and cells arranged in long filaments. Some of the filamentous varieties can absorb nitrogen from sources not available to other algae, thus giving them an advantage in lakes

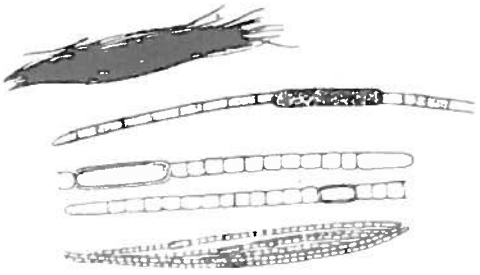
Figure 2: Common Bluegreen Algae



Anabaena



Microcystis



Aphanizomenon

Illustrations obtained from: *How to Know the Freshwater Algae* by G.W. Prescott, 1978.

where nitrogen may run out before phosphorus. Thus, when the nitrogen to phosphorus ratio is low in a lake, some bluegreens may have the opportunity to grow faster than the other algae present.

In general, bluegreens do very well in warm water and in high light levels, and therefore are considered to be summer algae. However, several species, such as *Aphanizomenon flos-aquae*, seem to be able to increase their population size in every season of the year in temperate lakes if other conditions are right, and they have been found making significant blooms in fall, winter and spring.

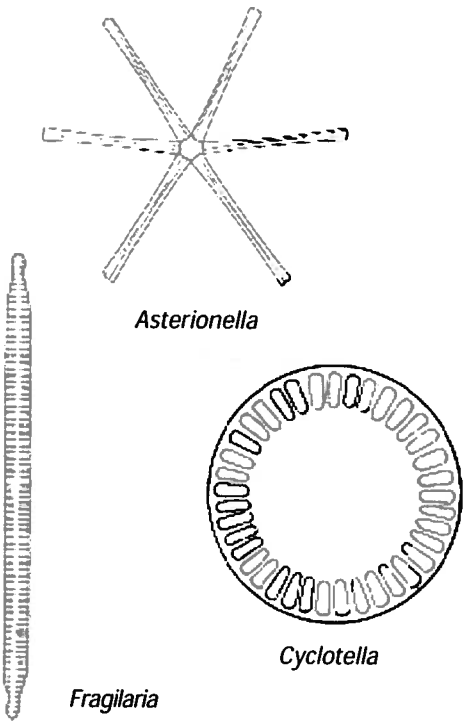
Common bluegreens found in King County lakes include *Aphanizomenon flos-aquae*, *Microcystis aeruginosum* and several species of *Anabaena* (Fig. 2). The last two named are most often implicated when toxic blooms are reported, but in fact most occurrences of these species are not toxic and should not cause concerns merely because of their identification in the phytoplankton of a particular lake.

Chrysophytes: Golden Brown Algae

The chrysophyte algae have all the necessary chlorophyll *a*, but also have pigments that give them a characteristic golden to brown color. Many are most common in spring through early summer, although one or two varieties can make large populations in late summer under the right conditions.

Diatoms are an important subgroup of the chrysophytes, often dominating spring phytoplankton since they can grow better than other algae in low light and cool temperatures, thus getting a head start on the growing season. Diatoms make hard siliceous coverings for their cells, known as "frustules." This characteristic has two effects: their growth can be limited by the amount of silica present as well as the phosphorus that limits other algae, and the extra weight of the frustule makes it harder for some diatoms to stay in the shallow water where light is most available. Therefore, many diatom populations will be found in spring before the beginning of thermal layering in area lakes, or in fall after it begins to break down, with one or two specific exceptions.

Figure 3: Common Diatom Algae

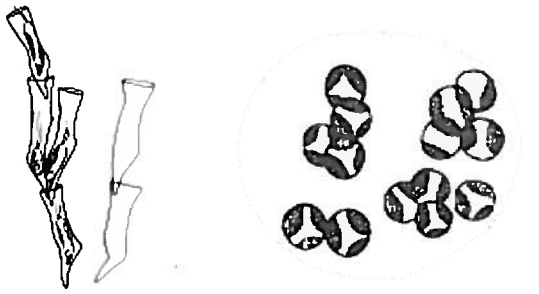


Illustrations obtained from: *How to Know the Freshwater Algae* by G.W. Prescott, 1978.

Diatom species can either be found as groups of cells (colonial) or solitary. Typical diatoms found in King County include *Cyclotella* species (solitary) and colonial varieties of *Fragilaria*, and *Asterionella* (Fig. 3). Some diatoms, such as several species of *Cyclotella*, have a reputation as indicators of clean water or oligotrophic conditions. Others, such as *Fragilaria*, are known to be more common in mesotrophic lakes.

Several other chrysophytes are quite common in lakes of our area. The colonial species *Dinobryon* does not make a frustule, but does make a thin protective covering shaped like a goblet or drinking glass, termed a "lorica." Individual cells connect to each other in a manner reminiscent of tree branching, and large colonies are more buoyant

Figure 4:
Other Chrysophyte Algae



Dinobryon *Gioeobotrys*

Illustrations obtained from: *How to Know the Freshwater Algae* by G.W. Prescott, 1978.

because of this shape, allowing *Dinobryon* to stay higher in the water column and persist through the summer in many lakes (Fig. 4).

Chlorophytes: Green Algae

Green algae produce chlorophyll as their predominant pigment, hence their bright green coloration. They are a large and varied group, with some characteristics closer to the vascular (higher) plants than found in other groups of algae, and therefore some authorities have considered some chlorophytes as evolutionary links to land plants. They can occur in lakes all year, but tend to reproduce and grow much better in warm temperatures and high light levels, thus they generally produce their biggest populations in summer.

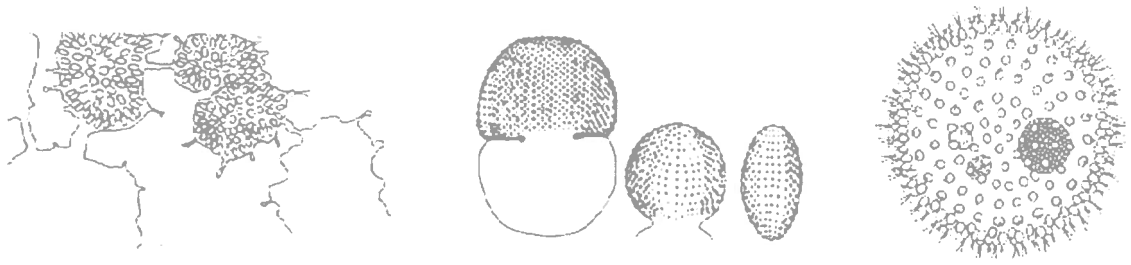
Green algae can be solitary or colonial, and both single cells and colonies can take many different shapes from spherical to elaborately geometrical to filamentous. Most of the filamentous green algae grow attached to surfaces rather than floating in the water. Some cells have the means to be mobile, having from one to four whip-like tails called "flagella," which they use to move through the water. Colonial balls of green algae, when each member cell has flagella, can move in characteristic tumbling, rolling motions through the water as all the flagella beat the water. Typical colonial greens found in area lakes include *Volvox* and a rather peculiar large colonial form called *Botryococcus*, which makes large amounts of oils that keep it buoyant through the season (Fig. 5). It often turns from green to bright orange as it gets old and dies off, in the same fashion as the changing color of leaves on deciduous trees.

Another specialized group of green algae, called the desmids, are often found in highly colored, acidic waters such as bogs and cool water wetlands. The desmids make a hard cell surface out of an organic material that can have an elaborate shape, ornamented with many spines and knobs. *Cosmarium* is one commonly found in King County lakes (Fig. 6).

Pyrrhophytes: the Dinoflagellates

The dinoflagellates are a group that has been characterized both as algae and protozoa because

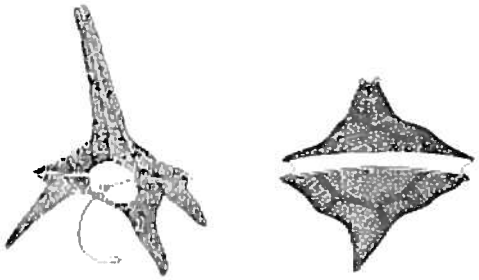
Figure 5: Common Chlorophyte Algae



Botryococcus *Cosmarium* *Volvox*

Illustrations obtained from: *How to Know the Freshwater Algae* by G.W. Prescott, 1978.

Figure 6: Common Dinoflagellates



Illustrations obtained from: *How to Know Freshwater Algae* by G.W. Prescott, 1978.

of their ability to move quickly through the water using two flagella. Their movements are vigorous, more characteristic of animals, but the dinoflagellates can also make food like plants. To confuse the issue, they can also ingest other foods as animals do.

Dinoflagellates are nearly always solitary and are common in marine water, where they are notorious for toxic blooms (red tides) that render shellfish poisonous for humans and other animals to eat. Freshwater dinoflagellates are mostly harmless to people, but can color the water red or brown on rare occasions. Large populations will generally occur in the summer, if at all, in King County. The most common forms seen are species of *Peridineum* and *Ceratium*.

Two Lesser Known Groups of Algae

There are two other groups of algae that have no common names, but which are found frequently in the lakes of King County.

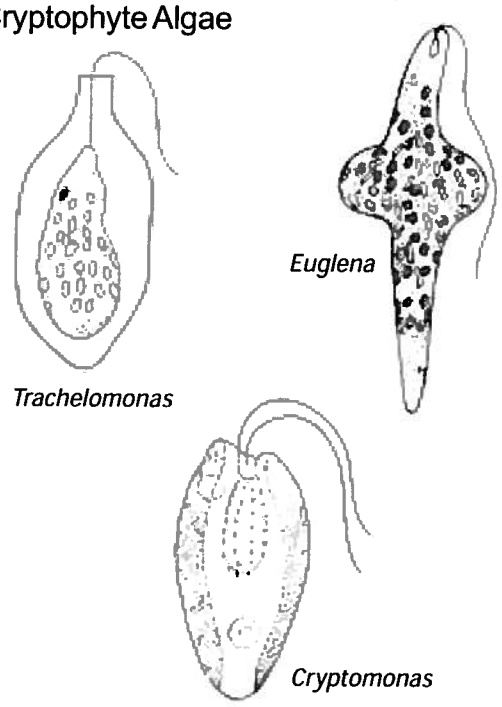
Euglenophytes

Euglena and its allies are often the first algae introduced to students in high school. Its large size and clear structure make it a good subject for beginning biologists to see through a microscope. These algae are always solitary, quite mobile, and generally are found in small bodies of water such as ponds and ditches rather than lakes. However, they have been found in several of the lakes in the Lake Stewardship Program, such as Jones and Paradise. Examples of common euglenoids include *Euglena* and the unusual *Trachelomonas*, which makes an organic shell often colored golden or brown (Fig. 7).

Cryptophytes

The cryptophytes are a group of solitary, mobile algae quite distinct from other groups, but with little variation among the species. They are generally small, solitary, and can move quickly using flagella. They are known as an excellent food source for many small planktonic animals. The amount present of these algal species can vary throughout the year, filling in quickly when other algal populations fail to thrive, but disappearing just as fast as the animals graze on them. *Cryptomonas* is a common inhabitant of lakes in King County (Fig. 7).

Figure 7: Common Euglenophyte and Cryptophyte Algae



Illustrations obtained from: *How to Know the Freshwater Algae* by G.W. Prescott, 1978.

Living with Wildlife

Canada Geese

Canada geese *(Branta canadensis)* are among the most familiar birds in Washington. They are a source of recreation for bird watchers and hunters and symbolize nature for many people. No one can miss the clear honking call of Canada geese when they fly overhead in their V-shaped formation.

Two groups of Canada geese populate Washington—migrating geese and nonmigrating (often called resident) geese. For a goose to migrate, it must be taught the flight path by its parents. Therefore, all following generations of nonmigratory Canada geese will also be nonmigratory, or resident geese, which will stay year-round in the vicinity where they were born.

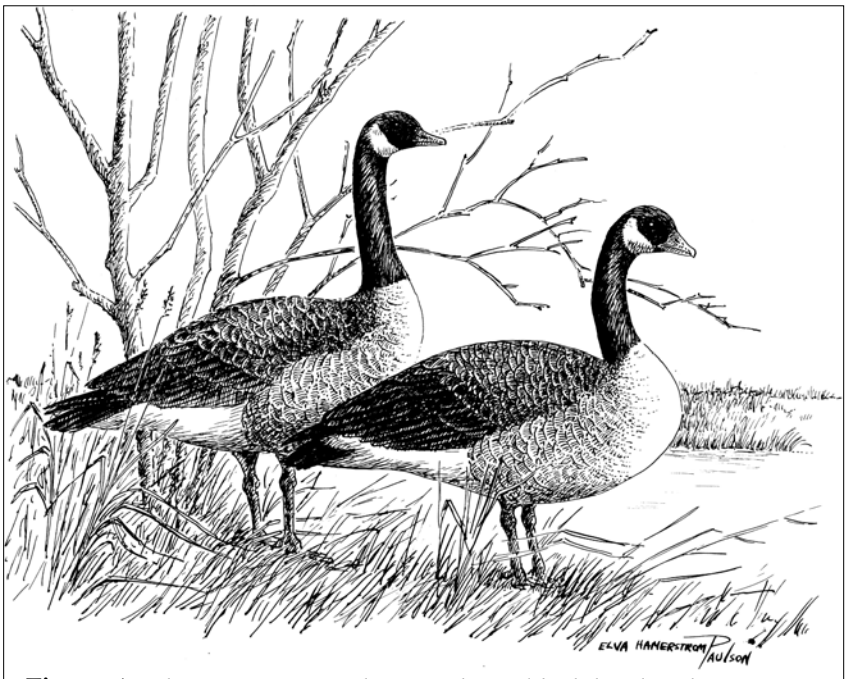


Figure 1. *The Western Canada goose has a black head and crown, a long black neck, and white cheek patches that connect under the chin. The adult gander (male) tends to be bigger than the goose (female) and averages 30 inches in length with a 60-inch wingspan.* *(Drawing by Elva Hamerstrom Paulson.)*

Populations of resident Canada geese have dramatically increased over the past 25 years, particularly in urban areas where there are few predators, prohibitions on hunting, and a dependable year-round supply of food and water.

Canada geese are particularly attracted to mowed lawns around homes, golf courses, parks, and similar areas next to open water. Because geese and people often occupy these spaces at the same time of the year, conflicts arise. Many citizens enjoy the presence of geese, but others do not.

Several subspecies of Canada geese breed or migrate through Washington. Their taxonomy has been confused by the introduction of mixed subspecies, and will likely remain unclear for a long time.

The **Western Canada goose** *(Branta canadensis moffitti,* Fig. 1) is the largest resident subspecies, referred to in the following as Canada geese, or geese.

Facts about Washington's Canada Geese

Food and Feeding Habits

- Canada geese graze while walking on land, and feed on submerged aquatic vegetation by reaching under the water with their long necks.
- Wild food plants include pondweed, bulrush, sedge, cattail, horsetail, clover, and grass; agricultural crops include alfalfa, corn, millet, rye, barley, oats, and wheat. Geese also eat some insects, snails, and tadpoles, probably incidentally.

Nests and Nest Sites

- Canada geese nest in areas that are surrounded by or close to water.
- Nest sites vary widely and include the shores of cattail and bulrush marshes, the bases of trees, the tops of muskrat lodges and haystacks, and unoccupied nests of eagles, herons, and ospreys. Nests have produced successful broods of geese and ospreys in the same year.
- Other nest sites include planter boxes and nesting structures provided specifically for geese.

- The nest is a bowl-shaped depression approximately 1½ feet in diameter lined with grass, leaves, and goose down.
- A pair of geese may return to the same nest site in consecutive years.

Figure 2. *The V-shaped flight formation allows each trailing bird to receive lift from the wingtip vortex of the bird in front of it, saving energy and greatly extending the range of a flock of birds over that of a bird flying alone.*
(Drawing by Jenifer Rees.)

Reproduction

- Canada geese usually begin nesting at three years of age.
- Adult pairs usually stay together for life unless one dies. Lone geese will find another mate, generally within the same breeding season.
- Between one and ten, but normally five to six eggs are laid in the nest in March, April, or May. Eggs are incubated by the goose (female) while the gander (male) stands guard nearby. The female leaves the nest only briefly each day to feed.
- Eggs hatch after 25 to 30 days of incubation. The young, called goslings, can walk, swim, and feed within 24 hours.
- Both parents (especially the gander) vigorously defend the goslings until they are able to fly, which is at about ten weeks. The young geese remain with their family group for about one year.
- If the nest or eggs are destroyed, geese often re-nest in or near the first nest. Canada geese can raise one clutch per year.

Longevity and Mortality

- Predators of Canada geese and their eggs include humans, coyotes, raccoons, skunks, bobcats, and foxes, as well as gulls, eagles, crows, ravens, and magpies.
- Canada geese hatched in urban environments may have very low first-year mortalities due to the abundance of food and relative scarcity of natural predators.
- Canada geese can live more than 20 years in captivity; in the wild they have a much shorter life span.

Viewing Canada Geese

Geese are among the few water birds that will tolerate the environmental conditions found in urban areas. They are often the largest and most conspicuous bird species that people see.

Geese are often seen in a V-shaped formation when flying (Fig. 2). Such a formation allows each trailing bird to receive lift from the wingtip vortex of the bird in front of it, saving energy and greatly extending the range of a flock of birds over that of a bird flying alone. Scientists have suggested that flying in V-formation may also be a way of maintaining visual contact and avoiding collisions.

Molting

Like most waterfowl, adult Canada geese go through a complete molt every year. Molting is an opportunity for geese to replace their worn, frayed, or lost feathers with new ones. The molt takes 30 to 45 days and is completed by mid-July, a time when the adult geese are free from activities such as nesting, brood rearing, and migrating.

