Silver Lake, Spokane County, WA
Integrated Aquatic Vegetation Management Plan

Prepared for the
Washington Department of Fish and Wildlife
and the
Silver Lake Homeowners

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INTRODUCTION

This Integrated Aquatic Vegetation Management Plan (IAVMP) has been prepared as an effort to develop a holistic, integrated approach to controlling and managing the growth of milfoil (*Myriophyllum* species) in Silver Lake and North Silver Lake, Spokane County, Washington. This IAVMP is, thus, an organized effort to protect the beneficial uses of this lake system, including water quality and fish and wildlife habitat. The process followed in the preparation of this Plan is outlined in the Washington Department of Ecology (WDOE) Aquatic Weeds Management Fund Program Guidelines (WDOE 2001a), the publication titled "A Citizen's Manual for Developing Integrated Aquatic Vegetation Management Plans" (WDOE 1994) and other WDOE vegetation management plan guidance (WDOE 2001b).

A vicinity map of Silver and North Silver Lake is shown in Figure 1. Silver Lake proper is 490 acres in size, has a mean depth of 30 feet and generally good water quality (Dion et al, 1976). There is one public boat launch on the lake, which is open year-round, plus two resorts and a Bible Camp so non-resident use of lake is considered moderate. As a result, Silver Lake supports a variety of beneficial uses including fishing, wildlife observation, swimming, water skiing, boating and waterfowl hunting. North Silver Lake is approximately 88 acres in size, a mean depth of approximately four feet and fair water quality (Lamb, 2008). The only public access to North Silver is a walk-in fishing access but the lake supports a catch and release trout fishery as well as seasonal waterfowl hunting.

These lakes are highly regarded as amenities by the local community, with property values near the lakes being influenced by this condition. However, the growth of a native milfoil species, *Myriophyllum sibericum* (Northern milfoil) has become problematic, due to large amounts of plant fragments that are released particularly from the shallow southern end of Silver Lake proper and wash up on shoreline areas throughout much of the lake. Northern milfoil is present in North silver Lake but is not reported to be a nuisance there. In addition, in 2001, the State-listed noxious weed *Myriophyllum spicatum* (Eurasian watermilfoil) was discovered in the northern end of Silver Lake. The aquatic plant survey performed for this IAVMP project found this invasive milfoil to be occupying approximately 50 acres in the northern part of Silver Lake at varying densities. Eurasian watermilfoil was also found in the southern end of North Silver Lake at low densities.

The current hindrance to lake recreation caused by the Northern milfoil, and the potential impacts of continued Eurasian watermilfoil growth on lake quality and uses, provided the impetus for the preparation of a grant application to the WDOE Aquatic Weeds Management Fund to support the development of an IAVMP. Mr. Chris Donley of the Washington Department of Fish and Wildlife (WDFW) was approached by Silver Lake residents Todd Hays and Jim Patterson to be the agency sponsor for an aquatic plant management planning grant from WDOE. Mr. Donley indicated that his agency was interested in helping the lake residents because it was becoming apparent that water quality and fish and wildlife habitat were declining in Silver Lake. WDFW felt that formation of a local Lake Management District, and obtaining the planning grant, would be the best way to bring about improvements in the two lakes. The grant application was prepared by Silver Lake resident Jim Patterson, submitted by WDFW, was approved for funding and a grant agreement between WDOE and WDFW was signed effective on October 29, 2007.

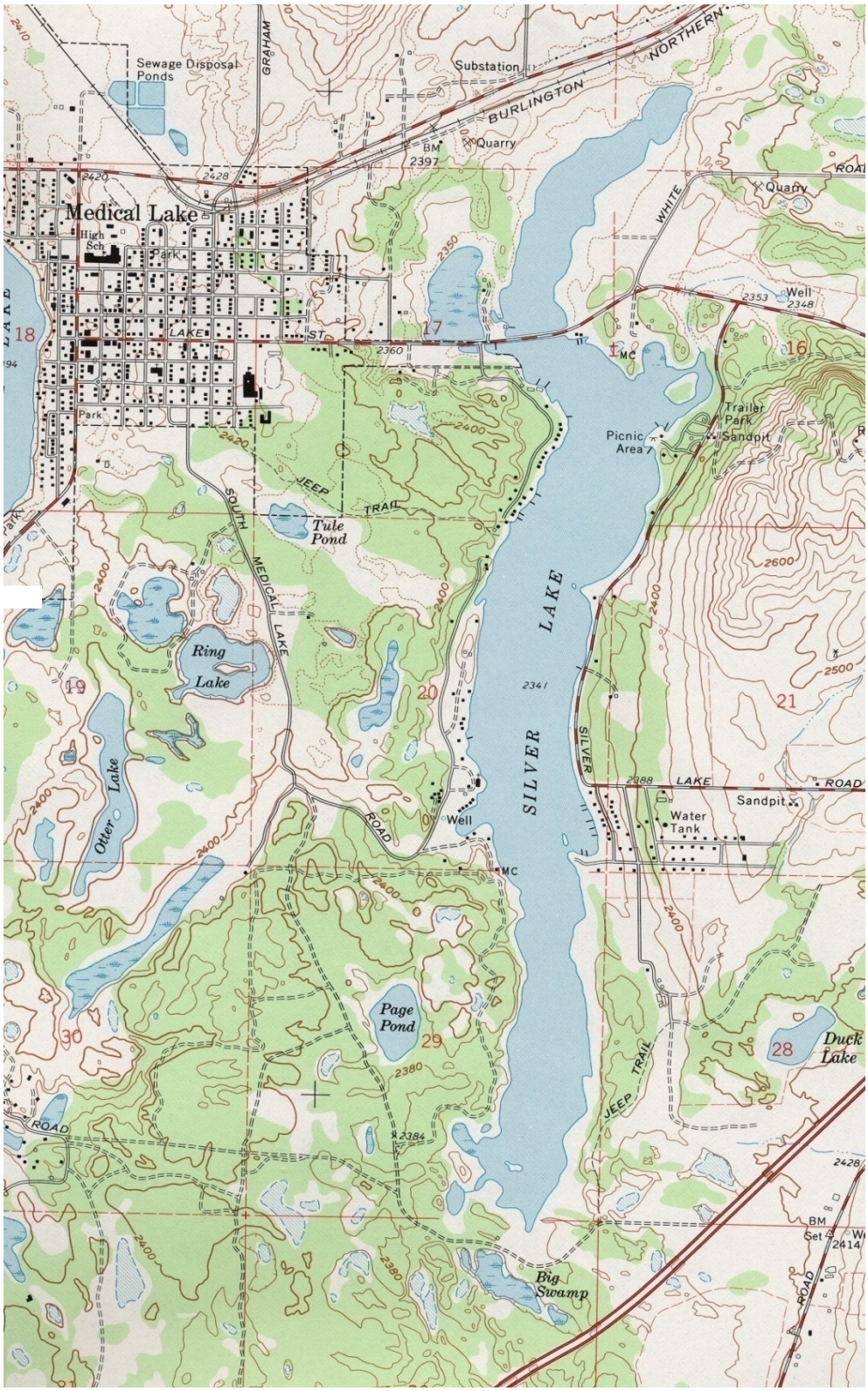

Figure 1. Map of the Silver Lake and North Silver Lake vicinity showing geo-physical features (from US Geological Survey Medical Lake Quadrangle, 7.5 Minute series map, 1973).

This IAVMP report was prepared by David Lamb, Lake Management Specialist (referred to as the Consultant herein) under contract with WDFW. In addition, many volunteer hours have been contributed by IAVMP and Lake Management District (LMD) Committee members (Todd Hayes and Jim Patterson, Chairs, respectively) and other lake residents. Mr. Chris Donley, District Fish biologist and Project Manager for WDFW is also credited with contributing many hours to this process and is acknowledged for his exemplary interest in helping the lake residents. Finally, Kathey Wyckoff, a relatively new resident of North Silver Lake, has been of considerable help thanks to her concern for milfoil issues and experience with milfoil management and Lake Management District formation at Long Lake, Thurston County, WA.

LAKE MANAGEMENT HISTORY

Information for this section of this Plan was obtained through an interview with Mr. Bill Butler, who is the former owner of the former North Silver Resort and has been on and around these lakes continually since 1964.

Silver Lake and North Silver Lake have not received any large scale management efforts, with the possible exception of the WDFW rotenone treatments for fisheries management (discussed in the Fish, Wildlife and Bird Usage section, below). That being said, there was an activity which had large scale impacts on the lake. In 1907 a company from New York obtained all of the water rights for these two lakes (which were not divided by the Medical Lake-Four Lakes Road at the time). The company then began to pump water out of the lake through a series of pipes and ditches to the site of present Airway Heights (approximately five miles north), to irrigate orchards. This pumping continued seasonally until 1921, by which time the lake had been drawn down 60 feet. At this point, Mr. Butler reports, it became apparent that the lake could no longer be a source of irrigation and pumping stopped. It took until 1956 for the lake to refill and actually have a discharge out the south end of the lake.

While the water level was down, Spokane County began to sell the exposed lands to adjacent landowners, and terrestrial vegetation began to encroach on the former lake bed. The Medical Lake-Four Lakes Road was constructed at its present location and the area that would become North Silver Lake was itself planted to orchard trees. A granite quarry was also opened and rock was removed to depths of about 60 feet. The two rock piles still remaining at the North Silver Resort site are a testament to this effort (see Figure 2). Upland and riparian trees also began to grow along the eastern shoreline of Silver Lake and stumps of these trees are well visible today. Slowly the water levels rose after 1921 and concurrently the level of Medical Lake-Four Lakes Road had to be raised to keep it usable.

As the lake returned to its historical level around 1956, the two lakes began to take on more of the recreational appearance that they have today. The U.S. Geological Survey set up a staff gauge and local residents monitored the surface elevation on daily to weekly bases until 1976. During that time the surface elevation was seen to rise and fall within a two to three foot range.

Mr. Gene Hackney opened the North Silver Resort and tapped into what soon became a very productive trout fishery. Mr. Butler bought the North Silver Resort in 1964 and operated it until he sold the land in 1988 to Mr. Terry McNabb. While Butler owned this resort he realized the need to control some of the aquatic plant growth in this shallow, productive system and he obtained a State herbicide applicators license. Mr. Butler then started a treatment business and performed small-scale applications for shoreline property owners in Silver (southern end, both east and western shores) and other area lakes.

Figure 2. Photograph of the Medical Lake-Four Lakes Road crossing between North Silver and Silver Lakes, as seen from the rock pile at the former North Silver Resort location. Riddle Hill, the high point in the watershed, is in the background.

Butler reported using several approved products including Reward® (active ingredient diquat), Aquathol® (active ingredient endothall) and Cutrien® (active ingredient chleated copper). Since Mr. McNabb also operated a lake / aquatic vegetation management company, his staff also performed small-scale treatments of native milfoil in Silver Lake.

The management of the fishery in Silver and North Silver Lakes is an important and long-term aspect of the lake management history of both Silver and North Silver Lakes. Information on the current status of the fishery is presented in the Bird, Fish and Wildlife Usage section, below.

PROBLEM STATEMENT

Lake User Groups

The primary lake "user group" active in the determination of the problem statement and management goals for this IAVMP was the lake residents, represented by the IAVMP Committee, and the Washington Department of Fish and Wildlife (WDFW). A second group, the Lake Management District

Committee, was formed to foster communication among the lake residents and to focus on developing a funding mechanism for milfoil control efforts.

Citizen and Agency Input

Public Education and Awareness

In order to provide opportunities for residents, management agencies and the general public to learn about and provide specific input into the development of this IAVMP and proposed aquatic plant controls, notices were distributed, newspaper articles were published and two public meetings were held. The public meetings took place on June 26 and October 14, 2008.

A notice about the June meeting was mailed along with a questionnaire to the lake residents prior to the first public meeting (see copies in Appendix A). An article about the IAVMP planning process was prepared by the Consultant and published in the local newspaper, the Cheney Free Press, in the June 26th issue (see copy in Appendix A). During the first public meeting a summary of available lake water quality information and an overview of the IAVMP process were presented by the Consultant and participant questions were answered. Attendance at this meeting was 54. The meeting notices, agenda, Project Summary handout and sign-in sheet are presented in Appendix A. A summary of the questionnaire responses is presented below.

The second public meeting was conducted after an aquatic vegetation survey was performed, initial problem statement and management goals were drafted and a recommended milfoil strategy was developed and reviewed by the IAVMP and LMD Committees. Notices about this meeting were distributed by e-mail and a notice in the Cheney Free Press was published on October 9. For this second meeting, the Consultant presented a summary of the earlier questionnaire responses, a summary of the aquatic vegetation survey findings, a discussion of the IAVMP Goals (i.e. for Eurasian watermilfoil and Northern milfoil), an overview of available aquatic plant control techniques and a description of the recommended control strategy. Also at this meeting, an update on the LMD formation was given (along with a showing of the PowerPoint presentation made to the Spokane County Commissioners on September 19, 2008) and time was given to attendees who wished to comment on the project. Attendance at this meeting was about 50. The meeting notices, agenda, Project Summary handout and sign-in sheet are presented in Appendix A. Just following this second meeting a fairly in-depth article was published in the Cheney Free Press about the aquatic plants problems and the IAVMP project (see Appendix A).

The key result of the public meetings was the bringing together of people from around both lakes and the exchange of thoughts on the management of aquatic vegetation in the lakes. In fact, it became apparent at the second meeting that there were differences in opinion as to the need for control of Northern milfoil, to the use of herbicides and for the need for an LMD (i.e. taxing organization). There were those from the north end of the lake, where Eurasian watermilfoil is present and spreading, who use the lake for drinking water and who strongly objected to the use of herbicides. These same north-enders seemed to object to the LMD as well. There were also people from the south end of the lake, where Northern milfoil is dominant and where floating plant materials are a considerable problem who were strong proponents of herbicides and the LMD. It was concluded at the end of the second meeting that more work needed to be done to educate the residents north and south about possible LMD options and on the relative costs, benefits and environmental impacts of the various milfoil control options.

