CITY OF FEDERAL WAY

Steel LAKE AquaTIC PLANT MANAGEMENT PLAN

Final Report
December 1995

Prepared by:
ENVIROVISION
in association with
Herrera Environmental Consultants

Prepared for:
City of Federal Way
Public Works Department
Surface Water Management Division

ACKNOWLEDGMENTS

Envirovision wishes to acknowledge the support of members of the steering committee for the Steel Lake Aquatic Plant Management Plan. Members include; Margaret Reyhner, Arline Cook, Terry Cook, Steve Seles, Glenda Seles, Tom Dezutter, Bruce Harpham, Allan Currie, Bob Ratcliff, Dave Renstrom, and Julie Garcia. Staff from the City of Federal Way also supported the project, this included Cary Roe, in addition to Dave Renstrom and Julie Garcia.

State agency staff also attended meetings and provided technical guidance. These included; Kathy Hamel (WDOE), Jennifer Parsons (WDOE), Phil Schneider (WDFW), and Mary Kautz (WDOE).

Last, Rob Zissette of Herrera Environmental Consultants provided his expertise in help with development of the plan and Resource Management Inc. performed aquatic plant surveys and plant mapping information.

This project was funded in part by the Washington State Department of Ecology's Aquatic Weed Management Fund.

PROJECT OVERVIEW

Steel Lake is located in the City of Federal Way in King County, Washington. It is a small (46 acres), shallow (mean depth 13 feet) lake with a watershed area of 243 acres that is primarily developed as residential and commercial property. There is no surface water inflow to the lake other than city stormwater outfalls. One outflow is located at the western end of the lake, and is generally seasonal in nature. In recent years the quality of the lake has deteriorated, largely due to an invasion from the non-native aquatic plants Eurasian Watermilfoil (Myriophyllum spicatum) and White water lily (Nymphae). These had colonized enough lake area to cause a restriction in recreational activities as well as limiting access to the lake in heavily infested areas. In past years, many lake homeowners have contracted individually to have nearshore areas sprayed with glyphosate (Rodeo®) to control lilies. With the invasion by Eurasian watermilfoil lake residents have joined together to develop a more comprehensive approach to plant control. In 1993, the City of Federal Way applied for and received a grant from the Department of Ecology to develop a long term plan to control aquatic plants. Since plans had already been underway to eradicate the milfoil through application of the aquatic herbicide fluridone (Sonar®), the application was performed in the spring of 1994.

This report provides a description of the aquatic plant control plan developed for the lake and summarizes the steps taken in development of the plan.

The basic recommendations selected for aquatic plant control in Steel Lake, are;

- periodic use of the herbicide glyphosate to control water lilies,
- annual diver surveys to monitor changes in the plant community,
- use of handcutting tools to control small patches of lilies or submerged plants,
- a contingency plan for re-invasion of milfoil or other non-native submerged plants,
- a prevention and education program to prevent the introduction of nuisance plants to the lake.

LAKE AND WATERSHED CHARACTERISTICS

Watershed Characteristics

The Steel Lake watershed is located approximately 20 miles south of Seattle, in the City of Federal Way, King County, Washington. The watershed is 243 acres in size and drains a gently sloping topographic area with elevations ranging from 440 feet to 500 feet (Figure 1). The entire watershed of Steel Lake lies within the City of Federal Way. Land use in the watershed is primarily comprised of single family residences (Figure 1 and Table 1). Steel Lake Park, multi-family residences, and vacant land comprise most of the remaining land in the watershed. It should be noted that the sub-basin boundary in Figure 1 and land use estimates in Table 1 are for Redondo Creek sub-basin CPR3, which includes an additional 88 acres of land located north and west of the lake outlet that actually drains to the outlet. Therefore, runoff from the wetland, open space, and development in this area does not drain into the lake. The largely urbanized nature of the watershed can be expected to contribute typical urban area pollutants to the lake. These include; oils, heavy metals. pesticides, fertilizers, and eroded materials, and others.

Historical land use estimates (Bortleson et al. 1976) indicate that less than 10 percent of the watershed has been developed in the past 20 years. Significant changes in land use are not anticipated in the near future because the watershed is almost entirely developed and major changes in zoning regulations are not expected (Renstrom 1995 personal communication).

Table 1. Land use estimates for the Steel Lake watershed[1]. (Source: D. Renstrom, written communication)

Land Use Classification	(Acres)	(Percent)
Single family residential	144.9	43.8
Multi-family residential	15.5	4.7
Institutional	5.8	1.8
Office	1.0	0.3
Open space	22.0	6.7
Steel Lake	47.4	14.3
Wetland	9.6	2.9
Parks and Recreation	25.2	7.6
Industrial	0.2	.1
Retail and Service	1.5	.5
Vacant	17.1	5.2
Public Right-of-Way	40.4	12.2
Total Watershed Area	330.6	100

[1] Land use estimates for Redondo Creek sub-basin CPR3 which includes 88 acres that drains to the lake outlet.

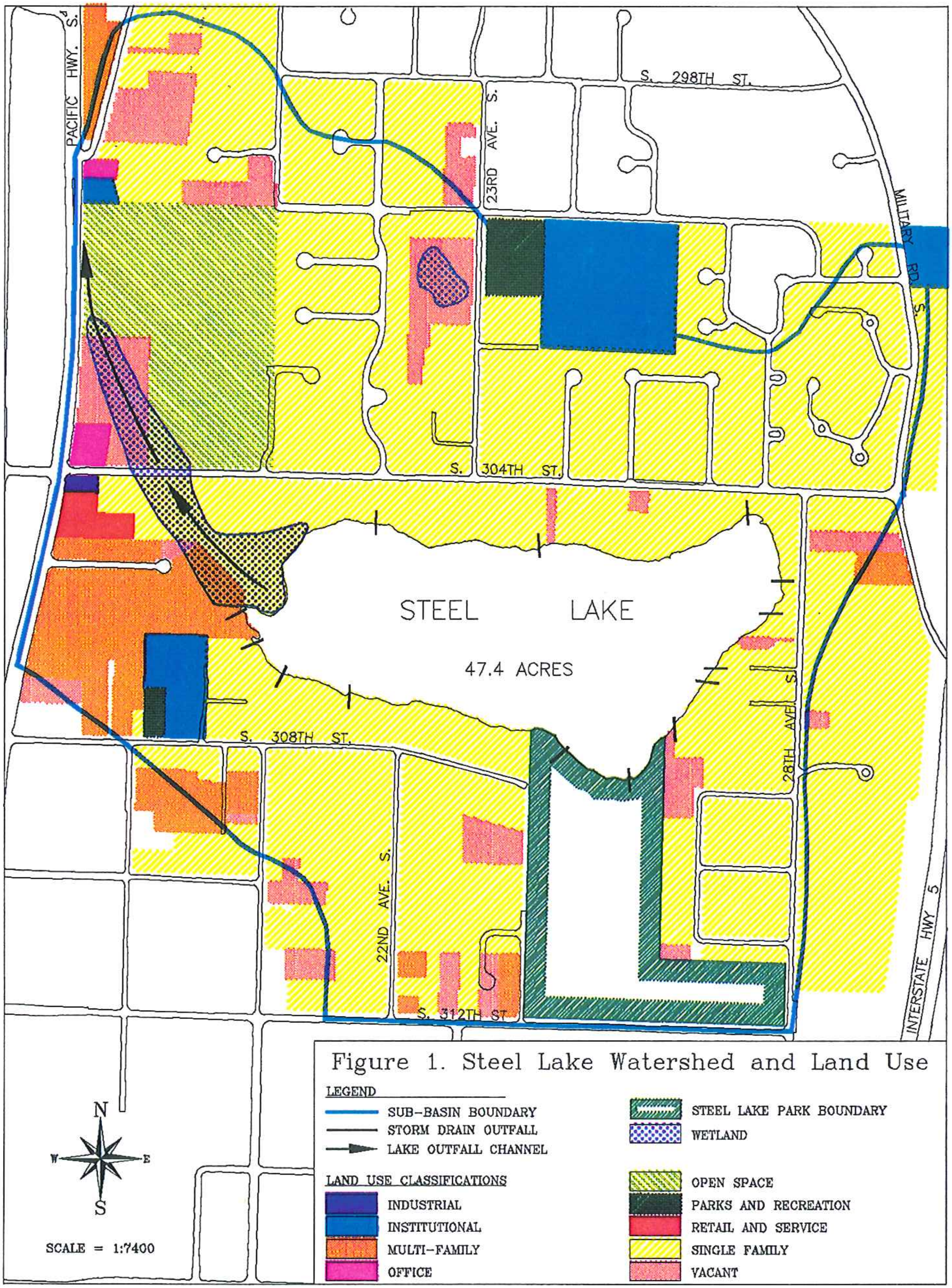


Figure 1. Steel Lake Watershed and Land Use

Wetlands in the Steel Lake Watershed have been mapped by the US Department of Fish and Wildlife as part of the National Wetland Inventory (NWI, 1987) (Figure 1). Wetlands in Steel Lake proper have been identified as either open water wetland (lacustrine-limnetic) or aquatic bed wetland (lacustrine-littoral). A wetland also exists at the outlet from the lake. The outlet initially flows through a palustrine-scrub-shrub/forested-seasonally flooded wetland and then through a palustrine-emergent-semi-permanently flooded wetland.The Washington Department of Natural Resources conducted a search of the National Heritage Program database for information on rare plants, high quality native wetlands, or high quality native plant communities in the watershed. There are no records of such plants communities in the Steel Lake watershed.

Lake characteristics

Steel Lake, located in the City of Federal Way, is 46 acres in size with a watershed area of 243 acres. Steel lake is relatively shallow with a mean depth of 13 feet, a maximum depth of 24 feet, and a lake volume of 600 acre-feet. Physical characteristics of Steel Lake are summarized in Table 2.

The majority of surface water enters the lake via 14 stormwater outfalls located around the perimeter of the lake (Figure 1). No streams flow into the lake. Steel Lake forms the headwaters of Redondo Creek. Outflow from the lake generally occurs only during the wet season (November through June). The lake outlet drains in a northwest direction from the west end of the lake, passing through a wetland to a culvert crossing at South 304th Street. The outlet continues to flow in a northwest direction, passing underneath Pacific Highway South and eventually discharging into Puget Sound at Redondo Beach. Although flow in the outlet is not regulated, this culvert has been observed to restrict outflow during extremely high lake levels (Renstrom 1995, personal communication).

Public access to the lake is from Steel Lake Park located on the south shore of the lake. The City of Federal Way maintains the park and a boat launch owned by the Washington Department of Fish and Wildlife (WDFW).

Table 2. Physical characteristics of Steel Lake and its watershed.

