INTEGRATED AQUATIC PLANT MANAGEMENT PLAN

FOR

LAKES ERIE AND CAMPBELL

OCTOBER 2000

FINAL
PREPARED BY:

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ACKNOWLEDGEMENTS

The Skagit County Public Works Department wishes to acknowledge, and thank, the many individuals who have contributed to the process of developing this Integrated Aquatic Plant Management Plan (IAPMP) for Lakes Erie and Campbell. The lake community initiated and supported the development of this IAPMP, and community members have attended community meetings about the plan. They provided valuable input and suggestions about the plan.

The members of the Citizen Advisory Committee—Marsha Flowers, Mike Goodman, Mary Kirkwood, Gilbert Moore, and Diane Ramerman—deserve special recognition and thanks. They volunteered many hours, gathered input from the lake community, and held long committee meetings in order to develop the treatment plan for Lakes Erie and Campbell. Diane Ramerman acted as chair and secretary, and kindly hosted the committee's meetings.

Terry McNabb of RMI kindly completed the aquatic plant survey, and drafted the Characterization of Aquatic Plant Communities and Problem Statement sections of this IAPMP, at no charge. Terry McNabb also attended a community meeting and a meeting of the Citizen Advisory Committee to provide technical expertise. In addition, he was a valuable source of technical information for County staff during the writing of the IAPMP.

Kathy Hamel of the Washington Department of Ecology provided valuable technical guidance and information about grant funding through Ecology's aquatic weed management program. In addition, Kathy Hamel reviewed the IAPMP and contributed useful comments about the plan. Jim Johnston, Karl Mueller, and Pete Castle of the Washington Department of Fish and Wildlife furnished important technical guidance on fisheries and wildlife issues and grass carp.

Lastly, the Skagit County Board of Commissioners supported the development of this IAPMP. The Board of Commissioners dedicated County resources, including significant amounts of staff time, to helping the lake community complete this important planning effort.

EXECUTIVE SUMMARY

An Integrated Aquatic Plant Management Plan (IAPMP) provides a planning framework for making informed decisions about lake management activities. This IAPMP for Lakes Erie and Campbell examines aquatic plant and water quality problems in the lakes, evaluates potential treatment methods, describes the treatment plan for the lakes, and explores plan costs and funding.

Excessive aquatic plant growth, algal blooms, and the colonization of Lake Campbell by Eurasian watermilfoil and an exotic water lily are the principal problems in the Erie/Campbell lake system. The treatment plan focuses on control of aquatic plants rather than algae. The plan uses a two-pronged control strategy, combining both short-term and long-term solutions to aquatic weed problems.

In 2001 and 2002, aquatic herbicides—Navigate, Aquathol, and RODEO—are used to provide short-term control of aquatic weeds in Lakes Erie and Campbell. Meanwhile, grass carp will be stocked into both lakes to furnish long-term weed management. Beginning in 2002, grass carp will be stocked into the lakes for ongoing, aquatic plant control. In the plan, the following control treatments are used:

- Navigate treatments in 2001 and 2002 to target the Eurasian watermilfoil infestation in Lake Campbell for eradication.
- Follow-up diver hand pulling, or spot treatments with Navigate, in 2003-2005 to remove remnant milfoil plants in Lake Campbell.
- Aquathol treatments in 2001 and 2002 for excessive aquatic plant growth in Lake Erie.
- 2001 RODEO treatment targeted at the exotic water lily in Lake Campbell.
- RODEO treatments in 2001 to control native water lilies in both lakes where their growth is limiting access to the lakes.
- A grass carp stocking program for both lakes.

A permit application for stocking grass carp into Lakes Erie and Campbell will be submitted in 2001. The grass carp stocking program begins with an initial stocking of grass carp into both lakes in 2002. State policy stipulates that grass carp may only be planted into naturally closed water systems (no outlet) or waters that are screened. Although it may be possible to get a variance from this policy, the plan makes provision for the installation of a screen at the outlet of Lake Campbell in 2002. Under the grass carp stocking program, carp will also be stocked into both lakes in 2004, 2007, and 2010. The plan also provides for maintenance of the outlet screen.

Ongoing monitoring and public education are incorporated into the plan. The plan includes programs that focus on preventing the introduction/re-introduction of noxious aquatic weeds into Lakes Erie and Campbell and limiting nutrient and sediment inputs into the lakes.

The following table summarizes the estimated costs for implementing the plan. The plan will cost $293,000. This amounts to an average annual cost to each owner of $2,930 (based on an estimate of 100 owners). With a ten-year lake management district (LMD), each owner would pay approximately $293 per year on average for a period of ten years. If the County is awarded a $75,000 grant from the Department of Ecology, the duration of the LMD will be shortened.

Executive Summary Table: Summary of Estimated Costs for the Plan.

CONTROL TREATMENT	2001	2002	2003	2004	2005	2006-10	Total 10 Year
Navigate-Campbell-E. milfoil	35,000	25,000					60,000
Diver Hand Pulling or Spot Treatment-Campbell-E. milfoil			5,000	5,000	5,000		15,000
Aquathol-Erie-native plants	25,000	15,000					40,000
RODEO-Campbell-exotic w.lily	2,000						2,000
RODEO-(E & C)-native w.lily	5,000						5,000
Carp permit application-(E & C)	2,000						2,000
Stocking grass carp-(E & C)		86,800		8,400		16,800	112,000
Maintenance of outlet screen		2,000	2,000	2,000	2,000	10,000	18,000
Prevention Program (E & C)							
Annual survey/Milfoil surveillance	2,000	2,000	2,000	2,000	2,000	10,000	20,000
Signs	2,000						2,000
Volunteer training	1,000		1,000		1,000	2,000	5,000
Brochures/mailing	1,000	500	500	500	500	2,500	5,500
Watershed Protection (E & C)							
Brochures/mailing	1,000	500	500	500	500	2,500	5,500
Total-Control	76,000	131,800	11,000	18,400	11,000	43,800	292,000
Contingency Plans							
Remove water lily mats		1,000					1,000
Total-Contingency							1,000
Grand Total							293,000

Notes: Cost for an outlet screen ($70,000) is included in the cost of stocking grass carp in 2002. The Prevention Program focuses on preventing the introduction/re-introduction of noxious aquatic weeds into the lakes. The Watershed Protection Program focuses on limiting nutrient and sediment inputs into the lakes. These programs are essential elements of an IAPMP. An approved IAPMP is needed to obtain grant funding from the Department of Ecology. Contingency planning is for treatments that may be needed. There may be water lily mats that need to be removed after herbicide treatments. Voluntary donations could be solicited at the boat launches to help fund plan implementation. E & C = Erie and Campbell. E. milfoil = Eurasian watermilfoil. w.lily = water lily.

Implementation of the plan will require an ongoing commitment by the lake community and the County. Funding must be secured, treatments will need to be scheduled, and ongoing monitoring and public education programs need to be established in order to implement the plan.

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INTRODUCTION

Lakes Erie and Campbell are located in westerly Skagit County on Fidalgo Island approximately three miles south of Anacortes (see Figure 1, Vicinity Map). The lakes have a long history of dense algal blooms, aquatic weeds, and fish kills. The approach to date has been to treat each problem independently without evaluating the cumulative impacts.

The Washington Department of Ecology has developed guidelines for Integrated Aquatic Plant Management Plans (IAPMP). If a plan is developed according to their guidelines, Ecology will approve the plan. Once a plan is approved, funds for implementation—although extremely limited—are available on a competitive basis. The Erie/Campbell IAPMP has been developed according to Ecology's guidelines.

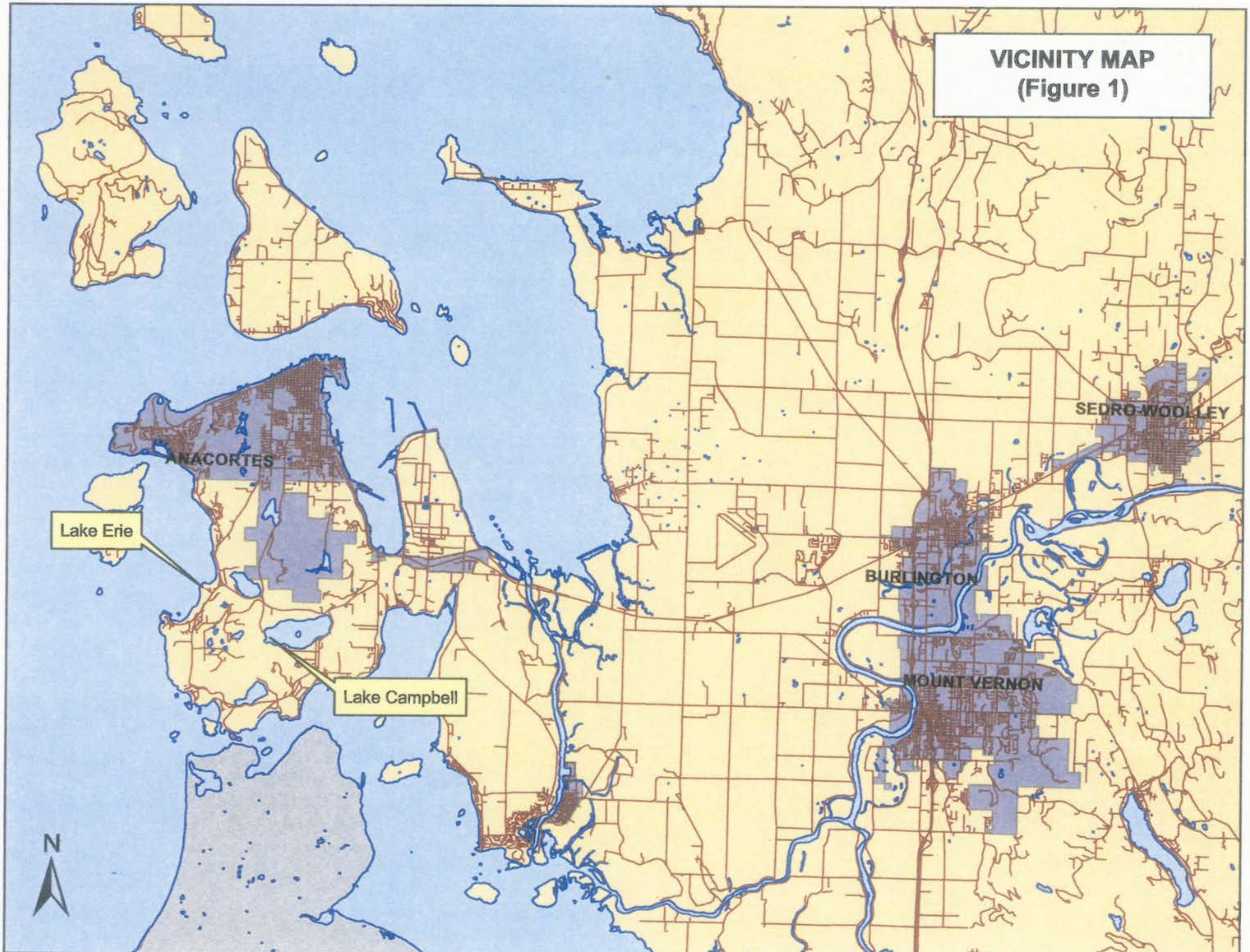
HISTORICAL BACKGROUND

Although separate lakes, Lake Erie drains into Lake Campbell via a half-mile stream. Lake Campbell then drains into Similk Bay through an intermittent stream. Lakes Erie and Campbell have an established history of water quality problems, largely the result of human interference with the natural hydrologic processes.

The lake residents, assisted by the County, have implemented a number of treatments to reduce the aquatic weeds without considering the collective impact of the treatments. There is no research evaluating if treatment alternatives are perpetuating a cycle whereby continued management is required.

Since the 1970s lake residents have complained about dense algal blooms, fish kills, related odors, and other water quality problems. So in 1980 the County applied for and obtained a grant from the Washington Department of Ecology and the Environmental Protection Agency to study the lakes. The study resulted in a report titled *Water Quality Analysis and Restoration Plan for Erie and Campbell Lakes* written by Entranco Engineers in 1983. The report, referred to as a Phase I – Lake Restoration Plan, included six key elements: 1) limnological and fisheries analysis, 2) data collection and project management, 3) preliminary engineering analysis of restoration alternatives, 4) community involvement program, 5) an environmental impact statement, and 6) development of a restoration plan and final report.

Algae blooms are the longest occurring problem. Algae can fill the lakes forming dense mats on the surface, choking out and killing other aquatic plants and fish. One of the preliminary restoration alternatives discussed in the report was using liquid aluminum sulfate to reduce the internal phosphorus loading thereby eliminating the major nutrient source for the algae. Phosphorus can be released from sediments when certain environmental conditions (such as anaerobic sediments) occur. Therefore, in 1985, 573 dry tons of aluminum sulfate (alum) were applied to both lakes. The result was a dramatic decrease in algae blooms the following summer. The cost of the alum application (materials, equipment, and labor) was $80,500. Entranco



VICINITY MAP
(Figure 1)
SEDRO-WOOLLEY
BURLINGTON
MOUNT VERNON
ANACORTES
Lake Erie
Lake Campbell
N

In the years after the alum treatment, the average size of the fish caught in both lakes has continued to decrease from 13.1" in 1985 to 10.8" in 1986 and 9.8" in 1987. No studies or research has been conducted to date to determine whether the alum impacted the average fish size, or if the two are unrelated.

Since the alum treatment in 1985, rooted aquatic weeds have increased both in numbers and variety. Both lakes are relatively shallow, which has allowed aquatic weeds to become established in addition to the ongoing algae blooms. The noxious, invasive, non-native aquatic weed, Eurasian watermilfoil (*Myriophyllum spicatum*), has become established in Lake Campbell. Eurasian watermilfoil was not documented in 1986, but is now considered dominant in Lake Campbell by the Washington State Department of Ecology Aquatic Weeds Program staff. Eurasian watermilfoil is also present in numerous other recreational lakes in Washington. It is likely that boats used in other infested lakes spread Eurasian watermilfoil to Lake Campbell. There is a danger that Eurasian watermilfoil could be spread from Lake Campbell to other non-infested lakes in the area. Lake Erie is at high risk of being infested by boaters coming from Lake Campbell. In addition, both lakes are at risk because Brazilian elodea (*Egeria densa*), another invasive, non-native aquatic weed, is found in Big Lake, which is about 17 miles east of Lake Campbell.

Traditionally, lake residents have used a large, mechanical weed harvester—similar to a wheat combine—to mow the aquatic weeds. In 1986, 610 wet tons of weeds were harvested from the lakes. The result was an immediate reduction in the mass of the vegetation making boating and swimming more enjoyable. However, it is likely the mowing disbursed plant fragments and seeds around the lakes, thereby increasing the area infested and perpetuating the need for treatment. It should be noted that the 1986 harvest was of native plants. Generally, milfoil produces more biomass than native species and is more expensive to harvest.

Harvesting can be a preferred method for treating milfoil once milfoil has become widespread within the lake. However, when milfoil is first invading a waterbody, harvesting tends to spread it. The most accepted treatment to eradicate milfoil is an aquatic herbicide called SONAR, in which the active ingredient is fluridone.

There is, however, a biological method that has been somewhat successful in reducing Brazilian elodea and sometimes Eurasian watermilfoil in lakes – a triploid grass carp, *Ctenopharyngodon idella*. Grass carp are rendered sterile by subjecting the eggs to a temperature or pressure shock which cause a third chromosome to form (triploid versus the normal, fertile diploid fish). Only triploid fish are allowed to be introduced, under permit, in Washington. Grass carp eat aquatic vegetation, although they have definite food preferences. Often the target plant, like Eurasian watermilfoil, can be one of the last species to be consumed. When carefully used, grass carp can be successful in reducing the population of aquatic weeds, but there are also risks in using an introduced species. In several lakes where grass carp were overstocked, all of the aquatic vegetation was consumed leaving a moonscape type aquatic environment. It is generally understood that a healthy fishery requires about 25 to 40 percent aquatic plant cover in a lake. However, the amount of cover needed varies with fish species, size of the lake, and whether there are surrounding wetlands. With the recent listing of the Chinook salmon under the Federal

Endangered Species Act, there is increased concern of the potential impacts of grass carp and other forms of aquatic plant control on salmonids.

Despite two major plans and a related Environmental Impact Statement, there has not been an integrated management plan that evaluates the issues and potential treatment alternatives collectively for Lakes Campbell and Erie. While alum may clear up the water by reducing the algae blooms, milfoil thrives in the clear water and increases in biomass. The biomass dies back the following winter increasing the internal phosphorous loading and allowing the algae to flourish the following summer. Herbicide treatments could possibly increase the cyclic effect. An integrated study is needed to evaluate the cumulative impacts of the various management methods.

Besides the need to study the cumulative impacts, financing constraints also require an integrated plan be developed. The costs of all treatment options have increased with time and the problems have intensified. Federal and state grants that have traditionally been available to offset the costs have all but disappeared. The County can not justify using countywide tax dollars to treat such a localized problem. And while the State of Washington actually owns the lake bottoms, there are limited state dollars available to address aquatic plant problems (about $400,000 per year statewide). The lake residents remain the only viable financial source at this time.

The residents are aware of the dwindling financial resources and are willing to pay a portion of the costs. The promulgated method for fee collection is to form a lake management district pursuant to the Revised Code of Washington Chapter 36.61. Lake residents can vote to form a district and assess themselves a fee to treat the lake. Residents of Lakes Erie and Campbell petitioned the Skagit County Board of Commissioners to hold a vote. However, before the Board can do so, a plan must be developed that identifies the approach and related cost to treat the lake. The budget must be identified in order to determine how much to assess each resident. The residents have requested that an Integrated Aquatic Plant Management Plan be developed in order to identify a comprehensive solution to aquatic plant management, and to allow them the avenue to finance the implementation of the plan.