Resident Questionnaires

Summary of Questionnaire responses

In addition to the initial public meeting notice, a questionnaire was mailed out to landowners around the lakes and provided to State regulatory agencies (WDOE, WDFW and WDNR) in June, 2008. Some of the questions on this had standard answers that could be circled and other questions gave space for people to write in their own thoughts. The 43 completed questionnaires were reviewed and the following summary prepared:

- Personal involvement in Silver Lake: 43 were 'Property Owners' and one was a 'Manager/agency Representative' (who is also a property owner).
- Water Quality rating: 22 chose 'Fair', 12 chose 'Poor' and eight chose 'good'.
- Most Important factor about Water Quality: 10 wrote in "good fishing" and/or "good fish habitat", eight indicated "lack of weeds", eight indicated "clean", six said "good swimming", five said "healthy", three indicated "safety", two "good boating", two "good clarity", one "no garbage" and one "overall lake use". (These results are paraphrased to simplify this summarization.)
- Effect of aquatic plants on usability of lake: 29 circled 'Significant Effect', eight circled 'Moderate Effect' and five circled 'Little Effect'.
- Most important factor about aquatic plants: (again, paraphrasing) 13 said "that they are controlled" or "not allowed to take over" or "provide a balanced ecosystem", nine said "that they are bad for fishing" or "bad for boating" or "bad for swimming", five indicated "that beneficial plants should be protected", three said "get rid of all milfoil", one questioned the "cost of controlling weeds" and one "homeowners should clean their beaches".
- Overall usability of lake: 21 circled 'Fair', 10 'Poor' and 10 'Good'.
- Most important factor about usability: 13 indicated "weeds or milfoil", six said "boating", five said "fishing" and/or "fish habitat", 3 indicated "swimming", 3 "water clarity" and or "water quality", two said "smell", one said "not crowded" and one "supports wildlife".
- Uses of the lakes: 39 circled 'Wildlife Observation", 34 circled 'Boating', 33 circled 'Swimming', and 29 circled 'Fishing'. In addition, one person wrote in "scenery" and one wrote "drinking water".
- Other comments: 16 indicated "the need to address milfoil" or "weed problem & support efforts", one wrote "WDFW boat launch", one "messy beaches", one "poor fishing", one indicated "secondary lot owner doesn't want to pay" and "no poisoning (rotenone)", one wrote in "geese", one indicated "long term investment", one "oppose actions not necessary", one " lake quality/milfoil hasn't changed for 30 years".

Conclusions from Questionnaire Responses

The conclusion drawn from the questionnaire responses are that this lake system (particularly Silver Lake) does have an aquatic plant problem that centers on the growth of milfoils and that lake usability has suffered as a result. Many people feel that the water quality and overall usability are only 'fair' and are concerned about the effects of this plant growth on the various uses of the lake.

Problem Categories

Discussions about the excessive growth of Northern milfoil, the new infestation of Eurasian watermilfoil and the control or elimination of these problems have been held by the two primary organizing committees, LMD and IAVMP, as well as by the community at large. These discussions led to the following Problem Categories being described for Silver Lake:

- Current and potential hindrance to swimming because of excessive plant growth,
- Potential hindrance to boating and water skiing,
- Current and potential degradation of fishing and fish habitat,
- Potential reduction in aesthetic appeal of the lake,
- Potential decrease in property values.

For North Silver Lake, which has substantially different uses, the following Problem Categories were apparent:

- Potential degradation of fishing and fish habitat,
- Potential degradation of waterfowl habitat and hunting.

Effected Beneficial Uses

Following from the discussion of the questionnaire responses, above, the following beneficial uses were identified (in order of preference, based on the number of returned questionnaires listing each use):

- Wildlife observation,
- Boating,
- Swimming,
- Fishing, and
- Drinking water.

Other general "Characteristic uses" of waters of the State, as defined in Water Quality Standards for Surface Waters of the State Of Washington (WAC Chapter 173-210A) likely apply to Silver and/or North Silver Lake:

- Primary contact recreation (swimming, wading, diving, water skiing),
- Agricultural water supply,
- Stock watering,
- Wildlife habitat, and

- Aesthetic values.

Finally, it is known that North Silver Lake and the southern end of Silver Lake are used for:

- Waterfowl hunting.

A map of specific beneficial use areas in silver and North Silver Lakes is presented in the Beneficial Use Areas section, below.

Problem Statement

The Problem Statement developed for this Plan is: Silver Lake is host to an extensive growth of milfoils, which are impacting (degrading) the human, fisheries and wildlife uses of the lake. The most apparent current problem is due to excessive growth of a native milfoil species, which dominates the shallow southern end of the lake. It is apparent that this plant must be controlled to prevent a continued hindrance to the beneficial uses of the lake. However, Eurasian watermilfoil (*Myriophyllum spicatum*) is also present along shorelines in the northern third of the lake and is likely expanding its coverage. EWM is one of the most invasive aquatic plant pests in North America. Like native aquatic milfoils, it has feather-like underwater leaves and emergent flower spikes. Usually, leaf shape and size can distinguish *M. spicatum* from other milfoil species; however this plant is a variable species that can hybridize with other milfoils, making it difficult to identify without chemical or DNA analysis. Every effort should be made to prevent the spread of this plant.

WATERSHED and LAKE CHARACTERISTICS

In order to fully understand the lake system, with its uses and problems, and the opportunities for its protection and management, the watershed and waterbody must be described. The following discussion summarizes the available information on Silver Lake and North Silver Lake.

Watershed

Watershed Physical Features

The Silver Lake / North Silver Lake watershed is located within the larger Crab Creek watershed, more specifically within Water Resource Inventory Area (WRIA) 43 which drains roughly from east to west across the “Channeled scablands” of Washington. The watershed covers 19.0 square miles (Dion et al, 1976). The watershed relief ranges from about 2,750 feet above sea level on Riddle Hill, east of Silver Lake, to 2,341 feet at the lake surface (USGS, 1973).

Watershed geology consists of basalt flows, metamorphic and granitic rocks and small amounts of glacial till, outwash and associated deposits (Huntting et al., 1961). Soils in the watershed can be summarized as a complex pattern of silt loams, sandy loams, loamy sands and marshes (Donaldson & Giese, 1968). Especially to the west of Silver Lake soil cover over bedrock is quite thin and there are a number of small ponds and vernal pools to be found (see Figure 1).

Watershed Land Use

Land use within the Silver / North Silver Lakes watershed is given by Dion et al. (1980) as 12% urban, less than 1% sub-urban, 84% agricultural, less than 1% forest or unproductive and 4% lake surface.

Lake

Physical Features.

North Silver Lake

No published information was found for North Silver Lake. For this present IAVMP project, the lake surface area was estimated from the USGS 7.5 minute map to be approximately 88 acres and from the aquatic vegetation survey the average depth was estimated to be about four feet, with the maximum depth of 19 feet being measured near the culvert that connects this lake to Silver Lake proper (Lamb, 2008). Due to its shallow nature, the lake bottom was almost entirely covered with aquatic plants and the bottom materials were predominantly silt / muck. The North Silver Lake shoreline is essentially undeveloped emergent plant habitats. However, at the southwest corner of the lake there are two private residences, one of which was formerly Butlers Resort, and a former rock quarry area. There is no apparent surface water inlet into North Silver Lake but areas of groundwater input have been apparent during winter ice-over conditions (Butler, 2008).

Silver Lake

Silver Lake has been monitored by the U.S. Geological Survey, the State of Washington and by resident volunteers so there are several publications dealing with the lake characteristics, water quality and aquatic vegetation. A bathymetric (depth contour) map of Silver Lake from the Washington Department of Game, 1957 is presented herein as Figure 3. Silver Lake is listed as having a surface area of 490 acres, a volume of 14,000 acre-feet, an average depth of 30 feet and a maximum depth of 80 feet (Dion et al, 1980). These areas and quantities are at the assumed surface elevation of 2,341 feet above sea level. Silver Lake has approximately nine miles of shoreline and, as of 1975, had 83 near-shore homes and 25% of the shoreline was developed (Dion et al. 1976). The current number of near-shore homes is 177 (tally of lake front and secondary lots with dwellings from County Assessors records by Jim Peterson).

Silver Lake has no surface water inlets, aside from the culvert connecting this lake with North Silver. There is no continuous surface water outlet from the lake although there is a reported dam on a channel at the south end of the lake and it can be assumed that if the water level in the lake reached a certain point, water would run out that end into the Big Swamp area (see Figure 1), possibly under Interstate 90 and into the Canyon Creek drainage.

Lake level data for the period October 1967 through September 1974 was requested from the U.S. Geological Survey, Water Resources Division office in Spokane. Lake level data was read and recorded typically 16 to 18 times a month during 1967 through 1971 by lake resident Max Glasgow. After that, readings were taken five to nine times a month through September 1975 when data collection ceased. A

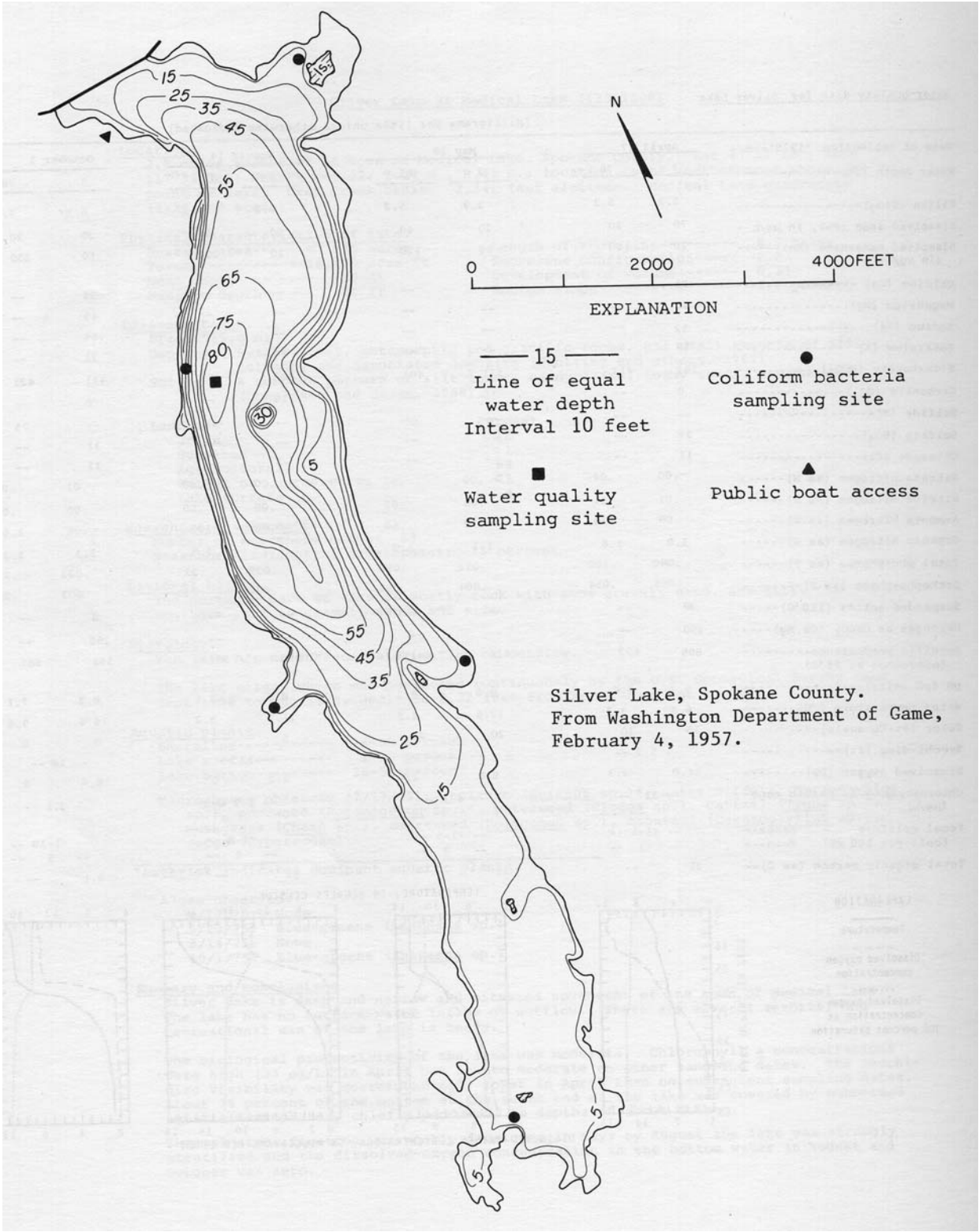

Figure 3. Bathymetric map of Silver Lake (Dion et al. 1980).

summary of annual fluctuations seen during this period is presented in Table 1. From this it is apparent that low elevations were seen in the fall (most often in October) and the high elevations were seen during March through June. Annual water level fluctuations averaged about two and one half feet and ranged, during this period, between 1.45 feet and 4.11 feet.

Table 1. Summary of Silver Lake surface elevation data for water years 1967 – 68 through 1973 – 74.

Water Year	Low Elevation*	Date(s)	High Elevation*	Date(s)	Fluctuation (ft)
1967 - 68	2039.70	September 30	2041.76	April 1 - 13	2.06
1968 - 69	2039.62	October 9	2043.50	June 4	3.88
1969 - 70	2041.66	December 3 - 9	2043.76	May 15 - 18	2.10
1970 - 71	2041.86	November 2 - 6	2043.56	June 9 - 16	1.70
1971 - 72	2042.00	October 20	2043.45	May 21	1.45
1972 - 73	(no data	provided)			
1973 - 74	2040.15	October 12 - 27	2044.26	March 1	4.11

The lake bottom is described as “mostly rock with some gravel, sand and silt” at the northern end and “gravel, sand and silt” at the southern end (Dion et al. 1980). As of 1975, aquatic plants in Silver Lake were described as occupying between 26 % and 50% of the shoreline, between 1% and 10% of the lake surface and between 25% and 50% of the lake bottom (Dion et al. 1976). More information on aquatic vegetation in Silver and North Silver Lakes is presented in the Aquatic Plant Characterization section, below.