Characteristic	English Units	Metric Units
Watershed area	243 acres	98.3 hectares
Surface area	46 acres	18.6 hectares
Lake volume	600 acre-ft	7.4×10^5 cubic meters
Maximum depth	24 feet	7.3 meters
Mean depth	13 feet	4.0 meters
Lake altitude	440 feet	134.1 meters
Shoreline length	1.3 miles	2.1 kilometers
Flushing rate	0.77 times/year	0.77 times/year

Water Quality

The King County Department of Metropolitan Services, formerly the Municipality of Metropolitan Seattle (Metro) began monitoring Steel Lake in 1971. The most complete and consistent data set exists for the winter period of 1976 and the winter period from 1980 to

1994. During these years, winter-time pH typically ranged from 6.5 to 7.5, dissolved oxygen concentrations ranged from 9 to 12, and conductivity levels ranged from 55 to 75. These values are typical of small lakes in the King County region (Metro 1994). Little data exists to evaluate conditions during the summer or fall periods.

The most common way lakes are classified is by their trophic state, which defines a lake in relation to the degree of biological productivity. Lakes with low nutrients, low algae levels, and clear water are classified as nutrient poor or "oligotrophic". Lakes with high nutrients, high algae levels, and low water clarity are classified as nutrient rich or "eutrophic". "Mesotrophic" lakes have water quality characteristics between these two classifications. "Eutrophication" is the term used to describe the process of lake aging, where lakes progress from oligotrophic to eutrophic conditions. Although eutrophication is a natural process that occurs slowly over time, it can be greatly accelerated by human activities in a watershed. Classifying a lake based on trophic level indicators is a useful way to describe gross changes in a lakes' water quality over time.

Total phosphorus, chlorophyll *a*, and transparency are the three water quality parameters most often used to rate the overall trophic condition of a lake. Threshold values for trophic state used by Metro to determine the overall condition of small lakes monitored in King County are presented in Table 3 along with a summary of the Steel Lake data. It should be noted that the available data for Steel Lake is not complete. For example, typically a summer period total phosphorus concentrations would be used to determine trophic status. Whereas in this case only winter period data was available for phosphorus. It is also improper to use summer period data for some constituents (e.g. chlorophyll and Secchi depth) and winter period for others. However, the data is adequate for making a few preliminary determinations.

Table 3. Trophic State Classification. (Revised from: Metro 1995)

Trophic State[1]	Total Phosphorus (µg/L) (Winter mean)[3]	Chlorophyll *a* (µg/L) (Summer mean)[4]	Transparency (meters) (Summer mean)
Oligotrophic	< 10	< 4	> 5
Mesotrophic	10-20	4 - 10	2-5
Eutrophic	>20	>10	<2
Steel Lake Range[2]	6-24	2.7-6.2	2.9-4.0
Mean (# of years)	15 (n=10)	4.0 (n=7)	3.4 (n=7)

(1) Source: Vollenweider, R.A. 1970.
(2) Range shown is range of seasonal arithmetic means from 1985-1994.
(3) Winter period includes data from November through April.
(4) Summer period includes data from May through October.

Winter total phosphorus levels are moderate, chlorophyll *a* levels are low to moderate, and transparencies are moderate compared to other small lakes monitored by Metro in King County (Metro 1995). Based on the measured values of phosphorus, chlorophyll a, and transparency, Metro has consistently classified Steel Lake as mesotrophic, or moderately nutrient enriched.

The primary source of pollutants to Steel Lake is probably stormwater runoff discharged from 14 outfalls located at various points on the shoreline, in addition to the runoff that enters the lake directly from shoreline property. Typical pollutants of concern in urban runoff include; suspended solids, nutrients, bacteria, fertilizers, pesticides and toxic substances (e.g., metals and polycyclic aromatic hydrocarbons) Elfish (1986). These pollutants result from normal daily activities that occur in the urban environment. For example, automobiles and road surfaces contribute metals and petroleum products and polycyclic aromatic hydrocarbons, gardening, cleaning and other household activities contribute fertilizers, pesticides, nutrients, and various toxic substances. There is no data available to determine whether these pollutants exist in Steel Lake, and no current evidence of toxic affects.

Failing septic systems may also be a source of pollutants such as nutrients and bacteria to Steel Lake. Approximately 35 acres of single-family residences, located in the northwest and northeast portions of the watershed, are currently served by on-site septic systems (Federal Way Water and Sewer and RPA, 1992). This area represents 18 % of the land that drains to Steel lake. Lakeshore residences and all other development in the watershed is sewered. Although the incidence of septic system failure in the watershed is not known, this information suggests that septic systems are probably not an important source of pollutants to the lake.

Fish and wildlife community

Steel Lake is managed by the Washington Department of Fish and Wildlife (WDFW) as a trout and warm-water fishery. Between 1947 and 1969, the lake was rehabilitated on five occasions by treating with rotenone to reduce populations of spiny-ray fish, and was stocked each year with approximately 7,000 recently hatched (fry) rainbow trout (Salmo gairdneri). Due to the mixed species character of the fish community and the poor survival of trout fry, the fish management program changed in the 1970's by eliminating rotenone treatments and by stocking with trout of catchable size (i.e. between 8 and 12 inches long) in the spring of each year (Pfeifer 1995 personal communication). In the past 10 years, a total of 46,635 trout were allotted for release into Steel Lake. Two surveys conducted in the past 10 years identified the presence of the following other fish species: largemouth bass (*Micropterus salmoides*), yellow perch (*Perca flavescens*), pumpkinseed (*Lepomis gibbosus*), and brown bullhead (*Ictalurus melas*).

Since 1991, approximately 6,000 trout were released into the lake each year. Approximately half were released in April prior to opening day of the fishing season, and the other half were released in June into a pen inside the fishing pier at Steel Lake Park for a fishing derby attended by an average of 600 children. Trout not caught in the pen were released into the lake. In 1995, there was no fishing derby and the fish management program consisted of releasing 5,350 trout in April. Although the future of the fish management program is uncertain, it may consist of releasing trout later in the spring and reducing the number released in the pen to increase fishing opportunities for the general public (Pfeifer, 1995, personal communication).

The Washington Department of Fish and Wildlife (WDFW) conducted a search of the nongame data system for known occurrences of threatened, endangered, and sensitive species of animals in the watershed. Bald eagle nests have been sighted adjacent to Puget Sound, approximately 2 miles west of Steel Lake. In addition, a great blue heron rookery (breeding area) is present 2.5 miles southeast of the lake. Although these species may visit Steel Lake no sightings of these or other priority (sensitive) species have been reported at Steel Lake (Thompson, 1995, pers. comm.). Other priority species that may visit the lake include the following cavity-nesting ducks: wood duck, Barrow's goldeneye, common goldeneye, bufflehead, and hooded merganser.

Aquatic Plant Community

The aquatic plant community in Steel lake was surveyed by Metro in 1976, 1978, and 1979, and by Resource Management, Inc. (RMI) in 1994 and 1995. The relative presence, density, and areal coverage of aquatic plants are summarized in Table 4. Historical aquatic plant maps are provided for the Metro surveys conducted in August 1976 (Figure 2) and August 1979 (Figure 3). Recent aquatic plant maps are provided for the RMI surveys conducted in May 1994 before the Sonar treatment (Figure 4) and September 1994 after the Sonar treatment (Figure 5). Results of the RMI survey conducted in May 1995 showed no significant change when compared to the September 1994 post-treatment survey.

Currently, aquatic plants inhabit 35 acres (76 percent) of the lake, with submerged macroalgae (Nitella sp.) comprising 31.4 acres (90 percent) of the total plant area and floating -leaved plants primarily consisting of waterlilies (Nymphaea odorata and Nuphar lutea spp. variegata) comprising the remaining 3.6 acres (10 percent). Nitella typically grows in dense stands between depths of 1 and 15 feet, but does not grow taller than 2 feet. Waterlily growth in Steel Lake is characterized by a large population which grows to a maximum depth of 5 feet at the west end of the lake, and a few small patches distributed along the remaining shoreline. Submerged macrophytes such as Large-leaf pondweed (Potamogeton amplifolius) and thin-leaf pondweed (Potamogeton pusillus) are present between depths of 5 and 10 feet at densities too sparse to map. Although they are not shown in the figures, small stands of emergent plants grow along 1,400 feet (20 percent) of the shoreline, covering a total area of 0.4 acres. Yellow flag iris (Iris pseudacorus) and cattail (Typha sp.) dominate the emergent plant community, while marsh cinquefoil (Potentilla palustris) and rushes (Juncas sp. and Eleocharis palustris) are also present (RMI 1994, 1995; Parsons 1995 personal communication).

Immediately prior to the 1994 Sonar treatment (Figure 4), submerged macrophytes were present in 7.8 acres of the area currently occupied by Nitella. Native pondweeds (Potamogeton amplifolius and P. pusillus) dominated the submerged macrophyte community. Eurasian watermilfoil (Myriophyllum spicatum, milfoil), the non-native macrophyte targeted for treatment, was present in 1.3 acres of the lake. Residents noticed this invasive plant growing in Steel Lake in the summer of 1992. They conducted several public meetings to develop control strategies, raised funds, and contracted with RMI for a Sonar treatment in 1993. However, pre-treatment observations indicated that the coverage and condition of milfoil (and native pondweeds) had dramatically declined. At least one aquatic plant expert believed the plants exhibited symptoms of herbicide damage. As a result, the treatment program was postponed until 1994. Investigations by Ecology did not detect herbicides, but did discover numerous caddis fly larvae (Triaenodes injecta) that feed on submerged aquatic plants (RMI 1994, Parsons 1995 personal communication).

Historically, aquatic plants inhabited approximately 27 acres (59 percent) of the lake (Figures 2 and 3), with submerged macrophytes and macroalgae comprising approximately 18 acres (67 percent) of the total plant area, and floating-leaved plants (waterlilies) comprising the remaining 9 acres (33 percent). Comparison of the 1979 and 1994 pre-treatment survey results indicates the although the total area coverage of submerged macrophytes did not change the relative density of these plants increased, and of course the plant composition changed to include stands of milfoil. During the same time period, the area coverage of submerged macroalgae increased, while floating-leaved plants (waterlilies) decreased. (The decrease in waterlilies is primarily due to approved herbicide (glyphosate) treatments in addition to non-chemical controls (i.e. mechanical harvesting, bottom barriers , and hand cutting) that have been conducted over the past 15 years.)

Table 4. Relative presence, density, and areal coverage of aquatic plants in Steel Lake.