The above noted problems with aquatic weeds and algal blooms and other water quality problems have impaired the beneficial use opportunities the lakes provide for lakeside residents and recreational users of the lakes and could have a negative impact on property values. Recreational opportunities such as fishing, swimming, boating, and shoreline related activities and aesthetics have been adversely affected by these problems. Extensive aquatic weed growth poses a safety hazard for recreational users like swimmers and water skiers because of entanglement problems. Excessive aquatic weed growth also causes problems for beneficial uses such as boating and fishing. In addition, it can result in the production of fish populations consisting of many small fish rather than fewer large fish, oxygen deficiencies in the water column (possibly causing fish mortalities), and the accelerated "filling in" of lakes from the accumulation of decomposing plant material. Algal blooms can cause aesthetic problems and foul odors, contribute to fish kills, and induce allergic and/or toxic reactions in humans and animals. In May 2000, a toxic blue-green algae bloom occurred in Campbell Lake.

LAKE AND WATERSHED CHARACTERISTICS

PHYSICAL CHARACTERISTICS

Lakes Erie and Campbell are located in westerly Skagit County on Fidalgo Island (Township 34 North, Range 1 East/Range 2 East, W.M.). Both lakes are shallow, kettle lakes of glacial origin. Lake Erie is approximately three-quarters of a mile in length and one-third of a mile in width. Campbell Lake is about 1.5 miles long and two-thirds of a mile in width. In general, both lakes are oblong in shape. Table 1 presents selected physical characteristics for Lakes Erie and Campbell. Figure 2, a bathymetric map, shows contour lines for lake depth.

Table 1. Physical Characteristics for Lakes Erie and Campbell

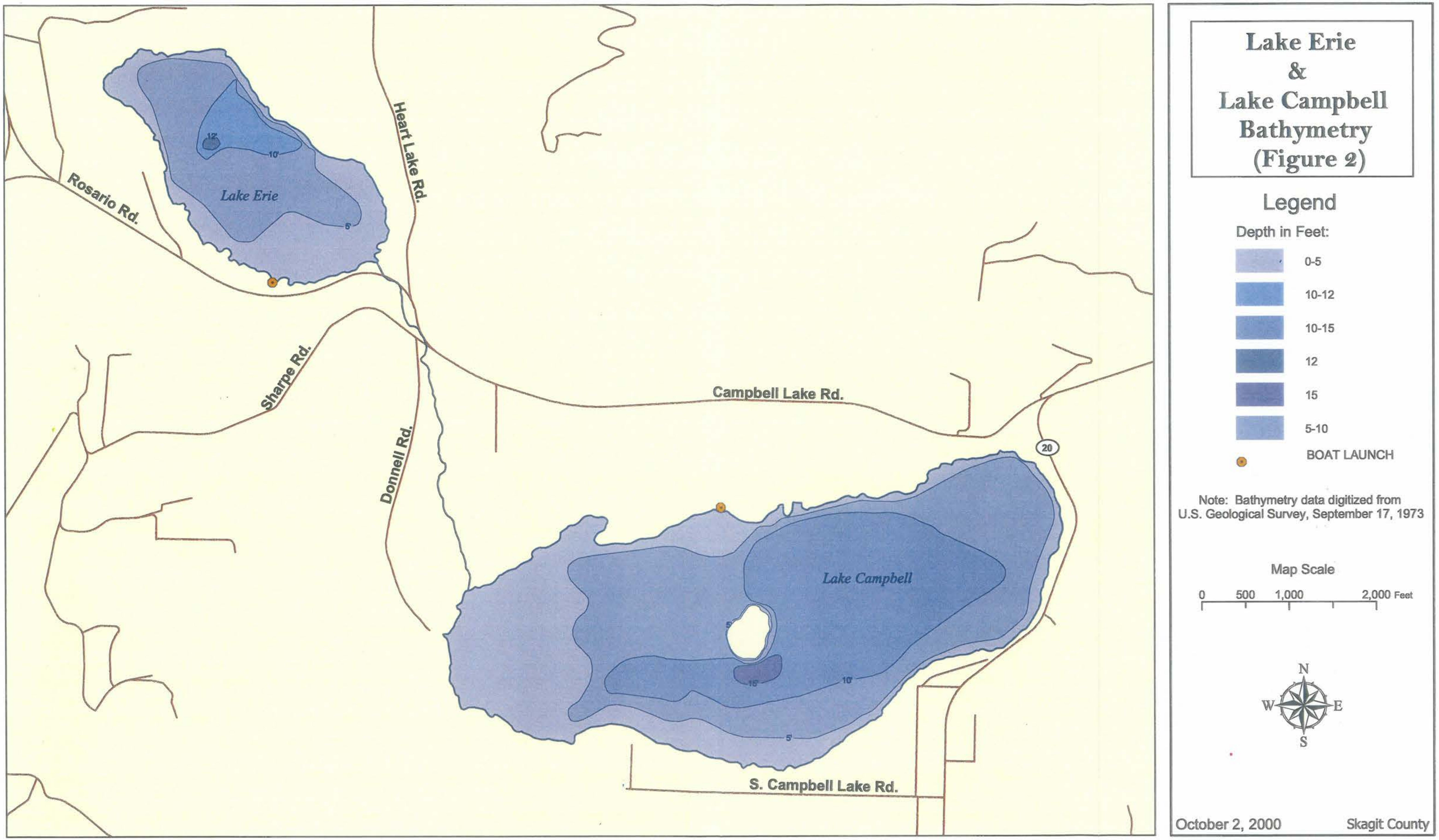
Parameter	Erie Lake	Campbell Lake
Surface Area (acres)	113	367
Mean Depth (feet)	6	8
Maximum Depth (feet)	12	16
Volume (acre-feet)	711	2,770
Shoreline (miles)	1.82	3.69
Altitude (feet above mean sea level)	90	43
Replacement Rate (volumes per year)	1.8	2.0
Drainage Area (square miles)	1.62	5.68
Sources: Entranco Engineers, 1983 and Washington State Department of Ecology, 2000		

Lake Erie receives runoff from several small drainageways on a seasonal, intermittent basis. Campbell Lake receives the overflow from Lake Erie and input from intermittent streams. A single, unscreened outlet on the lake's southern shore drains Campbell Lake and discharges into Puget Sound in the vicinity of Dewey Beach.

The Erie/Campbell lake watershed encompasses approximately 3,635 acres (5.68 sq. mi.), with 1,036 acres (1.62 sq. mi.) included in the Lake Erie sub-basin. Forestry, public/park, agriculture, and rural residential are the primary land uses in the watershed. The predominant land uses around the shoreline of the lakes are low-density rural residential and forestry.

On-site septic systems provide wastewater disposal in the Erie/Campbell watershed. Water supply within the watershed is primarily furnished by domestic wells, although the City of Anacortes does have water lines in the watershed that serve a limited number of residences. No public water systems draw surface water from either lake.

The Washington Department of Ecology's Water Rights Application Tracking System indicates that the City of Anacortes has a water right certificate for both Lake Erie (municipal use) and Lake Campbell (municipal and commercial/industrial uses). However, the City of Anacortes does not draw surface water from either lake.


Lake Erie
&
Lake Campbell
Bathymetry
(Figure 2)
Legend
Depth in Feet:
0-5
10-12
10-15
12
15
5-10
BOAT LAUNCH
Note: Bathymetry data digitized from U.S. Geological Survey, September 17, 1973
Map Scale
0 500 1,000 2,000 Feet
N
W
E
S
October 2, 2000
Skagit County
Lake Erie
12'
10'
5'
Rosario Rd.
Heart Lake Rd.
Sharpe Rd.
Donnell Rd.
Campbell Lake Rd.
20
Lake Campbell
5'
15'
10'
S. Campbell Lake Rd.

Five other parties have water right certificates for Lake Campbell. Uses include domestic-single, domestic-multiple, and irrigation. For Lake Erie, one party has a water right certificate for domestic-single, irrigation, and stock watering uses and one party has a water right application for recreational use. Both lakes have water right applications that have been rejected and water right certificates that have been cancelled.

WATER QUALITY

Eutrophication refers to the nutrient enrichment of a body of water. Excessive nutrient loading (usually phosphorus) results in excessive aquatic weed and algae growth and reduced visibility.

Based on a year-long study from September of 1981 to August 1982, Entranco Engineers in their 1983 report, *Water Quality Analysis and Restoration Plan for Erie and Campbell Lakes*, summarized the physical, chemical, and biological conditions of Erie and Campbell Lakes as follows:

- The lakes are shallow and eutrophic, as demonstrated by low Secchi disk visibility, high total phosphorus concentrations, and high chlorophyll-a values.
- Intensive algal growth is dominated by blue-green algae, which causes taste and odor problems and reduces aesthetics (blue-green algae blooms can also be toxic).
- Algal growth is phosphorus limited.
- Phosphorus input is primarily from internal sediment and plant internal sources.
- High pH generated by algae and plant growth accelerates sediment release of nutrients and ammonia toxicity.
- Significant weed growth contributes to internal phosphorus supply and interferes with recreational use of the lake.
- Dissolved oxygen concentrations are generally adequate to support aquatic life.
- Bacterial quality of the lakes appears good but should continue to be monitored.
- Occasional acute fish mortalities may be linked to un-ionized ammonia toxicity in Lake Erie.
- Fish are noted to have poor quality flesh during algal blooms.
- Overstocking of trout in Erie Lake may be involved in excessive chronic mortalities and may also, indirectly, result in increased algal blooms by directly decreasing zooplankton grazing.

Temperature stratification was not observed in either lake during the year-long study. Entranco Engineers' 1983 report concluded that sediment release and aquatic weeds were the most significant controllable sources of phosphorus loading, accounting for 92% of controllable phosphorus in Erie Lake and 81% of controllable phosphorus in Campbell Lake, and that lake restoration techniques should focus on in-lake phosphorus sources rather than on external nonpoint sources.

FISH AND WILDLIFE COMMUNITY

Lake Erie has been managed by the Washington Department of Fish and Wildlife (WDFW) as a "trout only" lake. Rainbow trout have been introduced in Lake Erie to provide recreational fishing. Currently, the lake is stocked with approximately 15,000 Rainbow trout (11-12 inches long) each spring. Perch, bass, and brown bullhead are found in Lake Erie, but the sports fishing is primarily for Rainbow trout. The stream between Campbell and Erie lakes provides low-quality spawning habitat for sea-run Cutthroat trout.

Campbell Lake is managed as a warm water fishery lake by the WDFW. Bass, bluegill, perch, brown bullhead, crappie, pumpkin seed, and sculpin are found in Campbell Lake. Historically, Campbell Lake was known as a good bass lake. However, dense aquatic weed growth has inhibited the feeding of larger bass and resulted in undersized fish. The WDFW occasionally plants trout and warm water species in Campbell Lake, but there has been a low success rate for introduced Rainbow trout. Since 1984, the WDFW has twice planted Chinook salmon in Campbell Lake (the last time was 5-6 years ago). However, the lake is not part of their native range. The outflow stream for Campbell Lake furnishes spawning habitat for Chum and Coho salmon, winter-run steelhead trout, and sea-run Cutthroat trout.

Most of the Erie/Campbell lake watershed is rural or undeveloped and it provides habitat for a wide variety of wildlife. The City of Anacortes has park/community forest lands within the watershed and part of Deception Pass State Park is in the watershed. Of special note, bald eagles, osprey, great blue herons, and a variety of waterfowl are found within the watershed. Erie and Campbell Lakes and associated wetlands provide nesting, forage, and cover for a number of waterfowl and wildlife species.

The Washington State Department of Natural Resources maintains a database to catalogue endangered, threatened, and sensitive plants; select rare animal species; and high-quality wetland and terrestrial ecosystems for the Washington Natural Heritage Program. A search of this database did not show any information on significant natural features for the aquatic habitat within Lakes Erie and Campbell. It can not be assumed that this database is all-inclusive. The database search did show that there are several high-quality terrestrial ecosystems in the Erie/Campbell lake watershed, including a high-quality forest ecosystem (Douglas fir/salal-oceanspray) located in the Southeast Quarter of Section 2, Township 34N, Range 1 East, W.M. that occurs down to the shoreline of Lake Erie. This high-quality forest ecosystem adjoins the conservancy area on the Water Body Usage Map (Figure 6) for Lake Erie.

The WDFW maintains data on species of concern (endangered, threatened, sensitive, candidate, and state-monitored species) and priority habitats and species. The WDFW's data shows Lakes Erie and Campbell as priority habitats. Both are waterfowl wintering areas. The wetlands associated with Campbell Lake and upland areas around the lake are also shown as priority habitats. In addition, there are numerous, other priority habitats within the Erie/Campbell lake watershed, including wetlands, urban natural open space, and old growth/mature forests. Species of concern within Township 34 North, Range 1 East and Township 34 North, Range 2 East (which would contain the Erie/Campbell lake watershed) include the bald eagle, peregrine falcon, osprey, common loon, great blue heron, and caspian tern. It can not be assumed that the WDFW's data is all-inclusive.

AQUATIC PLANT COMMUNITY

Aquatic plants are an important part of freshwater ecosystems. They serve important functions such as providing fish and wildlife habitat and protecting water quality and shoreline stability. Native plant communities are desirable from a habitat perspective. Sustaining a diverse and healthy balance of desirable plant species is important. However, aquatic plants become aquatic weeds when they begin to interfere with the beneficial uses of a water body. Noxious, invasive, non-native aquatic weeds, like Eurasian watermilfoil, are of special concern because they can out-compete more desirable native species. When these exotic aquatic plants are introduced into lake ecosystems they can replace native plant communities and thereby degrade fish and wildlife habitat.

Tables 2 and 3 present species lists and distributions for the aquatic plant communities of Lakes Erie and Campbell, respectively. This aquatic plant data is based on surveys conducted by the Washington State Department of Ecology Aquatic Weeds Program staff on 9/16/99 for Erie Lake and 8/4/99 for Campbell Lake.

Table 2: Species List for Aquatic Plants in Lake Erie

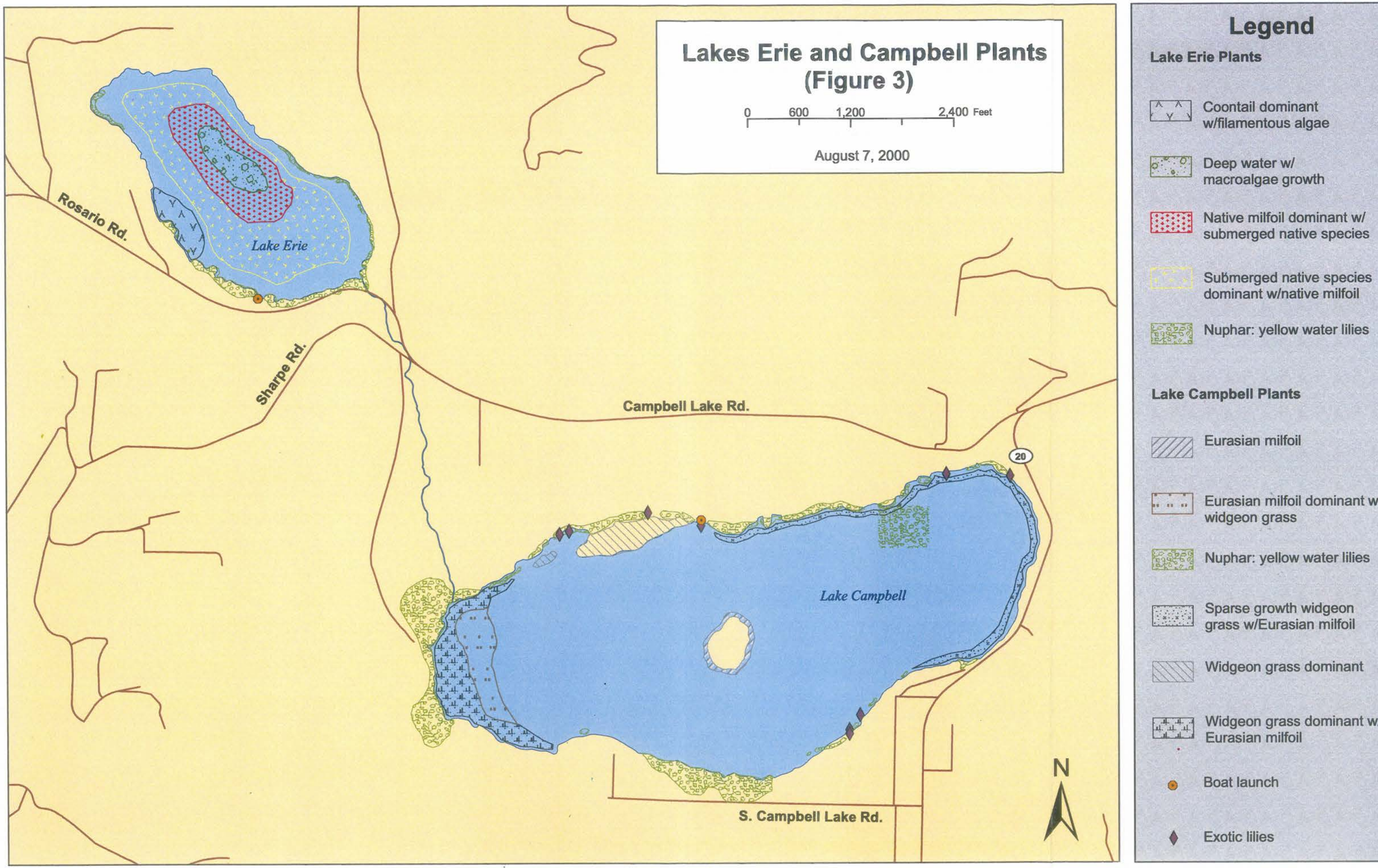
Scientific Name	Common Name	Distribution
Carex sp.	Sedge	2
Ceratophyllum demersum	Coontail; hornwort	2
Chara sp.	Muskwort	2
Eleocharis sp.	Spike-rush	2
Elodea canadensis	Common elodea	1
Myriophyllum sibiricum	Northern watermilfoil	2
Najas flexilis	Common naiad	3
Nuphar polysepala	Spatter-dock, yellow water-lily	3
Phalaris arundinacea	Reed canarygrass	2
Potamogeton foliosus	Leafy pondweed	3
Potamogeton pectinatus	Sago pondweed	3
Scirpus sp.	Bulrush	2
Solanum sp.	Nightshade	1
Sparganium sp.	bur-reed	1
Typha latifolia	Common cattail	2
Utricularia vulgaris	Common bladderwort	1