The young are still with the adults during the molt, and at this stage none of the family can fly—the young because they haven't grown their full flight feathers and the adults because they are replacing their flight feathers. Thus, the birds often move to areas that provide adjacent water for escape opportunities.

By late summer all of the family can fly, and they move to areas where there is abundant food, joining with other geese to form large flocks.

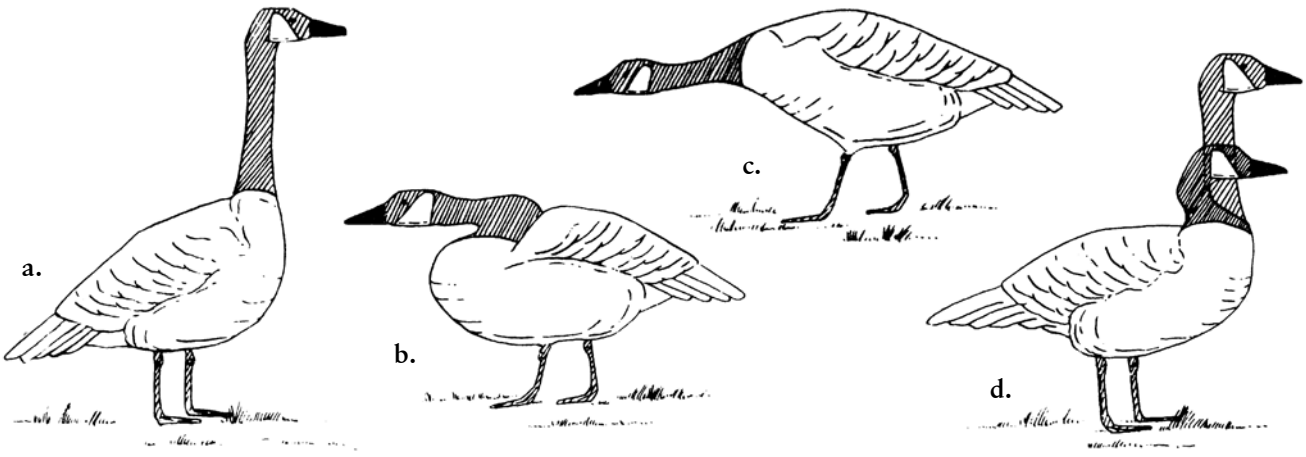


Figure 3. *Some common displays of Canada geese.* (From Stokes, *A Guide to Bird Behavior, Volume 1.*)

Displays

Visit nearly any body of water in a nearby park (especially during the breeding period) and you will likely observe several obvious visual displays within a large active flock (Fig. 3).

The **alert display (a)** is given when a goose is wary of some danger. The neck is vertical and straight and the head is horizontal.

The **bent-neck display (b)** is given in conflict situations with other geese. The neck is coiled back and the head is lowered and pointed toward the opponent. This display may be accompanied by a hiss.

The **head-forward display (c)** usually follows the bent-neck display and is an expression of increased threat. The goose extends its neck and holds the head low and points it toward the opponent. This display may be accompanied by a call.

The **head-pumping display (d)** is also given in conflict situations, and often precedes direct attack. The goose rapidly lowers and raises its head in a vertical pumping motion.

Nest Sites

Early in the breeding season, watch for a pair of geese quietly exploring an area. Later, listen for the honking call, which may be geese either greeting each other or engaging in a territorial squabble. Also, look for a lone male, feeding or resting, who is aggressive toward other geese or to you. Chances are its mate is on a nest nearby.

Because Canada geese are aggressive defenders of their nests and young, do not approach too closely; they may charge, and can inflict bruises with their beaks and wings.

Calls

The typical goose *ahonk, ahonk, ahonk* call is given during aggressive encounters, as a greeting, and when calling a mate. The call of the male is thought to be lower than that of the female, and when a pair flies overhead, you may be able to distinguish the two sounds.

A hiss-call is given when geese are defending their territories, their nests, or their young, and is usually given only at close distances.

Tracks

Canada goose tracks are often seen on mudflats in conjunction with their sausage-shaped droppings. Their feet turn inward when they're walking. The foot's three main toes fan out in front and are connected by webs (Fig. 4). The claws are broad and blunt, and their imprint can usually be seen.

Figure 4. *The Canada goose has four toes, but the hind toe is elevated and does not leave an imprint.* *(Drawing by Kim A. Cabrera.)*

Droppings

Droppings are cylindrical and five to eight times longer than wide. Fresh droppings are greenish and coated with white nitrogenous deposits. Older droppings are darker.

Because geese have a rudimentary digestive system, they eat often and expel undigested remains in short order. Adult geese produce 1 to 3 pounds of droppings per day per bird.

Preventing Conflicts

Canada geese are extremely adaptable. They use food and other resources present in urban landscapes for nesting, raising young, molting, feeding, and resting. This has led to increasing conflicts between geese and people.

In parks and shorelines with short grass, large flocks of geese can denude areas of vegetation and litter them with their droppings and feathers. Public swimming areas used by many geese have been closed to swimming (see "Public Health Concerns"). When nesting, geese can be aggressive toward humans, and may "attack" people who come near their nests or young.

In public areas with favorable habitat, it is rarely desirable, or possible, to eliminate geese entirely. Ideally, management programs should strive to reduce goose numbers and related problems to a level that a community can tolerate.

No single, quick-fix solution is likely to solve conflicts with geese. An integrated approach using several of the techniques described below in combination is required. Any approach to controlling geese ideally should be in place before the conflict starts—or quickly thereafter—as it is much more difficult to discourage geese after they have become attached to a site. After nesting has started, moving or scaring geese off a nest is illegal.

To prevent conflicts or remedy existing problems:

Stop feeding geese: When the diets of geese are no longer supplemented with handouts and they have to depend on the natural food supply, some or all the geese will move elsewhere.

In public areas, it is helpful to first install interpretive signs explaining the problems caused by feeding geese. Such signs might include the following in their text, preferably in the appropriate languages:

- Please don't feed the geese!
- Human food is not good for the geese because it lacks proper nutritional value.
- Feeding attracts more geese than the area can support naturally.
- Geese in high concentrations are more likely to get diseases and parasites.
- Geese droppings harbor parasites that can cause human health problems.
- Goose droppings increase algae growth that, in turn, results in fish kills.
- Goose droppings are unsanitary, unsightly, and contain parasites irritating to humans.
- Geese eat plants needed for ground cover and erosion control.
- Too many geese in one area may force the municipality to have them killed.
- Goose-management costs taxpayers money.

In order to prevent well-intentioned people from feeding geese, some localities may need to pass ordinances to regulate feeding and create authority to enforce such regulations.

Lawn management: Evolutionarily, Canada geese are tundra nesters that prefer to congregate on low vegetation adjacent to open water. Thus, areas of lawn next to water often attract geese. Large lawns provide food to graze on, room to take off and land, and an unobstructed sight line to scan for potential predators.

Although it can be expensive to transform a large lawn into something else—such as a play area or a landscape made up of plantings other than grass—it is the best long-term solution to human/goose conflicts. Such a transformation can occur over time and in phases; fencing or repellents may be necessary while the new landscape is getting established.

One important modification to a large area of lawn is to reduce its size to the point where geese no longer feel safe grazing on it. An open sight line (the distance from the geese to a place where a predator could hide) of less than 30 feet will generally cause geese to move to a more comfortable grazing area.

Any size lawn can be made less attractive to geese by increasing its growth height to 6 inches and reducing the number of tender new shoots it produces. Stopping fertilizing and watering will reduce both the palatability of the lawn and the time it takes to maintain it. (The grass can be maintained at any height with a weed-whacker.) All of the lawn—or only a wide portion bordering a body of water—can be maintained this way.

Barriers

Barriers are most effective when geese numbers are low, when geese are molting (not flying), and when the barrier is in place before geese begin using the area.

Low barriers may not deter flying geese from entering an area. However, since geese typically do not land in an area that is less than 30 feet wide, barriers, or lines of vegetation, can be used to break a site into smaller spaces. Low barriers can be combined with above-ground grids to prevent flying geese from accessing planted areas.

Plant Barriers

Geese have a fear of confinement you can take advantage of by the way you landscape. Shrubs, aquatic plants, and closely spaced groups of trees can be used to discourage geese if they block the birds' pathways to grazing areas and safety, and reduce the birds' sight lines to 30 feet.

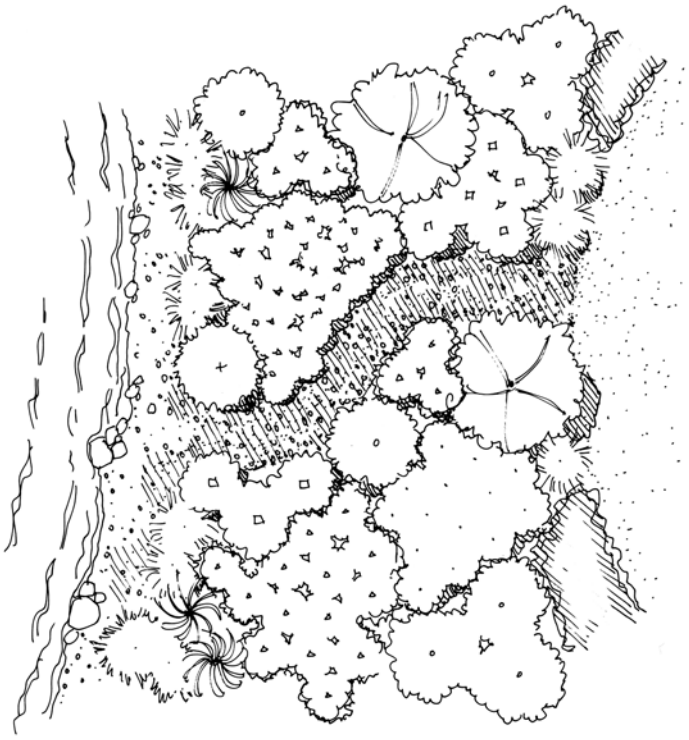


Figure 5. *Plants should be planted densely or in a staggered pattern to prevent geese from viewing a passage through the planting. Wind paths through plantings to allow access for people, but not geese.*

(Drawing by Jenifer Rees.)

For immediate results, plants should be at least 30 inches tall to prevent geese from seeing over them, and planted densely or in a staggered pattern to prevent geese from walking through gaps between the plants. Wide plantings (20 to 30 feet) are more effective than narrow plantings. In wide plantings, winding footpaths prevent the geese from having a direct line of sight through the planted area, yet still provide shoreline access for humans (Fig. 5).

Keep New Plantings in the Ground

Newly planted sites often suffer high plant mortality due to geese pulling small plants out of the ground. If still migrating, these geese would ordinarily arrive later and there would not be such pressure on the plants. To reduce this problem, or where barriers and other control tactics are not practical:

- Place large stones around the crowns of plants.
- Insert a metal staple (used to secure jute netting) over the crown of individual plants.
- Place long lengths of wood lath over the crowns of plants planted in a row. Secure the lath with metal staples or rocks.
- The above-mentioned devices will need to stay in place for two growing seasons—longer in areas where emergent plants are being established, or where there is a lot of pressure from resident geese.
- Another approach is to use large plant material (1-gallon containers instead of 4-inch pots or plugs). The larger root ball will have a better chance of getting established during the first few growing seasons.
- Drape bird netting over groups of new plantings; check netting daily for entangled birds.

Where space is limited, one or two rows of shrub plantings can be combined with a fence, as described below. Ideally, the fence should be installed first and the shrubs planted as closely as possible to it so that as the shrubs grow, they envelope the fence.

Geese often gain access to grazing areas by simply walking out onshore from the adjacent body of water on which they have landed. Therefore, introducing a barrier of aquatic plants along the shoreline of a water body can create both a physical and a visual barrier to geese. Barriers of native aquatic vegetation that are at least 3 feet wide and include tall material, such as bulrush *(Scirpus* spp.), are most effective (Fig. 5).

If the limiting factor is the absence of an area on which to establish the new aquatic planting, constructing such an area can help. In man-made water bodies, cutting and filling can achieve a stable substrate on which to plant a barrier of aquatic plants. The water level of the pond, or other impoundment, can be temporality lowered to allow construction of the planting area. However, along natural water bodies, construction of a planting area can be more problematic—water levels may not easily manipulated, placing fill in deeper water is more likely to create unstable, slump-prone areas, and a permit may be required (contact you local wildlife office for permit information).

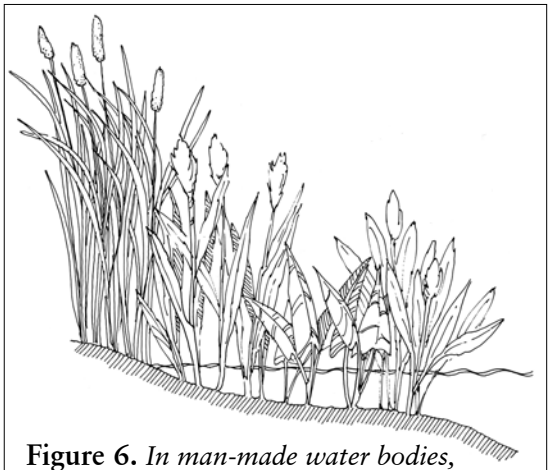


Figure 6. *In man-made water bodies, cutting and filling can provide a stable substrate on which to plant a barrier of aquatic plants. The water level of the pond, or other impoundment, can be temporarily lowered to allow construction of the planting area.*

(Drawings by Jenifer Rees.)

Fences

Fences can be made from woven wire, poultry netting, plastic netting, plastic snow fencing, monofilament line, or electrified wire. Fences should be at least 24 inches tall (3 feet may be better), firmly constructed, and installed to prevent the geese from walking around the ends.

Regardless of the material, lower openings should be no larger than 4 inches to prevent goslings from walking under or through the fence. Thus, a fence made from five monofilament lines (at least 20-pound test) should have lines set at 4, 8, 12, 18, and 24 inches above ground.

Fences used in areas with tidal influence need to prevent geese entering the shore at all tide levels while not trapping fish. Turning field fencing upside down—moving the wider holes to the bottom—may accommodate fish passage.

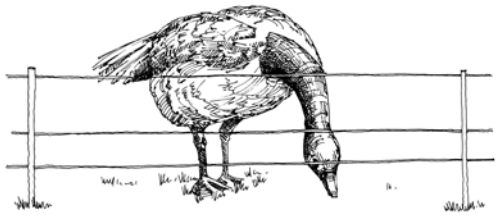


Figure 7. *A low electric fence may be a temporary solution when geese have young or are molting. Flag the lines to warn people, and expect pets and wildlife to knock them away.*

(Drawing by Jenifer Rees.)

Many electric fences are portable and can be set up in one or two hours and quickly taken down for storage when not in use (Fig. 7). The strands only need to be placed 4, 8, and 12 inches above the ground.

Due to the variables affecting your selection of a power source, and fence design and operation, it is best to consult a reputable dealer for the specifics regarding its use (look under "Fence Contractors" in your phone directory). Information is also available from farm supply centers. Most home improvement centers carry suitable units. Consult your local zoning office and neighborhood covenants to determine if electric fences are permitted where you live.

Grids and Netted Rooms

A grid or network of multiple parallel lines of wire, stainless-steel cable, twine, rope, or monofilament (50 pound test) stretched 1 to 2 feet above a water body or other area will create a flight hazard and deter geese. There should be no more than 5 feet of space between lines. If humans need to access the area under the grid, the grid can be installed high enough to accommodate them. To prevent geese from walking under the grid, install a perimeter fence as described earlier.

Attach separate lines to each vertical support (do not run the same length of wire through the entire grid) so that you will not have to rebuild the entire grid should one line break. Wherever two grid wires cross, tie the lines together to prevent rubbing and possible line breakage.

In places with large numbers of geese, and where funding is available, newly planted areas can be entirely enclosed in netting for the first few growing seasons. A netted room built high enough to allow access for maintenance can be constructed using wooden vertical supports sunk in the ground, horizontal steel cable supports, and heavy-duty bird netting. Such netting is commercially available from companies that specialize in bird control. Previously used bird netting may be available from habitat restoration companies, as well as used gill netting from fisherman and fish hatcheries. The cost of new netting makes seeking out an alternative worthwhile.

Where long runs of steel cable are being installed to support netting, each line should get a separate length of cable, fitted at one end with an eyebolt, and at the other end with a turnbuckle. This will allow the cable tension to be adjusted or the cable to be removed if needed. The netting can be attached to the cable with nylon string, wire, or hog rings. Hog rings and a special tool to attach the rings are recommended for large projects.

Note: All grids, netting, and fencing material should be regularly monitored for holes, trapped wildlife, sagging, and overall effectiveness.

Harassment and Scare Tactics

Harassment and scare tactics are used to frighten Canada geese away from feeding, loafing, and resting areas where they are unwanted. Because geese learn that real physical danger isn't associated with harassment and scare devices, the birds will quickly learn to ignore them, no matter how effective these devices may be initially. Because of this, and to take advantage of geese being neophobic (fearful of novel objects), two important rules are: (1) never rely solely on one tactic, and (2) vary the use by altering the timing and location. Harassment and frightening devices are only as effective as the person deploying them.

Harassment and scare devices are available from the Internet, at over-the-counter bird-control businesses, and at some farm and garden centers.

Harassment and scare tactics include:

Eyespot Balloons

Like most birds, geese rely more on vision than on their other senses to avoid danger, and so visual stimuli can be effective. Commercially available eyespot balloons are large, helium-filled balloons with a large, eye-like images. (Large colored spots on three sides of any helium balloon can suggest eyes.) Tether balloons on a 20- to 40-foot monofilament line attached to a stake or heavy object. The balloons should be located where the wind will not tangle them in trees and utility lines, and should be repositioned at least once per day. Two balloons should be adequate for an average size yard.

Flags and Streamers

Flags and streamers work best in areas where there is a steady wind. A simple flag design uses plastic garbage bags mounted on tall poles (Fig. 8).