	Common Name	1976[a]	1978[a]	1979[a]	1994[b] (Pre-Treat)	1994[b] (Post-Treat)
Relative Presence						
Rooted Floating-Leaved						
Nymphaea odorata	Waterlily	Dominant	Dominant	Dominant	Dominant	Dominant
Nuphar lutea spp. v	Waterlily	Present	Present	Present	Present	Present
Brasenia schreberi	Watershield	Present	Absent	Absent	Absent	Absent
Submerged macrophytes						
Potamageton amplifolius	Pondweed	Present	Present	Dominant	Dominant	Present
Potamageton pusillus	Pondweed	Dominant	Dominant	Present	Dominant	Absent
Elodea canadensis	Waterweed	Present	Present	Present	Present	Absent
Najas flexilis	Naiads	Dominant	Dominant	Dominant	Unknown	Unknown
Myriophyllum spicatum	Milfoil	Absent	Absent	Absent	Present	Absent
Utricularia vulgaris	Bladderwort	Absent	Absent	Present	Absent	Absent
Ceratophyllum demersum	Coontail	Absent	Present	Absent	Absent	Absent
Submerged macroalgae[(c)]						
Nitella sp.	Nitella	Present	Dominant	Dominant	Dominant	Dominant
Chara sp.	Muskgrass	Dominant	Present	Present	Absent	Absent
Relative Density of Submerged Macrophytes						
North Shore		Moderate	Sparse	Moderate	Dense	Sparse
East Shore		Moderate	Sparse	sparse	Dense	Sparse
South Shore		Moderate	Sparse	Sparse	Dense	Sparse
Areal Coverage (acres)						
Floating-leaved plants		9.6	8.5	8.2	3.6	3.6
Submerged macro-phytes/algae		19.1	8.6	6.2	6.5	0
Eurasian watermilfoil		0	0	0	1.3	0
Submerged macroalgae		0	8.9	12.6	23.6	31.4
Total		29	26	27	35	35

a Source: Metro 1976, 1978, 1979.
b Source: RMI 1994.
c These plants may have been misidentified in earlier surveys due to their similarity.

Characteristic Use

One of the first tasks for the steering committee was to develop a list of beneficial uses the lake provides and identify where those uses occur. Table 5 contains a list of characteristic or beneficial uses Steel lake provides to area residents; people and wildlife. In particular, the lake supports a large city park, excellent wetland habitat, and a trout stocking program. It is also important to note that no motorized boats are allowed to be used in the lake.

Table 5. List of Beneficial Uses for Steel Lake.

Beneficial Use	Location
Swimming	Around homes and in City park
Non-motorized Boats	Entire Lake
Fishing	Whole lake (Fishing derby at park site)
Sailing	Whole lake
Waterfowl Habitat	Concentrated along western shore
Aesthetic enjoyment	In lake and surrounding shoreline
Birdwatching	Throughout the lake
Irrigation	One water right and two claims exist
Wetland Habitat	Near the lake outlet (western end of the lake)
Wildlife Habitat	Crayfish, turtles, and frogs primarily near shore
Trout Stocking	Deep water habitat (No trout spawn in the lake.)
City park	Approximately 700 feet of shoreline
Fish Habitat	Spawning (warmwater fish) occurs near docks and lilies in the west end. No salmon spawn in the lake.

Figure 2. Steel Lake aquatic plant survey results, August 1976 (Metro 1994)

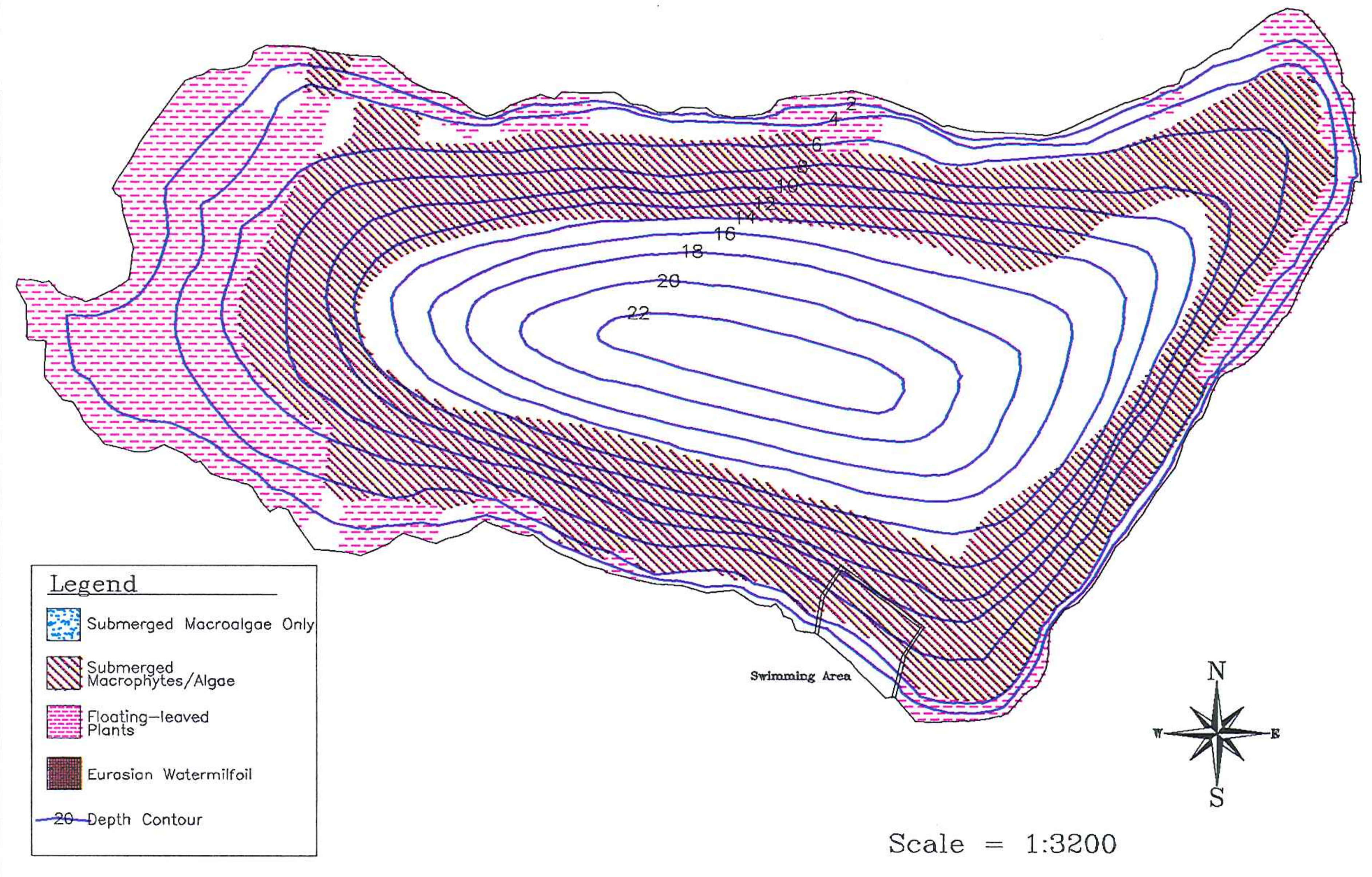


Figure 3. Steel Lake aquatic plant survey results, August 1979 (Metro 1994)

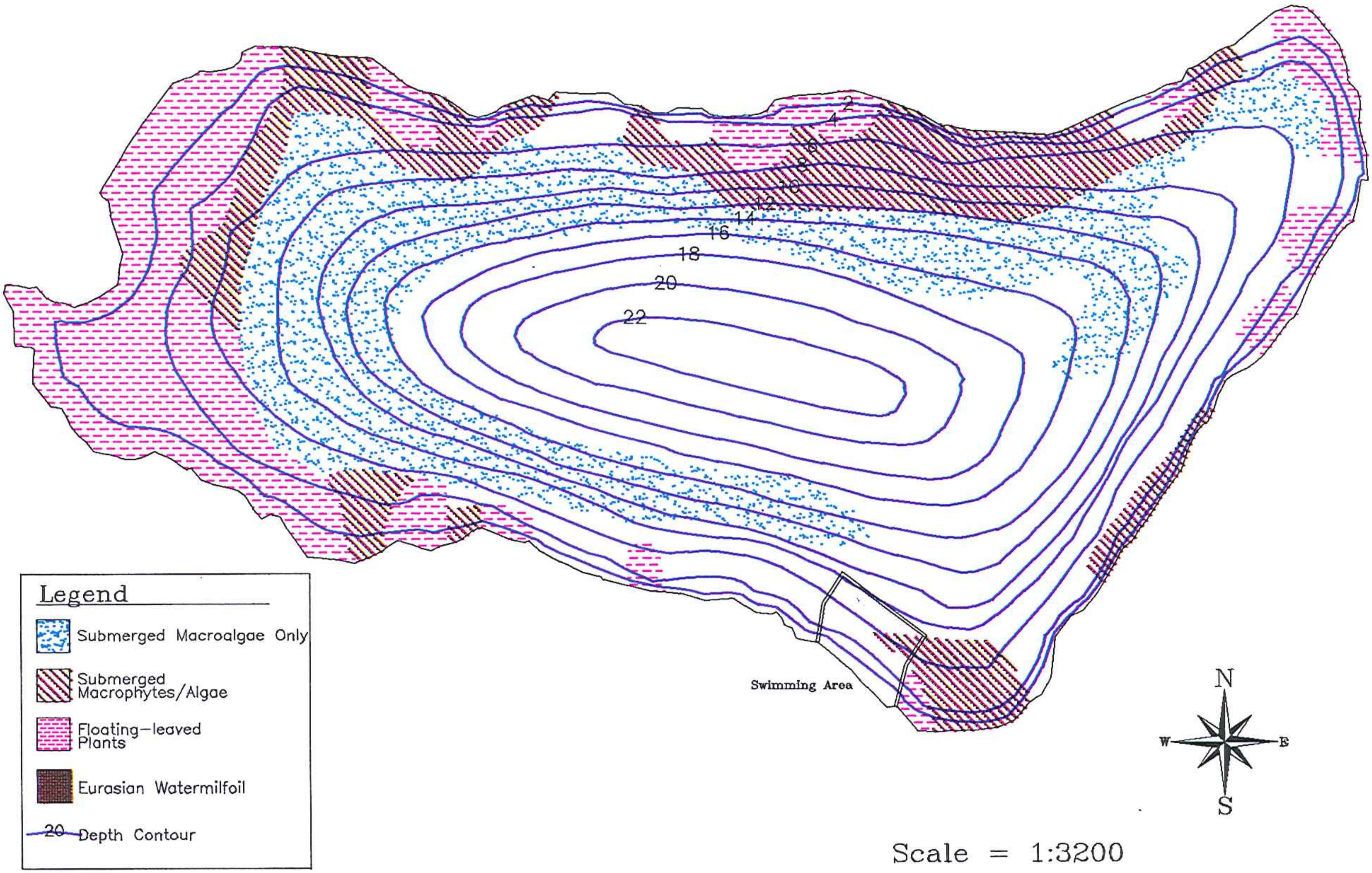


Figure 4. Steel Lake aquatic plant survey results before treatment with Sonar®, May 1994 (RMI, 1995)