Distribution Key:
1 = few plants in only one or a few locations
2 = few plants, but with a wide, patchy distribution
3 = plants in large patches, co-dominant with other plants
(Source: Washington State Department of Ecology, 2000)

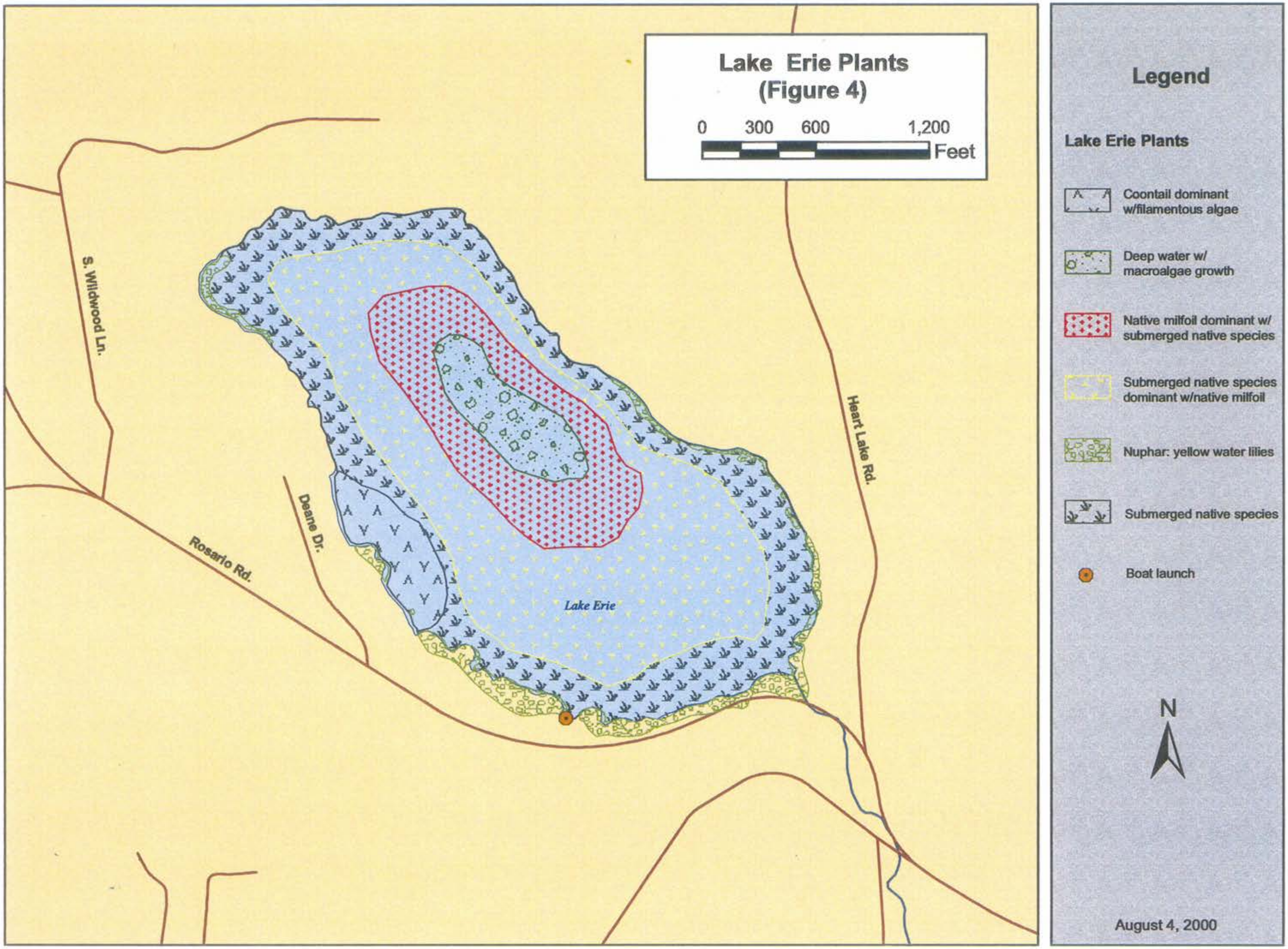
Table 3: Species List for Aquatic Plants in Lake Campbell		
Scientific Name	**Common Name**	**Distribution**
Ceratophyllum demersum	Coontail; hornwort	3
Iris pseudacorus	Yellow flag	3
Juncus sp.	Rush	2
Lemna trisulca	Star duckweed	2
Myriophyllum spicatum	Eurasian watermilfoil	4
Nuphar polysepala	Spatter-dock, yellow water-lily	3
Nymphaea odorata	Fragrant water-lily	2
Potamogeton pectinatus	Sago pondweed	2
Potamogeton sp. (thin leaved)	Thin leaved pondweed	2
Scirpus sp.	Bulrush	2
Typha latifolia	Common cattail	2
Distribution Key: 1 = few plants in only one or a few locations 2 = few plants, but with a wide, patchy distribution 3 = plants in large patches, co-dominant with other plants 4 = plants in nearly monospecific patches, dominant (Source: Washington State Department of Ecology, 2000)		

IAPMP Aquatic Plant Survey

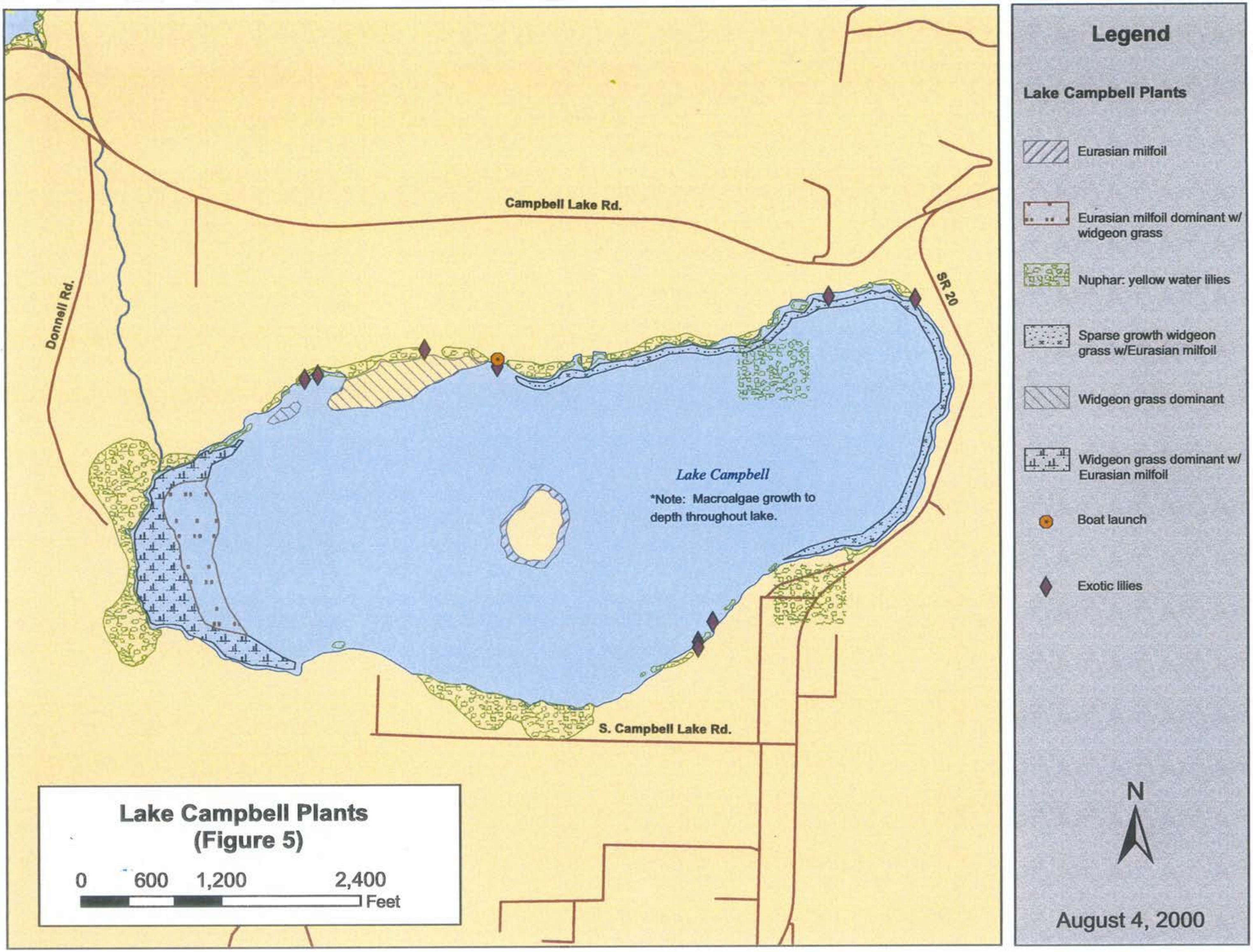
For this IAPMP, Resource Management, Inc. (RMI) surveyed the Erie-Campbell lake system on July 24, 2000 to map the extent and types of aquatic vegetation present in the two lakes and characterize the aquatic plant communities. Survey results are presented visually in the aquatic plant coverage maps for Lakes Erie and Campbell, Figures 3, 4, and 5. Figure 3, which shows both lakes on the same map, is provided for perspective. Figures 4 and 5, on which the lakes are shown separately, show the aquatic plants at a larger scale than Figure 3.



Lakes Erie and Campbell Plants
(Figure 3)
0
600
1,200
2,400 Feet
August 7, 2000
Rosario Rd.
Lake Erie
Sharpe Rd.
Campbell Lake Rd.
20
Lake Campbell
S. Campbell Lake Rd.
N
Legend
Lake Erie Plants
Coontail dominant w/filamentous algae
Deep water w/ macroalgae growth
Native milfoil dominant w/ submerged native species
Submerged native species dominant w/native milfoil
Nuphar: yellow water lilies
Lake Campbell Plants
Eurasian milfoil
Eurasian milfoil dominant w/ widgeon grass
Nuphar: yellow water lilies
Sparse growth widgeon grass w/Eurasian milfoil
Widgeon grass dominant
Widgeon grass dominant w/ Eurasian milfoil
Boat launch
Exotic lilies



Lake Erie Plants
(Figure 4)
0 300 600 1,200
Feet
Legend
Lake Erie Plants
Coontail dominant w/filamentous algae
Deep water w/ macroalgae growth
Native milfoil dominant w/ submerged native species
Submerged native species dominant w/native milfoil
Nuphar: yellow water lilies
Submerged native species
Boat launch
N
August 4, 2000
S. Wildwood Ln.
Deane Dr.
Rosario Rd.
Heart Lake Rd.
Lake Erie


Legend
Lake Campbell Plants
Eurasian milfoil
Eurasian milfoil dominant w/ widgeon grass
Nuphar: yellow water lilies
Sparse growth widgeon grass w/Eurasian milfoil
Widgeon grass dominant
Widgeon grass dominant w/ Eurasian milfoil
Boat launch
Exotic lilies
N
August 4, 2000
Campbell Lake Rd.
Donnell Rd.
SR 20
S. Campbell Lake Rd.
Lake Campbell
*Note: Macroalgae growth to depth throughout lake.
Lake Campbell Plants
(Figure 5)
0 600 1,200 2,400
Feet

Characterization of Aquatic Plant Communities

There are a few characteristics that Lakes Erie and Campbell have in common, which will have a bearing on the development of an aquatic plant management plan.

The littoral zone (shallow water zone) of a lake is defined as that portion of the water body that supports submerged aquatic plant growth. This zone is that portion of the lake extending from shoreline outward to the greatest depth occupied by rooted aquatic plants. The key determining factor in defining that depth is light penetration. Aquatic plants need sunlight for photosynthesis. Light becomes absorbed and extinct with depth in a lake naturally. Other factors like turbidity and algae populations can further limit the penetration of light in a lake. Since Lakes Erie and Campbell are both shallow systems, the majority, if not all, of the surface acres of these lakes have the potential to support submerged aquatic vegetation at problem levels.

The second point in common is that large portions of the shoreline have not been developed and are relatively pristine. This condition is not often found in the more urban lake environments in the Puget Sound area. Many of the lakes in this region have been fully developed with residential homes. Most of these lakes have cleared shorelines where vegetation like emergent wetland plants and lily pad communities have been completely removed. This littoral edge is important to many species of fish and amphibians. Lakes Erie and Campbell both have large undeveloped portions of the shoreline where these natural conditions still exist. Part of the management effort should be to maintain these areas where there is no interference with the various uses of lake front property.

Erie Lake

There is a diverse community of submerged aquatic plants and algae present in Erie Lake. As this lake system is relatively shallow and water clarity is fairly good, there are thriving aquatic plant communities throughout the lake. As seen in Figure 4, the map of Lake Erie plants, there are six basic vegetative zones in this lake that have importance from an aquatic plant management perspective.

The first zone is the emergent plant/native water lily communities mapped along the shoreline. The dominant plant in this community is the water lily, *Nuphar sp.;* the common name for this plant is Spatterdock. This lily provides excellent habitat for a number of fish and other aquatic organisms. However, it can also be a threat to the safety of swimmers. A number of drowning cases in the past few years have been attributed to swimmers becoming entangled in water lily growth. This plant community also has an understory of a number of common native submerged plants like Elodea (*Elodea canadensis)* and Coontail (*Ceratophyllum demersum*).

The second zone extends from the shoreline out to approximately the four-foot contour in the lake. At the time of the survey, this near shore area of the lake was characterized by populations of low growing submerged plants including Elodea, Coontail, various pondweeds (members of the *Potamogeton* family) and macro algae such as *Nitella.* There were some areas in this zone where native Milfoil had established as well.

The third zone extends from about the four-foot contour out to about the eight-foot contour. This zone of the lake has extensive growth of submerged vegetation forming surface mats and filling the water column. There are two dominant species of plants in this zone, Thin Leafed Pondweed (*Potamogeton sp.*) and native Milfoil (*Myriophyllum sp.*), which filled this area of the lake at levels that would be considered problematic. The dominant plant in this area of the lake was the

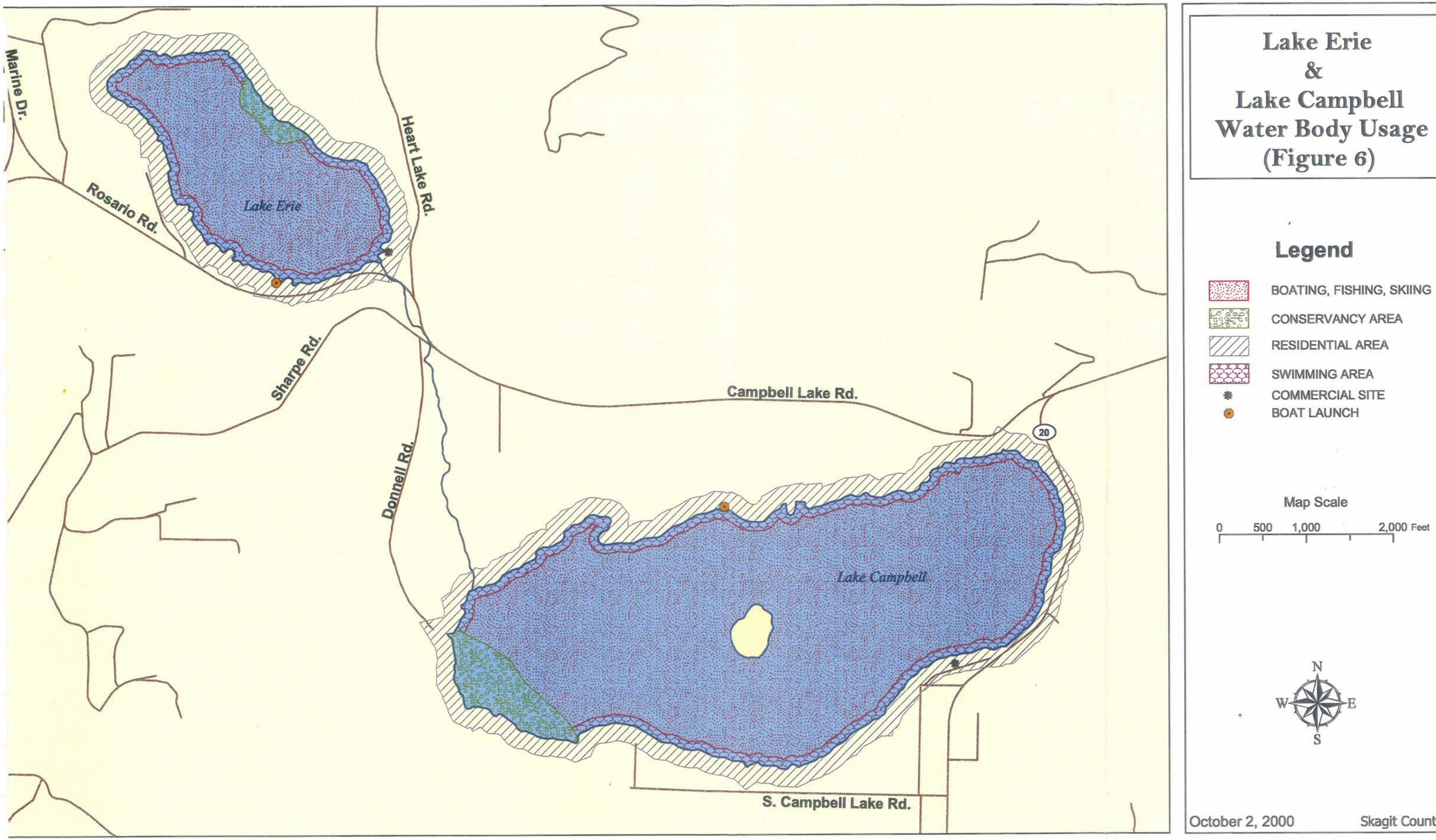
Native plant communities serve important functions in aquatic systems such as providing fish and wildlife habitat and protecting water quality and shoreline stability. Eurasian watermilfoil, an invasive, non-native aquatic weed, can out-compete other, more desirable native species thereby damaging the structure and function of aquatic ecosystems and degrading fish and wildlife habitat.