In addition, mylar tape can be made into 6-foot streamers and attached to the top of 8 foot long poles. Mylar tape is silver on one side, usually red on the other, and is very shiny and reflective.

A disadvantage of Mylar tape is that it is only effective in bright sunlight and wind. Poles with flags and streamers should be repositioned once per day.

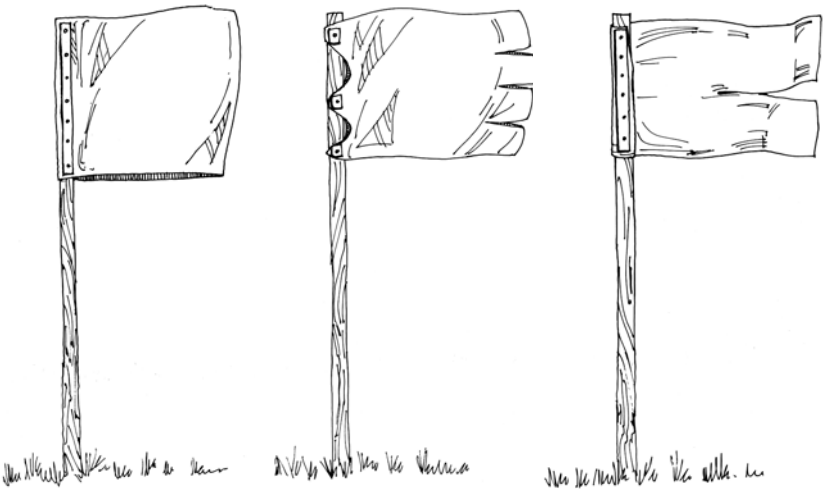


Figure 8. *Flag designs using a large plastic garbage bag on a pole. Note the wooden battens installed to prevent the flags from ripping.*

(Drawings by Jenifer Rees.)

Scarecrows

Scarecrows are only effective where geese view humans as dangerous predators, such as rural areas where they are hunted. Scarecrows can be made out of almost any

material; however, the design should include movement, bright colors (red, blaze orange, or safety yellow), and large eyes. For maximum effect, the arms and legs should move in the wind, and the scarecrow should be moved once per day.

Geese occasionally will find a swimming pool an acceptable area. Large, blow-up toy snakes are reported to work as a type of scarecrow. Simply buy two or three of these, add weights (sinkers), and put them in the pool. Streamers made of mylar tape may also work if strung across the landing zone.

Noisemaking Devices

Devices that make a loud bang can scare geese, causing them to take flight. Promptness (beginning as soon after the geese arrive as possible) and persistence are the keys to success when using these devices.

Types of noisemakers include propane cannons, blanks, and whistle bombs. Propane cannons are stationary devices that explode propane gas at irregular intervals. Shell crackers and whistle bombs are shells that are fired from a shotgun or special pistol. When fired they either scream for a distance of 50 yards, or explode. Pyrotechnics should only be used by skilled individuals who understand the dangers that these tools can pose.

Loud auditory tactics generally require permits from area police departments and may be restricted in urban areas because of noise ordinances. When such devices are used, it is important that all organizations involved in the process be kept in communication. In addition, the surrounding neighborhood should be advised of what the process is trying to accomplish.

The more geese are exposed to these fear-provoking stimuli, the faster they will become accustomed to them and ignore them. For this reason, noisemakers should be used sparingly, and propane cannons should be set so that they fire only a couple of times per hour.

Lasers

Recent research conducted by the National Wildlife Research Center indicates that relatively low-power, long-wavelength lasers provide an effective means of dispersing geese, gulls, crows, and ravens under low light conditions, while presenting no threat to the animal or the environment. The lower power levels, directivity, accuracy over distance, and silence of laser devices make them safe and effective species-specific alternatives to noisemaking devices.

Although researchers are not sure if birds see the same red spot as people, it is clear that in certain bird species the spot of laser light elicits an avoidance response. The birds view the light as a physical object or predator coming toward them and generally fly away to escape. ***Note:*** Lasers should never be aimed in the direction of people, roads, or aircraft.

At the time of writing, the cost of a laser device is still quite high. Check with dealers through the Internet and over the counter at bird-control businesses for current prices and instructions for use.

Dogs

When directed by a handler, dogs are the method of choice for large open areas such as golf courses, airports, parks, agricultural fields, and corporate parks. In residential areas, parks with continuous public use, areas bisected by roadways, and large water bodies, dog use may not be appropriate.

Results are often immediate. After an aggressive initial use (several times a day for one or two weeks), geese get tired of being harassed and will use adjacent areas instead.

A dog can be tethered to a long lead (which may require relocating the dog and tether frequently to cover more area), be allowed to chase and retrieve a decoy thrown over a large flock of geese, or be periodically released to chase the birds (if this is not against leash laws).

While the wolflike gaze of border collies is frightening to geese, these dogs rarely harm them. These dogs can be purchased already trained, or be trained; however, it is also possible to hire a border collie "service."

Other breeds of dogs can also do the job. It is recommended that they be from proven working stock, preferably with prior experience with or exposure to live animals, particularly birds.

Chemical Repellents

Taste-aversion products and other chemical repellents are unobtrusive, may be applied directly to the problem area, and will not permanently harm the geese. Drawbacks to repellents include the high costs of covering large

areas, the need for frequent application in rainy areas and during the growing season, odors associated with the few registered products, and their negative influence on the behavior of other wildlife.

If geese have used the area in the past, apply repellent before their return. Carefully read and follow all label and technical directions.

Lethal Control

If the above nonlethal control efforts are unsuccessful and the damage situation persists, lethal control may be an option. Lethal control techniques include legal hunting, shooting out of season by permit, egg destruction by permit, and euthanasia of adults by government officials.

Public Health Concerns

Canada geese are not considered to be a significant source of any infectious disease transmittable to humans or domestic animals, although their droppings are increasingly cited as a cause for concern in controlling water quality in municipal lakes and ponds.

Swimmers itch *(schistosome* or *cercarial dermatitis)* is caused by a parasite that can be spread by goose droppings, but does not mature or reproduce in humans. Recommendations to reduce the risk of swimmers itch are to: (1) vigorously towel off immediately upon exiting the water (including under bathing suits), and (2) take a soapy shower immediately after exiting the water.

If you do get the itch, a topical rash cream should alleviate some of the itching, and the rash should clear up within a week. If you have concerns or questions, contact a physician.

Legal Status

Canada geese are protected under federal and state law and a hunting license and open season are required to hunt them. Where lethal control of Canada geese is necessary outside of hunting seasons, it should be carried out only after the above nonlethal control techniques have proven unsuccessful and only under permits issued by the U.S. Fish and Wildlife Service. Currently, the only agency permitted for lethal removal is the U.S. Department of Agriculture's Wildlife Services.

Additional Information

Internet Resources

Centers for Disease Control and Prevention: www.cdc.gov/

Habitat Modification and Canada Geese: Techniques for mitigating human/goose conflict in urban and suburban environments: www.canadageese.org/nlcontrol.html

Prevention and Control of Wildlife Damage: wildlifedamage.unl.edu/handbook/handbook/

Seattle Audubon's Birds of Washington State: www.birdweb.org/birdweb/

Wildlife Control Supplies: www.wildlifecontrolsupplies.com/

Adapted from “Living with Wildlife in the Pacific Northwest” (see http://wdfw.wa.gov/wlm/living.htm)

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Illustrations: As credited

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Washington Department of FISH and WILDLIFE

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Aquatic Weeds

WATER WEEDS

Guide to Aquatic Weeds in King County

King County
Department of Natural Resources and Parks
Water and Land Resources Division
Noxious Weed Control Program
206-477-9333 TTY Relay:711

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Cover photos:
Brazilian elodea on boat motor (*center*)
Floating primrose-willow (*top right*)
Purple loosestrife (*lower right*)
Parrotfeather (*line drawing, lower left*)

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INTRODUCTION

WEED IDENTIFICATION PAGES

EMERGENT

FLOATING MAT

FLOATING LEAF

SUBMERGED

To see the complete King County noxious weed list, visit **www.kingcounty.gov/weeds**

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This information is available in alternate formats.
Call 206-477-9333 or TTY: 711

Printed on recycled paper. Please recycle.

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What are aquatic plants?

Plants that grow in water are called aquatic plants. They grow in a variety of forms. Emergent plants are rooted in the soil and grow along shorelines, floating plants grow in shallow to deep water and either have floating leaves or form floating mats on the surface of the water, and submerged plants grow mostly under water. Many native aquatic plants grow in Washington, and they are very beneficial to the environment and generally do not cause significant problems. These native aquatic plants developed in the area naturally and usually are kept in check by natural controls such as herbivores, insects and other plants. Native aquatic plants provide food and habitat for fish, birds, and other wildlife. They protect shorelines from erosion and often clean pollution from the water.

What are aquatic noxious weeds?

When aquatic plants are introduced to a new area without the natural checks and balances of their home waters, they can sometimes grow out of control, creating dense monocultures and overwhelming lakes and streams. This guide describes some of these invasive, non-native aquatic plants that have been introduced to Washington's water bodies (accidentally or as garden plants). They are all highly aggressive and create significant ecological and economic damage when they are not controlled. These invasive, non-native aquatic plants are called noxious weeds when they are identified by the Washington State Noxious Weed Board as having a significant negative impact on the state's natural and economic resources.

Impacts of invasive aquatic weeds:

- loss of native plants
- disruption of fish and wildlife habitat
- damage to commercial and sport fishing
- reduced recreational activities like boating and swimming
- clogged irrigation and drinking water structures
- decreased water quality

How to use this guide

This guide describes 21 aquatic noxious weeds on the Washington State Noxious Weed List to look out for in King County. The weeds are grouped by growth form: **emergent**, **floating mat**, **floating leaves**, and **submerged**. Many of the weeds in this guide are already widespread in King County, but some of them have only been found in a few locations or only in nearby counties. The guide does not include any native aquatic plants, some of which closely resemble these weeds. If you find a plant that looks like one of the weeds in this guide, we suggest you consult the more detailed references listed at the back of this guide or ask an expert for help with getting a positive identification.

What can we do about aquatic noxious weeds?

Everyone can help prevent new introductions by cleaning boats, trailers and other equipment, by never dumping aquariums into lakes and creeks, and by not planting invasive aquatic plants. Also, early detection of an invasive aquatic weed greatly increases the opportunity for preventing damage. If you find an aquatic noxious weed in a new area, it is important that the responsible agency or landowner is alerted as soon as possible, while there is still a chance to stop its spread. Even when invasive weeds are already widely established in a water body, it is still possible to reduce their impact and contain their spread. For instance, it can help to remove seed heads before they mature or to contain the weed by controlling new satellite populations.

What should I do if I find an aquatic noxious weed?

Mark the location of the plant with a weighted buoy if it's in the water, or a flagged stake if it's on the shore, and carefully collect a specimen including stems, leaves and any flowers or seed pods. Place the specimen in a sealed container with water and store in a cool, dark place. Contact the King County Noxious Weed Control Program at **206-477-9333** to make arrangements for getting the specimen identified. If this is not possible, contact the weed program and we can help determine if a site visit is needed to identify the plant.

What does the State Noxious Weed Law require when it comes to aquatic noxious weeds?

Washington's noxious weed law (RCW 17.10) requires property owners to control and stop the spread of designated noxious weeds on their property, including both aquatic and non-aquatic noxious weeds. The law applies equally to private and public property. However, this requirement does not include noxious weeds that are widespread in the state or the county, but only those weeds that the state weed board believes there is still an opportunity to eradicate from all or part of the state. The noxious weeds are classified by distribution: Class A weeds are the highest priority statewide because they are highly limited in distribution, Class B weeds have a split distribution and control is required only where they are not already widespread, and Class C weeds are the most widespread and their control is typically not required, although recommended where possible.

How do I know which weeds have to be controlled?

The King County and Washington State noxious weed lists are available online at **www.kingcounty.gov/weeds** or by contacting the King County Noxious Weed Control Program at **206-477-9333**. In this guide, the weed classification and any control requirement is provided for each weed described.

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How do I find out more about permit requirements for aquatic weed control?

Since aquatic plants are by definition growing in an easily disturbed, sensitive environment, any work done to remove them is regulated by state and local laws. In order to do any noxious weed removal in water, you need at minimum a pamphlet Hydraulic Project Approval (HPA) permit from the Washington Department of Fish and Wildlife, which is available free of charge from this Web site: **http://wdfw.wa.gov/licensing/aquatic_plant_removal/**, or by calling **360-902-2534**. Other permits from state and local agencies may be required for work involving bottom barriers, mechanical equipment or herbicides. Rules regarding aquatic herbicide use are administered by the Washington Department of Ecology and the Washington Department of Agriculture. For assistance, contact the King County Noxious Weed Control Program at **206-477-9333** or **noxious.weeds@kingcounty.gov**, the Washington State Department of Regulatory Assistance at **800-917-0043** or **assistance@ora.wa.gov**, and/or your local city government permitting office.

What help does the county provide for aquatic noxious weed control?

The King County Noxious Weed Control Program is available to provide information and advice on identification and control methods for aquatic weeds and to guide property owners through the complex permit regulations that exist when working in aquatic environments. In addition, because of the challenges involved with controlling aquatic weeds, the noxious weed program will help landowners find out about additional resources and may be able to provide direct assistance in some cases for the highest priority aquatic weeds. Call the program for more information at **206-477-9333** or email us at **noxious.weeds@kingcounty.gov**.

Common Reed
Phragmites australis

Identification: 12 foot tall clone-forming grass with large feathery flower head and stiff blue-green leaves. Easiest to recognize when it reaches full height in July.

Impacts: Dense, tall growth excludes all other vegetation, dramatically reducing habitat value of shorelines and access to water.

Habitat: Freshwater and brackish wetlands and river corridors. There is a large infestation along the Duwamish River in Seattle, with smaller infestations in a few other spots, including along the Sammamish River and in Union Bay.

Control: Not realistic to control by hand due to six foot deep rhizome mass. Prevent seed production by cutting before seeds mature. A licensed aquatic herbicide applicator can spray actively growing plants with a systemic non-selective aquatic herbicide. Most effective when flowers are first forming.

Look-alikes: Pampas grass is also tall with feathery plumes, but doesn't grow in wetlands and forms clumps rather than large clones. Reed canarygrass is similar but not as tall, more yellow-green in color, and lacks the feathery plumes.

Legal Status: Class B, control required in King County.

Cordgrasses
Spartina alterniflora, S. anglica, S. densiflora, S. patens

Identification: These four grasses begin by forming circular patches at the upper edge of tidelands and then spread out to create dense single-species stands covering the mudflats. All cordgrasses have fringed ligules (found at base of leaf where it attaches to stem).

Impacts: Species of spartina can drastically change the nature of Pacific Northwest tidelands, obliterating mudflats that are critical for oysters and other shellfish as well as important habitat for migratory birds.

Habitat: Mudflats, saltwater marshes and estuaries. Common cordgrass (*Spartina anglica*) was found on Vashon Island beaches several years ago but appears to be eradicated. Look for cordgrasses on beaches around Puget Sound.

Control: Pull seedlings and dig out small clumps, removing all the roots and rhizomes. For larger infestations, contact the King County Noxious Weed Control Program. Herbicide should only be applied by a licensed aquatic herbicide applicator.

Look-alikes: Other beach grasses. The Spartina species are the only salt-tolerant grasses that have a ligule-like a fringe of hairs.

Legal Status: Class A, eradication required in King County.

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Flowering Rush
Butomus umbellatus

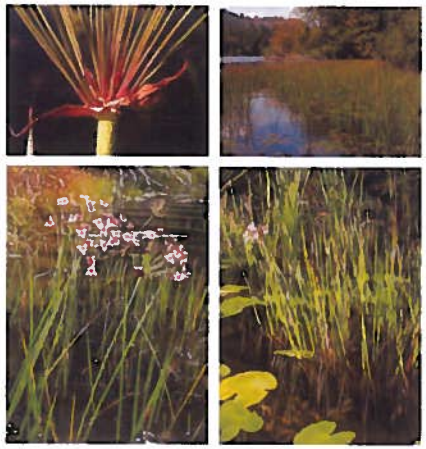
Identification: Emergent form has stiff leaves up to six feet tall that are triangular in cross-section and twist at the tips; submerged form has long ribbon-like, limp leaves that float on the water's surface. Distinctive light pink flowers in umbrella-like clusters atop round stalks. Only blooms sporadically and is difficult to identify without flowers. Blooms June through August.

Impacts: Crowds out native wetland and shoreline vegetation. Interferes with boat propellers, swimming and fishing.

Habitat: Freshwater lakes, ditches, sloughs and wetlands. Emergent in saturated soil or shallow water, and submerged in water up to nine feet deep. Not known to be in King County.

Control: Carefully dig small infestations, making sure to remove all plant parts (spreads vegetatively). Herbicide should only be applied by a licensed aquatic herbicide applicator. If you think you have flowering rush, contact the King County Noxious Weed Control Program for verification.

Look-alikes: Several native aquatic plants have ribbon-like underwater leaves, including species of bur-reed (*Sparganium spp.*), water-plantain (*Alisma spp.*) and arrowhead or duck-potato (*Sagittaria spp.*) Sedge species (*Carex spp. or Scirpus spp.*) and giant bur-reed (*Sparganium eurycarpum*) may have leaves that are triangular in cross-section.



All photos by Ben Legler

Legal Status: Class A, eradication required in King County.

Garden Loosestrife
Lysimachia vulgaris

Identification: Tall perennial wetland plant with showy bunches of five-petalled yellow flowers. Leaves often in whorls of three and usually have tiny black or orange dots on the underside visible with magnification. Blooms mid July through August. Difficult to spot when not in bloom.

Impacts: Very aggressive plant outcompetes even hardy natives such as cattails. Crowds out native plants, has little habitat value for native animals and fills in shallow waterways.