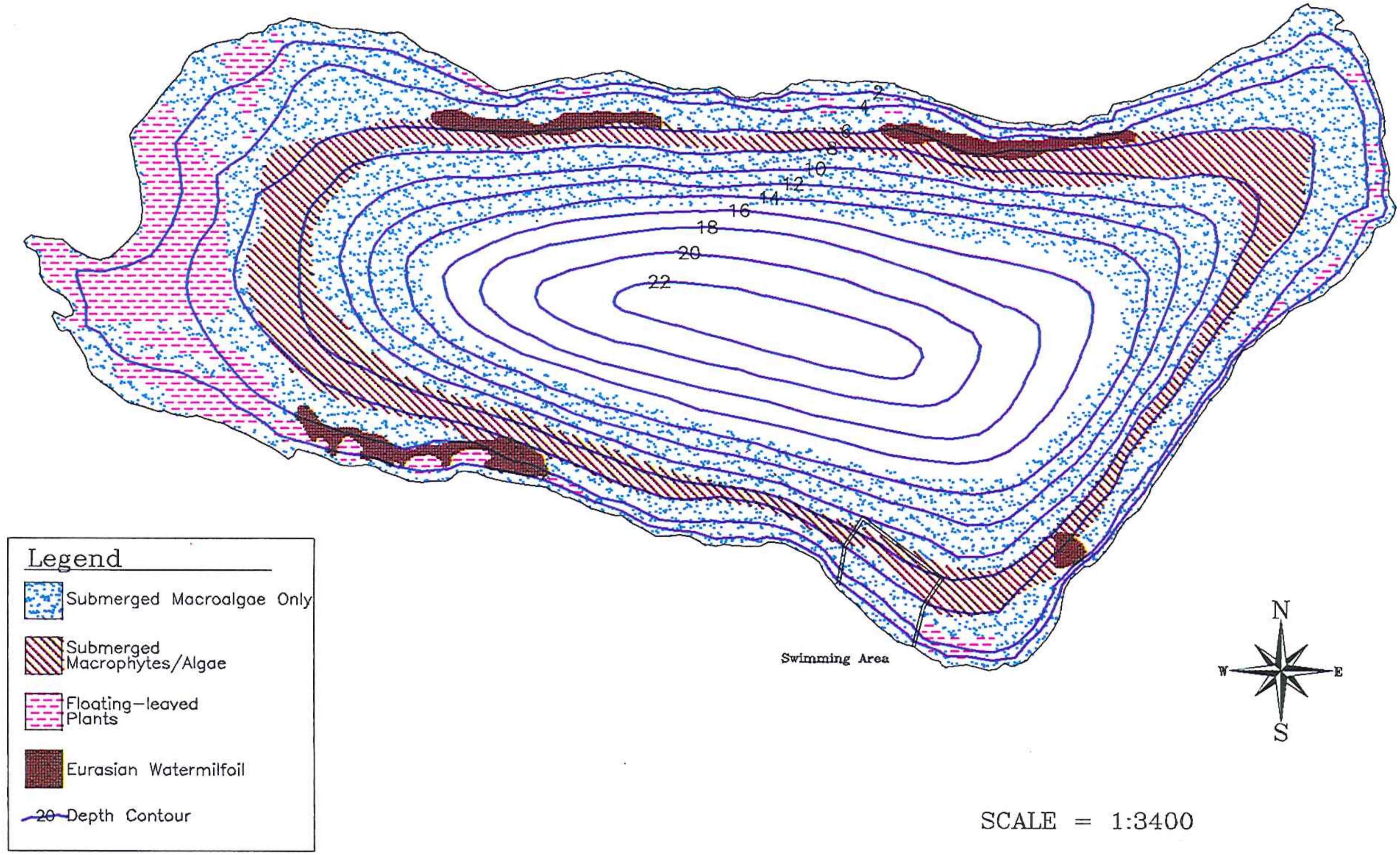
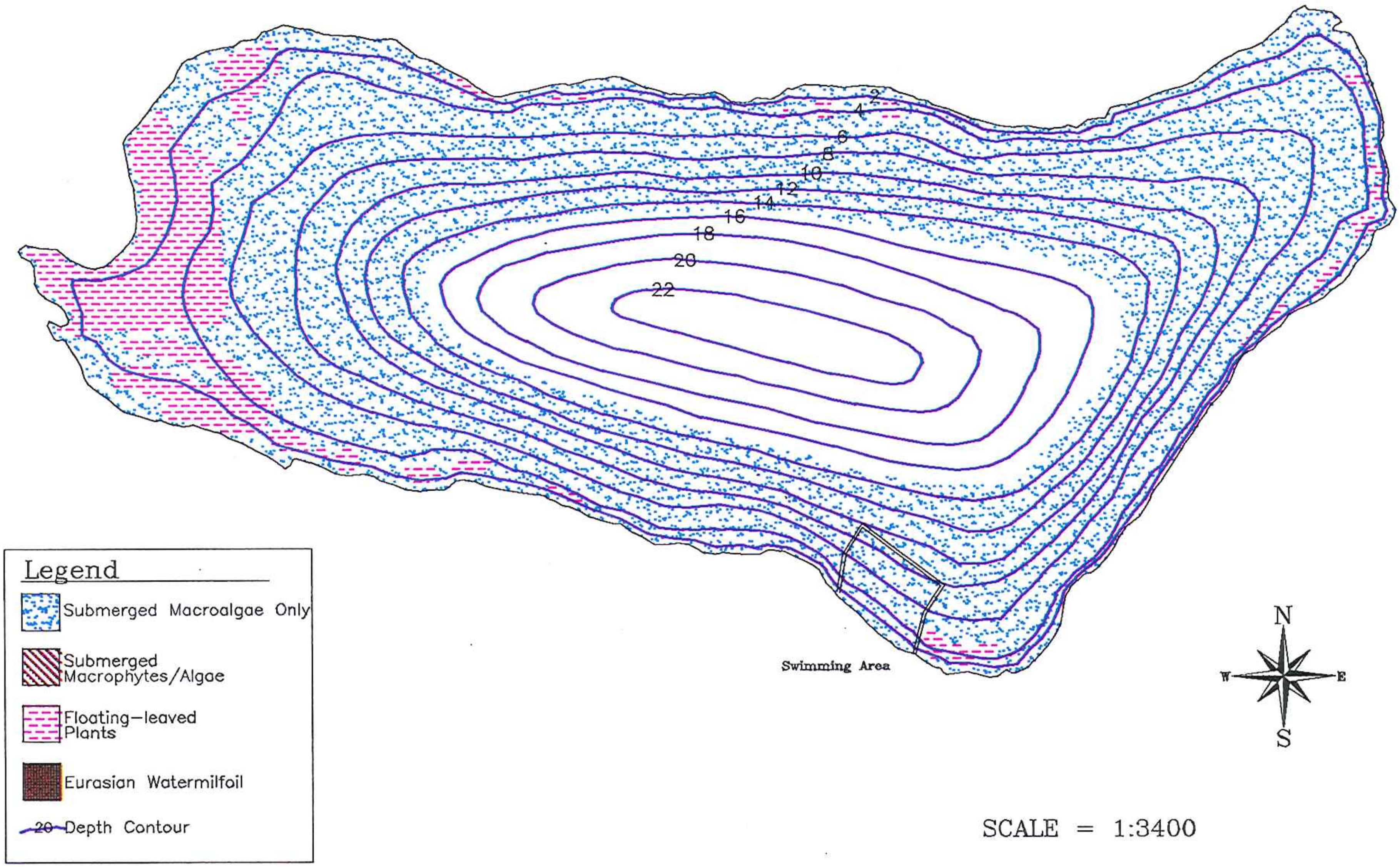


Figure 5. Steel Lake aquatic plant survey results after treatment with Sonar®, September 1994 (RMI, 1994)



PROBLEM STATEMENT FOR STEEL LAKE

Development of the Problem Statement for Steel Lake, began by creating a list of the problems experienced. This initial problem list is provided below. Some of the problems identified were not directly associated with aquatic plant populations; and therefore can not be addressed through development of an aquatic plant control plan; these are listed separately.

Aquatic Plant Associated Problems:

- Milfoil, a non-native, invasive species was colonizing the lake
- Water lilies have colonized the western end of the lake
- It is difficult to access portions of the lake due to the dense aquatic plant stands
- Floating masses of decayed vegetation are creating safety hazards and unsightly views
- Recreational activities such as fishing, swimming, canoeing, sailing, are being restricted from some portions of the lake due to difficulties in navigating through dense plants
- Property values may not be increasing at the expected rate due to poor lake conditions
- Aesthetic value of the lake is deteriorating
- The existence of the milfoil represents a potential for invasion to other area lakes
- With the exception of the sonar treatment, control techniques currently being used (pesticides, hand pulling, and some screening) are limited to the property of people who have chosen to try to control the plants and therefore are less effective than if a lake-wide effort was made.

Other Problems Identified:

- The lake is becoming shallower; filling in
- Algae blooms occur during the summer
- The wetland at the outlet is causing water to back up and causing increased lake filling
- Too many waterfowl are staying on the lake year round. (Populations may decrease if aquatic plants are decreased.)
- "Swimmers Itch" is sometimes experienced

The list of problems was used to create a problem statement for Steel Lake. The purpose of the problem statement is to describe as clearly as possible how the lake and its inhabitants are being negatively impacted by aquatic plants. The following problem statement was developed for Steel Lake:

Aquatic plants, including the non-native species Myriophyllum spicatum, (milfoil) in Steel Lake have increased to the extent that they are impairing the use and aesthetic value of the lake. Dense aquatic plant beds are restricting access; fishing, swimming, sailing, and other types of boating are restricted to the mid-section of the lake, due to the obstruction caused by plants in the shallower, nearshore area. Milfoil was reportedly colonizing area up to the 15 foot depth interval in Steel Lake. Submerged plants have the potential to colonize over 50% of the lake area, further restricting available area for recreation activities. The non-native lily, Nymphaea sp. continues to colonize an increasing portion of the west end of the lake. The lilies in combination with the very shallow water depth, have greatly restricted use of this portion of the lake. Personal efforts to control the lilies are offset if adjacent properties are not also maintained, and consequently suffer from the need for a lake-wide approach. Large sections of root and plant mass break away and float to the surface of the lake, forming unsightly *clumps and causing potential boating safety problems. Property values may be affected by the plant problems. This may be especially true of the western end of the lake, where water depth limitations in combination with lily beds are causing the "waterfront" to move farther from the existing shoreline. Lake homeowners are so concerned about deterioration of the lake that many voluntarily contributed $4.00/ foot of lake frontage toward a milfoil control project. The lake has recently been treated with Sonar (flouridone) to eradicate the milfoil, but a long-term strategy needs to be identified for control of aquatic plants, and to assure milfoil does not become re-established in the lake.*

AQUATIC PLANT MANAGEMENT GOALS

The final step before beginning development of a plant control plan was to define program goals against which the program could be evaluated. Setting project goals is an important step because they will determine what control strategies will work, and will ultimately be used to evaluate whether the program has been a success. The list of beneficial uses and problem statement for Steel Lake was used to develop a list of goals for managing the lake plant problem. This list was developed with the aid of the steering committee.