Inflow, Outflow and Water Budget

Neither North Silver Lake or Silver Lake have measurable surface water inlets or outlets. Therefore, no information is available regarding the water budget of these water bodies.

Water Quality

Water quality has been monitored infrequently in Silver Lake and never in North Silver. Data for 1913 was published by Kemmerer et al.(1924), for 1974 and 1975 by the Washington Department of Ecology, in cooperation with the US Geological Survey (1976 and 1980), and in 1997 by the WDOE (2008).

The 1923 data was determined using methods which are not comparable to more modern methods and the sample site was not identified, so these data (with the exception of temperature) will not be discussed

herein. However, the 1974 through 1997 data are valuable in describing overall water quality conditions in, at least, Silver Lake. The Silver Lake sampling site is shown in Figure 3.

Water Clarity

Water clarity, measured using a Secchi disk is one of the most basic of water quality measurements. Secchi disk clarity (or visibility) in June 1974 was reported by Dion et al. (1976) as 18 feet (5.5 meters), which is good. In 1975, measured Secchi values were 5.2 feet (1.6 meters) in April, 14 feet (4.3 meters) in May, 13 feet (4.0 meters) in August and 16 feet (4.9 meters) in October (Dion et al. 1980).

Secchi Disk clarity was also monitored by lake resident volunteers in 1997. The reported values in June July and August of that year (two dates sampled per month) ranged between 12.1 and 14.0 feet (3.7 to 4.3 meters; WDOE 2008). These results were stated as indicating low to moderate productivity (productivity is also known as "Trophic Status").

Temperature

Lake water temperature is primarily a function of ambient air temperature, solar radiation and inputs of groundwater. Temperature is measured in water quality studies because it influences the levels of oxygen in the water (see below) and the production of plants (including algae) and animals.

In the 1913 Kemmerer study, August water temperatures ranged from 72.3°F (22.4°C) at the surface to 44.7°F (7.1°C) at 46 feet (14 meters) deep. The temperature dropped consistently from surface to the deepest depth sampled but if these data are graphed, a zone of more rapid temperature drop with increasing depth (referred to as the "thermocline") can be seen. When a thermocline develops, it can prevent circulation of the lake waters and force the deeper, cooler waters to become low in oxygen and thus be inhospitable to fish.

In June 1974, measured water temperatures ranged from 23.7°C at the three foot depth to 6.7°C at 72 feet deep (Dion et al. 1976). While these were the only depths for which temperature was reported, the data are very similar to those from 1913. In 1975 the range of temperatures reported by Dion et al. (1980) for the three foot depth and the lake bottom (depths varied between 76 and 81 feet) were 6.9°C and 3.7°C in April, 12.5°C and 4.3°C in May, 21.7°C and 5.2°C in August and 16.6°C and 5.6°C in October. These results show how the surface waters warmed considerably between April and August while the deep water remained relatively constant. Graphs presented by Dion et al. (1980) show that the lake was stratified, with a strong thermocline, between May and October (see Figure 4).

Dissolved Oxygen

Oxygen is produced by photosynthesis in green plants and algae during daylight but consumed by their respiration during darkness. Oxygen is needed for fish and aquatic invertebrate respiration both day and night. The oxygen that is available for aquatic plant and animal growth is that which is dissolved in the water; this can come from plants and algae or from the atmosphere. Dissolved oxygen is easily measured and is a standard test of water quality conditions.

Dissolved oxygen data from June 1974 were 8.9 milligrams per liter (mg/L) at the three foot depth and 0.4 mg/L 72 feet deep at the single monitoring site. This situation, with dissolved oxygen concentrations near the maximum possible (based on the water temperature) in the upper waters and much lower in deeper waters (which are not in contact with the atmosphere) is not unusual. However, dissolved oxygen levels less than 5 milligrams per liter are limiting to salmonid fishes (i.e trout). Dissolved oxygen concentrations in 1975 at the three foot depth were 14.0 mg/L in April, 9.8 mg/L in

May, 9.2 mg/L in August and 8.4 in October. Thus, it can be seen that warmer water holds less dissolved oxygen. At the deeper depth on the same dates, however, the dissolved oxygen was 3.3, 2.4, 0 and 0 mg/L, respectively. Thus, at the deepest depth measured, the lack of re-oxygenation from plants or the atmosphere, and the typical consumption of oxygen by bacteria breaking down organic matter, can keep oxygen at the lowest possible levels. Only lake turnover, which undoubtedly occurs but is not seen in the available data, can overcome this condition. Figure 4 also shows how oxygen levels can become reduced (compare dotted line which is the temperature-based oxygen saturation levels with the dashed line which is observed oxygen levels in 1975).

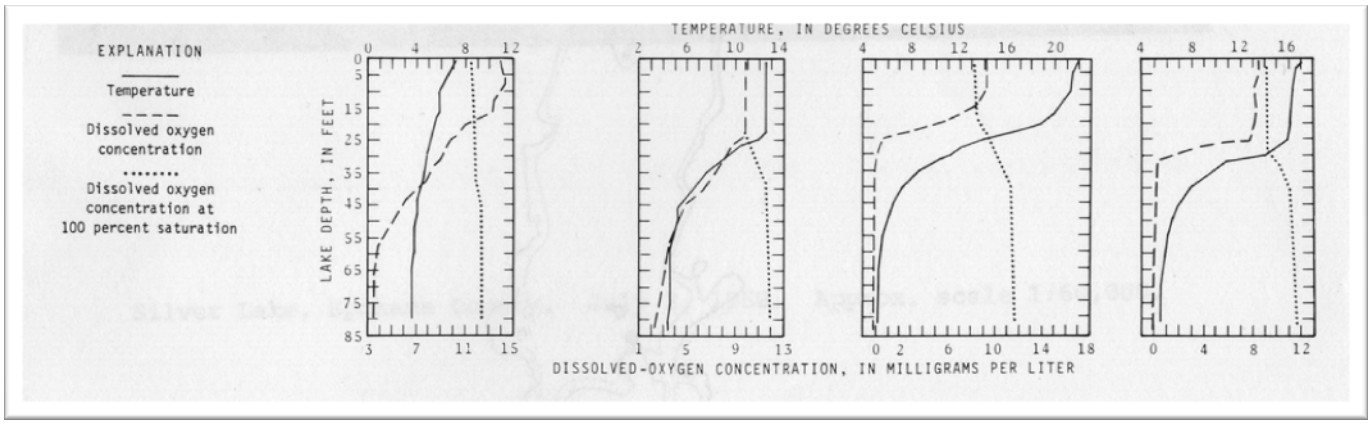

Figure 4. Graphs showing temperature and dissolved oxygen fluctuations for four dates in 1975 (from left April, June, August and October) in Silver Lake; from Dion et al 1980.

Nutrients

Nutrients are required for plant and algae growth. Phosphorus and nitrogen are two nutrients which can bring about excessive growth of algae (and loss in water clarity) in lakes. While aquatic plants typically get most of the phosphorus and nitrogen they need from lake bottom sediments, algae must have these nutrients dissolved in the water. In most temperate climate lakes, either phosphorus or nitrogen will be the "limiting nutrient" meaning the one which added to the water will bring about the greatest increase in algae growth. Because of this importance to lake productivity, both are frequently measured as part of water quality monitoring efforts. Further, both dissolved and "total" forms of these nutrients are measured; dissolved nitrogen or phosphorus are more readily available for algal growth but "total" includes nutrients held in particulate forms (i.e. phosphorus held within algae cells or bound to sediment particles) which could become available to algae should that nutrient be released from particulate form.

Phosphorus and nitrogen forms were measured by laboratory analysis of water samples collected from Silver Lake in 1974 and 1975. The nitrogen forms determined were nitrate, nitrite, ammonia and organic nitrogen. The phosphorus forms were dissolved ("orthophosphate") and total phosphorus. The available data is shown in Table 2; the result of these levels of nutrients is given in ***Algal Productivity*** section, below.

Table 2. Silver Lake phosphorus and nitrogen analysis results from Dion et al. 1976 and 1980.

	Parameter:	Nitrate	Nitrite	Ammonia	Organic Nitrogen	Ortho Phosphorus	Total Phosphorus
Date	Depth (feet)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
6/24/1975	3	0.01	<0.01	0.06	1.2	0.013	0.032
	72	0.01	<0.01	0.71	1.3	0.13	0.15
4/17/1975	3	<0.01	0.01	0.09	1.8	0.005	0.08
	76	0.04	0.01	0.3	1.6	0.054	0.1
5/20/1975	3	<0.01	<0.01	0.12	1.1	0.004	0.032
	81	0.07	0.02	0.46	1.2	0.057	0.095
8/14/1975	3	<0.01	<0.01	0.06	1.2	0.001	0.029
	80	<0.01	<0.01	1.2	1.5	0.21	0.23
10/1/1975	3	0.01	<0.01	0.06	1.3	0.002	0.022
	78	0.01	<0.01	1.6	1.3	0.29	0.32

Algal Productivity

The biological productivity (the capacity to support and foster algal growth and thus an aquatic food chain) of Silver Lake waters was described as "moderate" by Dion et al (1980). Chlorophyll *a* is the primary pigment in green plants and algae and its concentrations are analysed as a standardized measurement of the productivity of a lake. Chlorophyll *a* in Silver Lake "photic zone" (where sunlight can support plant and algae growth) water samples taken in 1975 were "high" in April (i.e. 33 micrograms per liter µg/L) but "low to moderate" (i.e. 1.9 to 4.3 µg/L) in May, August and October (Dion et al. 1980).

Coliform Bacteria

Coliform bacteria are organisms of the E-coli family which are pollution indicators, and thus reflective of water quality. Since these organisms normally live in the intestines of humans and warm blooded animals, they do not usually survive long in lakes at ambient temperatures; however, if they are found at high levels in lakes their presence can be a sign of contamination from septic tanks. Four Silver Lake sites were sampled in 1974 and five sites were sampled in 1975 for fecal Coliform bacteria. The maximum fecal Coliform count (measured in "colony forming units") was 9 in 1974 and 18 in 1975. The mean count in June, 1974 was 4. The 1975 counts were less than 1 in April, 2 in May, 4 in August

and 5 in October. These results can be considered as indicating a low human health risk (at the time of the sampling). No recent Coliform data was found.

Water Rights

A search of the WDOE's Water Rights Applications Tracking System made in September 2008 indicated that there are 29 Certificates, Permits or Claims for surface water from Silver Lake (see WDOE report in Appendix A). While the current validity or use of these listed water rights is not indicated on this report, the purposes listed included 'domestic single family' (DS, 19 listed rights), 'domestic general' (DG, 3 rights), 'domestic multiple family' (DM, 1 right), 'irrigation' (IR, 9 listed rights).

Bird, Wildlife and Fish Usage

Birds and Wildlife Table 3 gives a list of birds and wildlife which was provided by Silver Lake resident Jim Patterson. Other species whose presence has been documented by State agencies is given in the Rare, Threatened or Endangered Species section, below.

Fish (The following is excerpted from a Management Brief prepared by WDFW Fisheries Biologist Marc Divens following completion of several survey efforts in 2008.)

For 35 years WDFW managed Silver Lake as a put, grow and take rainbow trout fishery. Annual harvest of rainbow trout was commonly 75,000 fish with some years exceeding 100,000 fish. Because of repeated illegal stocking of largemouth bass, tench and assorted panfish species, multiple rotenone treatments were conducted on the lake (1955, 1959, 1967, 1976, 1981 and 1987). Continued illegal stockings made it increasingly difficult to manage the lake as a trout fishery until put, grow and take management of the lake was suspended in the early 1990's.

The end result of the repeated illegal stockings was the suspension of the long standing trout management scheme and the creation of an unbalanced warmwater fishery that provided for low recreational fishery value. In 1999, WDFW proposed to treat the lake again with rotenone to establish a balanced warmwater fishery that would be more recreationally productive. Area residents resoundingly rejected the proposal and other management alternatives were considered for the lake.

In response to lake residents requesting that WDFW find alternative management strategies, Silver Lake has been sampled regularly since 1999 by the WDFW Regional Warmwater Fisheries Assessment Team to monitor trends in population abundance, as well as various indices of population structure. Species composition data from a standardized fisheries survey conducted in 1999 showed a high proportion of the lake biomass to be tench, an introduced fish species with little recreational value. Following the defeated proposal to rehabilitate the lake fishery through rotenone treatment, several alternative management actions were implemented in 2000 to enhance the fishery. These alternative actions included:

- Adopting a change in the statewide largemouth bass regulation for the lake in 2003 from a 5 fish limit / no more than 3 over 15 inches *to* a 12-17 inch slot limit, where only largemouth bass under 12 inches may be retained, except for one fish over 17 inches / 5 fish daily limit;
- A change in the crappie regulation in 2004 from no limit *to* a 9" minimum length / 10 fish daily limit; and
- The introduction of tiger muskellunge in 2003 to develop a predator population of fish large enough to effectively prey on the over-abundant 12 to 14 inch tench population, while also

developing a trophy tiger muskellunge fishery. The statewide regulation for tiger muskie, one fish daily greater than 50 inches in length, was adopted in 2008 for Silver Lake as well to protect these valuable hatchery reared fish.

Table 3. Silver Lake birds and wildlife provided by Mr. Jim Patterson.

Birds	**Mammals**	**Amphibians**
bald eagle	mule deer	turtles
osprey	whitetail deer	
blue Heron	moose	
ducks	coyote	
coots	racoon	
geese	porcupine	
robins	muskrats	
quail	chipmunks	
sparrows	squirrels	
swallows		
black birds		
hummingbirds		
red tail hawks		
owls		
crows		

Fishery monitoring efforts at Silver Lake over the past decade have included annual spring and fall standardized fish population surveys and seasonal tiger muskellunge diet sampling following their introduction to the lake. Although beyond the scope of this summary, a full analysis of research results is planned for 10 years post tiger muskellunge introduction to the lake. This summary is provided for fishery managers and interested parties to recap the most current fish population survey results.