Habitat: Wetlands, stream and river corridors, lake margins, ditches, in shallow water or saturated soil. On Lake Washington, Lake Sammamish, Lake Burien, the Sammamish, Snoqualmie and Raging Rivers, and some associated wetlands. Not known elsewhere in King County.

Control: Very difficult to control by hand. At minimum cut the plants at base to prevent seed formation. Dig up small infestations, try to get all the roots. Herbicide should only be applied by a licensed aquatic herbicide applicator unless the plants are growing away from the water. Discard plants in garbage, not yard waste.

Look-alikes: Similar looking garden ornamental *Lysimachia punctata* has flowers in leaf axils.

Legal Status: Class B, control required in King County.

Hairy Willowherb
Epilobium hirsutum

Identification: Tall, wetland-dwelling relative of the native plant fireweed. Showy magenta flowers and long skinny seed-pods that burst open to release fluffy white seeds. Stems and leaves covered with soft hairs. Flowers have four notched petals and a white center. Leaves opposite, lance-shaped and toothed along the edges. Rhizomes thick and spreading. Flowers in July and August.

Impacts: Pushes out native wetland plants, can grow densely enough to impede water flow, spreads easily to undisturbed wetlands.

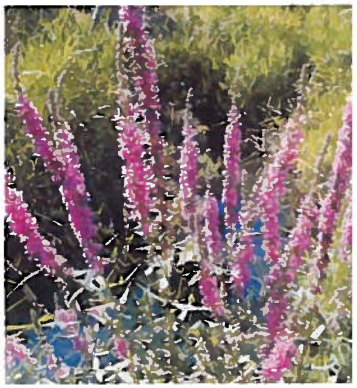
Habitat: Places with wet or moist soil, including pastures, meadows, wetlands, streambanks and lakeshores. Can also spread into drier areas.

Control: Dig out small infestations, being careful to get all the roots. Mature plants can be cut off at the base to prevent seed production. Mowing does not work and may spread the infestation. Herbicide should only be applied by a licensed aquatic herbicide applicator unless the plants are growing away from the water. Discard plants in garbage, not yard waste.

Look-alikes: Native fireweed (*Epilobium angustifolium*) is not hairy. Purple loosestrife (*Lythrum salicaria*) is found in the same habitats, but has a square stem, smooth-edged leaves and flowers with five petals.

Legal Status: Class B, control required in King County.

Purple Loosestrife
Lythrum salicaria



Identification: Tall perennial wetland plant with showy, compact spikes of magenta flowers. Stem is square and leaves are opposite, smooth edged and narrow. Blooms mid-July through August.

Impacts: Has up to 2.5 million seeds per plant and also spreads by rhizomes. Outcompetes native plants and provides little habitat for native animals.

Habitat: Wetlands, streams, lakeshores and wet pastures. Fairly widespread in King County.

Control: Dig or pull plants in soft soil or cut plants at base to prevent seed formation. Herbicide should only be applied by a licensed aquatic herbicide applicator unless the plants are growing away from the water. Always throw this plant in the trash, never in compost or yard waste.

Look-alikes: Hardhack (*Spiraea douglasii*) is a native woody shrub with spikes of fuzzy pink flowers and wider, alternate leaves. Fireweed (*Epilobium angustifolium*) is a tall upland native perennial with more open spikes of flowers and alternate leaves. Plants in the mint family have square stems, but the leaves are usually toothed.

Legal Status: Class B, control required in King County.

Reed Canarygrass
Phalaris arundinacea

Identification: Bright green wetland grass up to six feet tall. Leaves stick out at a wide angle from the stem (like corn) and have a large ligule (thin membrane on stem where the leaf attaches), Flower spikes held high above leaves on tall stems. Forms large, dense stands. Can be found year round.

Impacts: Highly invasive grass. Clogs streams and ditches, destroys wetland restoration sites, degrades wildlife habitat.

Habitat: Wet pastures, ditches, wetlands and shorelines. Common and widespread.

Control: The best long-term control is to shade it out, since it does not do well without full sun. Mowing can reduce its impact but will not kill it. Herbicide should only be applied by a licensed aquatic herbicide applicator unless the plants are growing away from the water. Mowing first and spraying regrowth can be effective.

Look-alikes: Many other grasses, but tends to be taller, more robust and more dense in growth than other grasses that grow in wet areas.

Legal Status: Non-regulated noxious weed, control not required in King County.

Reed Sweetgrass
Glyceria maxima

Identification: Tall aquatic grass with variegated (green and white striped) leaves to 8.5 feet tall. Striped leaves are very distinctive. Emerges in June, flowers in July and August.

Impacts: Forms dense monocultures in shallow water around lakes, in ponds and along streams.

Habitat: Freshwater lakes, wetlands and river corridors. Known to occur in only a few isolated locations in Washington.

Control: Not realistic to control by hand due to six-foot-deep rhizome mass. Prevent seed production by cutting before seeds mature. Licensed applicators can use an aquatic non-selective herbicide such as glyphosate with appropriate permits. Spraying is most effective when flowers are first forming.

Look-alikes: Variegated reed canary grass and native Glyceria grasses are similar. Other ornamental grasses are variegated but don't grow in the water. Get positive identification before controlling.

Legal status: Class A, eradication required in King County.

Yellow Flag Iris

Iris pseudacorus

Identification: Large yellow iris that grows in water. Bright showy flower, tall leaves in folded, fan-like clusters. Dense rhizomes. Blooms late April through June.

Impacts: Forms impenetrable mats. Outcompetes native plants and degrades habitat of native animals. Accumulates sediment and fills in waterways.

Habitat: Lakeshores, wetlands and creeks. Common and widespread in King County.

Control: Difficult to control by hand. Often requires repeated use of heavy tools such as pick-axes or hatchets to remove sections of rhizome. Herbicide should only be applied by a licensed aquatic herbicide applicator unless the plants are growing away from the water. Spray or wipe actively growing plants with a systemic herbicide.

Look-alikes: Cattail (*Typha latifolia*) leaves are not flattened and folded like iris. Nothing else that grows in water looks like it in bloom.

Legal Status: Non-regulated noxious weed, control not required in King County.

Floating Primrose-willow and Water Primrose

Ludwigia peploides, Ludwigia hexapetala

Identification: Low growing perennial that forms mats in water up to 10 feet deep. Showy yellow five-petalled flowers in leaf axils, smooth-margined alternate leaves, prostrate stems float on water. Blooms late July to August.

Impacts: Clogs waterways, impedes recreation. Ecological pest that outcompetes native plants.

Habitat: Freshwater wetlands and ponds. In King County there is one floating primrose-willow infestation on a tributary to the Cedar River and one water primrose infestation in a private pond in Renton.

Control: Hand pull or rake up small infestations, being sure to get as many roots as possible (roots will resprout). Herbicide can only be applied by a licensed aquatic herbicide applicator.

Look-alikes: The native water purslane (*Ludwigia palustris*) has inconspicuous green flowers and opposite leaves. No wetland native has showy yellow flowers like this.

Legal Status: Class A and B, control required in King County.

Parrotfeather
Myriophyllum aquaticum

Identification: Spikes of feathery leaves emerging up to a foot above the water. Looks like miniature pine trees or horsetails growing on the water's surface. Emerges in late May and persists into October.

Impacts: Clogs irrigation canals and slow-flowing streams and rivers, filling entire water column. Harms recreation, wildlife habitat, and native plants.

Habitat: Freshwater waterbodies and streams. Currently in a few small private ponds in King County. Still sold as a water garden plant on the internet (illegal to buy or sell it in Washington), so it could potentially be found anywhere.

Control: Very difficult to eradicate. Pull or rake, being very careful to remove all fragments from the water. Manual control requires persistence over many years. Herbicide can only be applied by a licensed aquatic herbicide applicator.

Look-alikes: Underwater stems resemble other milfoil species, but above water stems are very distinctive and hard to confuse with anything else. Horsetail is similar but larger and doesn't grow in water.

Legal Status: Class B, control required in King County.

Fragrant Water Lily
Nymphaea odorata

Identification: Round floating leaves ("lily pads") with the stem attached at a slit in one side. Showy flowers are usually white to pink. Leaves are round and stay floating even as the water level drops (the stems are not stiff like our native pondlily). Leaves emerge in spring and persist until fall. Flowers continuously bloom from June through October.

Impacts: Forms dense mats on the water surface that impede recreation, create ideal mosquito breeding areas, and can alter water quality by increasing water temperature and decreasing dissolved oxygen. Plant die-back in the fall can contribute to algae blooms.

Habitat: Lakes, ponds, slow-moving water up to eight feet deep. Widespread and common in King County.

Control: Long, stout rhizomes are difficult to remove. Pull plants or use bottom barriers to maintain small areas of open water. Use hand or mechanical weed cutters to clear larger areas, making sure to remove cut plants from water. Persistent pulling over several years can result in eradication. Herbicide can be applied by a licensed aquatic herbicide applicator.

Look-alikes: Native yellow pondlily (*Nuphar lutea*) has ball-shaped yellow flowers and large, heart-shaped leaves that stick up as the water level lowers. The native watershield (*Brasenia schreberi*) has oval leaves with no slit, stem attached at center of leaf, and lower leaf surface and stem covered in a slippery gelatinous substance.

Legal Status: Non-regulated noxious weed, control not required in King County.

Yellow Floating Heart
Nymphoides peltata

Identification: Floating, bottom-rooted perennial with several leaves per stem. The small (3-10 cm) floating leaves are nearly round to heart-shaped with wavy leaf margins and purplish undersides. One to five flowers per stalk are held above the water surface, and they are bright yellow with five distinctly fringed petals. Blooms June thourgh August.

Impacts: Forms dense mats on the water surface that impede recreation, create ideal mosquito breeding areas, and can alter water quality by increasing water temperature and decreasing dissolved oxygen.

Habitat: Wetlands, lakes, ponds, slow-moving water up to 12-feet deep, also can grow in wet mud.

Control: Hand pulling can work with small infestations, but plant fragments will form new plants. Herbicide is effective and can be applied by a licensed aquatic herbicide applicator.

Look-alikes: The native yellow pondlily (*Nuphar lutea*) has ball-shaped yellow flowers and large, heart-shaped leaves that are held out of the water as the water recedes. The native watershield (*Brasenia schreberi*) has oval leaves with no slit, stem attached at the center of leaf, and lower leaf surface and stem covered in a slippery gelatinous substance.

Legal Status: Class B, control required in King County.

Brazilian Elodea
Egeria densa

Identification: Long-stemmed submerged perennial with non-toothed leaves in whorls of four (up to six) and small white, three-petalled floating flowers. Can top out and form mats on the surface. Blooms in summer.

Impacts: Spreads rapidly by fragmentation, clogs waterways, impedes recreation, outcompetes native species, reduces fish habitat, can alter water quality.

Habitat: Lakes, ponds, slow-moving water up to 30 feet deep. Known infestations in lakes Union, Washington, Sammamish, Fenwick and Dolloff.

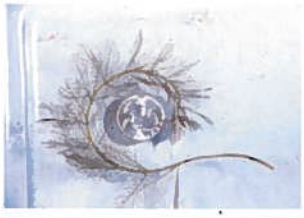
Control: Clean fragments from boats, motors and trailers to prevent spread. Small areas can be cleared by hand-pulling, taking care to remove all plant fragments from the water. Herbicide can only be applied by a licensed aquatic herbicide applicator.

Look-alikes: Hydrilla (*Hydrilla verticillata*) has visibly toothed leaves in whorls of five and grows from tubers. The native American waterweed (*Elodea canadensis*) has smaller leaves in whorls of three.

Legal Status: Class B, control required only in selected areas where it is not already well established.

Eurasian Watermilfoil
Myriophyllum spicatum

Identification: Feathery underwater leaves, long reddish or green stems and small emergent spikes of tiny flowers. Can top out and form mats on the surface. Leaf "feathers" have more than 14 leaflet pairs and leaves collapse against stem when plant is removed from water. Blooms in summer.



Impacts: Spreads rapidly by fragmentation, clogs waterways, impedes recreation, outcompetes native species, reduces fish habitat, can alter water quality.

Habitat: Lakes, ponds, slow-moving rivers up to 20-feet deep. Fairly common in King County.

Control: Clean fragments from boats, motors and trailers to prevent spread. Hand pull small infestations, taking care to remove all plant fragments from the water. Dense, whole-lake infestations can be mowed with a mechanical harvester to maintain open water (not recommended for partially infested water bodies). Herbicide can be applied by a licensed aquatic herbicide applicator.

Look-alikes: Native milfoil species, which generally have fewer than 14 leaflet pairs and hold their shape out of water, and variable-leaf milfoil (*Myriophyllum heterophyllum*), a Class A noxious weed not known in King County. All milfoils can be difficult to tell apart. If you think you have an invasive milfoil, contact the King County Noxious Weed Control Program for verification.

Legal Status: Non-regulated noxious weed, control not required in King County.

Fanwort
Cabomba caroliniana

Identification: Submerged plant with opposite, finely divided fan-shaped leaves on longish stalks and showy pink or white flowers held above the surface of the water.

Impacts: Spreads rapidly by fragmentation, clogs waterways, impedes recreation, outcompetes native species, reduces fish habitat, can alter water quality.

Habitat: Lakes, ponds, ditches, slow-moving water up to 30 feet deep. Not currently known from King County. Only known infestation in Washington is in channels off the Columbia River around Longview and Kelso.

Control: Clean fragments from boats, motors and trailers to prevent spread. Hand pull small infestations, taking care to remove all plant fragments from the water. Herbicide can be applied by a licensed aquatic herbicide applicator. Contact the King County Noxious Weed Control Program if you find this plant.

Look-alikes: Several native aquatic plants. Coontail (*Ceratophyllum demersum*) has divided leaves that are whorled around the stem. Marsh marigold (*Megalodonta beckii*) and water buttercup (*Ranunculus aquatilis*) both have similar looking submerged leaves, but they are smaller and alternate on the stem. Common bladderwort (*Utricularia vulgaris*) has conspicuous round bladders attached to the leaves.

Legal Status: Class B, control required in King County.

SUBMERGED

Hydrilla
Hydrilla verticillata

Identification: Long-stemmed, submerged, perennial with visibly toothed leaves in whorls of five. Flowers inconspicuous. Grows from small tubers.

Impacts: One of the top 10 federally listed noxious weeds. Spreads rapidly by fragmentation, clogs waterways, impedes recreation, outcompetes native species, reduces fish habitat, alters water quality. Extremely aggressive and persistent.

Habitat: Lakes, ponds, ditches, slow-moving water up to 30 feet deep. The only known historical infestation in Washington State was in Pipe and Lucerne lakes in Maple Valley/Covington.

Control: If you find this plant, call the King County Noxious Weed Control Program immediately. Very difficult to eradicate.

Look-alikes: Brazilian elodea (*Egeria densa*) has smooth-edged leaves in whorls of four. American waterweed (*Elodea canadensis*) has smooth-edged leaves in whorls of three.

Legal Status: Class A, eradication required in King County.

What services does the county weed program provide to county residents?

- Early detection and eradication of pioneering infestations of high-priority noxious weeds
- Weed surveys and consultations
- Best Management Practices and fact sheets for noxious weeds in the county
- Cooperative Weed Management Area coordination
- Advice on the appropriate use of weed control methods and tools
- Training and coordination of Weed Watcher volunteers to monitor lakes for noxious weeds
- Presentations and slide shows on weed identification and control

What can property owners do?

Prevent weed infestations:

- Follow noxious weed laws and quarantines
- Never put non-native plants or aquarium contents into a natural water body
- Choose non-invasive species for gardens
- Clean boats, trailers, boots, and other equipment before moving between water or wetlands
- Become a Weed Watcher and help find new invaders

Control weed infestations:

- Obtain necessary permits before working in water
- Use integrated pest management and control weeds safely and appropriately

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- Follow Best Management Practices for aquatic weeds
- Properly dispose of noxious weeds and weed seeds
- Contact the noxious weed program if you are unsure about what to do
- Monitor the area and follow up as needed to keep the weeds out after the first year of control

Contact us with questions and concerns: www.kingcounty.gov/weeds or 206-477-9333.

Resources for additional information

King County Noxious Weed Control Program, **www.kingcounty.gov/weeds** or **206-477-9333**

Washington State Department of Ecology, Aquatic Plants, Algae and Lakes, **http://wdfw.wa.gov/licensing/aquatic_plant_removal**

Washington State Department of Fish and Wildlife: Aquatic Plants and Fish, **http://wdfw.wa.gov/publications/00713/wdfw00713.pdf** or **360-902-2534**

Center for Aquatic and Invasive Plants, University of Florida **http://plants.ifas.ufl.edu/**

An Aquatic Plant Identification Manual for Washington's Freshwater Plants, Washington State Department of Ecology, June 2001, Publication 01-10-032, **www.ecy.wa.gov/programs/wq/plants/plantid2/**

A Field Guide to the Common Wetland Plants of Western Washington and Northwestern Oregon, Sarah Spear Cooke, Editor, Seattle Audubon Society, 1997.

Aquatic and Riparian Weeds of the West, Joseph M. DiTomaso and Evelyn A. Healy, University of California Agriculture and Natural Resources, 2003, Publication 3421.