Single-species stands of Eurasian watermilfoil provide poor habitat for waterfowl, fish, and other wildlife. Significant rates of plant sloughing and leaf turnover and decomposition of high biomass at the end of the growing season increase the internal loading of phosphorus and nitrogen to the water column. Dense mats of Eurasian watermilfoil interfere with the beneficial uses of a water body.

Eurasian watermilfoil spreads primarily by stem fragments, which can root and produce new plants. In late summer, this plant's stems become quite brittle and roots begin to form on the stem. Stem fragments can be created by boats, harvesting operations, wave action, and wildlife. Milfoil also fragments naturally. Prevention of Eurasian watermilfoil invasion requires control of fragment spread.

CHARACTERISTIC USE

Lakes Erie and Campbell offer varied recreational opportunities for both residents and visitors. Both lakes have public boat launches, which furnish lake access for recreational activities such as fishing, boating, water skiing, swimming, wildlife viewing, and aesthetic enjoyment. Privately owned docks and other access/view points allow lakeside residents to enjoy these recreational amenities too. Lake Erie provides a trout fishery and Campbell Lake furnishes a warm water fishery. Lake Erie has a privately owned campground and Campbell Lake has a resort. Erie and Campbell Lakes and associated wetlands provide habitat for a number of waterfowl and wildlife species. The lakes' location in the Puget Sound lowlands and proximity to State Highway 20 have made them popular destinations for visitors from around the region who travel to the lakes to enjoy their recreational amenities. The Water Body Usage Map, Figure 6, portrays the water body use areas for Lakes Erie and Campbell.


Lake Erie
&
Lake Campbell
Water Body Usage
(Figure 6)
Legend
BOATING, FISHING, SKIING
CONSERVANCY AREA
RESIDENTIAL AREA
SWIMMING AREA
COMMERCIAL SITE
BOAT LAUNCH
Map Scale
0 500 1,000 2,000 Feet
October 2, 2000
Skagit County
N
S
E
W
Marine Dr.
Heart Lake Rd.
Rosario Rd.
Lake Erie
Sharpe Rd.
Campbell Lake Rd.
Donnell Rd.
20
Lake Campbell
S. Campbell Lake Rd.

PROBLEM STATEMENT

Erie Lake

From an analysis of the conditions present in Erie Lake at the time of the aquatic plant survey, there is a significant submerged aquatic weed problem present in the lake. The pondweed and native milfoil growth that dominate the middle of the lake have formed dense mats that will interfere with recreational use of this lake and could pose a threat to swimmers. The levels of surface area coverage present could also have an impact on fisheries and water quality. Warm water fisheries tend to thrive when the percent plant cover in the littoral zone of the lake are in the 30 to 40 percent coverage range. In this case, the majority of the surface acreage in the lake is littoral zone and dense plant coverage makes up over 70 percent of that area. In addition, dense surface mats of aquatic weeds can cause increased water temperatures as they absorb sunlight during the day and convert that energy to heat. At night as these plants respire, they can cause significant reductions in dissolved oxygen and increased levels of carbon dioxide that can impact fish and other aquatic life.

The primary focus of the management plan for this lake should be to significantly reduce the dense aquatic plant growth in the center zones of the lake. There could also be a focus on the filamentous algae problem present adjacent to the homes on the southwest shoreline. There may be a need for limited control of *Nuphar* (water lily) and submerged vegetation in the shoreline areas where this growth is limiting access to the lake by shoreline residents as well.

Campbell Lake

There are local areas of the lake where Eurasian watermilfoil and Widgeon Grass pose a problem. Since Eurasian watermilfoil is listed as a noxious weed and is a threat to both Campbell Lake and any surrounding lakes, like Lake Erie, that boaters might transport this plant to, it should be targeted for control. The exotic water lily growth should also be targeted before it spreads further and replaces native Spatterdock communities. The primary water quality issue for Campbell Lake currently is the intense algae bloom.

It should be recognized that Campbell Lake is a shallow system and that absent the algal bloom conditions in the lake, submerged aquatic plants would in all likelihood pose a widespread problem. If management options are selected that reduce the algae populations and result in clearing the water up, it is probable that a significant submerged aquatic weed problem will develop. The management plan needs to recognize and address this probable impact of treatments to control algae.

MANAGEMENT GOALS

Lakes Erie and Campbell are both shallow and eutrophic (nutrient rich) in nature, conditions that are conducive to the growth of aquatic plants and algae. Phosphorus, a primary limiting nutrient for aquatic plant and algae growth, comes principally from nutrient cycling within the lakes. Given these fundamental conditions, there are no "easy fixes" for the management problems of the Erie/Campbell lake system. Aquatic plants will tend to flourish when algal growth is controlled, and vice versa.

It is important to acknowledge that Lakes Erie and Campbell will never experience the same high water quality and lack of plants that deep-water lakes do because of their shallow and eutrophic nature. The goals of this IAPMP recognize that it is not realistic or desirable, in the case of Lakes Erie and Campbell, to manage for "pristine" lake conditions. These goals reflect the underlying focus of the IAPMP, which is to enhance the water quality and beneficial uses of the lakes in an environmentally and fiscally responsible manner.

The management goals for Lakes Erie and Campbell are:

- Eradicate or reduce Eurasian watermilfoil.
- Control other aquatic plants in problem areas where they impair beneficial uses of the lakes.
- Prevent the spread of Eurasian watermilfoil to Erie Lake and other nearby lakes.
- Eliminate the need for the weed harvester.
- Reduce algae blooms.
- Manage aquatic weed and algal bloom problems in a financially feasible manner.
- Manage for lake conditions that sustain a diverse and healthy balance of native plant communities to support the needs of lakeside residents and beneficial uses of the lakes.
- Develop an educational program that promotes lake and watershed stewardship and a greater awareness of the threat of noxious aquatic weeds.
- Develop funding mechanisms to continue long-term control of noxious aquatic weeds.

PUBLIC INVOLVEMENT

The citizens of the Lake Erie/Campbell community have a long-standing history of public involvement. They have worked together for the last 25 years to help develop and implement a strategy for managing their lakes. The lake community has formed a lake association, the Lake Campbell/Erie Association, and initiated the process for forming a lake management district (LMD). Meetings and newsletters of the lake association have focused on lake management issues, problems, techniques, and strategies, and the association has coordinated the volunteer efforts of citizens, like weed harvesting, to control aquatic weeds. The lake community intends to form a LMD to help fund the implementation of this IAPMP.

There has been substantial public involvement in the development of this IAPMP. At the request of the lake community, the County assigned personnel (both newly hired and existing staff) to assist the community in developing an IAPMP. County staff prepared a draft IAPMP, which was presented to the lake community at an August 22, 2000 community meeting.

At the August 22nd meeting, public input was gathered on the draft plan. The community raised numerous concerns about the draft IAPMP and decided that the draft plan was not acceptable. A strong interest was expressed in pursuing the use of several treatment methods and funding mechanisms that were not recommended by County staff in the draft IAPMP. The community then elected a Citizen Advisory Committee, comprised of members of the lake community, to respond to the community's concerns and develop a new treatment plan for the lakes.

Marsha Flowers, Mike Goodman, Mary Kirkwood, Gilbert Moore, and Diane Ramerman were elected to serve on the Citizen Advisory Committee. The committee included two community members from Erie Lake and three from Campbell Lake.

The Citizen Advisory Committee and County staff met on August 30, September 7, and September 11, 2000, and responded to the community's concerns. Terry McNabb of RMI attended one meeting to present information on aquatic herbicides and other treatment methods. The committee examined the feasibility of those treatment methods and funding mechanisms put forth by the lake community at the August 22nd community meeting, gathered additional input from the community, and developed a new treatment plan.

A second community meeting was held on September 19, 2000, at which the committee presented the new treatment plan to the community. The community responded favorably to the new treatment plan at the September 19th meeting, and consequently, the IAPMP was then amended to reflect the community's consensus approval of the new treatment plan. In the final IAPMP, the draft IAPMP's recommended strategy for aquatic plant control was replaced by the committee's new treatment plan.

The Washington Department of Ecology also reviewed and commented on the draft IAPMP. Input on management options was also gathered from the WDFW. Ecology's comments and WDFW input were considered by the committee during the drafting of the new treatment plan.

EVALUATION OF POTENTIAL TREATMENT METHOD COMBINATIONS AND LIKELY IMPACTS TO FLORA AND FAUNA

When aquatic plants, due to excessive growth, reach levels that interfere with the beneficial uses of a water body or noxious aquatic weeds are introduced into a water body, aquatic plant controls need to be considered. In the case of Lakes Erie and Campbell, algal blooms, as well as excessive macrophyte growth and the introduction of noxious aquatic weeds, are problematic. This section of the IAPMP provides an overview of control methods.

This overview of treatment methods borrows extensively from *A Citizen's Manual for Developing Integrated Aquatic Vegetation Management Plans* (Gibbons et al. 1994). Because this manual was published in 1994, treatment costs noted in this section of the IAPMP, which are used primarily for comparative purposes, reflect 1994 costs, unless otherwise noted.

CHEMICAL APPLICATION

1. Aquatic Herbicides

Aquatic herbicides are one of the principal methods of controlling aquatic weeds in Washington. They are chemicals specifically formulated for use in water to kill or control aquatic plants. Systemic herbicides are absorbed by and translocated throughout the plant. They are capable of killing the entire plant. Consequently, systemic herbicides can provide long-term control of aquatic weeds and can be used to remove vegetation from a water body. Contact herbicides kill the plant surface that they contact when applied. They do not provide control of root systems. Target plants can regrow from the root systems. Consequently, contact herbicides generally provide maintenance control of aquatic weeds rather than removal of the weeds from the water body.

Only those aquatic herbicides that currently are allowed to be used for aquatic weed control in Washington are discussed in this IAPMP. Two herbicides, diquat and triclopyr, that are currently under consideration for such use were not evaluated. If their use for aquatic weed control is allowed in the future, they will need to be evaluated as management options.

Copper sulfate and copper chelates have been used as aquatic herbicides. Copper compounds can also be used for algae control. Copper is persistent in the environment and can be toxic to fish and other aquatic organisms. The Washington Department of Ecology strongly discourages the use of copper in Washington waters and copper compounds are not allowed in waters with salmonids. Consequently, copper compounds were not considered as a management option in this IAPMP.

Although aquatic herbicides have been one of the principal methods used to control aquatic weeds, their use should be carefully considered because it involves the introduction of a substance into the environment that could potentially have adverse effects on organisms other than the target plants. The transport of herbicides in water to non-treatment areas is a special concern with aquatic applications. Herbicides used on aquatic weeds in lakes enter water, where they may be moved from place to place within a lake by currents or downstream if they enter an outlet stream. In addition, people may remove treated lake water for uses such as domestic water supplies or irrigation.

a. Fluridone

Fluridone (SONAR) is a slow-acting, systemic herbicide used in the management of aquatic plants in freshwater lakes, ponds, etc. It is applied in liquid or slow-release pellet form and is effective in controlling submersed and emergent aquatic plants, especially where there is little water movement. Its use is most applicable for whole-lake or isolated bay treatments to control a variety of exotic and native species. Injury symptoms include retarded growth, "bleached out" leaves, and plant death.

The effects of SONAR treatment become noticeable seven to ten days after application. Control of target plants often requires 60 to 90 days to become apparent. Due to its slow-acting nature, SONAR is best applied during the early growth phase of the target plant, usually spring-early summer. Envirovision (1997) reported that susceptible weed species need to be subjected to SONAR at levels above ten ppb (parts per billion) for over eight weeks to maximize effectiveness and provide the best chance of eradication.

Advantages Because it is a systemic herbicide, SONAR is capable of killing roots and shoots of aquatic plants, thereby providing some relatively long-term control. A variety of aquatic plants are susceptible to SONAR treatments. Eurasian watermilfoil is particularly susceptible to the effects of SONAR. Although fluridone is considered to be a non-selective herbicide, when used at low concentrations, it can be used to selectively remove Eurasian watermilfoil. When used to manage Eurasian watermilfoil, SONAR is applied several times during the summer to maintain a low, but consistent concentration in the water. To be effective, fluridone concentrations of ten to 15 ppb must be maintained in the water column for ten to 12 weeks. Fluridone has a very low order of toxicity to zooplankton, benthic invertebrates, fish, and wildlife and, if used according to label instructions, does not pose any effect to human health.

Disadvantages Since SONAR is a slow-acting herbicide, its control effects may not be evident for several months. It is not effective in flowing water situations because of the long uptake time needed for absorption. Because of potential drift out of the treatment zone, SONAR is not suitable for treating a defined area within a large, open lake. Since a variety of aquatic plants are susceptible to SONAR treatments, non-target plants, including beneficial ones, may be adversely affected. There is a potential for the release of nutrients to the water column and consumption of dissolved oxygen from decaying plants. Irrigating with water treated with SONAR may damage irrigated vegetation. SONAR-treated water from lakes should not be used for irrigation for 14 days following application. To protect drinking water sources, applications should not be made within 0.25 miles of a potable water intake, except for whole-lake treatments where treatment rates are 20 ppb or less.

Although SONAR provides long-term control, treatment costs (materials and application) by private contractor are relatively high, ranging from about $700 to $1,000 per acre, depending on the scale of treatment. A recent cost estimate (August 2000) by RMI for SONAR treatments was $75,000 to $100,000 for Lake Erie and $200,000 to $300,000 for Lake Campbell, for a combined cost of between $275,000 to $400,000.

b. Glyphosate

Glyphosate (RODEO or Pondmaster) is a non-selective, broad-spectrum herbicide used primarily for control of emergent or floating-leafed plants. It is a systemic herbicide that is applied to the foliage of actively growing plants, where it is quickly absorbed and then translocated throughout the entire plant. RODEO provides effective control of many emergent and floating-leafed plants, such as fragrant water lily (*Nymphaea odorata*), purple loosestrife (*Lythrum salicaria*), and water lilies (*Nuphar spp.*). RODEO is not effective against submersed plants or those with most of their foliage below water. Thus, it will not provide effective control of Eurasian watermilfoil.

Glyphosate binds tightly to soil particles on contact and is unavailable for root uptake. Consequently, proper application to emergent foliage is critical for herbicidal action to occur. Injury symptoms include wilting and yellowing of plants, followed by complete browning and death. Symptoms may not be evident for up to seven days.

Advantages Since it is a systemic herbicide, RODEO is capable of killing the entire plant, thereby furnishing long-term control benefits. It carries no swimming, fishing, or irrigation label restrictions and dissipates rapidly from natural waters (its average half-life in an aquatic system is two weeks). RODEO has a low toxicity to benthic invertebrates, fish, birds, and mammals.

Disadvantages RODEO is a non-selective herbicide, so its use can impact non-target plants that are susceptible to its effects. There is a possibility of drift from aerial applications affecting non-target plants, but the risk of drift is anticipated to be negligible if applications are made according to label instructions and permit requirements. Label restrictions include a restriction against using this herbicide within ½ mile of a potable water intake.

Treatment costs (materials and application) by private contractor average about $250/acre, depending on the scale of treatment.

c. Endothall

Endothall (Aquathol) is a fast-acting, non-selective, contact herbicide that is not readily translocated within aquatic plants. Aqueous or granular forms of the dipotassium salt of endothall is permitted in State waters with stringent use restrictions on water contact, irrigation, and domestic purposes over and above label restrictions.

Since endothall kills only the plant tissues it contacts, the entire plant is not killed and regrowth can occur from unaffected root tissues. Thus, this herbicide provides primarily short-term control of aquatic weeds. Duration of control is dependent on contact efficiency and regrowth from unaffected roots. Control effectiveness typically lasts from a few weeks to several months.

In some circumstances, season-long control is possible. Carryover effectiveness into the following growing season is not typical. Eurasian watermilfoil is susceptible to endothall.