Silver Lake was surveyed September 24 – 26, 2008. Fish were captured using boat electrofishing, gill netting, and fyke netting. Sampling locations were selected by dividing the shoreline into 26 sections of

approximately 400 meters each. Sixteen sections were sampled by nighttime boat electrofishing. Gill netting and fyke netting were used to sample eight sections each. The total electrofishing time was 9600 seconds. Gill nets and fyke nets were set in the evening and retrieved the following morning for a total of eight net-nights of effort for each gear type. Each fish captured was identified to species, measured to total length (mm; TL) and weighed (g).

Species composition by weight (kg) and number were calculated from all data collected using boat electrofishing, gill netting, and fyke netting. Catch per unit of effort (CPUE), by gear type, was calculated for each fish species collected. Length frequency histograms were created to evaluate the size structure of species with a minimal sample size of 30 fish, which included largemouth bass, bluegill sunfish, pumpkinseed sunfish, black crappie, yellow perch, and tench. The Relative Weight (W_r) index was used to evaluate condition the condition of largemouth bass, bluegill sunfish, pumpkinseed sunfish, black crappie and yellow perch.

Ten fish species were sampled from Silver Lake in September 2008 (Table 4). Largemouth bass was the most abundant species by weight, followed by bluegill. Bluegill and yellow perch were the most numerous species (Table 4). In addition to bluegill and yellow perch, other panfish species sampled in lower numbers included black crappie and pumpkinseed sunfish. Of those species regularly stocked, eight tiger muskellunge and four brown trout were sampled. One adult smallmouth bass and two adult walleye were sampled…species, which were most likely the result of illegal introduction.

Table 4. Species composition by weight and number for fish sampled at Silver Lake (Spokane County) in September 2008 (from WDFW, 2008).

	Species Composition					
	by Weight		**by Number**		**Size Range (mm TL)**	
Species	**(kg)**	**%**	**(#)**	**%**	**Min**	**Max**
Black Crappie	2.852	1.28	40	1.72	32	248
Bluegill	39.666	17.86	1104	47.52	32	192
Brown Trout	32.86	14.80	4	0.17	697	771
Largemouth Bass	55.803	25.13	325	13.99	43	491
Pumpkinseed Sunfish	5.406	2.43	207	8.91	66	145
Smallmouth Bass	1.48	0.67	1	0.04	476	476
Tiger Musky	23.609	10.63	8	0.34	561	1111
Tench	26.038	11.73	63	2.71	60	453
Walleye	3.564	1.61	2	0.09	490	597
Yellow Perch	30.769	13.86	569	24.49	95	268

Silver Lake largemouth bass sampled in 2008 ranged in length from 43 to 491 mm TL (Table 4). Largemouth bass of all size classes were sampled indicating stable year-class strength and likely angler compliance with the 12 to 17 inch slot-limit regulation adopted in 2003. The condition of largemouth bass sampled varied both above and below the national 75th percentile for fish less than 300 mm TL. However, majority of largemouth bass greater than 300 mm TL exhibited condition above the national 75th percentile, which is common in lakes with adequate forage fish as adult bass become increasingly piscivorous as they grow. In Silver Lake, younger largemouth bass below 300 mm likely experience extensive interspecific competition with the lake's abundant panfish species for common forage.

Silver Lake bluegill ranged in length from 32 to 192 mm TL (Table 4). Bluegill greater than 200 mm (eight inches) were not sampled in this survey. Larger bluegill, which have been observed in previous sampling efforts, may be experiencing greater competition with the recent growth of the yellow perch population. Although the condition of bluegill in this survey varied, the majority sampled exhibited condition that was below the national 75th percentile.

Yellow perch sampled ranged in length from 95 to 268 mm TL (Table 4). Although the majority of yellow perch sampled were small (less than eight inches), some perch sampled were larger and of a size commonly of interest to anglers. Now several years after yellow perch were first observed in the lake, there are some which may be offering some angling opportunity. The majority of yellow perch sampled exhibited condition that was below the national 75th percentile.

Black crappie sampled ranged in length from 32 to 248 mm TL (Table 4). Few were sampled that exceeded the minimum length regulation of 209 mm TL (nine inches). The condition of black crappie sampled was at or below the national 75th percentile and appeared to decrease as fish length increased. This is common in Washington populations as adult black crappie, which become increasingly piscivorous with increased size, lack a suitable forage fish species in Washington waters. Although young-of-the-year yellow perch can provide a short-term forage for crappie in some waters, the recent illegally introduced addition of yellow perch to the Silver Lake fish community has likely increased overall competition for overall forage available within the lake.

The eight tiger muskie sampled ranged in length from 561 to 1,111 mm TL (Table 4). No tiger muskie sampled were larger than the 50 inch minimum length limit regulation. Tiger muskie were sampled that are of a size which is capable of preying on the tench available as forage, which has taken several years to occur in the lake following their initial stocking. Future surveys and diet work should reveal whether they are having the desired effect.

The four large adult brown trout sampled ranged in length from 697 to 771 mm TL (Table 4). Although it is likely that some of these fish, stocked as juveniles, are preyed upon by bass and tiger muskie, survivors can reach trophy proportions within the lake and provide a unique angling opportunity.

Rare, Threatened or Endangered Species.

WDFW Priority Habitats and Species Information

The WDFW maintains a number of databases that contain information about the locations of important fish and wildlife species that should be considered in land use decisions and activities. For the Silver Lake IAVMP project, a request was submitted to the Priority Habitats and Species program which provides detailed 1:24,000 scale Habitats and Species maps with standard explanatory reports describing the resources of concern. For this, available information from the following locations was requested: the southwest one quarter of Section 9, the east one half of Section 17, the east one half of Section 20, the east one half of Section 29 and the northeast one quarter of Section 32, all within Township 24 North, Range 41 East Willamette Meridian. The result of this request were several maps indicating the following habitats or species which are on the Priority Habitats and Species List or on the Species of Concern List:

PHS Form #: 903119. Site Name: Medical Lake Wetlands General Description: "Waterfowl concentration areas associated with wetlands and open water used during migration and breeding. Tiger salamander occurrence documented. Great Blue Heron nesting and foraging. Painted turtle occurrence

documented. Furberer use." This habitat and these species includes all of the Silver Lake and North Silver Lake.

PHS Form #: 908065. Site Name: Silver Lake General Description: "Waterfowl breeding concentrations. Mallard, Wigeon, Pintail, Cinnamon Teal, Redhead, Northern Shoveler". This habitat and these species include the wetland at the very south end of Silver Lake.

The only other information provided by WDFW following this request was a map showing the Bald Eagle "Buffer Management Zone", an 800-foot nest tree protection area which is located around the south end of Clear Lake, two miles or more from Silver Lake. It does not appear that aquatic vegetation control work performed at Silver or North Silver Lake will have any effect on this management zone.

WDNR Natural Heritage Program

Initially, a review of the Washington Department of Natural Resources (WDNR) web-based "Rare Plant List" and "High Quality / Rare Ecological Communities List" was conducted but this was found to be too general for this project needs. Following this, an e-mail request was made to the WDNR Natural Heritage Program for information on the presence or absence of rare plants or high quality ecological communities in the Silver Lake/North Silver area. The initial response to this was a listing of surveyed land sections in Washington identified by the Natural Heritage Program as reported to contain Natural Heritage Features associated with wetlands. None of the areas of concern at Silver/North Silver appeared on that listing. A subsequent communications with Ms. Sandra Moody, Environmental Review Coordinator with the Natural Heritage Program indicated that there were two rare plant species that occur in vernal pools near the south end of Silver Lake. While the actual distance that these pools are from the lake was not available, it appears that these would not be connected to the lake and therefore should not be impacted by activities (especially herbicide applications) in Silver Lake.

The letter received from the Natural Heritage Program confirmed the names of the two plants in question but did not provide more information on specific locations. The two plants are *Sclerolinon digynum* (Northwestern yellowflax) and *Trichostema oblongum* (Oblong bluecurls). The *Sclerolinon* has a State "Threatened" status and is found within and on the margins of vernal pools in grasslands and mound and swale topography. The *Trichostema* is under review (in need of additional field work before a status can be assigned) and is found in alkaline soils in vernally moist areas that often dry by summer. This would seem to confirm that these plants would not be expected to be found in or adjacent to the lakes. The Natural Heritage Program letter can be seen in Appendix A.

Beneficial Use Areas

Beneficial use areas on Silver Lake were identified for this planning effort and are indicated on the beneficial Use Area map, Figure 5. The paragraphs which follow present descriptions of the variety of beneficial use areas around Silver and North Silver Lakes.

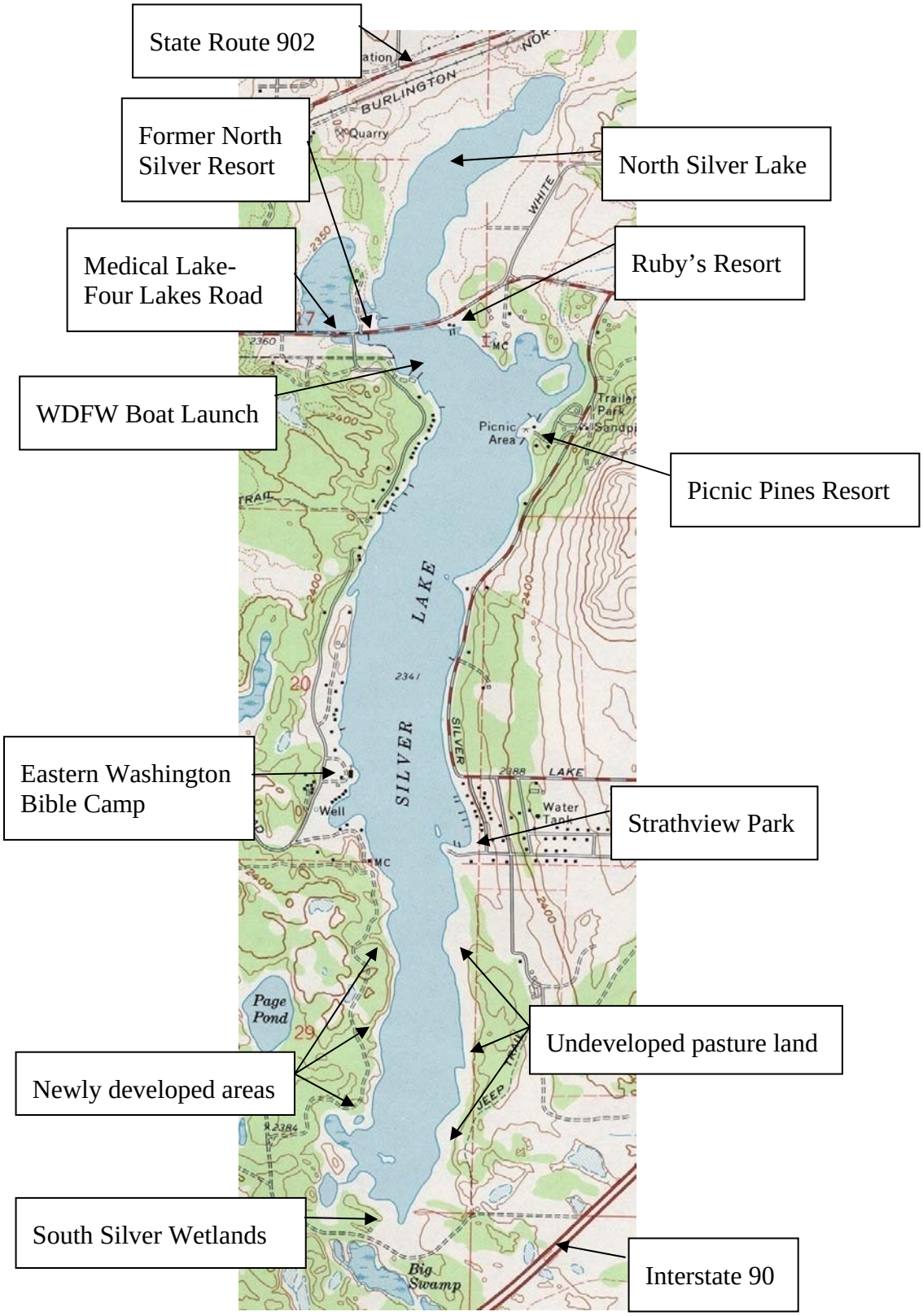

Figure 5. Beneficial use areas, significant wetlands and road access to Silver Lake.

WDFW Boat launch

The WDFW public access is a boat launching facility located at the northwest corner of Silver Lake (see Figure 6). This facility was renovated during 2007 and 2008 to construct new launch ramps, add handicapped / ADA features and construct boat loading and fishing floats.

Figure 6. Photograph of WDFW public access on Silver Lake, Spokane County, WA.

Ruby's Resort

Ruby's Resort is located on the north shore of Silver Lake, right off the Medical Lake-Four Lakes Road (see Figure 5). Ruby's facilities include a fishing dock, swimming area, 16 campsites, showers and store. Ruby's has 450 feet of lake frontage and is open from April through September.

Picnic Pines Resort

The Picnic Pines Resort is also located near the north end of Silver Lake. This facility has a swimming beach, boat launch, fishing docks, 28 RV sites, 10 tent sites and a picnic pavilion on the shoreline. There is a restaurant/lounge, a trailer park which is in the process of being replaced with condominium units and 10 docks for use by the homes on the property. The resort owner, Mr. Chuck Groom, indicated that much of his shoreline is packed with aquatic vegetation which impacts the use of his docks by boats.

Eastern Washington Bible Camp

The Eastern Washington Bible Camp is a 350-acre property with 1,000 feet of lake frontage located on the west side of the lake. Figure 7 shows part of the camp shoreline. The Camp has 17 dormitory cabins with a total of 425 beds. There is also a cafeteria building, a lodge with two meeting rooms and 12 hotel style rooms and a gym / chapel building. The shoreline has a large beach / swimming area (including several large inflatable water toys) and a kayak / canoe launch area. The Camp is primarily a summer season operation and Camp staff have had to hand-remove aquatic vegetation to keep the swimming area clear. Mr. Terry Andrews, Camp Manager indicated that aquatic plants also inhibit fishing along the Camp area.