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Wetland and aquatic plants whose sales are prohibited in Washington State

"The Quarantine List"

COMMON NAME	SCIENTIFIC NAME
African elodea	*Lagarosiphon major*
Australian swamp stonecrop	*Crassula helmsii*
Brazilian elodea	*Egeria densa*
cordgrass, common	*Spartina anglica*
cordgrass, dense-flowered	*Spartina densiflora*
cordgrass, salt meadow	*Spartina patens*
cordgrass, smooth	*Spartina alterniflora*
delta arrowhead	*Sagittaria platyphylla*
Eurasian watermilfoil	*Myriophyllum spicatum*
European frog-bit	*Hydrocharis morsus-rana*
fanwort	*Cabomba caroliniana*
flowering rush	*Butomus umbellatus*
floating primrose-willow	*Ludwigia peploides*
garden loosestrife	*Lysimachia vulgaris*
grass-leaved arrowhead	*Sagittaria graminea*
hairy willow herb	*Epilobium hirsutum*
hydrilla	*Hydrilla verticillata*
marsh dew flower	*Murdannia keisak*
mud mat	*Glossostigma diandrum*
parrotfeather	*Myriophyllum aquaticum*
purple loosestrife	*Lythrum salicaria*
reed sweetgrass, tall manna grass	*Glyceria maxima*
ricefield bulrush	*Schoenoplectus mucronatus*
slender-leaved naiad, brittle naiad	*Najas minor*
swollen bladderwort	*Utricularia inflata*
variable-leaf milfoil	*Myriophyllum heterophyllum*
wand loosestrife	*Lythrum virgatum*
water caltrap, devil's pod, bat nut	*Trapa bicornus*
water chestnut, bull nut	*Trapa natans*
water primrose	*Ludwigia hexapetala*
water soldier	*Stratiotes aloides*
yellow floating heart	*Nymphoides peltata*

Current quarantine list and more information and photos can be found at Washington State Noxious Weed Control Board, **www.nwcb.wa.gov**

Index

Common and Scientific Names

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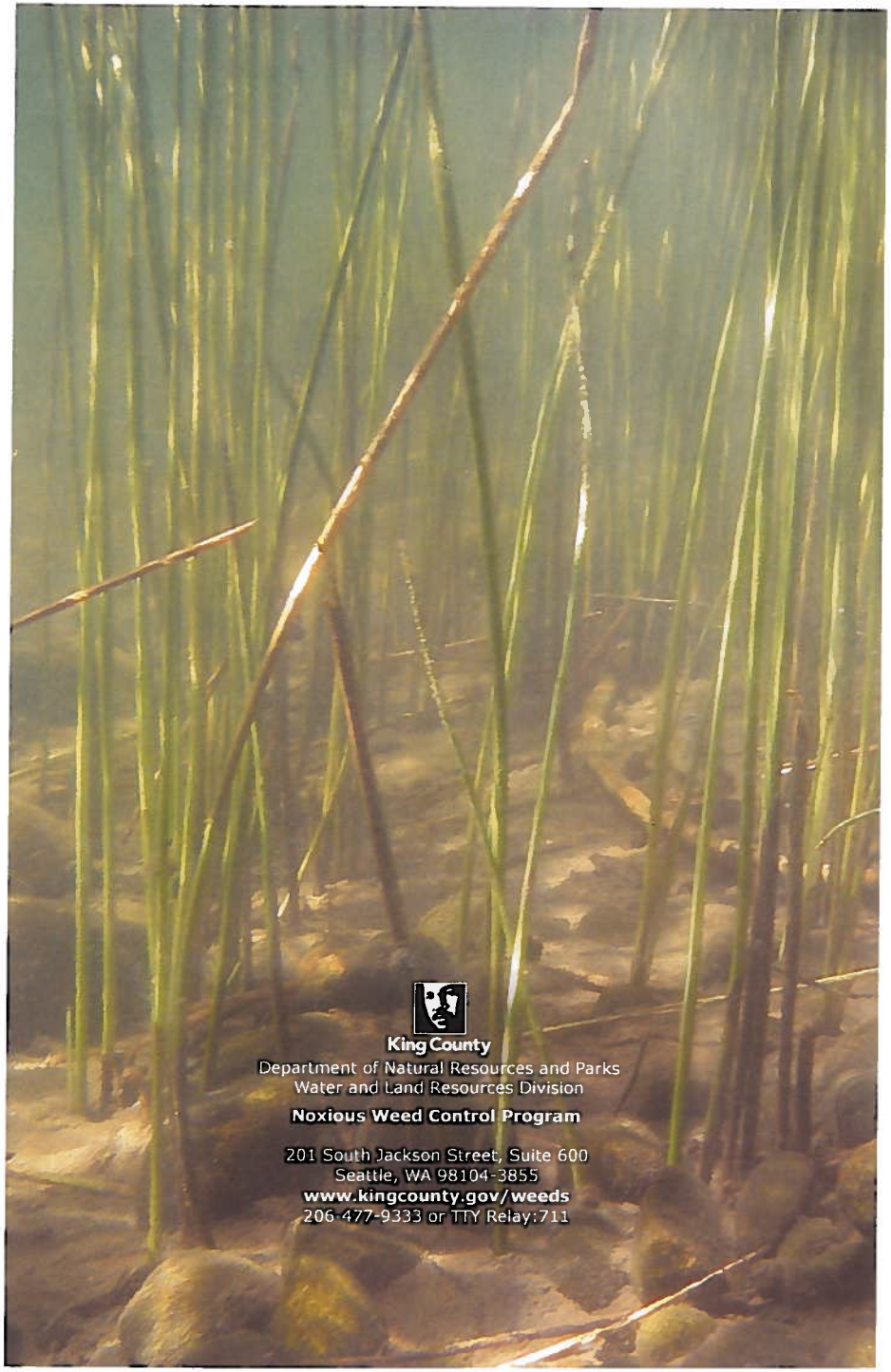


Eurasian Watermilfoil

Myriophyllum spicatum

Class B Non-Regulated Noxious Weed
Control Recommended

Variable-leaf Milfoil

Myriophyllum heterophyllum

Class A Noxious Weed
Control Required

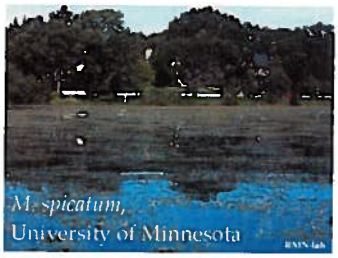
Haloragaceae

Legal Status in King County: Variable-leaf milfoil is a Class A Noxious Weed according to Washington State Noxious Weed Law, RCW 17.10 (non-native species that is harmful to environmental and economic resources and that landowners are required to eradicate). In accordance with state law, the King County Noxious Weed Control Board requires property owners to eradicate variable-leaf milfoil from private and public lands throughout the county (eradicate means to eliminate a noxious weed within an area of infestation). Eurasian watermilfoil is a Class B Non-Regulated Noxious Weed (non-native species that can be designated for control based on local priorities). The State Weed Board has not designated this species for control in King County. The King County Weed Control Board recommends control of Eurasian watermilfoil where feasible, but does not require it. State quarantine laws prohibit transporting, buying, selling, or distributing plants, plant parts or seeds of these milfoils.

BACKGROUND INFORMATION

Impacts and History

- Eurasian watermilfoil is native to Eurasia but is widespread in the United States, including Washington. In King County it is present in numerous lakes and slow moving streams and rivers.
- Variable-leaf milfoil is native to the eastern United States. It was introduced to southwestern British Columbia several decades ago and was confirmed in Thurston and Pierce Counties in 2007.
- Both of these plants are very aggressive and can outcompete native aquatic plants, forming dense


M. spicatum, University of Minnesota


M. spicatum, Andrzej Martin Kasiński


M. heterophyllum Dan Tenaglia - missouriplants.com


M. heterophyllum, University of Florida

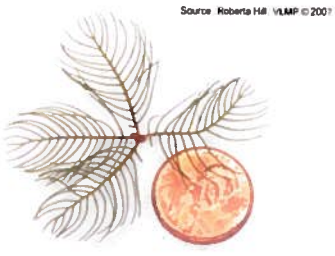
monotypic stands. They can reduce biodiversity, change the predator/prey relationships in a lake and adversely impact the food web.

- These milfoil species impact recreation by eliminating swimming opportunities, fouling boat motors and snagging fishing lines.
- When allowed to grow in dense stands and "top out", the floating mats or emergent flower stems prevent wind mixing, and extensive areas of low oxygen can develop during the summer.
- Stagnant mats create mosquito breeding areas and increase the water temperature underneath by absorbing sunlight.
- These plants die back in the fall, and the resulting decay uses up dissolved oxygen and adds nutrients to the water, potentially increasing algae growth and related water quality problems.

Description, Reproduction and Spread

Milfoil species (*Myriophyllum* spp.) can be very difficult to tell apart, particularly when not in flower. Not only can the vegetative structures look very similar, but Eurasian watermilfoil (M. *spicatum*) is known to cross with the native northern milfoil (*M. sibiricum*), creating an invasive hybrid. Anyone who finds a new, aggressive population of milfoil should consult an expert to get a positive identification before taking action to control it.

Eurasian watermilfoil (*Myriophyllum spicatum*)



- Perennial, rhizomatous plant grows in water to 20 feet (possibly up to 30 feet) deep.
- Forms tangled underwater stands and dense floating mats.
- Leaves are in whorls of four, and are feathery, with generally more than 14 leaflet pairs per leaf. Leaves often appear squared-off at the tip. Leaves usually collapse against the stem when the plant is pulled from the water.
- Stems are long, branched near the surface, and usually reddish.
- Flowers are tiny and borne on reddish spikes above the water surface.
- Spread is generally by plant fragments or rhizomes.

- Can be confused with the native northern milfoil (*Myriophyllum sibiricum*), which generally has fewer than 14 leaflet pairs per leaf. The native milfoils also tend to retain their shape when pulled from the water rather than collapsing against the stem.

Variable-leaf milfoil (*Myriophyllum heterophyllum*)

- Perennial, rhizomatous plant grows in water to 15 feet deep.
- Forms tangled underwater stands and dense floating mats.
- Submersed leaves are in whorls of four to six, and are feathery, with six to 14 leaflet pairs per leaf.
- Flowering spikes emerge up to six inches above the water and have bright green, leaf-like bracts that are in whorls of 4 to 6 with toothed to entire margins.
- Flowers are tiny and borne in the axils of the leaf-like bracts.
- Submersed stems are stout (up to 8 mm in diameter), reddish, often with numerous branches. A cross-section of the stem will reveal "pie-shaped" air chambers.
- Spread is by plant fragments, rhizomes and seed.
- Has the ability to produce terrestrial plants with leaves resistant to drying. These apparently do not colonize new areas, but aid in the survival of the species in years when the water level is unusually low.
- Can be confused with the native western milfoil (*M. hippuroides*), which also has emergent flower stems with leaf-like bracts, and vegetative plants can be confused with the native northern milfoil (*Myriophyllum sibiricum*), which also has fewer than 14 leaflet pairs per leaf.

Habitat

- Milfoils grow in still and slow moving water, generally up to about 20 feet deep for Eurasian watermilfoil, and six to 15 for variable-leaf milfoil, depending on water clarity.
- They tend to cluster at downwind ends of smaller water bodies or in quiet coves where fragments can settle out of the water column and take root.
- Both tolerate a wide range of pH.
- Eurasian watermilfoil can tolerate brackish water.

Local Distribution

- Eurasian watermilfoil is widespread in western Washington and in King County, with established populations in the large lakes (Lakes Washington, Sammamish and Union), the Sammamish River, and a number of smaller lakes (notably Green Lake in Seattle).
- Variable-leaf milfoil was discovered in a lake in Thurston County in 2007, the first confirmed record in Washington State. It has since been found in another lake in Thurston County, as well as in two lakes in Pierce County (Blue and Clear Lakes), all four of which are privately owned. Since it is particularly difficult to distinguish from the native western milfoil (*M. hippuroides*), it may be established in other areas as well. The Washington State Department of Ecology is investigating other potential populations. At this writing, there are no confirmed populations of variable-leaf milfoil in King County.

CONTROL INFORMATION

Integrated Pest Management

- The preferred approach for weed control is Integrated Pest Management (IPM). IPM involves selecting from a range of possible control methods to match the management requirements of each specific site. The goal is to maximize effective control and to minimize negative environmental, economic and social impacts.
- Use a multifaceted and adaptive approach. Select control methods which reflect the available time, funding, and labor of the participants, the land use goals, and the values of the community and landowners. Management will require dedication over a number of years, and should allow for flexibility in method as appropriate.

Planning Considerations

- Survey area for weeds, set priorities and select best control method(s) for the site conditions and regulatory compliance issues (refer to the King County Noxious Weed Regulatory Guidelines).
- Small infestations may be effectively removed using manual methods or hand tools.
- Milfoil spreads by fragmentation, so care must be taken to contain and remove all plant fragments when using manual or mechanical control methods. Otherwise, the infestation will spread.
- Any control actions taken will necessarily affect all landowners adjacent to the water body and will require their approval and participation in order to succeed. In addition, many control options will be expensive and it will be more cost-effective to pool resources.
- Commit to monitoring. Once initial control has been achieved, be sure to conduct follow up monitoring and control in subsequent years in order to catch any overlooked patches or returning infestations before they can spread. Without this, control efforts can be wiped out within a few years. Monitor the site each year for at least three years after last observing any milfoil, and then again after three years.
- Any water body with a public boat launch should be monitored regularly since milfoils can be re-introduced easily from plant fragments on a boat or trailer.

Permitting and Regulatory Requirements

- Permits are required for all weed control work in natural water bodies.
- At minimum, the pamphlet **Aquatic Plants and Fish** is required. This pamphlet is published by the Washington State Department of Fish and Wildlife and acts as a Hydraulic Project Approval (HPA) permit. It is available free of charge online at http://wdfw.wa.gov/hab/aquaplnt/aquaplnt.htm or by calling (360) 902-2534. This "pamphlet HPA" is all you will need for most manual or light mechanical control methods.
- More extensive control, including some bottom barrier placement and all herbicide use, will require additional permits from Washington State. See the sections below for details.
- Permits and licenses are required for all herbicide use in aquatic systems. Minimum requirements include a pesticide applicator's license with an aquatic endorsement from the Washington Department of Agriculture and a permit from the Washington Department of Ecology.
- Some incorporated cities also regulate any work conducted in natural waterbodies. Contact your local jurisdiction for details.
- **Permit requirements can change from year to year. Contact the King County Noxious Weed Control Program for more information on current permitting requirements.**

Early Detection and Prevention

- Look for new plants. Get a positive plant identification from an authority such as King County Noxious Weed Control Program staff.
- Look for plants along lake shorelines and in stagnant or slow-moving water in wetlands and streams. Since these plants are often spread as fragments attached to boat motors and trailers, check especially around boat launches. Also check at the downwind end of the waterbody, and anywhere else where fragments could congregate or settle out of the water column.
- The best time to begin surveys is late spring when plants are visible, and surveys can continue into early fall when the plants senesce (die back).
- Clean all plant material off of boats, motors and trailers, and check bilgewater for plant fragments any time you have been in an infested water body (or a potentially infested water body).
- **Never dispose of unwanted aquarium or water garden plants or animals in a natural water body**. Variable-leaf milfoil in particular is still sold in some areas as an aquarium plant, and may have been introduced to Washington waters by careless dumping of aquariums.

Manual Control

- At minimum, an HPA pamphlet permit is required for all manual control activities in natural waterbodies. In incorporated areas, check with your local jurisdiction for other possible permit requirements.

- Hand pulling and the use of hand mechanical tools is allowable in all critical areas in unincorporated King County.
- Hand pulling can be successful for a very small area but is impractical for large infestations. Be sure to contain and remove all plants and plant fragments from the water.
- Weed rakes and weed cutters can assist in maintaining open water in a discrete area, such as around a dock, but will not eliminate the plants. Be sure to contain and remove all plants and plant fragments from the water.
- All manual control sites should be monitored for several years for signs of plants growing from roots or fragments.
- **DISPOSAL**: Milfoils can be composted on land away from water or placed in yard waste bins. Do not leave any plant parts or fragments in the water or near the water's edge. Variable-leaf milfoil can grow on exposed soil during periods of low water, so extra care should be taken to dispose of it away from the water.

Mechanical Control

- At minimum, an HPA pamphlet permit is required for all mechanical control activities in natural waterbodies. In incorporated areas, check with your local jurisdiction for other possible permit requirements.
- Cutting and harvesting using boat-mounted cutters or in-lake harvesting barges is effective at maintaining open water in water bodies with 100% of the available habitat infested. It must be done on a regular basis to maintain control. However, these methods will quickly spread these plants by creating numerous fragments, so cutting and harvesting are not recommended for small or partial infestations. Neither method will eradicate an infestation. In unincorporated King County, only an HPA pamphlet permit is required for cutting and harvesting noxious weeds.
- Diver dredging using boat or barge mounted suction dredges can be effective for small infestations or as a follow-up to herbicide treatment. Special care must be taken to remove all fragments. This method causes a temporary increase in turbidity and requires specific authorization from the Washington Department of Fish and Wildlife (WDFW).
- Rotovation (underwater rototilling) is not recommended since it causes severe fragmentation of the plants. Rotovation also results in significant short term turbidity and loss of water clarity and quality, as well as destruction of benthic habitat. Rotovation requires an individual HPA permit.

Cultural Methods

- An opaque bottom barrier can be used to suppress growth in small, discrete areas like at a boat launch or around a swimming area. Barriers need to be regularly cleaned because plants will root in the sediment that accumulates on top of them. This is not practical for large-scale infestations. Bottom barriers in Lake Washington and Lake Sammamish are not allowed without prior authorization by the Washington Department of Fish and Wildlife (WDFW) due to potential impact on sockeye salmon

spawning areas. A pamphlet HPA at minimum is required for bottom barrier installation. Other permits may also be required.

- Waterbodies with control structures can sometimes use water level drawdown to control submerged weeds. Generally the bottom must be exposed to heat or cold long enough to dry out completely, something that can be difficult to achieve in rainy western Washington. Occasionally drawdowns can backfire and increase subsequent germination of weed seeds, especially with variable-leaf milfoil. Drawdowns can have major impacts on native plants and other aquatic organisms. Carefully weigh the pros and cons before deciding on this option. A drawdown is not covered by the pamphlet HPA. Consult your local WDFW office for permit information.