Advantages Contact herbicides, such as endothall, generally are faster-acting than systemic herbicides. Signs of tissue death are often evident in one to two weeks. Impacts on non-target plants from drift are usually minimal with proper application of this product.

Disadvantages A variety of aquatic plants are susceptible to endothall, so impacts on non-target plants are a possibility. Endothall does not provide long-term control of aquatic plants because the entire plant is not killed. Currently, there is an eight-day swimming restriction following endothall treatment (the Department of Ecology has proposed that this be changed to a 24-hour swimming advisory). There are also fish consumption restrictions (within three days of treatment) associated with this herbicide. In addition, there are restrictions on using water from treated areas for domestic purposes, watering livestock, irrigation, and preparing agricultural sprays.

Treatment costs (materials and application) by private contractor average about $500 to $700 per acre, depending on the scale of treatment.

d. 2,4-D

The use of the herbicide—2,4-dichlorophenoxyacetic acid (2,4-D)—is currently approved for Eurasian watermilfoil removal projects. 2,4-D (Aqua-Kleen or Navigate) is a relatively fast-acting, systemic herbicide used for controlling many submersed, emergent, and floating-leafed plants. Broadleaf aquatic plants are very susceptible to this herbicide.

This herbicide is currently approved for removal of limited, pioneering infestations of Eurasian watermilfoil. Government entities in Washington State received legislative permission to use 2,4-D for Eurasian watermilfoil control effective May 10, 1999. Although no permits are required, there are some special requirements to be followed such as notification of the Departments of Health, Ecology, Agriculture, and Fish and Wildlife and all lake residents 21 days prior to treatment, sponsorship by a government body, and application only in water bodies where Eurasian watermilfoil occupies 20% of the littoral zone or less. Treatment areas must be marked by buoys. The Department of Ecology may prohibit the use of 2,4-D products, if they contain dioxin in excess of the standard allowed by the U.S. Environmental Protection Agency. WDFW may impose timing restrictions on the use of 2,4-D to protect salmon and other fish and wildlife.

2,4-D is applied in a granular formulation and can be effective for spot treatment of Eurasian watermilfoil. When used at the label rate of 100 pounds per acre, 2,4-D treatments have been shown to selectively affect Eurasian watermilfoil, leaving native aquatic species relatively unaffected. When eradication is the goal, treatment up to two times per year may be necessary.

Advantages Since 2,4-D is a systemic herbicide it can kill the entire plant and provide long-term control benefits. As noted above, this herbicide can be used for spot treatment of Eurasian watermilfoil. 2,4-D is primarily toxic to green plants and much less toxic to mammals, birds, fish, shellfish, insects, worms, fungi, and bacteria. When properly used, it does not persist in the environment at levels harmful to animals and aquatic organisms. It does not concentrate in food chains.

Disadvantages Non-target plants may be negatively impacted by treatment. There is a potential for the release of nutrients to the water column and consumption of dissolved oxygen from decaying plants. As noted above, 2,4-D is primarily toxic to plants, but toxicity to fish, aquatic invertebrates, birds, and mammals has also been observed. When treating with 2,4-D, there is a 24-hour swimming restriction for treatment areas. According to current labels (3/99) aquatic herbicide formulations of 2,4-D may not be applied to waters used for irrigation, agricultural sprays, watering dairy animals, or domestic water supplies.

In August 2000, RMI estimated treatment costs for Navigate (2,4-D) at about $500 per treated acre.

2. Aluminum sulfate

Entranco Engineers in their 1983 report, *Water Quality Analysis and Restoration Plan for Erie and Campbell Lakes*, note that aluminum sulfate (alum) is a chemical coagulant that has been commonly used for the treatment of industrial wastewater and municipal drinking water supplies. Alum treatments have also been used in the restoration of eutrophic lakes. Their purpose is to lower a lake's phosphorus content by removing phosphorus from the water column and retarding its release from lake sediments. Alum treatments remove phosphorus from the water column by the precipitation of aluminum phosphate, sorption of phosphates on the surface of aluminum-hydroxide polymers or floc, and entrapment and sedimentation of phosphorus-containing particulate matter by the aluminum-hydroxide floc.

The addition of alum to natural waters results in the formation of an aluminum-hydroxide complex. The white floc that is formed settles through the water column to the lake bottom. The floc physically entrains algal cells and suspended solids and chemically binds with dissolved phosphorus during sedimentation, removing all these materials from the water column. Alum treatments can significantly reduce the level of total water column phosphorus. Because phosphorus is an essential limiting nutrient for algae, alum treatments indirectly control algal growth. In addition, the alum floc that covers the sediments acts as a phosphorus seal to retard future sediment phosphorus release. An attendant benefit is increased water clarity. Alum treatments can provide a substantial moderate-term (two to five years or more) reduction in water column phosphorus and corresponding algal growth.

Based on 1985 and 1986 post-restoration monitoring, Entranco Engineers, in a 1987 report titled *Erie and Campbell Lakes Final Report: Restoration Implementation and Evaluation*, concluded that the restoration work for Lakes Erie and Campbell (1985 alum treatment and 1986 mechanical plant harvesting) had resulted in a pronounced improvement in water quality in both lakes. Mean summer total phosphorus concentrations and chlorophyll-a concentrations were reduced significantly in both lakes, with the most dramatic reduction seen in Lake Erie. Secchi depth visibility also increased in both lakes, with the most pronounced improvement occurring in Lake Erie. Lake Erie's traditional late summer blue-green algae bloom was totally averted in 1986 and recreational opportunities were greatly enhanced. In both lakes, the alum treatment was responsible for most of the reduction in internal phosphorus loading.

Alum treatments introduce a potentially toxic substance, aluminum, into lakes. Excessive concentrations of dissolved aluminum can be toxic to Rainbow trout and other fish and invertebrates. This toxicity problem can be avoided if alum is applied in a dosage/manner that does not consume all the alkalinity in the system during application. In lake waters, pH decreases (acidity increases) and alkalinity is reduced as alum is added. Water quality monitoring is needed to ensure that pronounced reductions in pH do not occur as the result of an alum treatment. Applications that result in a post-treatment pH below 6.0 are not considered environmentally safe in regards to aluminum toxicity. A buffering agent can be added to ensure that lake waters do not become too acidic. Other concerns about alum treatments include their impact on aquatic communities and acid-rain-sensitive lakes and the possibility of bioaccumulation of aluminum in aquatic organisms.

No fish kills resulting from the 1985 alum treatment were observed on Campbell Lake. In Erie Lake, about twenty trout and several hundred prickly sculpins died. In their 1987 report on post-restoration monitoring, Entranco Engineers reported on longer-term impacts of the alum treatment on the Erie Lake trout population finding that results tended to indicate that:

- There was little or no influence of alum on the 1985 trout growth.
- Poor trout growth was observed over the 1986/1987 winter period.
- Lake restoration activities were not detrimental to overall trout survival, but there was a successive reduction in trout size between 1985 and 1987.
- Benthic invertebrates appeared in the trout diet each month after the alum treatment, but the large grazing zooplankter, *Daphnia pulicaria*, showed an apparent reduction.

Entranco Engineers pointed out that it was difficult to pinpoint why trout growth was poor during the winter of 1986/1987 and trout size decreased between 1985 and 1987.

In their 1983 report, Entranco Engineers recount that there is no known danger of aluminum toxicity to humans resulting from alum treatment. However, concerns about alum treatments and human health have been raised. Pathogenic bacteria in the floc that settles to the lake bottom may survive for short periods. The floc could be hazardous if ingested by recreational users, such as swimmers or water skiers, or taken into a potable water supply. If a treatment lake serves as potable water supply, there may also be a concern about aluminum in drinking water. Concerns have been raised about a potential link between aluminum intake and Alzheimer's disease.

One likely impact of alum treatments would be accelerated aquatic plant growth due to increased transparency in the water column. Macrophytes are likely to be light limited in eutrophic lakes with dense algal blooms. As transparency and light penetration increase because of decreased algal blooms, aquatic plant growth will be stimulated, which in turn could result in an increase in internal phosphorus loading that is attributable to plant internal sources.

Advantages Removes dissolved phosphorus, algal cells, and suspended solids from the water column. Retards phosphorus release from lake sediments. Reduces the level of total water column phosphorus. Controls algal growth. Increases water clarity.

Disadvantages Introduces aluminum, a potentially toxic substance, into lakes. Alum treatments will worsen aquatic weed problems. Periodic treatments are required. Alum treatments are expensive.

The cost of the 1985 alum application for both lakes was $80,500 (materials, equipment, and labor) or $168 per acre. Entranco Engineers estimated the costs for engineering/monitoring services at $36,100 or $75 per acre. If engineering/monitoring costs are included, total treatment costs in 1985 were $116,600 or $243 per acre. Cost savings were realized during the 1985 alum application because, instead of using a private contractor, the County managed the rental/mobilization of the application barge and County personnel were used to apply the alum.

A more recent alum treatment (1997) on a Washington lake (Horseshoe Lake) cost significantly more per acre than the historical treatment costs for Lakes Erie and Campbell. Alum treatments for this 85-acre lake cost $95,000 (not including engineering costs) or $1,117 per acre. If engineering costs of $15,000 were included, the cost per acre would be nearly $1,300. However, a buffering agent was used during the Horseshoe Lake treatment, whereas a buffering agent was not used during the 1985 alum application for Lakes Erie and Campbell.

Alum treatments costs for Lakes Erie and Campbell will be dependent on factors such as, the required aluminum sulfate dosage and whether a buffering agent is needed to avert reductions in pH. With alum treatments, there is a potential for pronounced reductions in the pH of the water body, and it is very important not to let the pH of the water body fall below 6.0 at any time. Water sampling and testing is needed to determine aluminum sulfate dosage rates and buffering needs. The testing needed to calculate dosage rates, etc. and estimate treatment costs for Lakes Erie and Campbell were not included in the scope of this IAPMP. Therefore, specific cost estimates are not available for this IAPMP. If alum treatments were selected as a management option, the water sampling and testing needed to calculate dosage rates/buffering needs and develop specific cost estimates would be included in the scope of the contract for the alum treatment work.

Discussion with contractors and review of costs for recent, alum treatment projects indicates a wide range—$500 to $1,300 per acre—of cost estimates for alum treatments. Obviously, given this wide range, any cost estimates presented in this IAPMP are preliminary in nature and could be inaccurate. Water sampling and testing is needed to accurately project alum treatment costs for Lakes Erie and Campbell.

Given the above range ($500 to $1,300 per acre), alum treatment costs for Lakes Erie and Campbell could range from $240,000 to $624,000. Based on discussions with contractors, $750 per acre seems to be a reasonable estimate of alum treatment costs for Lakes Erie and Campbell. At this rate, costs for Lake Erie and Lake Campbell would be approximately $85,000 and $275,000 respectively. The total cost would be $360,000. Treatments would be required periodically.

Mechanical Control Methods

1. Mechanical Harvesting/Cutting

Harvesting/cutting involves cutting aquatic plants below the water surface, with or without the collection of cut plant fragments for upland disposal. It is considered a short-term method that temporarily removes nuisance plants. Harvesting is usually performed during the summer to maximize the removal of plant material. Mechanical harvesters are large, floating machines that cut and collect aquatic plants. Mechanical weed cutters cut plants several feet below the water's surface but do not collect the plants.

A mechanical weed harvester has been utilized extensively by lakeside residents to control aquatic weeds in Lakes Erie and Campbell. Weeds were harvested and disposed of in upland locations, thereby reducing in-lake plant material. As a result, recreational and aesthetic enjoyment of the lakes was temporarily enhanced. This mechanical weed harvester is owned by Skagit County and it is loaned to Lakes Erie and Campbell.

Harvesting is effective in immediately creating open water areas because it entails physical removal of vegetation from the water. The duration of control depends on factors such as frequency and timing of harvest, water depth, and depth of cut. Harvesting has not proven effective at achieving long-term reductions in milfoil growth. Milfoil usually regrows to pre-harvest levels within 30 to 60 days, depending on water depth and depth of cut.

Advantages Harvesting is most suitable for large, open areas with few surface obstructions. Harvesting operations usually do not interfere with recreational uses of a water body and bottom disturbances are minimal. The removal of in-lake plant biomass with mechanical harvesting eliminates a potential source of internal nutrient loading. The nutrients in the plant biomass that is removed are not available for nutrient cycling within the aquatic ecosystem from which the plants are removed. Mechanical harvesting can also reduce sediment accumulation by removing organic matter that normally decays and adds to bottom sediments. Harvested vegetation can be composted and used as a soil amendment.

Disadvantages Harvesting creates plant fragments, which is especially problematic with Eurasian watermilfoil because it can spread rapidly by fragmentation. This method is not recommended as a control for early infestations of noxious aquatic weeds because of the high potential for rapid spreading of plant fragments. Non-target plants and animals can be detrimentally affected by the indiscriminate nature of mechanical harvesting. One effect can be fish and invertebrate mortalities. Harvesting can lead to enhanced growth opportunities for plant species that invade harvested areas. Repetitive treatments are needed because of regrowth of aquatic weeds. Cut vegetation needs to be collected and removed from the water and upland sites are needed for disposal. Capital costs for the purchase of mechanical harvesters are high and they have recurring maintenance costs. Harvesting also has operational costs, although in the case of Lakes Erie and Campbell these costs have been greatly reduced by the volunteer efforts of lakeside residents. However, there are liability issues for the County when citizen volunteers operate the County's mechanical harvester.

Costs for harvesting operations are highly variable. Gibbons et al. (1994) note that the average costs of local harvesting operations range from $200 to $700 per acre.

2. **Rotovation**

Rotovators are floating machines that use underwater rototiller-like blades to uproot aquatic plants. Mechanical rotovation involves tillage of a water body's bottom to remove aquatic plant root systems. Bottom sediments are tilled to a depth of four to six inches to dislodge plants, including the roots. This seriously impairs the growth of rooted aquatic plants. Certain plants, such as milfoil, have roots that are buoyant and float on the surface where they can be collected. Rotovation is generally most effective when performed in the winter and spring during reduced plant growth.

Bottom tillage has been used effectively for long-term control of milfoil where populations are well-established and the creation of stem fragments is not a critical concern. Single treatments using a crisscross pattern have resulted in milfoil stem density reductions of 80 to 97%. Seasonal rotovation in an area is at least as effective as three to four harvests. Depending on plant density, rotovation can provide control for up to two or three years.

Advantages This method has the potential to remove the entire plant and provide long-term control. It generally reduces plant density. Treated areas have shown increases in species diversity of native plants, which is a potential benefit to fisheries. Rotovation can be scheduled to avoid interference with peak summertime recreational uses because it is most effective when conducted in the winter and spring.

Disadvantages Bottom obstructions limit the use of rotovation. Water intake pipes or buried utility lines needed to be avoided. Rotovation disturbs bottom sediments, which causes short-term increases in turbidity. This disturbance can also result in short-term impacts on water quality and release of nutrients and toxic substances from sediments. Rotovation can result in fish and invertebrate mortalities. It is not species specific, so non-target plants could be removed unintentionally. Like harvesting, this method produces plant fragments. Consequently, rotovation should not be used to control early infestations of noxious aquatic weeds.

Costs for bottom tillage vary depending on treatment scale, plant density, machinery used, and site constraints. Although rotovation can furnish longer-duration control than mechanical harvesting, treatment costs are substantially higher. Contract costs for rotovation in Washington range from $1,200 to $1,700 per acre, depending on treatment size.

3. Diver Dredging

Diver dredging utilizes a small barge or boat carrying portable dredges with suction heads that are operated by scuba divers to remove individual rooted plants, including their roots, from the sediment. Divers use sharp tools to dislodge plants. Then, the plant/sediment slurry is suctioned up and carried back to the barge or boat through diver-operated hoses. On the barge or boat, the plant parts are sieved out and retained for disposal, and the water sediment slurry is filtered and discharged back to the water or piped off-site for upland disposal. The plants are disposed of off-site. Removal rates vary from approximately 0.25 acres per day to one acre per day.

This method can be highly effective under appropriate conditions. Removal efficiency is dependent on sediment condition, density of aquatic plants, and underwater visibility. Diver dredging is best used for localized infestations of low plant density where fragmentation must be minimized. Hence, it has good potential for control of Eurasian watermilfoil. Diver dredging can also be utilized as a long-term maintenance tool following herbicide treatments.

Advantages Diver dredging is species and site specific. It can be employed in tight places or around obstacles where larger machinery can not be used, and places where herbicides can not be used. Disruption of sediment is minimized. Because plant parts are collected and disposed of off-site, spread of plant fragments is minimized. This is very important in the control of Eurasian watermilfoil.

Disadvantages Diver dredging is slow, labor intensive, and expensive. Returning dredged residue directly to the water may result in some plant fragment loss through sieves. When dredged slurry is disposed of in upland sites, diver dredging is much more costly. The utility of this method can be significantly diminished in dense plant beds. Because it disturbs bottom sediments, diver dredging can result in short-term, localized increases in turbidity in the treatment area and release of nutrients and toxic substances from sediments. Sediment and non-target plants may be inadvertently removed during dredging operations.

Costs for diver dredging can be highly variable, depending on density of plants, equipment costs, and disposal requirements for dredged material. In addition, the use of contract divers for dredging work is subject to stringent state regulations on certification, safety, and wages, which can affect project costs. Costs (without transport of dredged material) range from $1,100 to $2,000 per day.

4. Mechanical Dredging

Dredging equipment could be used to provide large-scale dredging capabilities. Dredging removes plant materials and bottom sediments. Sources of internal nutrient loading are removed by dredging. It can provide long-term aquatic weed control in areas where unsuitable rooting substrates are exposed or lake depth is increased beyond the depth of light penetration. In addition, dredging can reduce sediment nutrient release by exposing nutrient-poor substrates.