Figure 7. Photograph of Eastern Washington Bible Camp.

Strathview

The Strathview Homeowners Association operates a community lake access, called Strathview Park, for use by its members. Strathview Park is approximately three acres in area and includes a boat launch, swim beach, docks and picnic area. The Park includes a point of land that encloses a bay in which the beach and docks lie (see map Figure 5 and photo Figure 8). The Strathview Homeowners Association encompasses 125 secondary lots.

General Developed Shoreline Areas

Residential development along the shorelines of Silver Lake proper is concentrated along the west side. North of the bible camp the homes are older while south of this camp homes have only been built within the last 10 years, for the most part. There are not many secondary lots on the west side of the lake.

On the east side of the lake, shoreline development is limited by the presence of Silver Lake Road and the large landholding (currently used for cattle grazing) along the southeast part of the lake, south of Strathview. Therefore, shoreline development on the east side is concentrated in the Strathview area, and from Picnic Pines northward. Most shoreline homes have boat docks but because of the nature of Silver Lake's shoreline, predominantly rocky or wetland, few homes have beaches.

Figure 8. Photograph of part of Strathview Park, located on the Eastern shoreline of Silver Lake taken from the point looking east into the enclosed bay.

North Silver Lake

North Silver Lake is essentially a conservancy area with the former North Silver Resort and one home adjacent to that being the only structures with a developed shoreline. Figure 9 is a photograph looking northward over North Silver Lake showing the natural vegetation along the shorelines.

Figure 9. Photograph of North Silver Lake looking northward from the rock pile at the former North Silver Resort. The foreground is the location of one of the two rock quarries.

South End Wetlands

The southern third of Silver Lake proper becomes very shallow and supports the majority of the Northern milfoil in the lake (see Aquatic Plant Characterization section, below) as well as a major fishing and waterfowl hunting area.

AQUATIC PLANT CHARACTERIZATION

Aquatic vegetation in Silver Lake has been documented more frequently than water quality. Both of the Dion et al. publications listed aquatic plants present and the WDOE has inspected the lake on a number of occasions. However, no data on aquatic plant presence was found for North Silver Lake. The following is a summary of published information on historical plant data.

Previous Aquatic Plant Survey Results

The first published notes of aquatic vegetation in Silver Lake were by Dion et al. (1976) and simply mentioned that approximately 26 – 50% of the shoreline was "covered" by emergent aquatic plants and approximately 1 – 10% of the lake surface was similarly "covered". Dion et al. (1980) repeated this information and added that approximately 26 – 50% of the lake bottom had aquatic plants (not

indicating if these were submersed or emergent). However, Dion et al. (1980) did provide a list of plant species found in 1975. This list included the emergent species bulrush (genus *Scirpus*), cattail (genus *Typha*), smartweed (genus *Polygonum*), sedge (genus *Cyperaceae*) and the submersed species water milfoil (genus *Myriophyllum*), pondweed (genus *Potamogeton*), waterweed (genus *Elodea*), coontail (genus *Ceratophyllum*) and muskgrass (genus *Chara*, which is not a vascular plant but actually a macro-algae). This document also contained the note that "About 35% of the bottom at the south end of the lake was covered with submersed aquatic macrophytes, chiefly pondweed, to depths of about eight feet". Macrophytes are vascular aquatic plants and the area referred to is what is currently found to be dominated by Northern milfoil.

The current WDOE Lake Water Quality Monitoring website (www.ecy.wa.gov/programs/eap/lakes/wq/docs/lksilsp1.html) included information on aquatic plants from a survey in 1995 and other records. Table 5 presents that list which includes 10 submersed and five emergent species. The only notes given with that data were that WDOE was out on the lake with WDFW staff for an informal plant ID training; and that there was heavy plant growth at the south end (no species were give for that growth).

Table 5. Aquatic plant species list for Silver Lake, from the August 1995 survey by WDOE (from WDOE website: www.ecy.wa.gov/programs/eap/lakes/wq/docs/lksilsp1.html).

Submerged species:		**Emergent species:**	
Scientific name:	Common name:	Scientific name:	Common name:
Ceratophyllum demersum	coontail	*Alisma* sp.	water plantain
Chara sp.	muskgrass	*Hippuris vulgaris*	common marestail
Elodea canadensis	common waterweed	*Juncus* sp.	rush
Myriophyllum sp.	watermilfoil	*Polygonum* sp.	smartweed
Myriophyllum sibericum	Northern watermilfoil	*Veronica* sp.	speedwell
Potamogeton pectinatus	sago pondweed	*Zannichellia* sp.	? unknown plant
Potamogeton sp.	thin-leaved pondweed		
Ranunculus sp.	Water-buttercup		
Ranunculus longirostris	long beaked water-buttercup		

The current WDOE Aquatic Plant Monitoring website (www.ecy.wa.gov/programs/eap/lakes/aquatic plants/index.html) contains a list of Silver Lake species seen in surveys conducted in 1994 through 2007. Table 6 presents that list which includes 17 submergent and 12 emergent species. Notes on the

apparent density of these species included on this website ranges from “few plants” to few but patchy distribution” for the waterweed (*Elodea* species), the pondweeds (*Potamogeton* species), and water-buttercup (*Ranunculus* species). Coontail (*Ceratophyllum* species), muskgrass (*Chara* species) and Eurasian watermilfoil were found at “few plants but patchy distribution” to “large patches”. The Northern milfoil was the most dense species mentioned in this report, at “large patches” to “nearly monospecific patches”.

Table 6. Aquatic plant species list for Silver Lake, from the WDOE surveys 1994 through 2007 (from WDOE website: www.ecy.wa.gov/programs/eap/lakes/aquatic plants/index.html).

Submerged species		**Emergent species**	
Scientific name:	Common name:	Scientific name:	Common name:
Ceratophyllum demersum	coontail; hornwort	*Dulichium arundinaceum*	three-way sedge
Chara sp.	muskgrass	*Eleocharis sp.*	spike-rush
Elodea canadensis	common waterweed	*Hippuris vulgaris*	common marestail
Elodea nuttallii	Nuttall's waterweed	*Juncus sp. or Eleocharis sp.*	small grass-like plants
Isoetes sp.	quillwort	*Limosella aquatica*	mudwort
Myriophyllum sibiricum	northern milfoil	*Phalaris arundinacia*	reed canarygrass
Myriophyllum spicatum	Eurasian watermilfoil	*Polygonum amphibium*	water smartweed
Potamogeton filiformis	slender leaved pondweed	*Polygonum hydropiperoides*	common smartweed
Potamogeton illinoensis	Illinois pondweed	*Polygonum sp.*	smartweed
Potamogeton pectinatus	sago pondweed	*Schoenoplectus sp.*	naked-stemmed bulrush
Potamogeton praelongus	white-stemed pondweed	*Scirpus sp.*	bulrush
Potamogeton richardsonii	Richardson's pondweed	*Solanum sp.*	nightshade
Potamogeton vaginatus	sheathing pondweed	*Typha latifolia*	common cat-tail
Potamogeton sp.	thin leaved pondweeds		
Potamogeton zosteriformis	flat stem pondweed		
Ranunculus aquatilis	water-buttercup		
Ruppia cirrhosa	ditch-grass		

2008 Aquatic Plant Survey Results

Overview of Methods

The 2008 aquatic vegetation survey conducted for this IAVMP project covered both North Silver and Silver Lakes. The vegetation sampling was performed using a weed rake (rake-on-a-rope; single throw per site) as well as observations from a boat, where possible. A sample site interval grid of 250 feet was chosen to describe the plants present and the apparent density of the milfoils across these two lakes. A hand-held Global Positioning System (GPS) unit was used to determine and record the coordinates of the sample sites and the 2001 plant ID manual (WDOE 2001c) was used to key out plants seen in the samples. Volunteers were used, and are gratefully acknowledged, to operate the boat and to record species presence, water depth and substrate type data for each point that was sampled. The survey was performed on July 19, 2008 on Silver Lake (114 sites sampled) and on July 26, 2008 on North Silver (35 sites sampled). The tabulated data collected during this survey, and Google™ ortho-photos showing the sampled sites are presented in Appendix B.

It was determined that representative samples of milfoils from Silver Lake would be submitted for DNA sequence testing to verify the species present. This was felt to be important because of the regional presence of a hybrid of two milfoil species (*M. spicatum* x *M. sibericum*) and because of the inordinately high density of the apparent native (Northern) milfoil. A total of nine samples (six from Silver and three from North Silver) were submitted to Ryan Thum at the Water resources Center at Grand Valley State University. An overview of the testing methods and results are presented in Appendix B.

While this survey focused on submersed plants, observations were made of shoreline plants as well. Emergent aquatic plants were widely present but species were not recorded. However, two sighting of the noxious wetland weed Purple Loosestrife (*Lythrum salicaria*) were noted.

2008 Survey Findings

The submersed plant species seen from the 2008 survey, and the frequency of species occurrence, are shown in Table 7. In this Table, the plant species are put in order of decreasing frequency of occurrence (that is, the number of sites each was found at). So, it is quite apparent that the northern milfoil, at 128 sites, is the most widely distributed, by a wide margin. Next are the thin leafed pondweeds (of which there are several species with this general description) at 82 sites and musk-grass at 43 sites. Eurasian watermilfoil was found at 28 sites, which puts this species fifth on the list. The last species, curly leaf pondweed, is notable because it has not been identified in Silver Lake before and because it is a potential problem causer. Curly leaf pondweed has been seen to cause problems in lakes because of dense growth and because it dies off early in the summer season and can thus foster algal growth by releasing nutrients into the water. This species was only seen at site #295, located near Ruby's Resort, and its presence should be monitored. It was estimated to occupy 20% of the sample site at that location.

Table 7. Species listing and frequency of occurrence for the 2008 aquatic vegetation survey of Silver Lake and North Silver Lake.

Species Common Name	**# of sites**
northern milfoil	128
thin leaf pondweed	82
musk grass	43
coontail	34
Eurasian watermilfoil	28
ditch-grass	20
flat-stem pondweed	16
water buttercup	7
white-stemed pondweed	4
curly leaf pondweed	1

As indicated above, the density of the milfoils was also recorded as part of the 2008 data collection effort. Of the 128 sites where northern milfoil was found, its apparent density (that is percent coverage of the lake bottom or percent of the collected sample) ranged from 99% to "less than 10%" (<10). The most dense growth of this species was at the south end of Silver Lake. The average density of northern milfoil at all sites where it was encountered was 49.7%, which indicated that is was fairly dense wherever it was found. The Eurasian milfoil was found at 28 sites and its density ranged from 90% to <10%. The highest densities were seen at sites 301, 303 and 305 (at the north end and northern west side of Silver Lake). The average density of Eurasian milfoil was 36.9% which indicates that this plant has become well established where it is found.

From the depth data collected, it can be seen that aquatic vegetation grows from two to about18 feet of water depth in Silver Lake. That is to say that three sites greater than 18 feet deep had any vegetation, and even at 18 feet six sites had some vegetation and three did not. This illustrates that even with the fairly high level of turbidity that was seen at the time of the survey, light can penetrate to the bottom with sufficient intensity to allow plant growth at about this depth.

Lake bottom sediments were not always caught on the weed rake and bottom materials were seldom seen from the boat so information on sediment type at the sample sites is minimal. And, in fact, only soft mucky sediments would be likely to be collected on the rake. So, it is not surprising that the only sediment data collected with this survey indicated that the bottom was primarily organic muck; that is composed of decayed plant materials. This was seen at 32 of the 149 sample sites.

One final note of plant species presence relates to an emergent wetland weed that was seen near two of the sample sites. This plant, purple loosestrife (*Lythrnm salicaria*) is typically monitored by WDFW and also by the Spokane County Noxious Weed Control Board. This is an invasive, State-listed noxious weed, and the Silver Lake homeowners should report these findings to one or both of these agencies. The locations recorded were near (shoreward of) sample sites #231 (southwest corner of Silver Lake) and #285 (northeast corner of Silver Lake).

Distribution of milfoil species

The Silver Lakes survey data allowed for the development of a map showing the distribution of milfoils, and thus, the location of recommended treatment areas. This map (see Figure 10) indicates all sample points where Eurasian milfoil was found, at any density. The map also shows points where northern milfoil was found to be occupying 50% or more of the sample (or, if the vegetation was visible, 50% of the visible bottom at the site). The areas outlined in red or green are those areas which were used for the determination of acreages to be treated (see Recommended Control Strategies section below).

DNA sequence Testing Results

The analysis of DNA sequences is becoming more widespread as variable plants such as the milfoils are found to hybridize and create plants of even more varied appearances and, in some instances, different responses to herbicide treatments. DNA sequencing analyses the plant and compares the results with markers of similar spots on the DNA chain with those from known species.

The results from Silver and North Silver Lake samples are presented in Table 8. Fortunately, the DNA results agreed with the appearance of the samples, which were based on the observed rigidity (or flexibility) of the plant and on the number of leaflets seen per leaf. So, based on this limited sampling, there are no hybrid milfoils in Silver or North Silver Lakes.