After the goals were listed, committee members were asked to select their top three goals. This resulted in a ranking of four priorities for plant control, since there was a tie vote between eradication of non-native submerged plants and improved water clarity. Since water clarity can not be directly affected by control of aquatic plants, eradication of non-native submerged plants was selected as the goal for this plan. The top three goals are listed below in order of their rank, the remainder were not prioritized. Development of the management plan was based on attaining these three goals.

Priority Goals

- Control waterlilies to the maximum extent allowed by WDFW
- Control submerged plants to a level where they do not hinder recreation
- Eradicate non-native submerged plants

Unranked Goals

- Remove all submerged plants from public swimming area
- Remove sediments/increase water depth (Decrease plant habitat)
- Maintain the diversity of the palustrine (inner) portion of the wetland (excluding the monotypic lilies bed)
- Improve water clarity
- Decrease sedimentation

AQUATIC PLANT CONTROL ALTERNATIVES

The aquatic plant management goals are based on controlling three plant community types: waterlilies, native submerged plants, and milfoil. The feasibility of different plant control techniques depends on plant type and the degree of control desired. Therefore, control alternatives are presented for each plant community type for two levels of control.

All control alternatives described by Ecology (1994) were considered for use in Steel Lake. Only the most feasible alternatives are presented in this report. Summary descriptions of the method, control zone and duration as it would be implemented in Steel Lake and the primary advantages and disadvantages are provided for each alternative. A more detailed listing of advantages and disadvantage of each technique is provided in Ecology (1994). Cost estimates are provided on a per treatment basis and also on a control period of 10 years.

Waterlily Control

Given the success of the milfoil control program and the current lack of submerged plants in Steel Lake, control of waterlilies is of the most concern to the lake community. Controlling lilies to the maximum extent allowed by WDFW was the number one goal identified by the steering committee. Waterlily growth in Steel Lake is characterized by the large population at the west end of the lake and a few small patches distributed along the remaining shoreline. By character, waterlilies are found in nearshore areas and are most problematic in areas of four feet depth or less. Currently, there are approximately 4 acres of waterlilies in Steel Lake, including 2 acres surrounding undeveloped property and 2 acres in front of developed property. Historical surveys (Figures 2 and 3) indicate that the total area of waterlilies could expand to 10 acres if left uncontrolled.

To meet WDFW requirements, the waterlily control plan must leave a minimum of 25% of the lily habitat for fish and wildlife habitat. The steering committee agreed this could best be accomplished by leaving a conservancy area of 2 to 3 acres near the lake outlet. This would protect the wetland located at the outlet, preserve needed habitat, and not hinder lake access by property owners. Consequently, the maximum control area for waterlilies could range from 2 acres under existing conditions to 7 acres at maximum extent of the lily beds.

In order to allow evaluation based on different control intensities and control zones, waterlily control alternatives are separated into two categories; methods that are more appropriate for control of selective areas, and those that are appropriate for control of large areas of waterlily.

Selective Waterlily Control Methods

Hand Cutting

Hand cutting is a manual method of cutting stems of aquatic plants close to the sediment surface. Two tools that are most effective on waterlilies include the Water Weed Cutter and the Lake Weed Shaver (McComas 1993). The Water Weed Cutter has a V-shaped, straight-edge blade that cuts a 3-foot path. It is best used by throwing it from the shore or dock and pulling it back with a jerky motion. The Lake Weed Shaver has a straight-edge blade that cuts a 6-foot path. Because of its weight, it is best used by dragging it behind a boat. To be most effective, either tool should be used before the waterlilies become very dense and the blade must be routinely sharpened.

Although cut fragments of waterlily will not re-root and grow as some submerged plants do, these fragments should still be removed to prevent aesthetic impacts from floating debris and onshore decay of the plant material. Cut fragments float and are best removed with a modified fish seine that encircles small working areas or is positioned down-wind of the working area. The net should have at least a 1-inch mesh so that it will not trap small fish.

There are no depth limitations for these tools and therefore the control zone for this method could include any portion of the lake waterlily beds. However, since it requires manual labor it is best suited for small patches of lilies that may be hindering lake access. Because plant roots (tubers) are not removed using these tools, the duration of control is comparatively low. The frequency of application is dependent on water depth; monthly cuts will maintain deep areas, but more frequent cuts may be necessary for areas less than 3 feet deep.

Equipment costs are low: $100 for the Water Weed Cutter, $200 for the Lake Weed Shaver, and $500 for a modified fish seine. The estimated 10-year cost is $2,000 which does not include labor provided by property owners. The primary advantage of hand cutting is the low cost. The primary drawback is the high amount of labor required to provide adequate control.

Weed Rolling

The Weed Roller is a relatively new product that controls aquatic plant growth by periodically disturbing the lake bottom. The drive head is typically mounted to the end of a dock in water depths of up to 8 feet. It slowly rotates a string of three aluminum tubes which repeatedly roll over a broad arc on the lake bottom. Each 6-inch by 10-foot tube is connected with a flexible coupler to follow the bottom contour. The Weed Roller converts 110-volt household current to 24-volt direct current (DC) and covers up to a 270° sweep in 15 minutes. Adequate control is typically achieved by operating the Weed Roller continuously overnight once every week or two during the growing season.

Since a power source and structural support is required to operate the weed roller, the control zone is limited to area directly adjacent to docks. Although the effectiveness for waterlily control has not been documented, the manufacturer claims it is effective at controlling the growth of cattails and bulrushes and therefore should be effective for waterlily control. King County Surface Water Management Division is currently testing the Weed Roller at two sites.

A complete unit with accessories sells for approximately $2,500. The estimated 10-year cost is $100,000, which is based on purchase of 40 units to control 0.5 acres, and does not include installation and electricity. Advantages of the Weed Roller include the high degree of control, low amount of labor, and the fact that it will control all plant types within its path. The main drawback is the limited area of control. The Weed Roller requires hydraulic approval from the Washington Department of Fish and Wildlife.

Bottom Barriers

Bottom barriers are manufactured sheets of material that are anchored to the lake bottom to prevent plants from growing, similar to weed barriers commonly used in lawn and garden activities.. Several bottom covering materials have been used with varying degrees of success. A woven polyester material such as Texel® is one of the most effective bottom barriers because it is durable and it provides efficient exchange of gas produced from decaying organic matter (roots). It is typically installed in the winter, when lilies are not present, by unrolling 30×50-foot sections and anchoring them with sand bags spaced 10 feet apart. Bottom barriers should be maintained on an annual basis to ensure adequate coverage and anchoring. Bottom barriers can be relocated to other areas after 2 years if sediment accumulation is not excessive. Re-installation may be necessary to control encroachment of lilies in areas adjacent to dense growth.

There are no limits to the control zone for bottom barriers. They are effective in deep as well as shallow water and do not have special requirements that eliminate their use in different areas. The control zone would be defined by the number of 30*50 foot sections installed. Further, they can be used to control submerged plants as well as lilies. Control intensity and duration varies depending upon sediment accumulation and encroachment from adjacent area. If properly installed and maintained annually, bottom barriers can provide a high level of control for five years or more.

The cost of applying bottom barriers is approximately $0.80 per square foot or $35,000 per acre. Annual maintenance costs are estimated to be $5,000 per acre. The estimated 10-year cost is $80,000 based on 1 acre of material, which could be relocated to control up to 4 acres of lilies. The primary advantage of bottom barriers is the intense level of control and the ability to be very selective about the control area. The main disadvantage is the high cost per acre controlled. Bottom barriers require hydraulic approval from the Washington Department of Fish and Wildlife and a shoreline permit from the City of Federal Way.

Extensive Waterlily Control Methods

Mechanical Harvesting

Mechanical harvesting involves cutting plants below the water surface, conveying them onto the harvester, and offloading them at the boat launch for disposal or composting at a suitable site. Harvesters are manufactured by several companies; various sizes and features are available to meet specific requirements. Maximum cutting depths range from 5 to 8.2 feet with a cutting width or swath of 6.5 to 12.1 feet.

Harvesting provides immediate control of the problem plants, but the duration of control depends on water depth and the depth of cut. Past experience with harvesting waterlilies in Steel Lake indicates that adequate control could be achieved with two or three cuts per season.

Harvesting of waterlilies in Steel Lake could be performed at a cost of approximately $1,500 per acre per year, based on two cuts each year. The estimated 10-year cost is $60,000 for a control area of 4 acres. The primary advantages of harvesting are the immediacy of the control and the fact that plant material that would normally add to the lakes nutrient load and cause increased sedimentation is removed from the lake. The primary drawback of harvesting is the shorter duration of control and therefore the need for repeated applications. Mechanical harvesting requires hydraulic approval from Washington Department of Fish and Wildlife.

Dredging

Dredging, or removing accumulated sediments has typically been used to either deepen a lake, or to remove nutrient laden sediments for water quality improvement. It can also be used to control the amount and type of aquatic plant habitat present. This is based on the idea that different plant types grow best at different water depths, therefore, if sediments are removed (causing deeper water) plant types will change accordingly. If enough material is dredged to reach background soils that do not support aquatic plant growth, then dredging actually results in elimination of plant habitat.

A portable cutter-head dredge could be used to remove sediment and waterlily tubers from Steel Lake. A slurry of chopped sediment material and lake water is pumped to shore for dewatering and disposal. Dredging would result in short-term, localized water quality impacts, but may also result in long term improvement in lake water quality due to removal of nutrient laden sediments.

The design of the dredging program could vary widely from increasing the depth of the entire lake by 4 feet or more, to dredging a narrow band near the lily bed to decrease available lily habitat. Costs would change accordingly, since cost is based on the volume of material removed. Estimated costs for Steel Lake ranged from $320,000 to $1,177,000.