Chemical Control

- Permits and licenses are required for all chemical control in water.
- Herbicides may be the most reasonable option for eradication of large submerged noxious weed infestations. Professional licensed contractors are available for hire to perform this task.
- Herbicides can only be applied to aquatic systems in Washington State by a licensed pesticide applicator. Aquatic formulations of herbicides are not available for sale over the counter to anyone without an aquatic pesticide license. **NEVER apply non-aquatic herbicide formulations to water since most of them include ingredients that are toxic to aquatic organisms.**
- Multiple years of treatment may be required to eradicate a milfoil infestation. For several years following treatment, monitor areas for new plants germinating from the seed bank. Remove any new growth using one of the manual control methods above.

Specific Herbicide Information

Milfoil species are dicots, and therefore selective herbicides can be used to control them with minimal collateral damage to the primarily monocot native plant communities. 2,4-D, a selective herbicide, and fluridone, a non-selective herbicide, have both been used to control Eurasian watermilfoil to good effect in western Washington lakes. However, 2,4-D cannot be used in waterbodies that support salmonids (salmon and trout species). Triclopyr, another selective herbicide, has been approved for control of submerged plants as of 2008 and shows promise as an alternative herbicide for milfoil control. Endothall and diquat, which are both contact herbicides, will control existing vegetation, but will not kill the roots, so the control is temporary.

The mention of a specific product brand name in this document is not, and should not be construed as an endorsement or as a recommendation for the use of that product. Chemical control options may differ for private, commercial and government agency users. **For questions about herbicide use, contact the King County Noxious Weed Control Program at 206-296-0290.**

Biological

- Triploid grass carp have been tried as a control for milfoil species, but milfoil is not palatable to them, and they will generally eat everything else in the waterbody first. Grass carp are not allowed in water bodies where the inlet and outlet cannot be screened to prevent fish from leaving the waterbody. Grass carp are not allowed anywhere in the Lake Washington and Lake Sammamish system. They are not recommended as a control for milfoil, although they can be used if these species predominate. Care should be taken to evaluate potential impacts on the native plant community before choosing grass carp as a control method.
- In some situations, the native milfoil weevil (*Euhrychiopsis lecontei*) seems to control Eurasian watermilfoil. The weevil appears to prefer Eurasian watermilfoil over its native host, northern watermilfoil (*Myriophyllum sibiricum*), and in lakes where the weevil occurs naturally, Eurasian milfoil has been shown to be less of a problem. Ongoing research is exploring lake conditions in which the weevil may thrive, including water pH and the abundance of insect-eating fish. Although no permits are needed to use native insects as biocontrol, currently the weevils are difficult to obtain in quantities high enough to have an effect on milfoil populations. Even when they have been specially reared and introduced, it can take several years for populations in a waterbody to reach sufficient levels to control milfoil populations. Biocontrols of any type will not eradicate milfoil, but if effective should reduce a milfoil population to below the threshold of significant impact.

SUMMARY OF BEST MANAGEMENT PRACTICES

- At all times at minimum a pamphlet HPA permit is required to do any activity that disturbs a lake bottom or wetland or streambed. For more extensive work, more specific permits will be required.
- Hand pulling or digging is recommended for small populations, with extreme care taken not to let fragments spread.
- Where a population has filled every possible inch of habitat in a waterbody and its connected waterways, cutting or harvesting when done consistently can maintain open water and diminish the adverse affects of these species.
- Bottom barriers can maintain small areas of open water around boat launches, swimming areas or docks, as long as care is taken to keep them free of debris and fragments.
- Diver dredging can be effective for small infestations or as a follow-up to herbicide treatment.
- To eradicate large areas of milfoil, herbicides are probably the best option.
- **Do not apply any herbicide to water without the proper licenses.** Hire a contractor to do the work.

Control in small isolated or man-made ponds

- Permits may be required (see "Permitting and Regulatory Requirements" section above).
- Drawdown can be very effective. Remove all plants and plant fragments. Let the bed dry out completely before refilling. Thoroughly clean pond liners. Examine or discard ornamental plants that may harbor plant fragments before re-introducing them to the pond.
- Manual control will work if the infestation is caught early and all fragments are removed.
- Bottom barriers may be effective over natural pond beds.
- Follow recommendations above for chemical control.

Control in small lakes

- Permits will be required for all control work (see "Permitting and Regulatory Requirements" section above).
- Community involvement will be essential for successful control efforts.
- For small pioneering infestations, manual control or bottom barriers may be effective. Monitor the lake for fragments and additional infestation sites. Maintain bottom barriers to prevent sediment buildup.
- For large or whole-lake infestations, chemical control will be the most effective (see above for chemical recommendations). Mechanical control may be used to manage infestations, but will not eradicate the weeds. Bottom barriers, if properly maintained, will create open water in small areas.

Control in flowing water (rivers, streams, ditches)

- Permits will be required for all control work (see "Permitting and Regulatory Requirements" section above).
- The most effective control will start with the furthest upstream infestation and move downward. If there are any weeds left upstream, any cleared site will likely be re-infested.
- If possible, contain the area being controlled with a boom to catch fragments before they float downstream.
- Manual control may be the most practical. Bottom barriers need to be securely anchored.
- Chemical control in flowing water is difficult. Consult an expert before considering this option.

Control along shores of Lakes Washington and Sammamish

- Permits will be required for all control work (see "Permitting and Regulatory Requirements" section above).
- Eradication of submerged aquatic weeds from these waterbodies is not practical.
- Bottom barriers, if properly maintained, can provide open water around docks, marinas, swimming beaches, and similar areas. Prior authorization by the Washington

Department of Fish and Wildlife (WDFW) is required due to potential impact on sockeye salmon spawning areas.

- Manual control of small patches may be sufficient.
- Mechanical control can be effective for lakeside communities or large marinas. Be sure to remove all fragments from the water.
- Spot control using chemicals can be effective in the right conditions. It is possible that more than one species of submerged noxious weeds may be present (particularly Brazilian elodea, which is increasing in these lakes). If this is the case, be sure to select an herbicide that will control all targeted weeds (consult BMPs for each weed or ask an expert for assistance in selecting herbicides). If there is any significant wave action or current, the chemicals will drift off target or quickly become diluted. Consult with a professional contractor before choosing this option. Neighboring property owners should be advised prior to spot chemical applications.
- Grass carp are not allowed in the Lake Washington and Lake Sammamish system.

Disposal Methods

- Eurasian watermilfoil can be left on land to dry out and/or decompose where it will not move into a waterway.
- Variable-leaf milfoil should not be left on the bank since it may root in damp soil.
- Both milfoils can be composted or placed in yard waste bins.

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Purple Loosestrife

Lythrum salicaria
Lythraceae

Class B Noxious Weed
Control Required

Legal Status in King County: Purple loosestrife is a Class B Noxious Weed (non-native species harmful to environmental and economic resources that landowners may be required to control based on distribution in the county and local priorities) according to Washington State Noxious Weed Law, RCW 17.10. In accordance with state law, the King County Noxious Weed Control Board requires property owners to control purple loosestrife on private and public lands throughout the county (control means to prevent all seed production and to prevent the dispersal of all propagative parts capable of forming new plants). In addition, state quarantine laws prohibit transporting, buying, selling, or distributing plants, plant parts or seeds of purple loosestrife.

BACKGROUND INFORMATION

Impacts and History

- Purple loosestrife is an invasive and competitive noxious weed that alters wetland ecosystems by replacing native and beneficial plants. Water-dependent mammals and waterfowl and other birds leave wetlands when their food source, nesting material and shelter are displaced by purple loosestrife.
- Dense infestations of purple loosestrife also alter the landscape by trapping sediments and thereby raising the water table.
- Although young shoots of purple loosestrife are palatable to cattle (and to white-tailed deer), larger plants are not, and so cattle graze preferentially on pasture grasses, giving purple loosestrife a distinct advantage in grazed areas. Over time, mature purple loosestrife plants will dominate, removing the use of the land as pasture. Similar processes can lead to destruction of hay meadows. Occasionally, deer browse the tops of mature plants in wetlands, but this doesn't appear to reduce the overall density of purple loosestrife.
- Purple loosestrife was introduced to the United States in the early 1800's at northeastern port cities, in ship ballast obtained from European tidal flats. Over the next 100 years it spread through canals and other waterways as far as the Midwest. It arrived in marine

estuaries in the Pacific Northwest in the early 1900s, suggesting that it was spread by maritime commerce.

- Purple loosestrife has also been commonly cultivated for the horticultural trade and became prized by bee-keepers in the mid 1900s. Deliberate planting and escapes from cultivation undoubtedly aided in the spread of infestations across the country.
- Purple loosestrife was first collected in Washington in 1929 from Lake Washington. The first eastern Washington collection was in the 1940s from the Spokane area, although there are reports that it escaped from a garden to the Spokane River ten years earlier.

Description

- Perennial emergent aquatic plant, reaching over 9 feet tall and 5 feet wide. As many as 30-50 herbaceous stems annually rise from a persistent perennial tap root and spreading rootstock.
- **Square stems** (usually 4-sided, sometimes 6-sided). Leaves are usually opposite. The leaves are linear in shape, 1.5 to 4 inches long, with smooth edges, and are sometimes covered with fine hairs.
- The showy **magenta or purple flowers appear from July to October** on flowering spikes. The flowers have 5 to 7 greenish sepals, 5 to 7 magenta petals and 12 stamens. Flowers will continue until frost.
- In winter months, dead, brown flower stalks remain with old seed capsules still visible.




Habitat

- Occurs in freshwater and brackish wetlands, lake and river shorelines, ponds, shallow streams and ditches, wet pastures and other wet places.
- Grows on moist or saturated soils or in shallow water. Can tolerate a range of soil pH and nutrients.
- Requires partial to full sunlight. Productivity is significantly reduced at 40% of full light.

Reproduction and Spread

- Spreads mainly by seed but also by stem and root fragmentation. A mature plant may have as many as thirty flowering stems capable of producing an estimated two to three million, pepper-sized seeds per year. Most seeds remain viable after two years in a natural water body, and stored in laboratory conditions they are viable for about three years.
- Dispersal is mainly by water, but seeds can also be transported on feathers and fur of waterfowl and other wetland animals as well as in mud on boots, tires, boats and pets. There is also some evidence of wind dispersal.
- Seedling densities sharply fall beyond 34 feet of the parent plant.
- Seed banks build for years, unnoticed until the right conditions of disturbance appear, resulting in a population explosion. Mature plants can live for 20 years.
- Vegetative spread is also possible. Buried stems harbor adventitious buds with the ability to produce shoots or roots. Breaking off stems or roots during incomplete plant removal initiates bud growth. Removed stems left on moist soil will also grow roots and sprout.

Local Distribution

- Found on lakes and waterways throughout King County, with 1,214 total sites reported in 2010.

CONTROL INFORMATION

Integrated Pest Management

- The preferred approach for weed control is Integrated Pest Management (IPM). IPM involves selecting from a range of possible control methods to match the management requirements of each specific site. The goal is to maximize effective control and to minimize negative environmental, economic and social impacts.
- Use a multifaceted and adaptive approach. Select control methods that reflect the available time, funding, and labor of the participants, the land use goals, and the values of the community and landowners. Management will require dedication over a number of years, and should allow for flexibility in method as appropriate.

Planning Considerations

- Survey area for weeds, set priorities and select best control method(s) for the site conditions and regulatory compliance issues **(refer to the King County Noxious Weed Regulatory Guidelines or local jurisdictions)**.
- Control practices in critical areas should be selected to minimize soil disturbance, or efforts should be taken to mitigate or reduce impacts of disturbance. Any disturbed areas need to be stabilized to control erosion and sediment deposition. Refer to the King County Surface Design Manual for further information about sediment and erosion

control practices (call 206-296-6519 or go to http://kingcounty.gov/wlr/Dss/Manual.htm for more information).

- Small infestations can be effectively hand-pulled or dug up if conditions allow (see section on Manual Control for more information). Isolated plants should be carefully removed in order to stop them from infesting a larger area.
- For larger infestations, the strategy will depend on the site. Generally work first in least infested areas, moving towards more heavily infested areas. On rivers, begin at the infestation furthest upriver and work your way downstream.
- Minimize disturbance to avoid creating more opportunities for seed germination.
- Properly dispose of all parts of the plant (see Disposal Methods section below).

Early Detection and Prevention

- Look for new plants. Get a positive plant identification by contacting your local noxious weed control program or extension service.
- Look for plants along river and lake shorelines, in ponds, wetlands, ditches and wet pastures.
- The best time to survey is in July and August when the plants are flowering; however, seedlings may not flower in the first year.
- Look for seedlings starting in June.
- Dig up or pull small isolated patches.
- Prevent plants spreading from existing infestations by cleaning off equipment, boots, clothing and animals that have been in infested areas.
- Don't buy or plant purple loosestrife. According to state quarantine laws it is illegal to buy, sell or offer purple loosestrife or any of its cultivars for sale.

Manual

- Hand pulling and the use of hand mechanical tools is allowable in unincorporated King County critical areas. Check with the local jurisdiction for regulations in other areas.
- If the plants are in flower or seed, **cut off and bag all flower stalks and seed heads.** It is very difficult to pull the plants without dispersing the small, lightweight seeds. Brush off boots, clothes and animals before leaving the infested area.
- Hand pulling is recommended when plants are rooted in mucky, sandy or other loose, wet soil. Grasp the base of the plant and pull slowly with steady pressure to release the roots from the soil. Pulling purple loosestrife by hand is easiest when plants are young. Older plants have larger roots that can be eased out with a garden fork. Remove as much of the root system as possible, because broken roots may sprout new plants.

- Cutting plants at the base when in flower may prevent seeding, but cut plants may continue to produce flowers. Sites should be consistently and regularly monitored until frost to cut and remove any subsequent flowers. Cutting will not kill the plants, and they will need to be controlled every year. Do not leave cut plant parts on site, because root and stem fragments can take root and form new plants.
- All manual control sites should be monitored for several years for plants growing from root fragments and from the seed bank.
- **DISPOSAL:** All purple loosestrife plant parts, including flowers, seed heads, stems, leaves and roots must be securely bagged, and discarded in the trash or taken to a transfer station. **Do not compost or place in yard waste. Plants may regenerate in compost. If you have the ability to burn plants, following all local regulations and restrictions, burning vegetative material is an acceptable disposal method. Do not burn flowering stems or seed heads.**
- **NOTE:** Under the Washington State Lythrum quarantine (WAC 16.752.400-415), it is illegal to transport, buy, sell, offer to sell, or to distribute plants, plant parts or seeds of purple loosestrife into or within the state of Washington. However, by following the recommendations in this Best Management Practices document you are covered under the King County Noxious Weed Control Program's permit to transport purple loosestrife for the purpose of taking it to a transfer station or landfill.

Mechanical

- Removal of purple loosestrife with hand held mechanical tools is allowable in critical areas and their buffers within unincorporated King County. Check with the local jurisdiction for regulations in other areas.
- Mowing is not recommended. Since plant fragments can produce new shoots, mowing may facilitate spread rather than control.
- Cutting alone is not a control option for purple loosestrife. New plants will grow from the roots. Cutting late in the season but before seed set reduces shoot production more than mid-summer cutting.
- Sheet mulching or covering using black plastic, landscape fabric, or cardboard and six inches of mulch is an interim option for dense seedling infestations. It does not kill the roots of mature plants, but it does slow down growth and seed dispersal. The covering must extend several feet beyond the edges of the infestation and be weighted so the plants cannot push it up. The edges of the covered area must be monitored for plants coming up from rhizomes extending beyond the sheet. Covering materials should also be monitored for damage or gaps and repaired or re-installed as needed.

Chemical

- **Precautions:**
  - Herbicides should only be applied at the rates and for the site conditions and/or land usage specified on the label of the product being used. **Follow all label directions.**
  - For herbicide use in critical areas and their buffers, certain restrictions apply depending on the site and jurisdiction. In unincorporated King County, refer to the **King County Noxious Weed Regulatory Guidelines** for a summary of current

restrictions and regulatory compliance issues. Elsewhere, check with the local jurisdiction.
    - For your personal safety, at a minimum wear gloves, long sleeves, long pants, closed toe shoes, and appropriate eye protection. Follow label directions for any additional personal protection equipment needed.
    - A Washington State pesticide license with an aquatic endorsement is required for the purchase of aquatic herbicides. **NEVER apply non-aquatic herbicide formulations to water since many include ingredients toxic to aquatic organisms.**
- For large infestations of purple loosestrife, herbicide use may be necessary for effective control.
- Cutting after spraying is not necessary. If cutting is desired, infested areas should not be cut until after the herbicide has had a chance to work, which may take several weeks.
- In sensitive areas or areas prone to erosion, careful spot-spraying will create less disturbance than manual or mechanical control.
- For several years following treatment, monitor areas for new plants germinating from the seed bank. In some cases several years of treatment may be necessary.
- When treating an area intermixed with native monocots (cattails, grasses, sedges, etc), using a selective broadleaf herbicide is recommended. The monocots will not be harmed by the herbicide and will be able to help suppress new plants emerging from the seed bank.

Specific Herbicide Information

Glyphosate (e.g. Rodeo®, AquaMaster® or Aqua Neat®): Apply to actively growing plants at early flowering stage. Application to pre-flowering plants or seedlings may also be effective, but unless the extent of the infestation is well known, plants can be difficult to locate when not in flower. Glyphosate works slowly, so plants may not appear to be affected for a couple of weeks. A second application a few weeks after the first may be helpful to control plants not in flower or otherwise skipped during the first application. Apply to foliage but avoid runoff. Caution: Glyphosate is non-selective and it will injure or kill other vegetation contacted by the spray including grasses, cattails and other monocots.

Imazapyr (Habitat®, Polaris®): Apply to foliage any time the plant is actively growing. Caution: Imazapyr is non-selective and highly effective even at low doses: it will injure or kill other vegetation contacted by the spray including trees, desirable vegetation, and grasses, cattails and other monocots. Also, imazapyr is soil-active and can harm trees and other plants rooted in the spray area or sometimes immediately downhill from the area being sprayed.