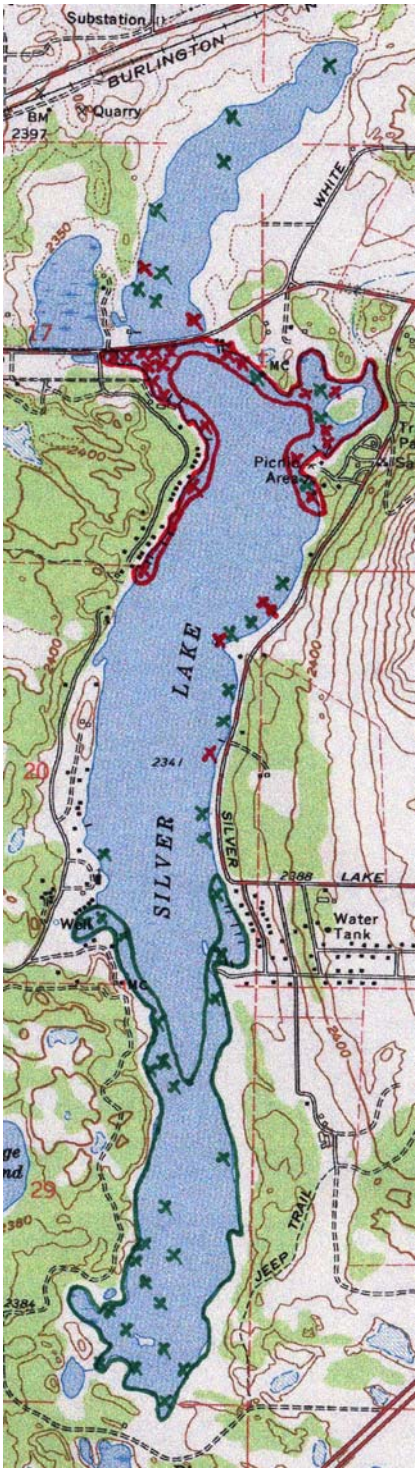

Figure 10. Map of Silver Lake and North Silver Lake, Spokane County, Washington showing Eurasian milfoil locations (red x's) and locations where northern milfoil was 50% or more of the sample or visible coverage (green x's). Areas recommended for control treatments are marked in red or green outline.

Table 8. DNA sequence test results for Silver / North Silver Lake samples collected during July 2008. Testing performed by Ryan Thum, Grand Valley State University, Michigan.

Site # - sample #	Species
242-1	M. sibericum
242-2	M. sibericum
268-1	M. sibericum
268-2	M. spicatum
302	M. spicatum
320	M. sibericum
339	M. spicatum
343-1	M. sibericum
343-2	M. spicatum

MANAGEMENT GOALS

Silver Lake

The development of the Problem Statement, the assessment of watershed and lake characteristics and the determination of desired beneficial uses have led to the following management goals for Silver Lake:

- Maintain recreational uses of the lake by removing or controlling excessive submersed aquatic plant growth from residential shoreline areas,
- Keep swimming and boat launch areas free of nuisance aquatic plants,
- Protect and enhance fish and wildlife habitat,
- Choose aquatic plant control techniques which have the widest public support, a low cost to benefit ratio and prevent adverse environmental problems either in the lake, the associated wetland areas or downstream of the lake, and
- To the extent possible, reduce milfoil growth to the point that chemical herbicides are not needed during each successive year.

The “action limit” for Eurasian watermilfoil in Silver Lake is zero plants; that is, controls are recommended whenever this milfoil is found in the lake. Eurasian milfoil is to be treated wherever it is found using the moderate or high intensity controls as outlined in this Plan.

The "action limit" for northern milfoil in Silver Lake is a reduction in its presence such that boating in the southern end of the lake is not severely hindered and that the generation of plant fragments is reduced to the point that shorelines in other areas of the lake are not inundated with fragments.

North Silver Lake

Due to the predominantly undeveloped, conservancy condition of North Silver Lake there was very limited resident or manager input for this area. However, in order to maintain the natural nature of this lake, the following management goals are indicated:

- Protect and enhance fish and wildlife habitat,
- Choose aquatic weed control techniques which have the widest resident support, a low cost to benefit ratio and prevent adverse environmental problems either in the lake and the associated wetland areas, and
- To the extent possible, reduce milfoil growth to the point that chemical herbicides are not needed during each successive year.

The "action limit" for Eurasian watermilfoil in North Silver Lake is zero plants; that is, controls are recommended whenever this milfoil is found in the lake. Eurasian milfoil is to be treated wherever it is found using the moderate intensity controls as outlined in this Plan.

There is no "action limit" for northern milfoil in North Silver Lake. At this time this plant does not hinder the stated beneficial uses.

CONTROL ALTERNATIVES

General Considerations and Permitting

This section of the IAVMP presents information on available techniques which can be used in the management of aquatic plant growth. Much of this information is excerpted from A Citizen's Manual for Developing Integrated Aquatic Plant Management Plans (WDOE 1994) and the Supplemental Environmental Impact Statements for the Department of Ecology's Aquatic Plant Management Program (WDOE 2001c, 2003). Additional information on new and developing control technologies is also presented where it appears to be appropriate in the near future (two to five years). While all possible techniques are addressed here, only those which are specifically applicable to Silver Lake, the developed Problem Statement and the Management Goals are discussed in detail. Following the review of appropriate techniques, an "Action Plan" has been developed which is presented in the next main section of this Management Plan.

•• Note: essentially all aquatic plant control activities require a permit from one or more State agencies. All manual, mechanical, and physical techniques described herein require issuance of a WDFW Hydraulic Project Approval. Application of chemicals to State waters to control algae or aquatic plants must be covered under a National Pollutant Discharge Elimination System (NPDES) permit. A NPDES permit has been issued to the Washington Department of Agriculture for control of State-listed noxious weeds and individual treatments must request coverage under this permit and certain monitoring must be

performed. Dredging may require a permit from the US Army Corps of Engineers. Permit guidance in the "Aquatic Plants and Fish" pamphlet (WDFW 1998) was developed in recognition of the importance of controlling aquatic noxious and nuisance weeds, the need to protect the aquatic resource and to facilitate the approval process for HPA projects. This guidance does not include efforts related to the NPDES permit.

Submersed Plant Controls

The No-Action Alternative

The focus of this IAVMP is on the plant species which have been shown, or have the potential, to negatively affect the beneficial uses in Silver Lake; that is, Northern and Eurasian watermilfoil. Based on the public opinion that there is a problem with aquatic plants, this Plan has investigated options for controlling or eliminating this problem. In order to maintain a perspective on the costs and benefits of various plant control options, the costs and benefits of the “no-action” alternative also must be kept in mind.

If organized action is not taken against noxious or nuisance submersed plant growth, there is a potential that the problem will get worse. Therefore, the "no-action" alternative is not acceptable due to the potential impact to the beneficial uses of the lake and potential negative environmental impacts (i.e. fish habitat degradation). The impact of continued, excessive submersed plant growth on fish habitat could include effects on water quality, on fish themselves and on fish food organisms. Impacts on water quality include pronounced stratification of temperature due to interception of solar radiation and reduction in circulation, as well as changes in chemical factors such as dissolved oxygen, pH and alkalinity due to daily cycles of photosynthesis and respiration. Perhaps a more significant impact to water quality can result from the rapid die-off (senescence) of dense plant beds, and concomitant reduction in dissolved oxygen and release of nutrients, which can happen on a seasonal basis. Release of nutrients, especially phosphorus, can foster excessive growth in free-floating algae which, in turn, can have other adverse effects on the lake. The reduction in oxygen levels can have direct negative effects on fish and fish food organisms. Low oxygen also causes the production of hydrogen sulfide and ammonia, both of which can also have toxic effects on fish and fish food.

Maintenance of dense beds of submersed plants can also foster the growth of mosquitoes and possibly other nuisance organisms.

Advantages of No-Action alternative:

- no treatment cost,
- no short-term hindrance to recreation or other lake uses due to treatment implementation.

Disadvantages of No-Action alternative:

- lake quality will decline,
- recreational opportunities will decline,
- fish and wildlife habitat will be reduced or impaired,
- property values will decline.

Appropriateness for Silver Lake:

- The No-action alternative is not appropriate due to the degradation that uncontrolled milfoil growth will cause and the desire of the lake residents to protect the identified beneficial uses described herein.

Currently Available Techniques - Preventive

Watershed Controls

The preventative techniques which may have utility in Silver Lake's milfoil control efforts focus on the control of inputs of the growth nutrient phosphorus. These techniques include both structural and non-structural (Best Management Practice) options which generally work to prevent erosion and sediment generation by controlling surface runoff.

Advantages of Watershed Controls (in general):

- reduce nutrient loading at their sources,
- provides shade and lowers stream temperatures
- reduces stream bank erosion and sedimentation in lake,
- reduces toxic chemicals and other pollutants in streams and the lake,
- provide benefits over wider area than the lake.

Disadvantages of Watershed controls (in general):

- may require changes in land use
- may require construction or modification of facilities, purchasing of property and hiring of maintenance personnel,
- may require regulatory support and personnel.

Costs of Watershed Controls:

- vary greatly (not determined)

Appropriateness for Silver Lake:

- Watershed controls are appropriate for water quality protection at Silver Lake but would not be expected to effect the growth of milfoil in either the short or long term. This is due in part to the fact that milfoil, like most aquatic plants, draws nutrients out of the sediments (as opposed to the water column) and also the apparent fact that milfoil can grow well in low nutrient (oligotrophic) as well as high nutrient (eutrophic) lakes. Therefore, watershed controls are not recommended for inclusion in the Integrated Treatment Action Plan.

In-Lake Nutrient Controls

The primary focus of many of the lake management alternatives is the reduction in nutrients (primarily phosphorus) as a means of limiting algae and aquatic plant growth. This is a valid approach and should be considered, especially for long-term reduction in productivity. It is, however, beyond the scope of

this IAVMP to evaluate the technical merit or costs of these nutrient-focused alternatives. Several recommended techniques will be discussed herein, however, because they also control or remove the actual aquatic plant growth.

Public Awareness and Involvement Program

The understanding and involvement of lake and watershed residents and lake users will be necessary if the process of nutrient, algae and aquatic plant growth controls is to succeed. Therefore, a public education and awareness program is strongly recommended for Silver Lake. Such a program would focus on, and promote, lake stewardship but would also keep the lake "community" informed about measures that are to be, and have been, performed in and around the lake. Especially important will be evaluation of control program effectiveness and program adjustments over time. Through newsletters, public meetings, exhibits at fairs and local media coverage (to name a few), information on the lake should be disseminated and opportunities given for reply from the community.

Some subjects which can interest lake residents and users are: simplified algae and aquatic weed information, sources of, and solutions to, nutrient enrichment, shoreline stabilization and re-vegetation, options for lawn fertilizer use, pet waste management, non-phosphate detergent use, and discouraging bird and waterfowl feeding. Training to teach plant identification can be very pertinent as well.

Whenever possible, the lake community should be directly included in information collection and synthesis as part of the public involvement program. This can include citizen representatives performing monitoring (data collection) efforts.

Advantages of a Public Awareness and Involvement Program:

- provides education and public awareness,
- provides opportunity to gather consensus and public support,
- provides opportunity to involve the lake residents and users in the lake management process.

Disadvantages of a Public Awareness and Involvement Program:

- requires committed organization to implement and provide continuity.

Costs of a Public Education and Awareness Program:

- $2,000 to $4,000 per year.

Appropriateness for Silver Lake:

- An ongoing Public Awareness and Involvement Program is very appropriate for Silver Lake and is recommended to be included in the Integrated Treatment Action Plan described below.

Currently Available Techniques - Physical Control

These techniques include manual or mechanical efforts that can remove, cover, shade or dry out all or part of problem plant growth.

Hand Removal

Removal of submerged vegetation by hand digging or pulling is a labor-intensive but generally small-scale management option. This method involves removing the entire plant (leaves, stems and roots) by hand or with a hand-held gardening tool, collecting the plant materials in a storage bag for transport and disposal on shore. In water depth greater than about three feet, the use of SCUBA divers is typically needed to effectively manage a location.

The effectiveness of plant removal depends on sediment type, visibility (water clarity), plant type, the density of target and non-target vegetation and thoroughness in removing the plant roots. Based upon these variables, the level of plant control can vary from one month to multi-year management.

Advantages of Hand Removal:

- immediate clearing of the water column,
- highly selective technique, in that individual plants are removed,
- can be implemented in sensitive area where disruption must be kept to a minimum,
- effective in aggressive control of sparse or small infestations in the lake, around docks or in swim areas.

Disadvantages of Hand Removal:

- technique is time consuming and labor intensive,
- visibility may become obscured by the disturbance of sediments during harvesting thus delaying plant removal or missing smaller plants,
- potential for spreading milfoil due to release of plant fragments,
- management can be costly in deeper water, especially when divers are used,
- control may only be short-term or seasonal; based on location and surrounding infestations.

Costs of Hand Removal:

- no cost if performed by volunteers,
- $800 - $1,600 per day for two divers and a support boat & operator,
- typical coverage from 400 to 2,000 square feet per day.

Appropriateness for Silver Lake:

- Hand removal is appropriate for small scale control of Eurasian and northern milfoil control in Silver and North Silver Lakes. Therefore, hand removal is included in the Integrated Treatment Action Plan described below.
- Hand removal is not considered appropriate for large areas which support extensive growth of either milfoil.

Bottom Barrier Installation

Bottom barriers are highly effective in the small to moderate scale control of aquatic vegetation. The barriers are typically synthetic (geo-textile) fabrics, or burlap, but a variety of other materials have been used including sand and gravel, polyethylene, polypropylene, synthetic rubber, fiberglass screens and nylon film. These materials cover the lake sediments and existing plants and prevent further growth. By covering the lake bottom that the plants emerge from, all plants are effectively prevented from growing in those areas. Washington State typically allows the use of burlap when covering native plant areas and burlap or synthetic material when covering noxious weed areas. These barriers are typically 100% effective in the installed areas initially and installation can be conducted at any depth with the assistance of divers and a support vessel for deeper installations. Bottom conditions do not typically impede most barrier installations, but logs and debris are typically cleared from the area. Duration of control is dependent upon type of material used, application techniques, sediment deposition and WDFW permit requirements.

Since gases are produced in the sediments under the barrier, the barrier must be attached or weighted to the bottom and allow these gasses to pass through it. Over time, these barriers can lose effectiveness if sediment builds up on them, providing a substrate for plants to root. Yearly maintenance by a dive team can prolong the effectiveness of this technique indefinitely (except with burlap which will decompose and must be replaced to maintain effectiveness).

Bottom barriers are expensive when used on a large scale and very labor intensive to remove after being in place for the time needed to kill milfoils. In addition, there can be environmental impacts if large areas of a lake bottom are covered with these materials blocking fish access to the bottom. Bottom barriers are most applicable for individual properties and are recommended for around docks. Bottom barriers may not work well in swimming areas when placed over soft sediments, however. If swimmers walk on them, they tend to push the mats into the sediment which in turn allows them to billow up with gas accumulation under them.