Advantages of dredging are the high intensity and long duration of control, and the benefit of increased water depth. For a small dredge project (small area and minimum depth gain) the duration of control may exceed 10 years for isolated lily patches, but may not exceed 5 years in areas adjacent to lilies left for conservancy. A small-scale dredging operation in shallow areas of the lake is unlikely to significantly improve water quality by removing nutrient-rich sediment, nor is it likely to significantly reduce suitable habitat for growth of submergent vegetation. A full-scale dredge project could result in large-scale reductions in available plant habitat, improved water quality, and a control duration of 10-50 years. The primary drawback of dredging is the high cost.

Dredging requires hydraulic approval from the Washington Department of Fish and Wildlife, and a temporary modification of water quality standards from the Washington Department of Ecology.

Herbicides

Glyphosate is the only herbicide available for waterlily control. Glyphosate is a systemic herbicide that is applied to the leaves of actively growing waterlilies. Glyphosate is formulated as Rodeo® or Pondmaster®. The herbicide is rapidly absorbed by the leaves and translocated throughout the entire plant including the roots (tubers). Wilting and yellowing of plants occurs within 7 days, followed by browning and death. Complete control may require a second treatment in the following year. Submerged plants are typically not affected by a glyphosate treatment.

Duration of control varies with depth and distance to nearest lily bed. Encroachment from adjacent stands of lilies will begin immediately and will be most efficient in nearshore areas. Experience on Steel Lake indicates control from glyphosate should last for a period of three to four years.

The primary advantage of glyphosate treatments are the low cost coupled with relatively long-term control of the plants. It is considered to have a very low toxicity to aquatic animals and comes with no swimming or fishing use restrictions. However, it is a chemical control method and therefore there are implied concerns associated with the use of toxins in natural environments. Other than chemical use concerns, the primary drawback of glyphosate use is the water quality impact from the release of nutrients by decaying vegetation. There is also concern associated with the possibility of affecting emergent vegetation from drift of the applied herbicide. Treatment costs by private contractor average $300 per acre. The estimated 10-year cost is $5,000 based on four treatments of 4 acres. Herbicide treatments require a temporary modification of water quality standards from the Washington Department of Ecology.

Native Submerged Plant Control

The number two goal identified by the steering committee was to control submerged plants to a level that does not hinder recreation. Historical observations indicate that the native pondweeds *Potamogeton amplifolius* and *P. pusillusi* can reach nuisance proportions. It has been estimated that the maximum extent of infestation would be approximately 10 acres. Other native submerged plants such as *Nitella,* and *Najas flexilis* do not grow tall enough or are not dense enough to hinder recreation in Steel Lake. These are important plants to protect since they provide valuable wildlife habitat and their presence eliminates plant habitat that might otherwise by available for invasion by one of the more nuisance plant types. Therefore, alternatives considered for native submerged plant control focused on controlling pondweeds while not adversely affecting the existing populations of other native plants. An additional requirement is that the alternative selected should not promote the growth of milfoil or other non-native submerged plants.

Currently, pondweeds are not present in densities that hinder recreation. During both 1993 and 1994 (before the sonar treatment) submerged plant densities were particularly low. The sonar treatment has caused an even further decline in the population. Therefore, alternatives are considered separately for the small pondweed population that currently exists, and for a large pondweed population that could be present in the future.

Selective Submerged Plant Control Methods

Hand Pulling

Hand pulling is a manual method of removing the entire plant, including roots. It is typically performed by divers uprooting individual plants, placing them in a mesh bag, and disposing or composting the removed material. Handpulling is not limited by depth or access problems, and in theory all problem areas could be controlled in this manner. However, the labor intensive nature of the work would limit control by this method to a maximum of 2 acres a year. Adequate control would be achieved by hand pulling plants once during early summer of each year in designated areas. Continual use of this method should help limit expansion of plant beds and maintain lower overall densities of the problem plants. The plant density and the level of effort should decrease in subsequent years.

Costs for hand pulling by contract divers range from $500 to $2,400 per day. Low to moderate pondweed densities could be controlled at a rate of approximately 0.5 acres per day. The estimated 10-year cost is $80,000 based on $2,000 per day and an average control area of 2 acres. The primary advantage of hand pulling is that non-target (beneficial) plants are not removed and may even colonize area inhabited by nuisance plants, due to the large competitive advantage they would be given. The primary drawback is the high cost per unit area controlled due to the high labor cost.

Hand Cutting

Hand cutting tools available for controlling waterlilies would also work for submerged plants. In addition, weed cutters with reciprocating blades could be used for pondweed control. For example, the Water-Weeder is a battery-powered, hand-held cutter that cuts a 4-foot swath down to 12-feet deep, and can be purchased for approximately $500. Hand cutting of pondweeds is less labor intensive than waterlily control because of lower pondweed biomass.

Handcutting tools should allow adequate control within the problem areas identified in Steel Lake. The control zone would primarily be limited by the amount of labor available. It has been estimated that control of 2 acres of pondweed should be adequate to meet current Steel Lake needs. Additional acreage located near private property could be controlled by individual property owners. Approximately two cuts per year should be adequate to maintain the pondweed to an acceptable level. The estimated 10-year cost is $2,000 which does not include labor provided by property owners.

Weed Rolling

Weed rollers could be used for submerged plant control as described for waterlilies. Unit costs are the same for both types of plants. The estimated first years cost is $100,000, which is based on 40 units to control only 0.5 acres, and does not include installation and electricity. Since this is new technology the average useful life of a weed roller is unknown. Assuming a maintenance cost of $500 per year, and a lifespan of over 10 years on each product, the estimated 10-year cost would be $105,000.

Bottom Barriers

Bottom barriers could be used for submerged plant control as described for waterlilies. Installation costs are the same for both types of plants, but annual maintenance costs would be about 25 percent less for submerged plants. The estimated 10-year cost is $65,000 based on 1 acre of material, which could be relocated to control up to 4 acres of pondweeds.

Extensive Submerged Plant Control Methods

Mechanical Harvesting

Mechanical harvesters could be used for submerged plant control as described for waterlilies. Unit costs would be approximately 50 percent lower for submerged plants because of lower biomass and a smaller control area. The estimated 10-year cost is $75,000 based on two cuts per year and a control area of 10 acres.

Dredging

Dredging of submerged plants could be performed as described for waterlilies, with similar unit costs. Alternatively, submerged plants could be controlled with diver-operated suction dredging of shallow sediments and roots (e.g., dredge depth of only 6 inches versus 2 feet for waterlily control). Suction dredging typically filters plant material and returns removed sediment and water to the lake. Material returned to the lake would temporarily decrease water clarity, but should not have long-term effects on water clarity. Costs of suction dredging are lower than cutter-head dredging because disposal costs are reduced. The primary advantages of diver-dredging is that is can be site and species specific, there are no obstacle or depth constraints and there are no associated disposal costs since all material is returned directly to the lake. Disadvantages are that it is slow and labor intensive and therefore expensive. Also, the process can result in production of plant fragments that can re-root and cause problems in other places.

Unit costs of suction dredging range from $1,100 to more than $2,000 per day. Assuming a daily rate of 0.5 acres at $2,000 per day, the 10-year cost of controlling 10 acres is $40,000. However, costs would double if regrowth requires additional control in the 10-year period.

Herbicides

Of the herbicides currently approved for use in Washington State, fluridone is the preferred herbicide for submerged plant control. Fluridone is a slow-acting, systemic herbicide that is applied to the water surface either as a liquid or slow-release pellets. Fluridone is formulated as Sonar® for aquatic application.

The herbicide is effectively adsorbed and translocated by both roots and shoots. Its use is most applicable to lake-wide treatments. Therefore, the control zone typically includes the entire open water area of the lake. Because it kills the plant and roots it has a relatively long control duration; four to five years. Fluridone is also effective at eliminating the non-native Eurasian watermilfoil, but it does not affect the macroalgae *Nitella,* one of the beneficial plants that presently occurs in Steel Lake. Effects of fluridone treatment become noticeable within 7 to 10 days of application, with complete control often requiring 60 to 90 days.

Advantages and drawbacks of fluridone are the same as those described for glyphosate. An additional drawback of fluridone is that it requires a whole-lake treatment to be effective and therefore can not be used to target specific zones and impacts beneficial submerged plants as well as nuisance plants. Treatment costs by private contractor range from $700 to $1,000 per acre. The 10-year cost is $50,000 based on two treatments (with two applications during each treatment) of the entire lake at $25,000 per treatment. (It should be noted that the cost per acre used here is taken from an Ecology reference manual for developing aquatic plant management plans. The actual cost of the most recent fluridone (as sonar) treatment of Steel Lake was $15,000 for two applications (one treatment). The higher cost estimate was used to provide the most conservative estimate of the expected cost for implementation of this alternative.)

Grass Carp

Grass carp are plant-consuming fish native to China and Siberia. Sterile (triploid) grass carp are raised in the southeast US for lake-wide, low-intensity control of submerged aquatic plants. Known for their high growth rates and wide range of food preference, these fish can control certain nuisance aquatic plants under the right circumstances. Stocking rates depend on climate, water temperature, type and extent of plant species, and other site-specific conditions. In 1990, Washington state adopted grass carp regulations that require the following conditions:

- Only sterile (triploid) fish can be planted
- Inlets and outlets must be screened to prevent fish from getting into other water bodies
- To insure sufficient vegetation is retained for fish and wildlife habitat, stocking rates are defined by WDFW based on the current planting model
- Lakes with public access require a lake restoration study.

Effectiveness of grass carp in controlling aquatic plants depends on feeding preferences and metabolism. Recent laboratory and field studies in Washington state indicate that thin-leaved pondweeds and *Elodea canadensis* are highly preferred, broad leaf pondweed and milfoil are less preferred, and that waterlilies are generally not eaten. The primary advantage of grass carp is the low cost (if a lake restoration study has been performed). Primary drawbacks are that effects are unpredictable and that all beneficial plants may be removed, resulting in serious impacts to fish and wildlife.

Costs range from $50 to $2,000 per acre, at stocking rates ranging from 5 to 200 fish per acre and average cost of $10 per fish. The relatively low abundance of pondweeds historically present in Steel Lake suggests that a low stocking rate would be effective at controlling the pondweed population. The 10-year cost estimate is $5,000 based on a stocking rate of 50 fish per acre (500 fish to control 10 acres). However, additional costs would likely include more than $200,000 for an environmental checklist, lake restoration study, and outlet screening required by the fish planting permit. In addition to a game fish planting permit, hydraulic project approval is required by WDFW.