Triclopyr (Garlon 3A® and Renovate 3®). Apply when plants are in the mid to full-bloom stage. Application to pre-flowering plants or seedlings may also be effective, but unless the extent of the infestation is well known, plants can be difficult to locate when not in flower. Triclopyr is a selective herbicide and will kill only dicots (broadleaf plants and trees). It will not harm monocots such as grasses, sedges, cattails and many native aquatic plants.

All the above listed herbicides require the addition of an approved surfactant. Follow label directions for selecting the correct type of surfactant. Be sure that the selected surfactant is approved for aquatic use in Washington State.

The mention of a specific product brand name in this document is not, and should not be construed as an endorsement or as a recommendation for the use of that product. Chemical control options may differ for private, commercial and government agency users. **For questions about herbicide use, contact the King County Noxious Weed Control Program at 206-296-0290.**

Biological

- Biological control can take up to six years to have a significant impact on the infestation. Purple loosestrife population density and the number of flowering plants can be reduced, but there will always be some plants remaining when using biological control agents. Releases should be made only at sites where loosestrife infestations are large and immediate eradication of the weed is not the primary objective.
- All biological control agents approved for use on purple loosestrife in Washington State will not feed on any plant species other than purple loosestrife in our area.
- Where feasible, biological control plans should incorporate another non-chemical control method to be able to prevent all seed production as required by state law. If the infestation is inaccessible, remove flowers at the edges of the infestation to the greatest extent possible. If *Galerucella* or *Hylobius* species are present, flower heads should be cut, bagged and properly disposed of by the time of flower drop in mid to late August. If *Nanophyes marmoratus* weevils are present, flower/seedheads should be cut very carefully in early September after emerging adult weevils have left the flowerheads for the season. If there is any chance of mature seeds being present in the seed heads, extreme care should be taken to avoid spread.
- Biological control is not recommended or prescribed for small infestations.
- Two species of *Galerucella* beetles were first released in Washington in 1992 and subsequently have been released in King County several times in many locations. These small golden-brown leaf-feeders defoliate plants and attack the terminal bud area, halting or drastically reducing seed production. The larvae feed constantly on the leaf underside. Loosestrife seedling mortality is high. These beetles are highly mobile and are often found in King County in locations far from release sites. *Galerucella* beetles do not do well near salt water.

Galerucella beetles feeding on purple loosestrife

Hylobius transversovittatus

- *Hylobius transversovittatus* is a root-mining weevil that also eats leaves. The adult beetle is reddish brown and ½ inch long. It eats from the leaf margins, working

inward. Eggs are laid in the lower 2-3 inches of the stem, or sometimes in the soil near the root. The larvae then work their way to the root, where they eat the carbohydrate reserves. Evidence of larvae in the root is a zig-zag pattern. *Hylobius* tolerates coastal areas and is a better choice for infestations near salt water.

- *Nanophyes marmoratus* is a tiny seed weevil. Larvae and adults impact purple loosestrife by feeding on unopened flower buds. Flower buds with larval feeding damage usually abort and fail to produce seeds. Adults also feed on developing leaves, further weakening plants. *Nanophyes* can also be successful when used in conjunction with *Hylobius*.

Nanophyes weevil on purple loosestrife

SUMMARY OF BEST MANAGEMENT PRACTICES

Small Infestations in Native and/or Desirable Vegetation

- Hand pulling is recommended for young plants or older plants in loose, wet soil.
- Larger plants from isolated small populations can be dug out from moist upland areas. This may be impractical to impossible when trying to remove hardy, woody roots in compacted soils. Care should be taken to minimize erosion when digging in saturated soils on shorelines.
- If the plants are in flower or in seed, **cut off and bag all flower heads.** Pulling plants in seed will disperse the small, lightweight seeds. Cut plants may continue to produce flowers, so these sites will have to be consistently and regularly monitored until frost to cut and remove any subsequent flowers.
- When digging or pulling on shorelines, take appropriate erosion control measures.
- If manual control is not possible due to site conditions or available labor, apply appropriate herbicide with wick wiper or spot spray to minimize off target injury.
- If using an herbicide in an area that has desirable grasses and other monocots, use a selective broadleaf herbicide to avoid injury to grasses and other monocots.

Large Infestations in Areas with Monocots

- Cutting alone is not a control option for purple loosestrife. Shoots and adventitious roots will develop. Cutting late in the season but before seed set reduces shoot production more than mid-summer cutting. Cut plants may continue to produce flowers, so these sites will have to be consistently and regularly monitored until frost to cut and remove any subsequent flowers.
- Sheet mulching using black plastic, landscape fabric, or cardboard and six inches of mulch is an interim option for dense seedling infestations. It does not kill the roots of mature plants, but it does slow down growth and seed dispersal. This method is also non-selective.
- If an area has desirable monocots present, use a selective herbicide and encourage the growth of the monocots.

- If the infestation is in a pasture, encourage healthy grassy areas by seeding and fertilizing. Use a mix of grass and clover species to improve resistance to purple loosestrife. Fertilize according to the soil needs.
- If using biological control, areas need to be monitored and any flowers removed and properly disposed of where feasible. If the infestation is inaccessible, remove flowers around the edges of the infestation to the greatest extent possible. If *Galerucella* or *Hylobius* insects are present, flower heads should be cut, bagged and properly disposed of by the time of flower drop in mid to late August. If *Nanophyes marmoratus* weevils are present, flower/seedheads should be cut very carefully in early September after emerging adult weevils have left the flowerheads for the season. If there is any chance of mature seeds being present in the seed heads, extreme care should be taken to avoid spread.

Control on Shorelines

- When large areas of weeds are removed, the cleared area needs to be replanted with native or non-invasive vegetation and stabilized against erosion. Refer to the King County Surface Design Manual for further information about sediment and erosion control practices (call 206-296-6519 or go to http://kingcounty.gov/wlr/Dss/Manual.htm for more information).
- Survey area and document extent of infestation.
- Focus on manual removal for small infestations if possible.
- When removing vegetation on shorelines (by lakes, streams and wetlands) use barriers to prevent sediment and vegetative debris from entering the water system.
- Cutting will not control purple loosestrife but it can serve in the interim until more effective control measures can be accomplished.
- For larger areas where herbicide use is warranted, spray using low pressure and large droplet size to reduce drift. If herbicide could potentially drift into the water or a wetland area, use only approved aquatic herbicides and surfactants after obtaining the necessary permits.
- Infested areas will need to be monitored for several years to control plants growing from root fragments and germinating from the extensive seed bank.

Control along Road Rights-of-Way

- Pull small infestations if possible.
- Spot spray larger infestations. Use a selective broadleaf herbicide in areas with desirable monocots such as grasses, sedges or cattails; if controlled with a non-selective herbicide, re-seed after control is completed.
- If plants are about to flower, they can be cut until a more effective control strategy can be used. Be sure to dispose of cut plant parts properly.
- If plants are sprayed, wait until the herbicide has had a chance to work before conducting any regular right-of-way mowing.

Disposal Methods

- All purple loosestrife plant parts, including flowers, seed heads, stems, leaves and roots must be securely bagged, and discarded in the trash or taken to a transfer station. **Do not compost or place in yard waste. Plants may regenerate in compost. If you have the ability to burn plants, following all local regulations and restrictions, burning vegetative material is an acceptable disposal method. Do not burn flowering stems or seed heads.**
- **NOTE:** Under the Washington State Lythrum quarantine (WAC 16.752.400-415), it is illegal to transport, buy, sell, offer to sell, or to distribute plants, plant parts or seeds of purple loosestrife into or within the state of Washington. However, by following the recommendations in this Best Management Practices document you are covered under the King County Noxious Weed Control Program's permit to transport purple loosestrife for the purpose of taking it to a transfer station or landfill.

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King County
Department of
Natural Resources and Parks
Water and Land Resources Division

Noxious Weed Control Program

BEST MANAGEMENT PRACTICES

Yellow-flag iris (*Iris pseudacorus*) Iridaceae

Class C Noxious Weed; Not Designated for Control

Legal Status in King County: Class C Noxious Weed (non-native species that can be designated for control under State Law RCW 17.10 based on local priorities.) The King County Noxious Weed Control Board does not require property owners to control yellow-flag iris, but control is recommended.

BACKGROUND INFORMATION

Impacts and History

- Alternate common names include yellow flag, paleyellow iris and yellow iris.
- On state weed lists in Connecticut, Massachusetts, Montana and New Hampshire in addition to Washington. Also on the USDA Natural Resources Conservation Service invasive plants list and on the Exotic Plant Pest List of the California Exotic Pest Plant Council.
- Yellow-flag iris displaces native vegetation along streambanks, wetlands, ponds and shorelines and reduces habitat needed by waterfowl and fish, including several important salmon species.
- It clogs small streams and irrigation systems, and it dominates shallow wetlands, wet pastures and ditches. Its seeds clog up water control structures and pipes.
- Rhizome mats can prevent the germination and seedling growth of other plant species. These mats can also alter the habitat to favor yellow-flag iris by compacting the soil as well as increasing elevation by trapping sediments.
- Studies in Montana show that yellow-flag iris can reduce stream width by up to 10 inches per year by trapping sediment, creating a new bank and then dominating the new substrate with its seedlings, creating still more sediment retention (Tyron 2006).
- Even when dry, yellow-flag iris causes gastroenteritis in cattle (Sutherland 1990), although livestock tend to avoid it. All plant parts also cause gastric distress in humans when ingested, and the sap can cause skin irritation in susceptible individuals.
- Native to Europe and the Mediterranean region, including North Africa and Asia Minor. Found as far north as 68 degrees North in Scandinavia.

- The earliest North American record comes from Newfoundland in 1911, and it was established in British Columbia by 1931. By 1961 yellow-flag iris was reported to be naturalized in Canada (Cody 1961). It was established in California by 1957 and in Montana by 1958 (Tyron 2006). It is now naturalized in parts of most states and provinces throughout North America except in the Rocky Mountains. (NRCS Plants Database).

Description

- A perennial, emergent iris that creates dense stands along freshwater margins. It is the only naturalized, emergent yellow iris in King County.
- Grows to 5 feet (1.5 m) tall.
- Has numerous thick, fleshy rhizomes.
- Flowers are yellow, showy, and sometimes have brown to purple veins at the base of the petals. Several flowers can occur on each stem.
- Can bloom from April to August; in western Washington usually blooms May into July. It will remain green all winter in mild years.
- Broad, flat, pointed leaves are folded and overlap one another at the base. They are generally longer in the center of the plant and fan out in a single plane toward the edges of the plant. The leaves are dark green to blue-green.
- Fruits are large capsules to 3 inches (8 cm) long. They are 3-angled, glossy green and contain rows of many flattened brown seeds.
- Seeds are corky, large - about ¼ inch (7 mm) across, and float. Seed pods grow in clusters that resemble little bunches of bananas. Seeds spread by water and usually germinate after the water recedes along the edges of the shore. They do not usually germinate under water.
- When not in flower or seed, can be confused with cattails (*Typha sp.*), which are round at the base and taller than yellow-flag iris, while iris are flattened along one plane and shorter. Can also be mistaken for native bur-reeds (*Sparganium sp.*), which have thick, spongy leaves that are somewhat narrower than iris leaves.

Habitat

- Occurs in freshwater wetlands, fens, ponds, lake shores, river and stream banks, wet pastures and ditches.
- Grows in standing water or next to it on saturated soils. Prefers silty, sandy or rocky soil.
- Generally grows in shallow water, but can create extensive mats over deeper water.
- Sometimes cultivated as a garden ornamental or used for landscaping purposes.

Reproduction and Spread

- Spreads by seed and vegetatively (rhizomes).
- Produces extensive thick, fleshy rhizomes, forming dense mats that exclude native wetland species. Up to several hundred flowering plants may be connected rhizomatously. Rhizome fragments can form new plants if they break off and drift to suitable habitat. Rhizomes that dry out remain viable and will re-infest an area if they are re-moistened.

- Flat spongy seeds disperse through water and germinate after the water recedes along shorelines. Submersed seeds will generally not germinate.
- Plants take three years to mature before flowering (Tyron 2006).
- The flowers are pollinated by bumble-bees and long-tongued flies.

Local Distribution

- Widespread throughout King County.
- Present along most lake shores and many stream banks in the developed areas of the county.
- A few shallow wetlands significantly impacted.

CONTROL INFORMATION

Integrated Pest Management

- The preferred approach for weed control is Integrated Pest Management (IPM). IPM involves selecting from a range of possible control methods to match the management requirements of each specific site. The goal is to maximize effective control and to minimize negative environmental, economic and social impacts.
- Use a multifaceted and adaptive approach. Select control methods that reflect the available time, funding, and labor of the participants, the land use goals, and the values of the community and landowners. Management may require dedication over a number of years, and should allow for flexibility in method as appropriate.

Planning Considerations

- Survey area for weeds, set priorities and select best control method(s) for the site conditions and regulatory compliance issues **(refer to the King County Noxious Weed Regulatory Guidelines or local jurisdictions)**.
- Isolated plants can be effectively dug up. Take care to remove all of the rhizomes, in order to stop them from infesting a larger area.
- For larger infestations, the strategy will depend on the site. Generally work first in least infested areas, moving towards more heavily infested areas. On rivers and streams, begin at the infestation furthest upstream and work your way downstream.
- If conducting manual control, be sure to collect any rhizome fragments that may float free.
- Minimize disturbance to avoid creating more opportunities for seed germination.

Early Detection and Prevention

- Look for new plants. Get a positive plant identification by contacting your local noxious weed control program or extension service.
- Look for plants along river and lake shorelines, wetlands, ditches and wet pastures.
- The best time to survey is in April to June when the plants are in flower.
- Look for seedlings starting in late winter.
- Dig up small isolated patches, being sure to remove all the rhizome.
- Don't buy, move or plant yellow-flag iris.

- Clean any tools and machinery that were used in an infested area before moving to another site.

Manual

- Hand removal with the use of hand tools is allowable in all critical areas in unincorporated King County. Check with the local jurisdiction for regulations in other areas.
- When removing manually, care should be taken to protect the skin, as resins in the leaves and rhizomes can cause irritation.
- Manual control is feasible for individual plants or small stands. You can easily pull seedlings in damp or wet soil.
- Dig out mature plants, taking care to remove all the rhizome. The rhizome is tough and may require heavier tools, such as pickaxes, pulaskis or saws. If you do not get all the rhizome, more plants will be produced. Keep watching the location after you have removed the plants, and new leaves will show you where you missed any sections of rhizome. Continue to remove the rhizome, and in this way you can eradicate a small patch.
- Simon (2008) found that for plants emergent in standing water for the entire growing season, cutting all leaves and stems off below the waterline can result in good control. This method is most effective if the plants are cut before flowering.
- Be sure to dispose of any removed pieces of rhizome away from wet sites. Composting is not recommended for these plants in any home compost system, because rhizomes can continue growing even after three months without water (Sutherland 1990).

Mechanical

- Removal of yellow-flag iris with hand held mechanical tools is allowable in critical areas and their buffers in unincorporated King County. Check with the local jurisdiction for regulations in other areas.
- In unincorporated King County, riding mowers and light mechanical cultivating equipment may be used in critical areas if conducted in accordance with an approved forest management plan, farm management plan, or rural management plan, or if prescribed by the King County Noxious Weed Control Program.
- Repeated mowing or cutting may keep yellow-flag iris contained and can potentially kill it by depleting the energy in the rhizomes after several years of intensive mowing (Tu 2003).

Cultural

- Small patches can be covered with a heavy tarp weighted at the edges for several years (Simon 2008). Be sure to extend the tarp well beyond the edges of the infestation and check periodically to ensure that plants are not growing up around the tarp. Other materials (heavy plastic, landscape cloth) are not as effective.
- Burning is not recommended. Seeds germinate and grow well after late summer burning (Sutherland 1990), and plants have a strong tendency to resprout from rhizomes after burning (Clark et al. 1998).

Biological

- Although a number of insects and pathogens are known to attack yellow-flag iris (Tu 2003), no biological control agents are presently known, and no research is currently being conducted.

Chemical

- Herbicides should only be applied at the rates and for the site conditions and/or land usage specified on the label. **Follow all label directions**.
- Herbicides can only be purchased and applied to aquatic systems in Washington State by a licensed pesticide applicator (contact Washington State Department of Agriculture for more information on pesticide licenses).
- There are federal, state and local restrictions on herbicide use in critical areas and their buffers. Refer to the **King County Noxious Weed Regulatory Guidelines** for a summary of current restrictions and regulatory compliance issues.
- For control of large infestations, herbicide use may be necessary. Infested areas should not be mowed until after the herbicide has had a chance to work, which may take several weeks, depending on the herbicide used.
- Due to dense growth, re-application a few weeks after initial treatment will probably be needed to get complete coverage (Tyron 2006).
- For several years following treatment, monitor areas for new plants germinating from the seed bank or from rhizome fragments. In some cases several years of treatment may be necessary.

Specific Herbicide Information

Since yellow-flag iris is a monocot, only non-selective herbicides are effective. However, non-selective herbicides will injure or kill any plant they contact, so special care must be taken when using these chemicals. Both of the herbicides discussed below are non-selective.

Glyphosate (e.g. Rodeo™ or Aquamaster™). This is the most frequently used chemical for controlling yellow-flag iris. Apply to actively growing plants in late spring or early summer. Apply directly to foliage, or apply immediately to freshly cut leaf and stem surfaces. Avoid runoff. (Tu, 2003). Follow the label for recommended rates for yellow-flag iris since higher rates may provide better results. A study in Montana showed good results with 5% Rodeo plus Competitor (Tyron, 2006). Glyphosate at lower rates is not as effective as either imazapyr or imazapyr and glyphosate combined.

Imazapyr (e.g. Habitat®). Simon (2008) found that 1% imazapyr (with 1% non-ionic surfactant) sprayed in the fall resulted in good control. Imazapyr sprayed in the spring, or a combination of imazapyr (1%) and glyphosate (2.5%) sprayed in fall both result in good control, but slightly less effective than imazapyr alone. Note that imazapyr has been shown to have some residual soil activity, so care should be taken to avoid spraying in the root zone of desirable plants, and do not replant the treated area for several months after application.