Although this method potentially offers a long-term solution for problems like algal blooms and excessive aquatic plant growth, it has several major drawbacks. First, dredging will be extremely expensive. In their 1983 report, *Water Quality Analysis and Restoration Plan for Erie and Campbell Lakes,* Entranco Engineers investigated the possibility of deepening Lakes Erie and Campbell by dredging them. In this report, Entranco Engineers estimated the cost of dredging Lake Erie at $4,480,000 and Lake Campbell at $14,500,000. This cost estimate included dredging to remove sufficient sediment to produce a three-foot increase in lake depth.

Entranco Engineers' 1983 cost estimate included the removal of 532,400 cubic yards of sediments from Lake Erie and 1,790,000 cubic yards from Lake Campbell. This works out to $8.41 per cubic yard for Lake Erie and $8.10 per cubic yard for Lake Campbell. RMI estimated current dredging costs at about $10.00 per cubic yard. Using this figure, dredging the lakes to produce a three-foot increase in depth would cost $5.3 million for Lake Erie and $17.9 million for Lake Campbell. The total cost would be $23.2 million.

Second, Entranco Engineers concluded in 1983 that the variable sediment composition and deep sediment deposits in Erie and Campbell Lakes make it unlikely that sediment nutrient release would be significantly reduced by dredging. Hence, some of the long-term benefits of dredging would probably not be realized, despite its high cost.

Third, there will undoubtedly be significant environmental impacts associated with dredging the bottoms of the lakes and disposing of the dredge spoils. The environmental review process associated with dredging will be probably be costly and time-consuming. In any case, it will probably be difficult to obtain permits to dredge the lakes because of fisheries issues.

Dredging is not considered a feasible management option for Erie and Campbell Lakes because of the above drawbacks.

MANUAL REMOVAL

1. Hand-Pulling

Hand-pulling involves digging out the entire plant with a spade or long knife and disposing of plant material on shore. Specialized gear is not required for hand-pulling in shallow waters. Work in deeper waters is best carried out using scuba or snorkeling equipment and collection bags for the disposal of plant material.

Effectiveness of plant removal is dependent on visibility, sediment type, and thoroughness in extricating the entire plant, especially the roots. A high degree of control, lasting more than one season, is possible, if complete plant removal can be achieved.

Advantages Hand-pulling results in the immediate removal of nuisance aquatic plants. It is species and site specific. This technique is suitable primarily for small initial infestations and long-term maintenance projects. It is useful in sensitive areas where disturbance must be kept to a minimum and in small areas around docks, floats, and beaches.

Disadvantages This method is slow and labor intensive. It is not practical for large areas. Diver visibility may become obscured by turbidity generated by diver swimming and digging. Workers may have a difficult time seeing and digging out all plant roots and plant fragments may be generated. Environmental impacts are mainly limited to short-term, localized increases in turbidity in the treatment area and some bottom disturbance.

Costs for hand-pulling will vary according to whether contract workers or divers are used, or work is performed by volunteer efforts. When contract divers and dive tenders are used, costs can range from $500 to $2,400 per day, with the area covered dependent on plant density.

2. Hand-Cutting

In hand-cutting, plants are manually cut below the water surface. Scythes, rakes, and other implements that can be pulled through weed beds are used.

Advantages Hand-cutting results in the immediate clearing of nuisance aquatic plants and it is a low-cost method. It is effective for small areas and in confined locations around docks and floats.

Disadvantages Like hand-pulling, this technique is slow and labor intensive. Visibility may become obscured by turbidity generated by cutting activities. Unlike hand-pulling, roots are not removed; so the efficacy of hand-cutting is usually short-term because plant regrowth is possible from the roots. Cutting will result in plant fragments. Cut plants must be removed from the water. Environmental impacts are mostly limited to short-term, localized increases in turbidity in the treatment area and some bottom disturbance.

If volunteer efforts are employed, costs are primarily limited to the purchase of a cutting implement, which can range from under $100 to over $1,000.

BOTTOM BARRIERS

In this method, barrier material is applied over the lake bottom to prevent plants from growing, leaving the water clear of rooted plants. Bottom-covering materials of various types have been used with varying degrees of success. Applications can be made up to any depth.

Bottom barriers can provide immediate removal of nuisance plant conditions upon placement. Duration of control is dependent on a number of factors, such as the type of material used, application techniques, and sediment composition. Elimination of nuisance plant conditions for at least the season of application has been achieved with synthetic materials like Aquascreen and Texel. Burlap affords short-term control for the least expense, furnishing up to two to three years of control before eventually decomposing.

Advantages Bottom barriers are site specific and usually can be easily applied to small, confined areas like around docks, moorages, or beaches. They are most appropriately used for localized, small-scale control where exclusion of all plants is desirable, other control methods can not be employed, and intensive control is needed regardless of cost. Bottom barriers are hidden from view and do not interfere with shoreline use of a water body. Their use does not result in the significant production of plant fragments.

Disadvantages Depending on the material, drawbacks to this technique can include high materials cost, labor-intensive installation, limited material durability, possible suspension due to water movements or gas suspension beneath barrier materials, and regrowth of plants above or below the material. This method is not suitable for large areas and it is not species specific. Bottom barriers may be damaged by boat anchors, fishing gear, or harvesters and they are potentially hazardous to swimmers and boaters. Periodic maintenance of bottom barriers is needed to remove accumulations of silt and any rooting fragments and prevent the creation of navigational or swimming hazards. Bottom barriers interfere with bottom-dwelling organisms and fish spawning.

One of the principal drawbacks to bottom barriers is their relatively high cost per unit of area controlled. The Washington Department of Ecology's web site reports that barrier materials cost from $0.22 to $1.25 per square foot and costs for commercial installation are up to about $750 for 1,000 square feet ($0.75 per square foot). Using an estimated cost of $0.97 per square foot for materials and installation, bottom barriers would cost $42,253 per acre.

Given their high cost per treated acre, it would be prohibitively expensive to treat large areas in Lakes Erie and Campbell with bottom barriers. As noted above, bottom barriers are most suitable for localized, small-scale control.

WASH AT PUBLIC BOAT LAUNCH

The purpose of installing a wash at the public boat launches on Erie and Campbell Lakes would be to prevent the introduction or reintroduction of noxious aquatic weeds into Erie and Campbell Lakes and the spread of Eurasian watermilfoil from Lake Campbell to other lakes in the area. Facilities for boat and trailer washing could enhance plant fragment removal. Unfortunately, there are unresolved issues regarding these facilities. Currently, there is no water service at the public boat launches. Wash facilities at the boat launches will be expensive to install, with installation costs estimated at $70,000 for each site. The question of who would pay for their construction and maintenance would need to be decided. There is also an issue of how effective the wash facilities would be and who would monitor or enforce their use.

WATER LEVEL DRAWDOWN

Water level drawdown to control aquatic plants involves exposing plants and root systems to prolonged freezing-desiccation or heat-desiccation to kill the plants. Drawdown for plant control is usually performed during winter months. Drawdown has not proven to be an effective method in Western Washington because climatic extremes are too narrow to provide control. Therefore, this method is not considered a viable management option for Erie and Campbell Lakes.

RAISING THE WATER LEVEL OF THE LAKES

Members of the lake community have suggested raising the water level in Lakes Erie and Campbell as a potential treatment method. Raising the water level would deepen the lakes, and some parts of the lakes, which now support submersed aquatic plant growth, would probably become too deep to support plant growth. The degree of control that could be expected is directly related to the extent of deepening. In other words, the deeper the lakes, the better the suppression of aquatic plant growth. However, as the lakes deepen, their surface area will expand. Upland area will be lost and new habitat for aquatic plants will be created along the edges of the lakes, as their surface area grows.

For this method to be effective, the water levels in the lakes would need to be raised and maintained throughout the growing season to suppress aquatic plant growth. Lakes Erie and Campbell do not have outlet controls, so impoundment structures would probably have to be built in order to raise the water levels any appreciable distance and maintain those levels.

In their 1983 report, *Water Quality Analysis and Restoration Plan for Erie and Campbell Lakes*, Entranco Engineers examined the possibility of raising the water level of Lakes Erie and Campbell by three feet through the use of an outlet control structure on each lake. They reported that a three-foot increase in the surface elevation of the lakes would inundate approximately 6.1 acres of lakefront land around Lake Erie and 12 to 25 acres around Lake Campbell. The amount of lakefront property affected by flooding would vary for each parcel, depending on slope and elevation. In addition, docks, bulkheads, boat houses, and other improvements located within the flooded area would be adversely affected. Landscaping and native plants along the flooded shoreline would be lost when inundated, and many trees would die if the base of their trunks were covered with water.

Entranco Engineers estimated that the cost of raising the water level of the lakes by three feet would be $950,000 for Lake Erie and $2,350,000 for Lake Campbell for a total cost of $3.3 million. Most of these costs were for cash compensation to property owners for flooded land, repair or replacement of improvements affected by flooding, and legal costs associated with settling damage claims. An outlet control structure was estimated to cost $80,000, with each lake requiring such a structure.

Raising the water level in Lakes Erie and Campbell is not considered a feasible treatment method because of its high costs and negative impacts on lakefront properties/improvements.

WATER COLUMN DYES

In this technique, dark-colored dyes are applied to the water to reduce the amount of sunlight reaching submersed plants. This suppresses aquatic plant growth by shading the plants from sunlight needed for photosynthesis. Aquashade is a commercial dye product available for applications in closed systems (water bodies with no outflow). It imparts a blue color to water.

The use of water column dyes is limited to shallow water bodies with no outflow. Lakes Erie and Campbell both have outflows.
To date, water column dyes have not been evaluated by the Department of Ecology in an Environmental Impact Statement. Consequently, Ecology would probably not issue a permit for their use in Lakes Erie and Campbell, although it may possible to get an experimental permit.

This method is not recommended and seldom used for large lakes because it is too expensive. Applications need to be applied early in the growing season and repeated to maintain shading. Aquashade costs about $50 per gallon. At the recommended dosage of one ppm (part per million), a gallon will treat one acre of water at average depth of four feet. The cost to treat the lakes twice during the growing season would be approximately $20,000 for Lake Erie and $80,000 for Lake Campbell. Aquashade is less effective when aquatic plant growth is within two feet of the surface, in which case, it is recommended that other methods of plant removal be used prior to dye use. This would increase treatment costs.

In summary, there are three problems with water column dyes that limit their use as a treatment method for Lakes Erie and Campbell:

1. The use of water column dyes is limited to water bodies with no outflow. Lakes Erie and Campbell both have outflows.
2. It may not be possible to obtain a permit to use water column dyes.
3. It is expensive to treat large lakes with water column dyes.

Consequently, water column dyes are not considered a feasible management option for Lakes Erie and Campbell.

BIOLOGICAL CONTROL

Many of the problematic aquatic plants in North America, such as Eurasian watermilfoil, are invasive, non-native species that have been introduced from other continents. Here they can grow extremely aggressively forming single-species stands that exclude more desirable native plants, even though these same species often are not aggressive competitors in their native range. These non-native species may be such successful competitors here, in part, because insects, diseases, or other factors that kept them under control in their native range are not found in their introduced range.

The biological control of aquatic plants focuses on the selection and introduction of organisms that detrimentally affect the growth or reproduction of a target plant. Theoretically, by stocking an infested water body with these organisms, the population of the target plant can be reduced and native plants can regain lost habitat.

Interest in using biological controls for nuisance aquatic plant growth has been stimulated by a desire to find more "natural" means of long-term control as well as reduce the use of expensive equipment or chemicals. Except for exotic species infestation, a realistic objective for the biological control of aquatic vegetation is not the eradication, but the reduction of target plant species to lower, more acceptable levels.

1. Triploid Grass Carp

Grass carp (*Ctenopharyngodon idella*) are exotic, plant-consuming fish native to large rivers of China and Siberia. Known for their high growth rates and wide range of plant food preference, grass carp can control certain nuisance aquatic plants under the right circumstances. They are most appropriately used for lake-wide, low-intensity control of submersed plants.

A permit is required from the WDFW for the use of grass carp in Washington. State regulations require that: only sterile (triploid) fish be planted, inlets and outlets be screened to prevent fish from migrating into other water bodies, and planting rates be determined by the WDFW. Stocking rates are regulated to ensure that sufficient aquatic vegetation is retained for fishery and other habitat needs. Because all inlets and outlets to a water body must be screened, the stocking of grass carp into water bodies that support a salmon or steelhead run is rarely permitted.

Using grass carp to control aquatic vegetation has produced highly variable results in Washington. The WDFW studied the effects of grass carp on aquatic plant communities, water quality, and public satisfaction for 98 Washington lakes and ponds stocked with grass carp between 1990-95. The WDFW published the results of this study in *Management of Aquatic Plants in Washington State Using Grass Carp: Effects on Aquatic Plants, Water Quality and Public Satisfaction 1990-1995* (Bonar et al. 1996). This study found that grass carp usually did not have a noticeable effect on aquatic plant communities until two years after stocking. After two years, submersed aquatic plants were usually either completely eradicated (39% of the lakes/ponds) or not controlled (42% of the lakes/ponds). So, in 81% of the lakes/ponds where grass carp were used, the result was either complete eradication or no control of aquatic plants. Control of submersed aquatic plants to an intermediate level of abundance, which is considered beneficial for warm water fisheries, occurred in only 18% of the lakes/ponds.

The average turbidity of sites where all submersed aquatic plants were eradicated was significantly higher than sites where plants were controlled to intermediate levels or not controlled. Eighty-three percent of the property owners that were interviewed were highly or moderately satisfied with the results of introducing grass carp. All landowners were highly or moderately satisfied when complete eradication or intermediate control occurred. When no control occurred, 54% of the property owners interviewed were highly or moderately satisfied.

In some of the lakes cited in the WDFW study, the planting rates of grass carp were much higher than the rates that are currently recommended by the WDFW. Based on the field results from some of the early grass carp stockings, the WDFW decided to significantly lower its recommended planting rates.

In *Aquatic Plants and Fish*, the WDFW indicates that grass carp should not be used in lakes unless complete eradication of aquatic vegetation is acceptable. In addition, their use should be restricted to situations where potential adverse impacts are minimal, such as small ponds, closed ditch systems, and lakes with no outlet. Grass carp should not be planted in lakes where submersed plant communities provide important habitat for fish and/or wildlife.

Grass carp exhibit distinct food preferences. Eurasian watermilfoil and water lilies are not preferred. Noticeable effects of grass carp on aquatic plant communities usually is not apparent until two years after stocking. Substantial removal of vegetation by grass carp may not become apparent until three to five years after their introduction.

Advantages Grass carp offer a biological control option. Depending on the problem plant species and other site constraints, proper use of grass carp can achieve long-term reductions in nuisance aquatic plant growth. Compared to other long-term control methods (bottom tillage, bottom barriers), cost for grass carp implantation are relatively low. However, if water body inlets and outlets need to be screened, this cost advantage could be diminished.

Disadvantages Since grass carp exhibit distinct food preferences, they do not graze all plants equally well. Grass carp implantation is generally not recommended for Eurasian watermilfoil control. Use of grass carp could indirectly increase milfoil populations in a water body by selectively removing highly preferred plants. The type of plants grass carp prefer may also be those that are most important from a habitat perspective. Grass carp may avoid areas of a water body where there is heavy recreational use, thus limiting plant removal. It may take several years to achieve aquatic plant control with grass carp and, in many cases, control may not occur or all submersed plants may be eliminated. Overstocking of grass carp could result in the eradication of beneficial plants or all submersed plants and have serious impacts on the overall ecology of a water body. Removing excess fish is difficult and expensive. All inlets and outlets to a water body stocked with grass carp must be screened to prevent their migration into other water bodies, where they may cause unplanned environmental damage. Fish loss due to predation is possible. Stocking a water body with grass carp may lead to increased algae growth and turbidity.

Costs for grass carp stocking are variable, depending on stocking needs and rates, cost of fish, and need for inlet/outlet screens. Stocking rates typically range from ten to 25 fish per vegetated acre. Costs for fish (air freight delivery) range from $10 to $12 per fish. The costs for stocking grass carp in Lakes Erie and Campbell is discussed in detail later in this IAPMP.

2. Milfoil Weevil

The milfoil weevil (*Euhrychiopsis lecontei*) has been found to be associated with declines of Eurasian watermilfoil in some lakes in the U.S. (northeastern and upper Midwest states). It is a native insect that feeds and reproduces on northern watermilfoil (*Myriophyllum sibericum*), a milfoil that is native to North America. The milfoil weevil also utilizes Eurasian watermilfoil and it can adversely affect this species by suppressing the plant's growth and reducing its buoyancy. Weevil feeding on Eurasian watermilfoil can cause the stems to collapse. Native milfoil has thicker stems than Eurasian watermilfoil and the mining activity of the milfoil weevil larvae does not cause it the same kind of damage.

In Washington, the milfoil weevil is found primarily in eastern Washington and occurs on both Eurasian and northern watermilfoil. There have not been any documented declines of Eurasian watermilfoil in Washington that can be attributed to the milfoil weevil. The densities of these native weevils in Washington appear to be significantly lower than the densities that have been associated with declines of Eurasian watermilfoil in other states.

Although the milfoil weevil shows promise as a biological control for Eurasian watermilfoil, more research is needed to determine its suitability as a control agent for milfoil in Washington lakes. At this point in time, it has not been established that the milfoil weevil is a viable management option for milfoil control in Washington lakes. If future research alters this assessment, this management option will need to be re-evaluated.