Eurasian Watermilfoil and other non-native submerged plants

The third goal identified by the steering committee was to eradicate non-native submerged plants. Eurasian watermilfoil (milfoil) is the only non-native submerged plant that has been present in Steel Lake. Eradication is desired because of its affect on lake recreation and navigation and because of the high potential for milfoil to be transported to other lakes. hindering recreation. The 1994 Sonar® treatment effectively eliminated milfoil from the lake, but this plant could return to the lake either from regrowth of plants that survived the treatment or from the introduction of milfoil fragments. Steel Lake is susceptible to re-invasion by milfoil and invasion by other non-native submerged plants such as parrotfeather (*Myriophyllum aquaticum*), brazilian elodea (*Egeria densa*), hydrilla (*Hydrilla verticillata*), fanwort (*Cabomba caroliniana*), and water hyacinth (*Eichhorinia crassipes*). The focus of control efforts for non-native plants is a prevention and detection program. A contingency plan is also presented in case control of a large area is required.

Milfoil Prevention and Detection Program

The objective of source control is to prevent parts of non-native submerged plants from entering the lake. A source control program could contain an education and/or an action component. Examples of public education include signage at the public boat ramp and information brochures for shoreline residents. Action components could consist of boat and trailer inspections, or construction of a washdown and fragment removal area at the public boat ramp. Costs of a source control program have not been estimated.

Hand-pulling by divers can be used to control isolated milfoil plants that survive the fluridone treatment or to remove any non-native submerged plant that are reintroduced by fragment transport. This procedure would require a diver survey of the entire plant habitat each year. Isolated plants, including all roots, are removed by the divers during the surveys. To ensure complete control, small sections of bottom barrier may need to be applied if relatively mature plants or *Hydrilla* tubers are encountered.

The primary advantage of controlling small infestations is that it reduces the chance that a large area would need to be controlled by a more intensive technique. A drawback of controlling small infestations are the high costs associated with diver surveys and hand pulling. Costs for hand pulling by contract divers range from $500 to $2,400 per day. A survey of the entire plant habitat, including removal of isolated non-native submerged plants, would take approximately 3 days. The estimated 10-year cost is $60,000 based on 3 days per year at a rate of $2,000 per day.

Contingency Plan for Extensive Control

A large area may require control in the future if small infestations of milfoil are not controlled. Two alternatives were considered for controlling a large area (10 acres) of milfoil: suction dredging and herbicides. Descriptions and costs of these alternatives have been discussed for native submerged plant control.

Water Lily Control

As described previously, the main area of concern for control of lilies in Steel Lake is the large patch in the west end of the lake. It is recommended that this patch (excluding the area has been designated as conservancy) and a patch along 308th (Figure 5) be treated with the herbicide glyphosate. The conservancy zone will consist of 2-3 acres near the outlet of the lake. To improve the habitat quality of this conservancy zone, it is recommended that glyphosate be applied here as well. However, the application should consist of a few 40' wide paths through the area. The purpose of these paths is to create an "edge affect" that will serve as better fish habitat. These pathways may have the added advantage of improving oxygen conditions within the lily bed and will also allow recreational access for wildlife enthusiasts.

Glyphosate was selected for the herbicide treatment because of effectiveness, duration, low cost, and low environmental impact. Glyphosate is a systemic herbicide that is absorbed by foliage and passed throughout the plant. Since it kills the tubers, it results in long-term control of the plant community. This herbicide has low toxicity to bottom-dwelling organisms, fish, birds and other mammals and dissipates quickly, therefore it is considered to have a low environmental impact. It is assumed that two applications of the herbicide will be required in any treatment year to insure application success. The herbicide would be re-applied every four years to maintain the control area. To treat 4 acres of waterlilies twice per treatment year is estimated to cost $2,400 per treatment year. An additional $1,300 will be required for obtaining a permit for the application. Over a 10 year period, glyphosate treatment has been estimated to cost $11,100.

There are also small patches of lilies that occur in places along the perimeter of the remainder of the shoreline. Equipment for handcutting would be made available to property owners who want to control lilies near their docks. Consequently, each resident would have access to equipment for control of lily beds they found to be a nuisance, but would be required to supply the labor for their removal. It is expected that most of these small patches would remain and provide a diversity of plant habitat throughout the lake. Cost for the handcutting equipment (a Lake Weed Shaver and seine net) has been estimated at $1000, with replacement every 5 years for a 10 year cost of $2000.

Another concern associated with the lily beds is the tendency for large "islands" to separate from the main beds and move out into the lake. These floating islands are a safety hazard; they can be unseen obstacles to boaters and attract children who can sometimes stand on the islands, but who could easily be hurt or drown if they broke through the mat of vegetation. Lake residents have tried various methods of removing these islands, but they are too large and awkward to handle. A technique that was successful at Lake Kathleen (King County) used a water pump and hose to wash sediment off the vegetation. Sections of washed vegetation were then removed by hand and placed on the boat for later disposal or composting. This technique is recommended for removing lily islands from Steel Lake. Allowing an average of one day per year at $1,500 per day (including labor and equipment), the estimated 10-year cost of island removal is $15,000.

Submerged Plant Control

At this time, the submerged plant population in Steel Lake is quite low and not causing a significant hindrance to recreational activity. Therefore, the intent of the control plan is to identify activities that can be used to maintain the community to a level where it does not cause recreational impact. It is believed that this moderate level of control will allow for continued submerged plant communities and diverse fish and wildlife habitat, while providing a mechanism for monitoring and control of the plants.

The first step in the submerged plant control program is annual diver surveys of the lake. The main purpose of these surveys is to search for Eurasian watermilfoil and any other exotic plants and handpull and remove them. However, it will also provide a means for monitoring the native submerged plant community and determining where future control efforts should be focused. The plan allows for two divers to work for two days during the annual survey. Depending upon plant densities and whether exotics are detected, this may allow extra diver time for handpulling native plants in beds that have been identified as potential problems. However, the primary purpose of the survey is to identify and remove exotics and provide a yearly update of plant populations for which to design the following years control strategy. The annual cost of the diver surveys has been estimated at $6000. (This includes costs associated with handpulling of newly found infestations of milfoil, as described below.)

A handcutting tool (such as the Water-weeder with reciprocating blades) will also be purchased as part of the submerged plant control plan. This tool will be the main element of defense against the native pondweeds. It would be available to all property owners who wish to control populations near their docks. Larger beds that are located outside what is considered private area that are identified as a nuisance, will also be controlled with this tool. However, the labor would still be provided by lake volunteers. The cost of these tools has been estimated at $500, with a 10 year cost of $1000.

The Eurasian watermilfoil control plan complements the plan for control of native submerged plants. The annual diver survey would be relied upon to detect new infestations of milfoil and immediate removal of the plants. If Eurasian watermilfoil or another exotic is found, a second dive would be planned for later in the same year to insure there were no surviving colonies. If the area infested is too large to control by handpulling, or if after two follow-up dives the exotic is still found, bottom barriers would be placed in all areas where the plant was detected. Treatment with herbicide is recommended as a final resort if these efforts do not result in eradication of the milfoil. If the herbicide triclopyr has been approved for use, it is recommended that this be used to "spot treat" identified areas. Otherwise, a whole-lake treatment with fluridone is recommended. Costs for bottom barriers have been estimated at $32,500 for up to one acre of coverage. Additional diver surveys would cost an estimated $2,000 per year. (This cost includes 2 one-day dives, and assumes a full day would be spent each time. It is possible that the follow-up dives would be less expensive than this since only a small portion of the lake would need to be surveyed and there would be little, if any, handpulling required.) The herbicide treatment would cost an additional $25,000. These additional diver surveys, bottom barrier installation, and herbicide treatments are contingency elements to the overall aquatic plant control plan for the lake. Since these cost would only accrue in the event of another infestation by milfoil or another exotic plant, the costs could be covered through an "early infestation grant" by the Department of Ecology. Therefore these costs have not been included in the total estimated costs for this project.

This plan does not exclude the use of additional bottom barrier by lake residents who may want to increase control in the area near their property. However, these activities would not be funded by this plan.

Plant Control Advisory Committee

Proper implementation of the described plan relies upon formation of a lake plant control advisory committee. This committee would have the following responsibilities:

- Review annual plant survey information and track potential problem areas
- Prioritize "public use areas" for handcutting of submerged plants (area near private property will be maintained by the owner)
- Review glyphosate application needs
- Review exotic plant problems and determine need for bottom barrier and as a last resort to recommend herbicide treatment if the situation can not be controlled.
- Recruit a cadre of volunteers to perform handcutting in public use areas
- Develop criteria and guidance for prioritizing control areas and strategies, to alleviate future property owner complaints about equability of approach.
- Produce an annual evaluation report that summarizes plant control activities, lake users perspectives on the plant community, and recommendations for the next years control strategy.

Criteria and guidance for prioritizing control areas should be based on defining a maximum level of control and enhancing the amount of habitat "edge". To achieve a healthy mixed stand of native vegetation throughout the lake and protect habitat diversity, it is recommended that the criteria establish a maximum control level of 25% for all plant community types in all parts of the lake. For example, if the lake is divided into quadrants, each quadrant would be reviewed separately to insure that at least 25% of the floating-leafed plant community and 25% of the submerged plant community, and 25% of the emergent plant community remains in each quadrant. In addition to insuring adequate plant coverage, control strategies should prioritize the maintenance and enhancement of habitat edge; edges between different plant types and plant stands and open water.

Further guidance will be needed on how to prioritize control areas. Priority should be based on either plant community densities, size of the area, or location. The committee will also need to define the area that is considered to be the responsibility of the property owner. For example, this area could be defined as all area within 50 feet of the shoreline and/or 20 feet from a dock.

It is also recommended that at least five fish habitat structures are placed on the lake to replace habitat lost through plant removal. These structures can include fish cribs, felled trees placed along the shoreline, old tire piles, or other structures recommended by the WDFW. This will require an Hydraulic Permit Approval by the WDFW.

PUBLIC EDUCATION PROGRAM

The public education program for Steel Lake consists of three parts; the milfoil prevention plan, educational activities to alert homeowners to lawn, garden, and home keeping best management practices for protecting the lakes' water quality, and annual workshops on the use of the handcutting tools, plant survey results, and other lake issues.

The current milfoil prevention program at Steel Lake is limited to one educational sign located near the boat launch. To improve the effectiveness of the milfoil prevention program it is suggested that physical constraints be placed in the portion of the public access parking lot that leads to the boat launch that funnel all cars and trailers to a stop sign with signage asking drivers to stop and closely examine their car, boat, and trailer looking for plant fragments. A trash can should be provided for easy disposal of the fragments. This would help provide both the opportunity and a reminder for the boat owner to do a close inspection. Public awareness could be further increased by asking volunteers such as lake residents or a local scout troop to officiate during opening day of the boating season and provide free inspections and distribute informative handouts.

All watershed residents should also be sent copies of a milfoil prevention brochure. A cadre of lake homeowners should be trained to identify milfoil and other invasive plants and perform periodic volunteer surveys of the lakeshore.