Recent research conducted in Coeur d'Alene Lake for the Idaho Milfoil Task Force resulted in a determination that bottom barriers should be left in place for ten weeks in order to kill milfoil (IMTF, 2005). This group used geotextile material mounted on ten foot by ten foot PVC pipe frames filled with sand to hold the barrier panels on the bottom. After the necessary treatment time, these barriers can be moved to other areas or removed from the lake and cleaned to be re-used.

Advantages of Bottom Barriers:

- no toxic chemicals are placed in the water,
- provides immediate removal of nuisance plant conditions upon placement,
- easily applied to small, confined areas around docks, moorage's or beaches,
- they are hidden from view (in deeper waters),
- effective in isolated management practices, especially in milfoil control
- some materials are reusable.

Disadvantages of Bottom Barriers:

- potentially high material cost for synthetic products,
- labor intensive and high costs for utilizing divers,

- limited durability of certain materials,
- not species specific,
- potential permit restrictions on location of barrier (spawning areas), type of material, type of plants attempting to control and length of time barrier will be allowed in place,
- gas accumulation under barrier can cause barrier to be lifted hindering boat passage or swimmers,
- periodic maintenance needed to remove sediment build up and secure placement,
- may need to be removed after two years to allow native vegetation to re-establish.

Costs of Bottom Barriers:

- $0.35 to $0.85 per square foot for materials (burlap or geo-textile),
- $0.35 to $0.60 per square foot for labor to place barriers,
- $0.30 to $0.50 per square foot for labor to remove barrier.

Appropriateness for Silver Lake:

- Bottom barriers are appropriate for small scale control of Eurasian and northern milfoil control in Silver and North Silver Lakes. Therefore, bottom barriers are included in the Integrated Treatment Action Plan described below.
- Bottom barriers are not considered appropriate for large areas due to the difficulty and thus cost of removing them.

Water Column Dyes

This technique involves the addition of dark colored dyes to the lake to suppress aquatic growth by shading plants or algae from sunlight. These can be blue or a blend of blue and yellow to absorb key portions of the visible light spectrum needed by submersed plant and algae growth. Dyes are most effective at depths of two feet and greater. Use of this technique is limited to lakes or ponds which have minimal dilution with clear water and no outflow.

Advantages of Water Column Dyes:

- treatment could control both aquatic plants and algae,
- no water use restrictions; treated water will not harm fish, waterfowl, pets or wildlife,
- no special equipment or applicator certification required.

Disadvantages of Water Column Dyes:

- not species specific (can affect all plants and algae),
- not effective when plants or algae are near surface,
- dilution from inflowing creeks would necessitate frequent reapplication,
- dyes may not be allowed due to outflow and domestic water rights.

Costs for Water Column Dyes:

- $12.00 to $15.00 per acre foot for materials.

Appropriateness for Silver Lake:

- Water column dyes are not appropriate for use at Silver Lake or North Silver Lakes due to their lack of target specificity and their limited expected efficacy in large lakes.

Sediment Removal

Removal of lake sediments can provide a nutrient and plant control option in lakes and ponds. Stormwater inputs, surface runoff, stream inputs and erosion can all contribute to the build-up of sediments in lakes. These sediments contain a pool of nutrients which can stimulate the growth of aquatic plants and algae. In shallow lakes (or shallow parts of lakes), the establishment of significant aquatic plant populations can result in accelerated accumulation of sediments and filling of the lake. The purposes of sediment removal, therefore, are to remove nutrients and aquatic plants and to deepen shallow areas so that future plant growth is reduced (both by reducing nutrient availability and by increasing the water depth and thus shading).

Sediment removal operations can be conducted using a variety of mechanical equipment from backhoes and drag lines, which dig the sediment from the shore, to floating barge hydraulic systems that remove a slurry of sediment and water and pump it to a settling pond on-shore. A significant consideration with sediment removal is the disposal of removed sediments and water. Lakes act as sinks for not only nutrients but also potentially toxic materials. Sediment testing is often required prior to establishing an appropriate sediment disposal plan. The water contained in the removed sediment is often substantial as well, which adds to the challenge.

Advantages of Sediment Removal:

- effective in removing existing plants and nutrient rich sediments,
- increases the depth of the system and reduces the areas available for plant growth,
- site specific management.

Disadvantages of Sediment Removal:

- operation costs are typically expensive and labor intensive,
- problems with equipment access and location for disposal,
- potential for turbidity release and short-term impacts to water quality,
- not species specific,
- potential permitting requirements,
- may remove beneficial habitat.

Costs for Sediment Removal:

- $200,000 to $400,000 for design, inspection, environmental monitoring,
- $0.15 to $0.80 per cubic foot for hydraulic dredge,
- disposal costs not possible to estimate; would be significant.

Appropriateness for Silver Lake:

- Sediment removal is not considered appropriate for milfoil control at Silver Lake due to the lack of target specificity, the need for sediment disposal areas and the high cost.

Water Circulators

Water circulators, some of which are also aerators, are well known in water treatment, and are particularly useful for algae control. One such device (or series of devices) is the SolarBee™. This is a floating solar-powered circulator. Depending on the model, the SolarBee is 10-17 feet in diameter and generates a flow rate of 1,250-10,000 gallons per minute. The SolarBee creates a four to six-foot diameter column of rising water below the machine and spreads this water gently across the top of the lake or reservoir in a long distance flow pattern. While most mixers and aerators can influence only 0.5 surface acres, SolarBee™s can impact up to 45 surface acres per machine. The SolarBee's mixing action reportedly has many positive effects on the water quality in lakes, wastewater ponds, and potable water reservoirs.

SolarBee™ (2008) indicates that its models have utility in reducing invasive aquatic weed growth. The continual oxidation of littoral sediments and overlying waters is believed to negatively impact the health and growth of invasive submerged aquatic plants by limiting ammonia-N availability. Since the science of controlling aquatic vegetation using the SolarBee is undergoing further study, this technique warrants additional investigation.

Advantages of water circulators:

- non-toxic,
- potential long-term effectiveness.

Disadvantages of water circulators:

- no documentation of effectiveness on aquatic plants.

Costs of water circulators:

- (not determined).

Appropriateness for Silver Lake:

- Due to the lack of documented use to control macrophytes, water circulators are not considered appropriate for milfoil control at Silver Lake.

Water Level Drawdown

Drawdown (or pump down) of the lake water levels, especially during the winter months, can have a dramatic impact on some aquatic weed problems. This methodology is possible where there is a water control structure which will allow lakes or reservoirs to be drained. Alternatively, high capacity pumps must be used to draw water levels down.

Drawdowns will expose the lake sediments to loss of water and, depending on location, to freezing. Freezing in particular can eliminate aquatic plants that have no over-wintering structure like seeds, turions, tubers or winter buds. The impact on the root crowns of prolonged exposure to sub-zero temperatures is often fatal. As the lake is refilled re-growth from these crowns either does not occur or is severely stunted. There can also be a reduction in some other types of problematic vegetation using

this technology if the drawdown is prolonged. The loss of water, and concurrent compaction that can result from drawdown can also be a benefit as it can slow the colonization and growth of some rooted plants.

This technique is not one that can claim eradication normally and plants will survive in portions of the lake where water remains over the sediments. If the drawdown can extend to the deep edge of the plant communities it is obviously more effective than shallower drawdown that can only expose near-shore areas.

Drawdown can have minimal cost if an outlet control structure of sufficient height is in place. This is not the case in the Silver/North Silver Lakes. Given the lake size, bottom topography and minimal potential for re-filling, it is unlikely that the lake could be drawn down without pumping, and pumping would likely be impractical. Finally, this technique can negatively impact the fish and wildlife habitat in the lake and would have obvious implications for water rights users.

Advantages of Drawdown:

- no addition of toxic chemicals to the water,
- useful to allow repair and maintenance of shoreline features.

Disadvantages of Drawdown:

- likely adverse environmental impacts,
- temporary loss of recreation,
- low probability of success given lake morphology and levels of inflows (capacity to refill lake after drawdown).

Costs of Drawdown:

- (not determined).

Appropriateness for Silver Lake:

- Drawdown is not considered appropriate for Silver Lake due to the lack of target specificity, the significant impacts that this would have to the lake biota (and potentially water quality), the potential difficulty in refilling the lake to ensure recreation uses will be available and the costs of pumping.

Currently Available Techniques - Mechanical Control

Hand Cutting

This technique involves cutting of plants below the water surface, but roots are not generally removed. Tools used in cutting include scythes, thin cables, rakes or other specialized devices that can be pulled through the weed beds by boat or from shore. One popular device consists of two single-sided stainless steel blades forming a "V" shape which are connected to a four foot handle and tied to a rope.

Advantages of Hand Cutting:

- immediate removal of nuisance submerged plant growth,
- costs are minimal,
- can be performed throughout the season as needed.

Disadvantages of Hand Cutting:

- labor intensive and time consuming,
- generally not species specific,
- visibility may become impaired by turbidity generated by cutting,
- short-term plant control as the root system is not removed; cutting is typically needed multiple times each season,
- may be difficult to contain and remove plant fragments.

Costs of Hand Cutting:

- cutting devices range from $50 to $800,
- no labor cost if performed by volunteers.

Appropriateness for Silver Lake:

- Hand cutting is not considered appropriate for Silver Lake milfoil control due to the likelihood that plant fragments would be released, thus spreading the infestation, and the difficulty in cutting milfoil in the many rocky areas of the lakes' shoreline.

Mechanical Harvesting

An extension of the hand cutting discussed above involves the use of larger equipment that can cut or mow aquatic plants below the water surface. Barge mounted weed cutters, for instance, will cut the stems of submerged vegetation over large areas, with that vegetation typically floating off or being collected by the operator with some other implement. Aquatic weed harvesters are an improved version of a large weed cutter. These systems cut, collect and transport the vegetation for disposal on shore. A typical weed harvesting system will consist of the harvester and a shore station for unloading the harvested vegetation into a transport system for disposal.

Aquatic harvesters have a number of cutting blades located on the harvesting head and a conveyor system behind the blades that collects the plants and deposits them on a barge. There is typically a storage conveyor system that the plants fall onto when cut that facilitates unloading the machine at the shore station. The shore station equipment is usually either a shore conveyor that mates to the harvester and lifts the cut plants into a dump truck or other transport vehicle, or a trailer conveyor that performs the same function as well as transports the harvester from lake to lake. Harvesting systems normally cut the plants from five to seven feet below the surface and can harvest up to two acres per day depending on the distances to off-loading sites.

Aquatic plant harvesters work well at cutting the plants and removing the bulk of the plant material from the lake. They do allow some plant fragments to escape, however, and they do not necessarily inhibit the continued growth of the cut plants. Harvesting is not species specific (unless used in single species dominated areas) and aquatic plant harvesters can remove significant amounts of young fish and

invertebrates during harvesting operations. Harvesters should not be used on lakes that are infested with milfoil in the pioneering or early colonization stages since additional fragments will accelerate the spread of the plant.

Advantages of Mechanical Harvesting:

- no chemicals added to lake,
- immediate removal of plants and contained nutrients,
- limited interference with use of the water body,
- minimal bottom disturbance,
- reduction in sediment accumulation by removing organic matter which normally decays and adds to the bottom sediments
- harvested plants can be used as compost.

Disadvantages of Mechanical Harvesting:

- slow process (two acres per day under ideal operating conditions), dependent on availability of off-loading sites,
- labor and equipment intensive; must involve cutting and collection of plant material,
- typically requires repeat cutting for full season control with fast-growing plants (such as Eurasian milfoil),
- creates plant fragments which have potential to spread and establish in other portions of the lake (especially a concern with exotic species),
- non-selective and can be detrimental to non-target plants and animals
- high capital costs for machine purchase or use by management consultant

Costs of Mechanical Harvesting:

- $600 to $900 per acre for contract commercial aquatic plant harvesters,
- $100,000 to $180,000 for harvester/off-loader purchase,
- cost of disposal not determined.

Appropriateness for Silver Lake:

- Mechanical harvesting is not considered appropriate for Silver/North Silver Lakes because of the need for regular, repeat cuttings, the difficulty in cutting effectively in rocky shoreline areas, potential fragment spreading, potential for unintentional removal of fish and fowl and the cost.

Rotovation

Rotovation, or underwater cultivation, is a newer concept in mechanical aquatic plant management. It can provide for longer term control of some aquatic plants (than with harvesting) and it can remove plants to greater depths than conventional harvesters (approximately 12 feet versus five to seven feet) can. Rotovators are basically underwater rototillers which churn the bottom sediments to a depth of up

to 12 inches. This action dislodges plants and root crowns. Typical rotovation will provide one to three years of acceptable weed control.

Dislodged plants must be collected as they float to the surface. As with plant cutting or harvesting, rotovation should not be considered in lake or river systems where plants are in the pioneering stages of an infestation and/or spread by fragmentation. Rotovation would not be expected to control non-rooted plants such as coontail (*Ceratophyllum demersum*).

Advantages of Rotovation:

- removes entire plant including roots,
- longer effectiveness than with harvesting,
- plant density becomes reduced after successive treatments.

Disadvantages of Rotovation:

- does not collect plants or fragments which are uprooted,
- temporarily destroys bottom habitat and potentially fish spawning areas,
- causes turbidity and potential release of nutrients,

Costs of Rotovation:

- $2,000 to $3,000 per acre for contract commercial operator.

Appropriateness for Silver Lake:

- Rotovation is not considered appropriate for Silver Lake due to the lack of target specificity, the potential that this will significantly spread the problem through fragment generation and the difficulty in using this technique in rocky shoreline areas.