WATERSHED CONTROLS

The goal of watershed controls is to reduce external nutrient and sediment inputs to a water body through the implementation of watershed best management practices (BMPs). Decreasing or eliminating the input of growth-stimulating nutrients, such as phosphorus and nitrogen, to a water body can help in the overall process of controlling excessive aquatic plant growth and algal blooms. Increased sediment levels in surface waters due to human-induced erosion can, among other things, clog stream channels, contribute to the natural "filling in" of lakes, and reduce the quality of aquatic habitat. Sediment can also carry adsorbed nutrients and pesticides into aquatic ecosystems. The use of BMPs to reduce external nutrient and sediment inputs complements other control methods and it is a useful part of integrated approach to lake management.

Examples of homeowner BMPs include maintaining septic systems, using prudent lawn and garden fertilizing practices, disposing of lawn clippings and other yard residue well away from the water's edge, and cleaning up pet wastes. Additional reductions in inputs of nutrients and sediments may be achieved by implementing prudent agricultural, forestry, construction, and road maintenance practices in the watershed.

Advantages BMPs are wide-ranging and usually easy to perform. Since the watershed and water body are interconnected—with the land-use activities in the watershed having a significant influence on the amount and content of runoff that flows into the water body—any reduction in nutrient and sediment loading to a water body because of BMPs can maintain or extend the efficacy of in-lake controls.

Disadvantages Using BMPs to control nuisance aquatic plant growth will not result in immediate, substantial growth reduction because in-lake conditions have already been created that support aquatic plant growth.

Implementation of most homeowner BMPs involves voluntary changes in behavior rather than direct out-of-pocket costs.

NO ACTION

Communities, for various reasons, may decide that no action is preferable to aquatic plant/lake management. When the no action alternative is considered, it is important to consider the possible consequences of not taking action.

If no action is taken to eradicate or control Eurasian watermilfoil, it is likely that this species will continue to spread in Campbell Lake. Its spread may cause a variety of ecological problems as a more natural, diverse plant community is replaced by single-species stands of Eurasian watermilfoil. Fish and wildlife habitat could be degraded. Dense beds of milfoil could contribute to internal nutrient loading, alter water quality, and interfere with the recreational uses of Campbell Lake. If action is not taken, the risk that Eurasian watermilfoil will be spread from Campbell Lake to Lake Erie and other non-infested water bodies will not be reduced.

The adverse impacts that can result from algal blooms and excessive macrophyte growth have been described above. If no action is taken to control algal blooms and the excessive growth of macrophytes, current problems in Lakes Erie and Campbell will not be addressed. In addition, algal blooms and excessive aquatic plant growth will in all likelihood continue to occur.

PUBLIC EDUCATION

A public education program for Erie and Campbell Lakes should focus on prevention. The program should educate lakeside residents and recreational users about aquatic weed and water quality problems. It should also familiarize them with the steps they can take to prevent the introduction or spread of noxious aquatic weeds and minimize human-source inputs of nutrients and sediment into the lakes.

The key ingredient for a successful public education program, concerned and involved citizens, is already in place. The citizens of Lakes Erie and Campbell have worked together for the last 25 years to help develop and implement a strategy for managing their lakes. A lake association, the Lake Campbell/Erie Association, has been formed and the citizens have initiated the process for forming a lake management district. The lake association's meetings and newsletters have focused on lake management issues, problems, techniques, and strategies and the association has coordinated the volunteer efforts of citizens, like weed harvesting, to control aquatic weeds. Education could be accomplished through:

- Continued lake-association meetings and newsletters;
- Mailings of educational brochures about aquatic weed and water quality problems, aquatic weed control, and BMPs to watershed residents;

- Neighborhood workshops to train citizens in the identification and control of noxious aquatic weeds and the use of BMPs;
- Prominent posting of signs about noxious aquatic weeds at the public boat launches;
- Periodic distribution of education brochures about noxious aquatic weeds to boat launch users; and
- Periodic monitoring of boats and trailers at the public boat launches for noxious aquatic weeds.

A public education program focused on prevention addresses underlying causes of aquatic weed and water quality problems. Consequently, it is a valuable and important part of an integrated approach to lake management.

TREATMENT PLAN

This section of the IAPMP describes the treatment plan for Lakes Erie and Campbell, which was developed by the Lakes Erie and Campbell Citizen Advisory Committee. While developing the plan, the committee considered the above treatment methods, and focused on the following input from the lake community:

- Be realistic and work with treatment alternatives that will likely be allowed and permitted by state and federal agencies.
- Separate political lobbying from the planning efforts that must take place now.
- Homeowners do not want a pristine lake, but rather improved lake usage and water quality.
- Property owners prefer biological treatment methods.
- The lake community favors lower cost alternatives.

The treatment plan uses a two-pronged control strategy, combining both short-term and long-term solutions to aquatic weed problems. Aquatic herbicides are utilized to provide short-term control of aquatic weeds in both lakes. The weed problems in Lakes Erie and Campbell will be treated with herbicides in 2001 and 2002. Meanwhile, grass carp will be stocked into both lakes to furnish long-term weed management. A permit application for stocking grass carp into both lakes will be submitted in 2001. Grass carp will be stocked into the lakes for ongoing weed control, beginning in 2002.

The plan focuses on treating aquatic weeds rather than algae problems for the following reasons:

- Past efforts to control algal growth have had only short-term success.
- Algae control is not financially feasible because of the high cost of alum treatments.
- Alum treatments will worsen aquatic weed problems.
- Algal blooms are a short-lived, inconstant, and recurring problem, whereas aquatic weeds are a constant, "everyday" problem.
- Aquatic weeds interfere more with the beneficial uses of the lake than algae.
- Given the increasing development that is occurring in the Erie/Campbell watershed and the internal nutrient loading within the lakes, algae control will be futile over the long-term.

Ongoing monitoring and public education are incorporated into the plan. The plan includes programs that focus on preventing the introduction/re-introduction of noxious aquatic weeds, and limiting nutrient and sediment inputs, into the lakes.

EURASIAN WATERMILFOIL CONTROL

Controlling Eurasian watermilfoil in Campbell Lake and preventing its spread to Erie Lake and other nearby lakes are important management goals in this IAPMP. An aggressive control program for Eurasian watermilfoil is needed to accomplish these goals. The treatment plan uses Navigate, an aquatic herbicide, for Eurasian watermilfoil control.

The most accepted treatment to eradicate Eurasian watermilfoil is the aquatic herbicide, SONAR. Unfortunately, its use is most applicable for whole-lake treatments. When used to manage Eurasian watermilfoil, SONAR is applied several times during the summer to maintain a low, but consistent concentration in the water. Because of this need to maintain a long-contact exposure time, whole-lake treatments or barrier systems are needed in large lakes systems such as Lake Campbell. The bottom line is SONAR treatments are expensive. RMI's cost estimate for treating Lake Campbell with SONAR was $200,000 to $300,000, depending on stratification conditions at the time of treatment.

SONAR may not be effective when used to treat shorelines or localized areas (spot treatments). The July 24, 2000 aquatic plant survey indicated that the Eurasian watermilfoil infestation in Lake Campbell was somewhat localized. The vast majority of the lake surface was not impacted by submerged aquatic weed growth. Eurasian watermilfoil was visible in the western bay of the lake, around the island in the center of the lake, and around the east and northeast shorelines of the lake. Given these conditions, SONAR treatments at this time would represent a very large financial outlay with minimal return on investment. Consequently, the plan will not employ SONAR treatments in Lake Campbell.

RODEO will not effectively control Eurasian watermilfoil. This leaves Aquathol and Navigate as herbicidal management options. Since it is a contact herbicide, Aquathol kills only the plant tissues that it contacts, rather than the entire plant. If Aquathol were used to treat the Eurasian watermilfoil in Campbell Lake, regrowth would occur from unaffected root tissues and recurrent applications would be needed for milfoil control.

Navigate is a systemic herbicide. Thus, in contrast to Aquathol, Navigate can kill the entire plant and provide long-term control of Eurasian watermilfoil in Campbell Lake. Unlike SONAR, Navigate can be used for spot treatment of Eurasian watermilfoil. Spot treatments with Navigate will be significantly less expensive than whole-lake SONAR applications. For the milfoil infestation in Campbell Lake, Navigate is the most cost-effective herbicide that is available at this time.

The treatment plan does not utilize mechanical harvesting for Eurasian watermilfoil control because this control method will spread the milfoil and worsen the infestation. Likewise, stocking grass carp into Campbell Lake will probably exacerbate the milfoil infestation because Eurasian watermilfoil is not a preferred species of grass carp. Using grass carp in Campbell Lake before the milfoil infestation is controlled, will most likely indirectly increase the milfoil population because the grass carp will selectively remove preferred species. This selective grazing will give Eurasian watermilfoil a competitive advantage over preferred species.

Therefore, the plan uses spot treatments with Navigate in 2001 and 2002, before the grass carp stocking, to target the Eurasian watermilfoil infestation in Campbell Lake for eradication.

Navigate is used because of its cost effectiveness and potential for long-term control. Because eradication of milfoil is the goal, two treatments with Navigate may be needed. These treatments should be followed-up by diver hand pulling to ensure that all milfoil plants have been removed.

Based on input from the citizen advisory committee, it is estimated that there are about 70 acres of Eurasian watermilfoil in Campbell Lake (GIS analysis of the aquatic plant survey results indicated 40 acres of milfoil). In 2001, the 70 acres of milfoil in Campbell Lake will be treated with Navigate, which costs about $500 per treated acre. It is unlikely that all 70 acres will need a second treatment in 2002. The plan projects that 50 acres will need to be re-treated in 2002. Costs for Navigate treatments will be $35,000 in 2001 and $25,000 in 2002. Treatment costs are shown in Table 4, which is in the Plan Costs and Funding section of this IAPMP.

Ideally, follow-up diver hand pulling will take place in 2003-2005 to ensure that all milfoil plants are removed. Turbidity will greatly influence whether diver hand pulling is feasible. Given the current algal bloom in Campbell Lake, it would not be feasible. Turbidity conditions will need to be reassessed in 2003-05 to determine if diver hand pulling is practical. If diver hand pulling is not feasible, spot treatments with Navigate will be used to target remnant milfoil plants. Five thousand dollars per year is budgeted in 2003-2005 for diver hand pulling/spot treatment of remnant milfoil plants, for a total cost of $15,000.

A permit called a short-term modification to State water quality standards must be obtained from the Department of Ecology prior to aquatic herbicide treatments. This permit typically takes 45 to 60 days to process.

WATER LILY CONTROL

The treatment plan targets the pioneering colonies of the exotic water lily in Campbell Lake for eradication. RODEO, a systemic herbicide, can provide effective long-term control of water lilies. In 2001, $2,000 is budgeted for spot treatments with RODEO to eradicate the exotic water lily in Campbell Lake.

Native water lilies in both lakes will be controlled in areas where their growth limits access to the lakes. Five thousand dollars is budgeted for RODEO treatments in 2001 to control native water lilies in both lakes.

Sometimes, after herbicide treatments, water lily rhizomes will rise up in large mats and float around lakes. These mats can float up against docks and block lake access. The plan includes a contingency plan (contingencies are treatments that may be needed) for removing water lily mats.

A permit for a short-term modification to State water quality standards must be obtained from the Department of Ecology prior to aquatic herbicide treatments.

OTHER AQUATIC WEED CONTROL MEASURES

Aquathol Treatments in Lake Erie

There is a significant submerged aquatic weed problem in Lake Erie. Aquathol will be used to control the submerged aquatic weeds in Lake Erie until grass carp are stocked into the lake.

Although Aquathol will not provide long-term control of aquatic weeds because it is not a systemic herbicide, Aquathol is used for short-term aquatic weed control in Lake Erie because other management options have major shortcomings. SONAR was too expensive to use, with treatment costs for Lake Erie estimated at $75,000 to $100,000. RODEO is not effective against submersed plants. Currently, the use of Navigate would not be permitted in Lake Erie. Navigate is only approved for Eurasian watermilfoil removal projects at this time. Lake Erie does not have a Eurasian watermilfoil infestation.

Non-herbicidal treatment methods also have drawbacks. The committee members noted that the worst weed problem in Lake Erie in the past five years occurred in the year following extensive use of the mechanical harvester. Grass carp will not provide immediate control of aquatic weeds. They should be viewed as a long-term control method.

To provide aquatic weed control in Lake Erie, the plan uses Aquathol and grass carp in succession. For short-term control, 50 acres in Lake Erie will be treated with Aquathol in 2001, and 30 acres will be treated in 2002. Aquathol costs about $500 per treated acre, so treatment costs will be $25,000 in 2001 and $15,000 in 2002. For long-term aquatic plant control in Lake Erie, grass carp will be stocked into the lake in 2002.

A permit for a short-term modification to State water quality standards must be obtained from the Department of Ecology prior to aquatic herbicide treatments.

Grass Carp

Grass carp will be stocked into Lakes Erie and Campbell, beginning in 2002, for ongoing, long-term control of aquatic plants. The objective is to achieve lake-wide, low-intensity control of excessive aquatic plant growth, thereby enhancing the beneficial uses of the lakes. The use of grass carp reflects the lake community's preference for biological treatment methods (rather than herbicides) and lower cost alternatives.

Excessive aquatic plant growth is interfering with recreational uses of the lakes. This was especially true of Lake Erie at the time of the aquatic plant survey, but nuisance aquatic plant growth was also problematic in Campbell Lake. Both lakes have a history of nuisance levels of aquatic plants. Fishery biologists from the WDFW's district office in La Conner indicated that planting grass carp in Lakes Erie and Campbell at low stocking rates would provide the following benefits:

- Reduction of aquatic plants with minimal risk of complete eradication of plants.
- Improvement of the warm water fishery in Campbell Lake by opening up fish habitat.

High densities of aquatic vegetation interfere with the foraging efficiency of larger, predator fish. One potential benefit of stocking Campbell Lake with grass carp would be an increase in the size of bass as habitat is opened up.

To use grass carp in any water in the State of Washington, a permit is required from the WDFW. Fishery biologists from the WDFW's district office indicated that they would recommend that a permit application to stock grass carp into Lakes Erie and Campbell be approved by the department. State regulations (WDFW POL-5220: Triploid Grass Carp Planting Policy) require that:

1. Grass carp may be planted after all required permits and documents are approved.
2. Only sterile (triploid) grass carp over eight inches in length can be planted.
3. A minimum of 25% of the lake shall remain vegetated with aquatic vegetation.
4. Escapement to non-targeted waters must be prevented.
5. Planting grass carp must not pose a significant threat to rare native plants, or to fish and/or wildlife. If these resources are being threatened by grass carp, the WDFW may remove or require the removal of grass carp.
6. The planting rate is determined by the WDFW, based on its current planting model.
7. A lake restoration feasibility assessment meeting the Department of Ecology's standards must be completed before planting grass carp into waters with public access.
8. The WDFW's Exotic Species Policy (POL-4001) must be followed to plant triploid grass carp.

The required permits/documents include:

- Documentation that the fish to be planted are triploid grass carp and certified disease free.
- Fish Planting Permit from the WDFW.
- SEPA Checklist.
- Hydraulic Project Approval (if screening is required).
- List of property owners adjacent to the targeted water and their consensus on the proposed planting.

An important consideration with respect to stocking grass carp into Lakes Erie and Campbell is whether a screen would be required at the outlet of Campbell Lake. WDFW policy stipulates that escapement of grass carp to non-targeted waters must be prevented. Grass carp may only be planted into naturally closed water systems (no outlet) or into waters that are screened. Screens can not prevent the migration of native fish species. Since there is a historic run of native sea-run cutthroat trout in the Erie/Campbell lake system, a selective barrier that allows the passage of sea-run cutthroat but keeps grass carp in Campbell Lake, or a variance from the policy requiring an outlet screen, is needed. The cost of a selective barrier is estimated at $70,000. There will also be maintenance costs associated with a screen.

There is not a consensus within the WDFW's district office as to whether a screen should be required at the outlet of Campbell Lake. Studies have shown that grass carp can survive in brackish waters. There is some concern within the district office that grass carp could survive in Similk Bay when peak flows from the Skagit River dilute the salinity in the bay. WDFW staff in the district office differ with respect to their support for granting a variance to the screening requirement.

Although screening the outlet of Campbell Lake would be expensive, the lake community would receive some benefit from a screen. Grass carp are riverine fish that have a tendency to migrate out of lakes. By preventing grass carp from migrating out of Campbell Lake, an outlet screen would protect the investment of the LMD (lake management district). Grass carp are expensive, costing $10 to $12 per fish. If they migrate out of the lake, that investment is lost.

The WDFW determines stocking rates for grass carp. Based on discussions with fishery biologists in the WDFW's district office, an incremental stocking program will be needed to ensure that the aquatic plant communities in Lakes Erie and Campbell are not overgrazed by grass carp. Overgrazing would be detrimental to fish, waterfowl, and other wildlife, and the overall ecology of the lakes. The number of grass carp that are stocked into a lake is based on vegetated acres rather than total surface acres.

In all likelihood, the WDFW will set the initial stocking rate at a low level—5 to 10 fish per vegetated acre. Monitoring (aquatic plant surveys) will be required to ascertain the effect of the initial stocking (and any subsequent stockings) on the aquatic plant communities. Based on monitoring, additional stockings may be permitted to increase the stocking rate in a gradual, phased manner in order to achieve the desired level of control. Periodic restocking will be needed because of mortality. The WDFW will not allow the cumulative stocking rate to exceed 25 fish per vegetated acre, and may very well set a lower rate depending on monitoring results.