To protect the lake from future water quality degradation, lakeside residents should also be provided with a series of informational brochures describing how lawn garden and housekeeping practices can impact lake water quality. Brochures could cover proper landscaping techniques to deter waterfowl and prevent pollution, maintaining a pollutant free zone within 50 feet of the shoreline, providing shoreline fish habitat and other timely subject matter.

Public education and involvement will also center around the annual plant survey. In the spring of each year the plant control advisory committee should plan a short workshop to describe plant survey results from the past fall and their plant control strategy for that year. During the workshop, volunteers should be trained on use of the handcutting tools, and a schedule agreed upon for maintenance of public areas. At this time everyone should be trained or re-trained on plant identification and survey techniques.

Since much lake related public education information is already contained in available brochures, there is little cost associated with developing the information. A $2000 cost has been included for development and reproduction of brochures, with an additional $250 for mailing and postage. Plant workshops are scheduled for every other year at a cost of $500 per workshop. The cost to modify the design of the boat launch facility has been estimated at $5000; this would cover the use of pre-fabricated concrete barriers, installation of large "speed bumps", and additional signage.

EVALUATION PLAN

The results of the aquatic plant control program must be evaluated against the goals set for the lake. In short, the program will have been a success if; 1) the glyphosate treatment controls lilies in the designated areas to an extent found to be acceptable by the majority of the lake users, 2) use of handcutting tools controls native submerged plants to a level where they do not significantly hinder recreation, and 3) milfoil is eradicated. It should be noted that this is a working plan, it is not necessary that all the goals be achieved by some given date, but instead that the lake plant community is continually being evaluated against these goals and each years control plan is developed accordingly.

The annual aquatic plant survey will provide the primary support for the evaluation plan. The results will provide evidence to evaluate extent of the lily beds, whether beneficial submerged plants such as nitella and najas are continuing to inhabit much of the submerged plant habitat and changes in density or colonization by other native submerged plants, and of course whether milfoil continues to be eradicated. Each years plant survey results will be evaluated against the stated plant management goals to set the following years plant control agenda. This evaluation can be provided by the plant advisory committee with limited support from City staff.

PLAN ELEMENTS, COSTS, AND FUNDING

Table 6 provides a summary of each element identified in this plan and the associated costs. Total cost for the plan for the first ten year period is estimated at $104,350, for an average of about $10,500 per year. The majority of the cost occurs during the first year when herbicide treatments, boat launch restructuring, and equipment purchases all occur.

To implement this plan and provide a long-term funding source for continued plant control activities, public education, and evaluation, a stable long-term funding source is needed. The City general fund, Surface Water Utility funds, and private funding sources (e.g. through formation of a special taxing district) are the most likely funding sources. The Department of Ecology Aquatic Plant Program can be applied to for additional funds to implement this plan once it has been approved by the department. However, that too will require a 25 % contribution from the applicant. The maximum amount available through this program for implementation activities is $75,000, which would require $18,750 contribution to the grant. This program is not appropriate for use as a long-term funding source because there would be no guarantee from year-to-year that funding would be received.

Formation of a special taxing district called a "Lake Management District" or LMD has become the most common way of obtaining funding for lake projects. LMD's are similar to Local Improvement District's (LID) and are formed when a capital project is planned that primarily or wholly benefits only a subset of the citizenry. Each property owner is assessed a "tax" based on some equitable plan for valuation. Perhaps the most simple valuation plan for a lake is based on the number of feet of shoreline owned or property size. Rate structures can also be fairly complex taking into account some combination of lakefront footage, property acreage, the extent of improvements, proximity to the lake, and the extent to which the improvement will benefit the property. The development of the rate structure can be critical to approval of an LMD, since balloting in King County is weighted to provide one vote for each dollar of assessed value. Formation of an LMD was the preferred funding alternative selected by the Steel Lake Advisory Committee. The LMD would fund the purchase of handcutting tools, periodic glyphosate treatments, annual diver surveys, design changes to the boat launch facility, and public education activities. Purchase of bottom barrier, additional diver surveys, and future herbicide treatments required to control re-invasion of milfoil or invasion by another non-native plant, would be funded through an early-infestation grant from the Department of Ecology Aquatic Plants Program.

To generate the funds for implementation of this plan, the LMD would need to generate approximately $10,500 per year, or an estimated $100 per parcel of lake property. (If grant funding was not available to implement contingency plans in the case of re-invasion by milfoil, it would increase this estimated cost, accordingly.) This estimate is based on the simplest of tax structures. More complex tax structures involving residences located outside the immediate lake shoreline, or a structure based on the number of feet of shoreline owned, or other property considerations would affect the final cost for each lake user.

Table 6. Estimated cost for implementation of the Steel Lake Aquatic Plant Control plan.

Plan Element	Year 1	Year 2	Year 3	Year 4	Year 5	Total 10 year	Total 20 year
Waterlily Control							
Herbicide	2400				2400	7200	14400
w/ Permit Fee	1300				1300	3900	7800
Handcutting	1000				1000	2000	4000
Root wad removal	1500	1500	1500	1500	1500	15000	30000
Pondweed Control							
Annual survey/Map	6000	6000	6000	6000	6000	60000	120000
Handcutting	500				500	1000	2000
Milfoil Eradication							
Follow up Surveys(1)	*2000*	*2000*	*2000*	*2000*	*2000*	*20000*	*40000*
Bottom barriers(1)					*32500*	*65000*	*130000*
Herbicide (1)					*25000*	*50000*	*100000*
w/Permit Fee					*2560*	*5120*	*10240*
Public Involvement							
Plant Workshop	500		500		500	3000	6000
Mailings/Postage	250	250	250	250	250	1250	2500
Boat launch design	5000					5000	5000
Brochures	2000				2000	6000	12000
Evaluation Program							
Plant mapping(2)	NA	NA	NA	NA	NA	NA	NA
Evaluation Report(3)	NA	NA	NA	NA	NA	NA	NA
Total Cost	20450	7750	8250	7750	15450	104350	203700

(1) These elements form the contingency plan for plant control. These costs have not been included in the total cost summary. It is unknown at what frequency they would be required, if required at all.

(2) These costs are included in previous cost categories.

(3) This report can be produced through efforts of lake volunteers with minimum support from City staff.

SUMMARY AND CONCLUSIONS

The 1994 fluridone treatment in Steel lake has been at least temporarily successful at eradicating milfoil and has also caused a large decrease in other submerged plants. This leaves control of the water lilies as the most immediate aquatic plant problem. This report details a plan for limiting the extent of the water lily community and improving navigability of the western most portion of the lake through the use of the herbicide, glyphosate. Control of the submerged plant community, to insure it does not again reach nuisance proportions, relies on the use of handcutting tools to keep the population in check and yearly monitoring to evaluate conditions. Bottom barriers are recommended for use in the event that plant populations in some areas become too extensive for hand control methods. Re-invasion by milfoil or other non-native plants will be closely monitored through annual diver surveys and a contingency plan is included in case invasions do occur. Public education and awareness programs will be focused on milfoil prevention, and providing general pollution prevention and best management practices information to lake residents. Furthermore, lake residents will be involved in development of the yearly plant control strategy and will be responsible for soliciting volunteers for surveys and submerged plant maintenance. This will insure long-term involvement of lake residents in lake management decisions and activities.

Implementation of this plan is estimated to cost $104,350 over ten years, or an average of $10,500 per year. It has been recommended that this cost be covered through development of a lake management district.

REFERENCES

Bortleson, G.C., N.P. Dion, J.B. McConnell, and L.M. Nelson. Reconnaissance data on lakes in Washington, Volume 2 King and Snohomish Counties. USGS Water Supply Bulletin 43-2.

Ecology. 1994. A citizen's manual for developing integrated aquatic vegetation management plans, first edition. Washington Department of Ecology, Water Quality Financial Assistance Program, Olympia, WA.

Federal Way Water and Sewer and RPA. 1992. Septic tank systems in the Federal Way Community. Federal Way Water and Sewer District, Federal Way, WA and Resource Planning Associates, Seattle, WA.

McComas, S. 1993. Lake smarts: the first lake maintenance handbook. Produced by Terrene Institute, Washington, DC in cooperation with U.S. Environmental Protection Agency, Office of Water, Office of Wetlands, Oceans and Watersheds Assessment and Watershed Protection Division, Washington, DC.

Metro 1994. Water quality of small lakes and streams: Western King County 1990-1993. Water Pollution Division, Municipality of Metropolitan Seattle.

Metro. 1976. A baseline survey of aquatic plants in selected lakes of King County. Municipality of Metropolitan Seattle, Seattle WA.

Metro. 1978. Distribution and community composition of aquatic macrophytes in selected waters of King County. Municipality of Metropolitan Seattle, Seattle WA.

Metro. 1979. Aquatic plants in selected waters of King County, distribution and community composition of macrophytes. Municipality of Metropolitan Seattle, Seattle WA.

Metro. May 24, 1995. Database retrieval: Selected water quality data and seasonal averages for Steel Lake. Provided to Rob Zisette, Herrera Environmental Consultants by Robert Brenner, King County Department of Metropolitan Services

National Wetlands Inventory (NWI) 1987. United States Department of Fish and Wildlife Service

National Wetlands Inventory, 1987. Poverty Bay 7.5 minute quadrangle.

Parsons, Jennifer. May 26, 1995. Personal communication (FAX transmittal to Rob Zisette, Herrera Environmental Consultants). Washington Department of Ecology, Environmental Investigations and Laboratory Services Program, Ambient Monitoring Section, Olympia, WA.

Renstrom, David. August 4, 1995. Written communication (Facsimile transmittal to Joy P. Michaud, Envirovision, detailing land use characteristics in the Steel Lake watershed) City of Federal Way, Department of Public Works, Surface Water Management Division, Federal Way, WA.

Renstrom, David. August 8, 1994. Personal communication (telephone conversation with Rob Zisette, Herrera Environmental Consultants). City of Federal Way, Department of Public Works, Surface Water Management Division, Federal Way, WA.

RMI. 1994. Steel Lake 1994 year-end report. Prepared for City of Federal Way and Steel Lake Homeowners by Resource Management, Inc., Tumwater, WA.

RMI. 1995. Steel Lake Eurasian Milfoil Control Program. 1995 Final Report.

Thompson, Trisha. June 1, 1995. Personal communication (telephone conversation with Rob Zisette, Herrera Environmental Consultants). Washington Department of Fish and Wildlife, Mill Creek, WA.

Vollenweider, R.A. 1970. Scientific fundamentals of the eutrophication of lakes and flowing waters, with particular reference to nitrogen and phosphorus as factors in eutrophication. Organization for Economic Co-operation and Development.