The above listed herbicides require the addition of an approved surfactant. Follow label directions for selecting the correct type of surfactant. Be sure that the selected surfactant is approved for aquatic use.

The mention of a specific product brand name in this document is not, and should not be construed as an endorsement or as a recommendation for the use of that product.

Chemical control options may differ for private, commercial and government agency users. **For questions about herbicide use, contact the King County Noxious Weed Control Program at 206-296-0290.**

Experimental

Preliminary trials indicate that injecting herbicide into the cut flowering stems of yellow-flag iris may provide a successful alternative treatment method with little or no non-target damage. Check with your local weed control agency for progress.

SUMMARY OF BEST MANAGEMENT PRACTICES

Small Infestations in Native and/or Desirable Vegetation

- Hand digging is recommended for very young plants not yet established.
- Larger plants from isolated small populations can be dug out from moist upland areas. This is difficult but possible with persistence.
- Replace any divots created when removing the plants to lessen the amount of disturbed soil.
- Plants emergent in standing water can be cut below the waterline.
- If manual control is not possible due to site conditions or available labor, apply appropriate herbicide by spot spray, stem-injection or wick-wiper to minimize off target injury.

Large Infestations

- Persistent mowing or cutting over several years may be effective. Cutting flowering plants will stop seed dispersal.
- Herbicide use may be necessary.
- If the infestation is in a pasture, combine control methods with ongoing good pasture management. Encourage healthy grassy areas by seeding and fertilizing. Use a mix of grass and clover species to improve resistance to weeds. Fertilize according to the soil needs.

Control in Riparian Areas or Lake Shores

- Survey area and document extent of infestation. Start eradication efforts at the headwaters and progress downstream whenever possible.
- Focus on manual removal for small infestations if possible.

- When removing vegetation near streams and wetlands use barriers to prevent sediment and vegetative debris from entering the water system.
- For larger areas where herbicide use is warranted, use the method that will cause the least amount of damage to desirable vegetation, such as spot spraying or wick wiping.
- When large areas of weeds are removed, the cleared area needs to be replanted with native or non-invasive vegetation and stabilized against erosion.
- Control of larger areas will need to incorporate a management plan lasting for several years to remove plants germinating from the seed bank and rhizome fragments.

Control on Road Rights-of-Way

- Dig up small infestations if possible.
- Spot spray if digging is not practical due to soil, site conditions or size of infestation.
- If plants are in grassy areas, re-seed after control is completed.
- If plants are sprayed, wait until the herbicide has had a chance to work (up to several weeks) before mowing.

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Fragrant Water Lily

Nymphaea odorata
Nymphaeaceae

Class C Noxious Weed
Control Recommended

Legal Status in King County: Fragrant water lily is a Class C noxious weed (non-native species that can be designated for control based on local priorities) according to Washington State Noxious Weed Law, RCW 17.10. The State Weed Board has not designated this species for control in King County. The King County Weed Control Board recommends control of this species where feasible, but does not require it.

BACKGROUND INFORMATION

History and Impacts

- *Nymphaea odorata* is native to the eastern half of North America, including southern Canada. It has been introduced as an ornamental in many parts of the world and is now found throughout North America. Although found throughout Washington, fragrant water lily is especially prevalent in western Washington lakes where it has been intentionally planted by property owners who admired the showy flowers.
- It is believed that fragrant water lily was originally introduced into Washington during the Alaska Pacific Yukon Exposition held in Seattle in the late 1800s.
- Left unmanaged, water lilies can restrict lake-front access and hinder recreation.
- Drownings in King County have been attributed to swimmers getting tangled in dense water lily stems.
- Water lilies foul boat motors and restrict passage for non-motorized boats.
- When allowed to grow in dense stands, the floating leaves prevent wind mixing and extensive areas of low oxygen can develop under water lily beds during the summer.
- Aggressive water lily mats can outcompete native plants, reduce biodiversity, change the predator/prey relationships in the lake and adversely impact the food web.
- Stagnant mats create mosquito breeding areas and increase the water temperature underneath by absorbing sunlight.
- Water lilies die back in the fall, and the resulting decay uses up dissolved oxygen and adds nutrients to the water, potentially increasing algal growth and related water quality problems.

Description

- Perennial floating leaved rooted aquatic plant, growing in about three to six feet of water. Blooms June to October.
- **Round, green leathery leaves** up to 10 inches across have a basal slit. The flexible leaf stalk is attached at the base of the slit. The leaves float on the surface of the water, rarely sticking up above it as water level drops.
- **Many-petaled Flowers** are showy and range from white to pink (rarely yellow). They are borne on an individual stalk which curls like a corkscrew after the flower has been fertilized and pulls the flower under water. Seeds are leathery capsules with numerous small seeds.
- Both flower and leaf stalks arise from **thick fleshy rhizomes**.
- Adventitious roots attach the horizontal creeping and branching rhizomes.

Habitat

- Fragrant water lily occurs in shallow freshwater ponds and lake margins 3-6 feet deep.
- It will also grow in slow moving water.
- It can tolerate a wide range of pH, and it prefers substrates from mucky to silty.

Reproduction and Spread

- Spreads by floating seed and by rhizomes.
- Seeds disperse through the water by wind and wave action.
- Rhizome pieces can also break off and move through the water before establishing in a new location.
- A planted rhizome will spread to cover about a 15-foot diameter circle in five years.
- Primary source of distribution to new water bodies is deliberate planting. Many cultivars of *Nymphaea odorata* are available in the nursery trade. However, waterfowl can also spread the plant between water bodies.

Local Distribution

- While fragrant water lily is widely present in western Washington, it is less so in eastern Washington and uncommon to absent in western Oregon lakes.
- *Nymphaea odorata* was found in 27 of 36 surveyed lakes in the developed areas of King County in 1996. The number of ponds and smaller wetlands containing the plant is considerably larger.
- Requests for water lily control represent a high percentage of the herbicide permit requests received by the Washington State Department of Ecology.

CONTROL INFORMATION

Integrated Pest Management

- The preferred approach for weed control is Integrated Pest Management (IPM). IPM involves selecting from a range of possible control methods to match the management requirements of each specific site. The goal is to maximize effective control and to minimize negative environmental, economic and social impacts.
- Use a multifaceted and adaptive approach. Select control methods which reflect the available time, funding, and labor of the participants, the land use goals, and the values of the community and landowners. Management will require dedication over a number of years, and should allow for flexibility in method as appropriate.

Planning Considerations

- Survey area for weeds, set priorities and select best control method(s) for the site conditions and regulatory compliance issues **(refer to the King County Noxious Weed Regulatory Guidelines)**.
- Small infestations may be effectively removed using manual methods or hand tools.
- For many lake and wetland infestations, the whole community will need to be engaged. Any control actions taken will necessarily affect all landowners adjacent to the water body and will require their approval and participation in order to succeed. In addition, many control options will be expensive.
- Commit to monitoring. Once initial control has been achieved, be sure to conduct follow up monitoring in subsequent years in order to catch any overlooked patches or returning infestations before they can spread. Without this, your control efforts can be wiped out within a few years.

Early Detection and Prevention

- Look for new plants. Get a positive plant identification from an authority such as King County Noxious Weed Control Program staff.
- Look for plants along lake shorelines and in stagnant or slow-moving water in wetlands and streams.
- The best time to begin surveys is late spring when new leaves arise, and they can continue into early fall when the plants senesce.
- Dig up small isolated patches.
- Don't plant fragrant water lily in natural water bodies. It is legal to buy and plant water lilies, but their use as an ornamental should be restricted to small self-contained ponds and other man-made water features with no hydrologic connection to any natural body of water.

Manual

- Hand pulling or cutting can be successful for a small area if repeated on a regular basis. Impractical for large infestations. Must remove all pulled or cut plants and plant parts from the water. HPA pamphlet permit required.
- Carbohydrate depletion is a technique whereby during each growing season, all emerging leaves are consistently removed. Reports indicate that it takes about two to three seasons to kill the plants. This method is difficult to sustain and impractical for large infestations.
- To completely remove plants by hand you must dig up the entire rhizome. HPA pamphlet permit required.
- All manual control sites should be monitored for several years for signs of plants growing from root fragments and from the seed bank.
- Hand pulling and the use of hand mechanical tools is allowable in all critical areas.
- Fragrant water lily can be composted on land or placed in yard waste bins.

Mechanical

- Permits are required for all mechanical control methods.
- An opaque bottom barrier can be used to suppress growth in small, discrete areas like at a boat launch or around a swimming area. Barriers need to be regularly cleaned because plants will root in the sediment that accumulates on top of them. Not practical for large-scale infestations.
- Cutting and Harvesting using boat-mounted cutters or in-lake harvesting barges is a reasonable long-term control solution. These must be done on a regular basis to maintain control. Neither method will eradicate an infestation.
- Rotovation (underwater rototilling) dislodges the large, fleshy waterlily rhizomes which can then be removed from the water. This process results in the permanent removal of waterlily rhizomes. Rotovation results in significant short term turbidity and loss of water clarity and quality.
- Other mechanical solutions that have been tried include mounting a backhoe to a barge and digging the plants out.

Chemical

- Herbicides may be the most reasonable option for eradication of large fragrant water lily infestations. Professional licensed contractors are available for hire to perform this task.
- Herbicides can only be applied to aquatic systems in Washington State by a licensed pesticide applicator. Aquatic formulations of herbicides are not available for sale over the counter to anyone without an aquatic pesticide license. **NEVER apply non-aquatic herbicide formulations to water since most of them include ingredients that are toxic to aquatic organisms.**
- For several years following treatment, monitor areas for new plants germinating from the seed bank. Eradicate any new growth using one of the manual control methods above.

Specific Herbicide Information

Glyphosate (e.g. Rodeo™ or Aquamaster™) Apply to actively growing foliage. Avoid runoff. Caution: Glyphosate is non-selective: it will injure or kill other vegetation contacted by the spray. NEVER substitute Round-up™ or other landscape formulations of Glyphosate: these have additives that can devastate aquatic systems.

Imazapyr (Habitat®) Apply to actively growing foliage. Caution: Imazapyr is non-selective: it will injure or kill other vegetation contacted by the spray.

Triclopyr (Renovate†3). Apply to actively growing foliage. Triclopyr is selective: it will injure other broadleaved plants but not grasses or other monocots such as cattails, rushes, or most native aquatic plants.

All the above listed herbicides require the addition of an approved surfactant. Follow label directions for selecting the correct type of surfactant. Be sure that the selected surfactant is approved for aquatic use.

The mention of a specific product brand name in this document is not, and should not be construed as an endorsement or as a recommendation for the use of that product. Chemical control options may differ for private, commercial and government agency users. **For questions about herbicide use, contact the King County Noxious Weed Control Program at 206-296-0290.**

Biological

- There is currently no biological control approved for fragrant water lily.
- Although a number of organisms have been studied in the past, there is no current plan to pursue biological control for fragrant water lily due to the widespread use of the plant as an ornamental in private, isolated water features.

SUMMARY OF BEST MANAGEMENT PRACTICES

- At all times at minimum a pamphlet HPA permit is required to do any activity that disturbs a lake bottom or wetland or streambed. For more extensive work, more specific permits will be required.
- Hand pulling, cutting or digging is recommended for small populations.
- Where this is not practical, cutting or harvesting can keep a large population under control when done consistently.
- Bottom barriers can maintain small areas of open water around boat launches, swimming areas or docks.
- To remove large areas of water lilies, mechanical methods (such as rotovation) or herbicides can be used.
- **Do not apply any herbicide to water without the proper licenses.** Hire a contractor to complete the work.

Disposal Methods

- Fragrant water lily can be left on land to dry out and/or decompose in an area where it will not move into a waterway.
- Fragrant water lily can also be composted away from water or placed in yard waste bins.
- Never dispose of fragrant water lily into waterways, wetlands, or other wet sites where it might grow and spread.

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Westerdahl, H.E. and K.D. Getsinger, eds. 1988. Aquatic plant identification and herbicide use guide, volume II: Aquatic plants and susceptibility to herbicides. Technical report A-88-9. Department of the Army, Waterways Experiment Station, Corps of Engineers, Vicksburg, MS.

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APPENDIX D

Sign Examples

DO NOT FEED THE BIRDS

Droppings Lead To Water Quality Problems Like Algae Blooms And Swimmer's Itch

18228

PREVENT

SWIMMER'S ITCH

The Parasite Causing Swimmer's Itch May Be Present In This Lake.

Shower Or Towel Dry Immediately After Leaving The Water.

For more information, or to report a case of swimmer's itch, contact the King County Health District at 206-296-4600

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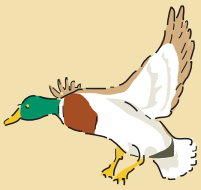
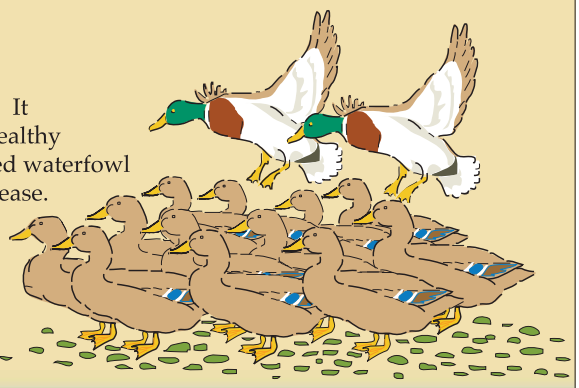
FOUR REASONS NOT TO FEED DUCKS AND GEESE



Many people like to feed wild ducks and geese but what seems like kindness can be very harmful. Here are several good reasons not to feed them:

1. HUMAN FOOD IS NOT GOOD FOR WATERFOWL

Human food is junk food for ducks and geese. It lacks minerals needed to make strong, healthy waterfowl. Overfed, undernourished waterfowl suffer from more illness and disease.



2. PARASITES IN WATERFOWL CAUSE SWIMMERS ITCH

Tiny parasites which live inside waterfowl release their eggs into the water. The larvae then burrow into water snails and grow into a larger form which can then dig into a swimmer. When the parasites die under the skin, swimmers may get an itchy allergic rash. Too many waterfowl often mean swimmers itch.

3. FEEDING WATERFOWL CAN INTERFERE WITH NATURE

Feeding waterfowl can artificially increase their population. Feeding also encourages waterfowl to "over-winter" in lakes and ponds--interrupting their natural migration patterns. When they stay through the winter the result can be an unhealthy build-up of duck and goose poop.

OTHER WAYS TO ENJOY WILDLIFE

If you enjoy feeding wild geese, ducks, birds and other animals, there are several petting zoos and parks throughout King County. The Audubon Society offers many programs for bird enthusiasts.

4. INCREASED NUTRIENTS CAUSE ALGAE AND WEED GROWTH

Waterfowl waste pollutes both water and surrounding beaches. Too many nutrients from these droppings fertilize murky green algae blooms and excessive aquatic weed growth crowding out other plants and animals. Lakes and ponds choked with aquatic weeds make it difficult or impossible for swimming and fishing.

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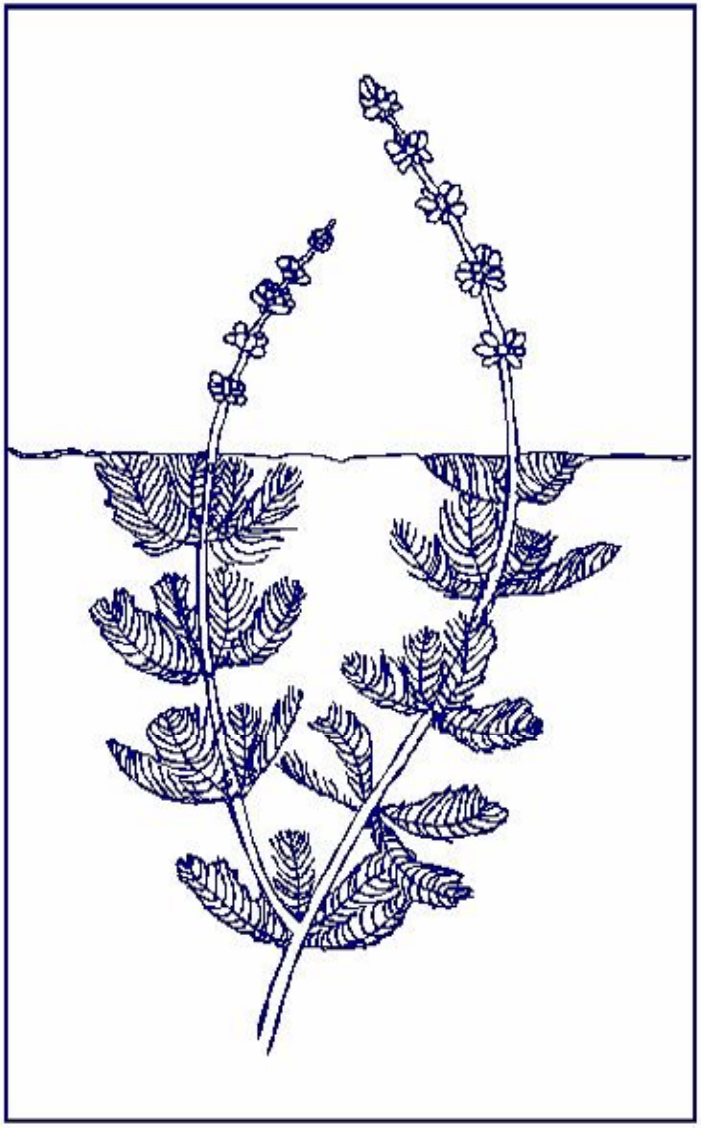
Remember to Check Your Boat for Milfoil



Steel Lake Management District

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