A permit application for stocking grass carp into both lakes will be submitted in 2001. Two thousand dollars is budgeted for preparing the permit application for grass carp stocking. An expert will be hired to prepare the permit application and compile documentation supporting the grass carp stocking. The expert will incorporate this documentation into the permit application to increase the likelihood that the permit will be granted.

To estimate the costs of stocking Lakes Erie and Campbell with grass carp, a cost of $12 per fish, 70 vegetated acres in each lake, and the following stocking schedule was used:

2002: 10 fish/vegetated acre.
2004: 5 fish/vegetated acre.
2007: 5 fish/vegetated acre.
2010: 5 fish/vegetated acre.

This works out to $16,800 in 2002, and $8,400 in each of the following years: 2004, 2007, and 2010. In Table 4, the cost for a screen, $70,000, was included in the cost of stocking grass carp in 2002. It may be possible to get a variance from the WDFW's screening requirement, but that is not guaranteed. For budget purposes, it was assumed that a screen would need to be installed at the outlet of Campbell Lake. Total costs for stocking grass carp will be $112,000.

Annual maintenance costs for the screen were estimated at $2,000. Total maintenance costs through 2010 will be $18,000.

When all costs are considered, grass carp will cost $132,000.

INVASIVE PLANT PREVENTION AND DETECTION PROGRAM

Navigate treatments are expected to eradicate or significantly reduce the Eurasian watermilfoil infestation in Lake Campbell. Nevertheless, this noxious aquatic weed could be reintroduced into Lake Campbell or introduced into Lake Erie by way of plant fragments on boats or trailers. In addition, both lakes are vulnerable to the introduction of other noxious aquatic weeds. Numerous noxious aquatic weeds are capable of spreading by plant fragmentation. A program to prevent the introduction/reintroduction of invasive, non-native plants and ensure the early detection of such infestations is a critical part of aquatic weed control.

There is a high potential for the introduction of invasive, non-native plants at the public boat launches at Lakes Erie and Campbell. Conspicuous signs about the danger of exotic plant introductions should be placed at the public boat launches. These signs should include instructions on how to properly clean boats and trailers to prevent the spread of plant fragments. The lake community could reinforce these messages by periodically conducting public information campaigns aimed at recreational users of the lakes. Volunteers could distribute educational brochures and assist with boat and trailer checks. It is also recommended that lake residents be mailed informational brochures annually to remind them of invasive plant problems and the importance of properly cleaning their boats and trailers.

At this point in time, the installation of wash facilities for boats and trailers at the public boat launches does not appear to be a financially feasible option. However, this alternative should continue to be explored.

Although prevention is the preferred method of control, early detection of noxious aquatic weed invasions is important because small-scale infestations are easier and less expensive to eradicate than large-scale ones. To be effective, early detection requires a trained group of volunteers from the lake community who would periodically check the lakes for exotic plants and periodic surveys to monitor the plant community. Volunteers should be trained in plant identification and survey techniques. Each would be responsible for surveying a particular section of the lake each month during the growing season to look for changes in the plant community and new invasions of noxious aquatic weeds. This volunteer effort should be supplemented with an annual survey by a professional.

To improve signage at the public boat launches, $2,000 is budgeted in the first year of the plan. For brochures, $1,000 is budgeted for the first year of the plan and $500 for every year thereafter. One thousand dollars is allocated for volunteer training every other year. Two thousand dollars per year is budgeted for the annual survey. Annual surveys could serve multiple functions by serving as part of the Invasive Plant Prevention and Detection Program, acting as follow-up surveillance in a Eurasian watermilfoil control program, and providing monitoring of aquatic plant communities for the grass carp stocking program.

CITIZEN ADVISORY COMMITTEE

Proper implementation of this IAPMP is dependent on a dedicated citizen advisory committee. The crucial role of the Lakes Erie and Campbell Citizen Advisory Committee in developing the treatment plan has already been described. For the plan to be effectively implemented, the committee will need to continue to be actively involved in managing the lakes. The programs to control Eurasian watermilfoil, stock grass carp, prevent exotic weed introductions, and educate the public will all require the ongoing participation of the committee in lake management activities. In addition, changing conditions may compel the committee to adapt its management strategy to deal with new problems. The ongoing duties of this committee will include:

- Reviewing aquatic plant survey and monitoring information, and tracking potential problem areas.
- Reviewing aquatic plant problems and deciding on the appropriate control strategy.
- Recruiting and directing volunteers for plant surveying and public education activities.
- Working with County staff in the selection and hiring of contractors.
- Conducting annual evaluations of the plan.
- Providing information and newsletters to lake residents and acting as spokespeople on plant control problems.
- Facilitating long-term implementation of the plan.

ONGOING MONITORING AND SURVEYING

The focus of ongoing monitoring and surveying will be the volunteer-conducted aquatic plant surveying and the supplemental annual survey by a professional for the Invasive Plant Prevention and Detection Program. Monitoring and surveying will also occur as part of the programs to control Eurasian watermilfoil in Campbell Lake and stock grass carp into both lakes. The Department of Ecology's Aquatic Weeds Program staff has an ongoing program to collect aquatic plant data for Washington lakes. It is recommended that the citizen advisory committee obtain and review data collected for Lakes Erie and Campbell. The Department of Ecology periodically collects water quality data for Lakes Erie and Campbell. It is also suggested that the citizen advisory committee review the Department of Ecology's water quality data to track trends in water quality.

ONGOING PUBLIC EDUCATION

A public education program for Erie and Campbell Lakes should focus on prevention. The program should familiarize lakeside residents and recreational users with the steps they can take to prevent the introduction or spread of noxious aquatic weeds and minimize human-source inputs of nutrients and sediment into the lakes.

The Invasive Plant Prevention and Detection Program will be an integral part of ongoing public education aimed at preventing the introduction or spread noxious aquatic weeds. Ongoing public education should also address lakeside stewardship and watershed protection/pollution prevention.

Lakeside residents should be educated on how they can lower the amount of pollutants entering the lakes from their properties and enhance the quality of shoreline habitat. Properties which adjoin the lakes have a high potential for adversely affecting the lakes because pollutants generated on these properties have direct access to the water. Often, lakeside residents remove native shoreline vegetation and logs, rocks, and other natural structures and plant lawns and ornamentals right to the water's edge. The lawns and ornamentals require watering, fertilizing, and pesticide treatments. Fertilizers and pesticides applied next to the shoreline have direct access to the water. The removal of native vegetation and natural structures along the lakeshore can reduce the quality of shoreline habitat. If properly maintained, shoreline property can protect water quality and the shoreline from erosion, and provide important wildlife habitat.

There are several ways that lakeside and other watershed residents can reduce the chances that aquatic plant growth and water quality problems will develop or worsen. Curtailing the flow of nutrients and sediments into the lakes through the implementation of BMPs is crucial to the success of this effort. Preventative maintenance or actions that can be followed include:

- Reduce fertilizer use. Do not exceed manufacturer-recommended application rates and use a phosphorus-free fertilizer on established lawns.
- Maintain septic tank systems.
- Develop lake-friendly landscaping practices. Utilize native grasses and plants for landscaped areas to reduce the amount of fertilizer and pesticides used. Plant a buffer strip of shrubs and tall grasses, preferably native species, along shorelines.
- Do not remove native vegetation and natural structures that exist along the shoreline or if necessary, only clear a narrow strip beside the dock area.
- Put lawn clippings and other yard residue in areas not draining directly into the water.
- Use low or no-phosphate soaps and detergents.
- Avoid using impervious ground covers that will cause increased runoff, which in turn, tends to transport more nutrients and sediments and cause erosion.
- Clean up after household pets and keep livestock away from lakes and streams. Animal wastes contribute to nutrient loading and livestock can cause bank collapse, which leads to increased sediments in the water.
- Do not feed waterfowl. Canada geese can contribute significantly to nutrient loading.

- Support ordinances that implement BMPs for agricultural, forestry, construction, and road maintenance practices in the watershed.

Ongoing public education addressing lakeside stewardship and watershed protection/pollution prevention can be carried out by volunteers from the lake community. Volunteers could mail out educational brochures about aquatic weed and water quality problems, aquatic weed control, and BMPs to watershed residents. For educational brochures, $1,000 is budgeted for the first year of the plan and $500 for every year thereafter.

PLAN COSTS AND FUNDING

ESTIMATED COSTS FOR PLAN

Table 4 summarizes the estimated costs for implementing the treatment plan. The plan will cost $293,000. This amounts to an average annual cost to each owner of $2,930 (based on an estimate of 100 owners). With a ten-year LMD, each owner would pay $293 per year on average for a period of ten years. If the County is awarded a $75,000 grant from the Department of Ecology, the duration of the LMD will be shortened.

Table 4: Summary of Estimated Costs for the Plan.

CONTROL TREATMENT	2001	2002	2003	2004	2005	2006-10	Total 10 Year
Navigate-Campbell-E. milfoil	35,000	25,000					60,000
Diver Hand Pulling or Spot Treatment-Campbell-E. milfoil			5,000	5,000	5,000		15,000
Aquathol-Erie-native plants	25,000	15,000					40,000
RODEO-Campbell-exotic w.lily	2,000						2,000
RODEO-(E & C)-native w.lily	5,000						5,000
Carp permit application-(E & C)	2,000						2,000
Stocking grass carp-(E & C)		86,800		8,400		16,800	112,000
Maintenance of outlet screen		2,000	2,000	2,000	2,000	10,000	18,000
Prevention Program (E & C)							
Annual survey/Milfoil surveillance	2,000	2,000	2,000	2,000	2,000	10,000	20,000
Signs	2,000						2,000
Volunteer training	1,000		1,000		1,000	2,000	5,000
Brochures/mailing	1,000	500	500	500	500	2,500	5,500
Watershed Protection (E & C)							
Brochures/mailing	1,000	500	500	500	500	2,500	5,500
Total-Control	76,000	131,800	11,000	18,400	11,000	43,800	292,000
Contingency Plans							
Remove water lily mats		1,000					1,000
Total-Contingency							1,000
Grand Total							293,000

Notes: Cost for an outlet screen ($70,000) is included in the cost of stocking grass carp in 2002. The Prevention Program focuses on preventing the introduction/re-introduction of noxious aquatic weeds into the lakes. The Watershed Protection Program focuses on limiting nutrient and sediment inputs into the lakes. These programs are essential elements of an IAPMP. An approved IAPMP is needed to obtain grant funding from the Department of Ecology. Contingency planning is for treatments that may be needed. There may be water lily mats that need to be removed after herbicide treatments. Voluntary donations could be solicited at the boat launches to help fund plan implementation. E & C = Erie and Campbell. E. milfoil = Eurasian watermilfoil. w.lily = water lily.

FUNDING

Implementation of the plan is dependent on securing funds to carry out management activities. Potential sources of funding include state grants, formation of a LMD, boat launch fees, and proceeds from enforcement action.

The Washington Department of Ecology can help fund the implementation of IAPMPs by furnishing a grant from its Aquatic Weeds Management Fund. Grant projects must address the control of excessive growth of freshwater aquatic weeds. Priority for funding is given to projects dealing with invasive, non-native aquatic plants. Algae control or alum treatments are not eligible for grant funding through the Aquatic Weeds Management Fund.

Local sponsors are required to provide 25% of the eligible project costs as a match to state funds. The maximum grant amount is $100,000 ($75,000 comes from Ecology and $25,000 comes from the local match). Each public body is limited to $100,000 per annual grant cycle. Project grants are intended to be "seed money" to help pay for initial projects that will be continued with local funds. Hence, it is important to identify and secure local, long-term funding sources.

This IAPMP will be submitted to the Department of Ecology for approval. Following approval of the IAPMP, an application for a grant from the Aquatic Weeds Management Fund will also be submitted. Unfortunately, grant funds are limited and funding is not guaranteed. Generally, the demand for grant funds exceeds the dollars available.

As noted above, the process for forming a LMD has been initiated by the lake community. A LMD could provide a local, long-term source of funding for implementation of the IAPMP. LMDs are special taxing districts that are similar to local improvement districts.

A LMD is formed when a lake improvement or maintenance project is planned that will primarily provide special benefits to a subset of the local community. Ordinarily, a LMD is set up to collect a certain amount of money for a specified period. To pay for the lake improvement/maintenance project, each property owner in the LMD is charged a special assessment, based on some equitable assessment plan. LMD special assessments are liens against the real property assessed. A LMD can include different zones that reflect different levels of benefit in each zone.

The formation of a LMD requires multiple public hearings and those property owners who will be assessed under the LMD must approve its formation through a vote. Voting is weighted to provide one vote for each dollar of assessment. A simple majority of the votes cast is required for LMD approval. If more than one lake is included in a LMD, a simple majority is required in each "lake zone" for LMD approval. A proposal to form a LMD must describe the details of the proposed LMD, such as, the proposed lake improvement/maintenance activities, LMD boundaries, duration of the LMD, amount of money to be raised, how assessments will be collected (annual or one-time payments), and estimated assessment to be imposed on each parcel in the LMD.

Establishing and collecting user-fees for the public boat launches on Lakes Erie and Campbell has been suggested as a way to help fund implementation of the plan. Much like wash facilities at the boat launches, there are unresolved issues regarding user-fees for the boat launches such as, who would be responsible for establishing, managing, and enforcing a user-fee program. In addition, the WDFW already requires users of the WDFW's public access sites to purchase an Access Stewardship Decal in order to use the sites. The decal costs ten dollars. The WDFW would have concerns about charging the public an additional fee (they are already paying for an access decal) to use its boat launches at Lakes Erie and Campbell. Monies generated by the access decal fee were earmarked by the state legislature for maintenance of the WDFW's public access sites. Therefore, it would be difficult to divert some of these funds to a LMD.

When a member of the public does use the WDFW's public access sites without an access decal, a citation can be issued by an enforcement officer. This infraction costs $69. The WDFW does not have sufficient personnel to aggressively enforce the access decal program, but any police agency can enforce the program and issue citations. To generate funds for the LMD, it appears that the LMD would have to:

- Convince an agency with enforcement powers to enforce the access decal program.
- Arrange for the court fines, or some portion thereof, that would be derived from an enforcement program at Lakes Erie and Campbell to be turned over to the LMD.

PLAN IMPLEMENTATION

The following is an outline for implementation of the IAPMP for Lakes Erie and Campbell:

Establish a citizen advisory committee. To implement the IAPMP, the committee needs to take responsibility for the plan. It is important that the lake community control whether and how the plan is carried out.

Secure funding sources. Apply for a grant from the Aquatic Weeds Management Fund and move forward with the process of forming a LMD.

Solicit and review bids for prescribed treatment plan.

Schedule treatments and follow-up monitoring.

Institute long-term monitoring. Develop a list of volunteers that are interested in conducting aquatic plant surveys. Establish a program to train volunteers, schedule plant surveying, and compile and review survey information. Schedule annual surveys by a professional and review survey information and recommendations.

Prepare a public education program. Arrange for the posting of prominent signs about aquatic weed problems/prevention at the public boat launches. Prepare newsletters and prepare or obtain fact sheets and educational brochures regarding aquatic weed and water quality problems, aquatic weed control, BMPs, and lake management activities. Distribute these newsletters, fact sheets, and brochures. Coordinate outreach efforts directed at educating recreational users of the lakes about invasive aquatic weed problems and their control. Coordinate mailings of informational brochures to lake/watershed residents and scheduling of educational presentations.

ONGOING MONITORING AND EVALUATION STRATEGY

The management goals in this IAPMP represent long-term objectives. Achieving these goals will require long-term commitment and flexibility. There are no "easy fixes" for the management problems of the Erie/Campbell lake system. Lakes Erie and Campbell are both shallow and eutrophic in nature, conditions that are conducive to macrophyte and algae growth.

Plans for ongoing monitoring have been described above. The monitoring and evaluation program should include an annual evaluation to track plan implementation, assess treatment effectiveness and determine whether management goals are being achieved, and recommend future management activities. Conditions in Lakes Eire and Campbell or community goals/needs may change over time. Program adjustments may be needed to address changing conditions and management goals.

A written evaluation should be completed annually by the citizen advisory committee. It should describe which elements of the IAPMP have been implemented, which have not, and why. The evaluation should also contain a summary of aquatic plant survey/monitoring results and an assessment of whether these results indicate that treatments have been effective and the plan's management goals are being met. The community should also be asked for input on their satisfaction with lake conditions and plan implementation. Information in the annual evaluation should be used to decide on the following year's activities and program adjustments.

COMMITMENT

Both the County and the citizens of Lakes Erie and Campbell have demonstrated an ongoing commitment to solving the aquatic plant and water quality problems in these two lakes.

The citizens of Lakes Erie and Campbell have worked together for the last 25 years to develop a strategy for managing their lakes. They have ensured that the County continued addressing their concerns about aquatic plant and water quality problems. Throughout the public involvement process for this IAPMP, the lake community showed its ongoing commitment to addressing the management problems for Lakes Erie and Campbell. Community members attended and actively participated in the community meetings. The members of the citizen advisory committee volunteered their time to develop the treatment plan, and they are committed to seeing that it is implemented. By initiating the process for forming a LMD, the lake community sent a strong signal about its commitment. The community is prepared to tax itself to fund the plan.

The County has supported the residents by obtaining funding and dedicating staff time, and will continue to allocate resources. Even with the recent passing of Initiate 695 that cut the Skagit County General Fund—the fund that supports aquatic activities—by $4.4 million, the County allocated more than 1,700 hours of staff time in 2000 to coordinate and obtain funding for an IAPMP. The County hired a lake management technician to draft the IAPMP and facilitate the

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