Sediment Agitation

Several automatic plant control products are commercially available that mechanically disturb the lake bottom to remove aquatic plants and prevent their re-growth within a well-defined area. They sweep, roll, or drag repetitively over the plants and sediments to keep the area free of aquatic plant growth. These devices must be attached to a dock or post to work properly and each product requires electricity to operate. Depending on the product, up to a 42 foot radius around the dock or post can be controlled. The Weed Roller®, manufactured by the Crary Company, uses a low-voltage power unit (attached to a dock) to slowly drive a long roller (metal cylinder or pipe) set on the lake bottom through an adjustable arc of up to 270 degrees. A reversing action built into the drive automatically brings the roller back to complete the cycle. Fin-like projections on the rollers help detach plants from the sediment and remove roots. The BeachGroomer®, by BeachGroomer Systems, Inc., attaches to a lawn pump to propel two seven-foot arms engineered with chains that turn to clear the lake bottom of weeds. The Lake Sweeper®, by Lake Restoration, Inc., uses light-weight rakes and a submerged pump to clear the lake bottom of weeds.

The ease of installation and operation varies depending upon the product. The type of lake bottom also is an important factor in selecting an automatic plant control device. It is best to install and start operating these devices in the spring before plants begin actively growing. If they are operated after plants have grown, the detached plants should be removed from the water with a rake or gathered by hand. Some manufacturers suggest preparing the area before installation by removing weeds and debris from the site

and some products don't work very well after the plants have grown. Once the plants are cleared from the area, these products can reportedly be used as little as one day per week or less to keep plants from re-colonizing the area. When not in use, the equipment should be stored beside a dock or in a place where people can not accidentally injure themselves. Little maintenance is required, but these units must be removed from the water in winter in areas where lakes are expected to freeze.

Advantages of Sediment Agitation:

- repetitive sediment agitation suppresses the re-growth of plants in areas where it is regularly used,
- open water adjacent to docks can be created and maintained,
- with some devices the treatment area can be modified by adding additional cylinders or rakes or by adjusting the travel arc,
- some products can easily be moved and can be shared by neighbors,
- operating costs are low - about the same as operating an ordinary pump.

Disadvantages of Sediment Agitation:

- repetitive sediment agitation will disturb some bottom dwelling animals and may interfere with fish spawning,
- if plants are present, sediment agitation will cause plant fragmentation, which may increase the spread of some invasive weeds,
- sediment agitation devices can cause a depression to develop where the unit operates as the fine sediment is dispersed to other areas of the waterbody,
- when the cleared area is to be used for activities such as swimming or wading, the equipment should be unplugged from the power source and moved and stored under or beside a dock. People may injure themselves if they step on the device,
- these products should be removed in the winter from lakes that freeze.

Costs for Sediment Agitation:

- purchase costs vary between products. The Beach Groomer® starts at $999, but you also need to purchase a one-to-two horse power pump (about $300) to operate the unit. The other products cost approximately $2,000.

Appropriateness for Silver Lake:

Sediment agitation devices are only appropriate for small scale control of all plant growth such as around docks or other near-shore features.

Diver directed suction removal

Diver suction removal has been used since the 1970s as an improvement to hand removal of sparse colonies of milfoil. The technique utilizes a small barge or boat carrying a portable pump with a suction hose that are directed by a SCUBA diver. Divers dislodge the plant tissue and root system from the sediments and basically vacuum up the plant material which is carried back to the barge. On the barge,

plant parts are sieved out and retained for land disposal while water and sediment materials are allowed to drop back into the lake.

Diver suction removal can be highly effective under the appropriate conditions. Efficiency of removal is dependent on sediment condition, plant size and density, and underwater visibility. It is best used for localized infestations of low plant density where fragmentation must be minimized. This technique is also selective in that divers can target a single species in a mixed population area.

An environmental concern with diver suction removal is that of turbidity and nutrient release from disturbed sediments. This is primarily applicable with light, organic sediments that often accumulate in heavy weed bed areas. However, the divers typically do not let the suction intake come near the sediments, rather they pull the target plants up out of the sediment and direct the plant into the suction intake. While sediment curtains can be used to minimize the drift of re-suspended sediment materials and also escaped plant fragments, there is no practical way of controlling nutrient release. Placement of sediment curtains is also time consuming and, thus, costly.

Advantages of Diver Suction Removal:

- species selective and site-specific control,
- minimal disruption of sediments and surrounding habitat with non-rooted plants,
- minimal release of plant fragments,
- no depth constraints, effective near obstacles,
- effective in covering large areas with light plant growth.

Disadvantages of Diver Suction Removal:

- labor intensive and expensive,
- may not be appropriate control method in dense plant beds,
- potential release of nutrients and sediments, potential short-term increased turbidity,
- may not work well in gravelly or rocky areas due to the difficulty in pulling up all root fragments

Costs of Diver Suction removal:

- $1,000 to $2,000 a day for two divers and support boat,
- typical coverage from 0.25 to 1.0 acres per day.

Appropriateness for Silver Lake:

- Diver operated suction removal has some applicability at Silver Lake and this is therefore included in the Integrated Treatment Action Plan described below. However, due to the expected cost of this type of treatment it is considered only as a backup technique.

Currently Available Techniques - Biological Control

The biological control of aquatic plants focuses on the selection of organisms that have an impact on the growth of a target plant. By stocking a lake with these organisms, or “agents”, the population of the target plant can be reduced. Biological control is not an exact science at this time. There have been a number of dramatic success stories with the control of aquatic weeds using some organisms. There have

also been some undesirable effects from their use. The majority of the tools in this field are in the experimental or review stage at this time.

Biological control agents are generally of two types. There are general agents like grass carp that will consume most aquatic vegetation. As such, they are of limited use when trying to target specific plants. The second type of "biocontrol" agent are those that are target-specific for problematic species. Many of these agents focus on exotic plants that have been introduced to this country. Research typically starts in the region of the world where these plants are from, and focuses on the organisms that keep it in check there. Once identified, these organisms are brought through a quarantine protocol into this country where further research is conducted to determine if there is operational potential for control. At this time there are no biological control agents available in Washington State which are effective against milfoil other than grass carp.

Grass Carp

Grass carp (or White Amur) are plant consuming fish native to China and Siberia. There are many aquatic plants that these fish will eat, but they have definite feeding preferences and will generally eat the plants they prefer first. Stocking rates are dependent on climate, water temperature, type and extent of plant species and other site-specific conditions. The recommended maximum stocking rate in Washington is 25 fish per acre (**Bonar et al. 1996**) and the typical stocking rate is nine fish per acre (**Hamel 2002**). A study of grass carp usage in Washington has indicated that in most cases grass carp either have little effect or will eat all submersed plants.

Periodic restocking is generally necessary to replace fish lost to predation or disease and to maintain the number of young, actively growing (and thus actively eating) fish. Only triploid (sterile) fish can be planted in Washington and by WDFW permit only. Grass carp must be imported by approved suppliers and be certified to be disease and Zebra mussel free and sterile. Inlets and outlet screens must be installed in the lake and be approved by WDFW biologists prior to stocking.

Water quality is seen to generally improve after introduction of grass carp; with the elimination of large mats of vegetation, bottom dissolved oxygen levels generally increase from levels lethal to fish and pH generally decreases with decreases in photosynthesis (**WDFW 1990**). However, water turbidity increases have also been documented due to grass carp stirring up bottom sediments. Effectiveness of grass carp in controlling aquatic weeds depends on feeding preferences and metabolism which vary from region to region. Some plant species which appear to be preferred include pondweed species, coontail and common waterweed. Plant control effectiveness is site specific and significant control of vegetation may not be apparent until two to four years following introduction.

Advantages of Grass Carp:

- non-toxic
- long-term effectiveness

Disadvantages of Grass Carp:

- may not control the milfoil that is problematic in Silver Lake,
- may alter composition of plant community without decreasing overall biomass,
- may decimate submersed aquatic plants and result in worse algae problems, and disruption of native fish habitat,

- inlet and outlet screens must be constructed and must allow passage of native salmonid fishes,
- carp foraging may cause turbidity and foster algal growth through re-suspension of sediment materials.

Costs of Grass Carp:

- $10.00 to $15.00 per fish (plus delivery),
- typical stocking rates are 9 to 15 fish per acre,
- inlet / outlet screen costs not determined.

Appropriateness for Silver Lake:

- Grass carp are not considered appropriate for use in Silver Lake due to their uncontrollable nature, lack of target specificity and, thus, potential adverse effects on the native plant populations and fish habitat in the lake.

Milfoil Weevils

A potential biological control agent that has received considerable research attention in several northwest, northeast and mid-western States, including Washington, is the aquatic weevil *Euhrychiopsis lecontei*. This organism has been associated with declines of milfoil in the United States (e.g. Illinois, Minnesota, Vermont, and Wisconsin). Researchers in Vermont found that this weevil can negatively impact milfoil by suppressing the plant's growth and reducing its buoyancy (Creed and Sheldon 1995).

The following description is excerpted from University of Minnesota, Department of Fish and Wildlife website (http://www.fw.umn.edu/research/Milfoil/Milfoilbc.html):

> The milfoil weevil is native to North America and is a specialist herbivore of watermilfoil. Adult weevils live submersed and lay eggs on milfoil meristems. The larvae eat the meristem and bore down through the stem, consuming the cortex, and then pupate (metamorphose) lower on the stem. Development from egg to adult occurs in 18-30 days at summer temperatures. The consumption of meristem and stem mining by larvae are the two main effects of weevils on the plant and this damage can suppress plant growth, reduce root biomass and carbohydrate stores and cause the plant to sink from the water column. Although the weevil has been quite effective at some sites, it has not been effective at other sites. Currently, we cannot predict when, where and how the weevils will or will not be effective. The aim of our work is to improve our understanding so we can predict effects and appropriate circumstances for use of biocontrol.

In Washington State, the milfoil weevil is present primarily in eastern Washington (including Fan and Sacheen Lakes) and occurs on both milfoil and northern watermilfoil (*M. sibiricum*), which is native to the State (Tamayo et. al. 1999). During the summer of 1999, researchers from the University of Washington determined the abundance of the milfoil weevil in 11 lakes in Washington. They found that weevil abundance ranged from undetectable levels to 0.3 weevils (adults and larvae) per stem. Fan Lake, Pend Oreille County had the greatest density per stem at 0.6 weevils (adults, larvae and eggs per stem) although the weevils there were present on northern watermilfoil not Eurasian milfoil. These abundance results are well below the recommendations made by other researchers in Minnesota, Ohio, Vermont, and Wisconsin of having at least 1.5 - 2.0 weevils per stem in order to control milfoil.

To date, there have not been any documented declines of milfoil in Washington State that can be attributed to the milfoil weevil, although Creed & Sheldon speculated that declines of Eurasian watermilfoil in Lake Osoyoos and the Okanogan River may have been caused by the milfoil weevil. In Minnesota, Cenaiko Lake is the only lake in that state that has had a Eurasian watermilfoil crash due to the weevil; other weevil lakes are yet to show declines in Eurasian watermilfoil.

The WDOE is currently involved in culturing milfoil weevils for use in experimental treatments on milfoil control. At the time of this writing there were still a number of factors related to the growth and survival of the weevil and their efficacy in causing declines in milfoil growth that need to be better understood before this organism can be seen to be an effective option.

Advantages of weevils:

- non-toxic,
- potential long-term effectiveness.

Disadvantages of weevils:

- Weevils may not control milfoil in lakes with populations of native watermilfoil,
- Weevil densities may be reduced below effective levels due to predation by sunfish and other environmental factors.

Costs of milfoil weevils:

- Milfoil weevils currently cost $1 each from commercial producers.

Appropriateness for Silver Lake:

- Milfoil weevils are not currently appropriate for use in Silver Lake. This technique should be re-evaluated when more is known about their growth and effect on milfoil.

Currently Available Techniques - Chemical Control

Chemical herbicides are one of the leading methods of controlling, and in some cases, eliminating, noxious aquatic plant growth. The herbicides which are approved for aquatic use by the USEPA are well reviewed and considered compatible with the aquatic environment when used according to label directions. In addition to the review and regulation provided by the EPA, the WDOE completed an Environmental Impact Statement (EIS) in 1992 for the aquatic plant management program which allows for the introduction of a number of compounds into State waters. This EIS was recently updated by WDOE and information contained in the Supplemental EIS documents (WDOE 2001b) have been used in the preparation of this IAVMP. Note that the application of chemicals for aquatic pest control can only be performed by a licensed pesticide applicator with an aquatics endorsement.

There are two general types of aquatic herbicides in use; referred to as “contact” and “systemic” products. Contact herbicides kill susceptible plant leaves and stems, generally leaving roots and some reproductive structures alive and capable of re-growth. As such, a contact herbicide is generally considered a maintenance tool, one that can provide relief from aquatic plant problems, but not something that can eliminate the problem from the lake system. Systemic herbicides are absorbed and carried throughout the plants thereby making them capable of killing the entire plant.

The contact herbicides approved for use in Washington State are Endothall and Diquat. The three systemic herbicides registered and approved for use in Washington are Fluridone, 2,4-D and Triclopyr. Glyphosate, another approved systemic product, is not appropriate for control of submersed plants and will not be discussed in this IAVMP.

Diquat

Diquat dibromide is a fast acting, broad spectrum contact herbicide and algaecide found in the product Reward® which is manufactured by Syngenta (formerly Zeneca Ag Products, Inc). A Reward® label is included in Appendix C. The WDOE completed in 2002 a formal Risk Assessment and Final Supplemental EIS for Diquat (WDOE 2002) which has additional information on this chemical.

Diquat is effective on a variety of submersed plants, including milfoil, and also some types of filamentous algae. Diquat's mode of action is to generate "reactive oxygen radicals" which disrupt photosynthesis. Diquat kills plants rapidly so depletion of oxygen and release of nutrients from plant decay is a potential problem. As with all contact herbicides, plant roots are not affected and repeated applications may be needed for complete season control.

Contrary to this general efficacy, Diquat was reported to have been used in Hayden Lake, ID with some apparent systemic effect. In this case, Reward® was applied by a diver or a "drop hose" to the lower third of plants in dense milfoil beds. The diver used a wand and nozzle connected to a pressure tank onboard a nearby support boat to treat one acre while the drop hose treatment involved holding the wand and nozzle down into the water while traveling in a boat across a two-acre bed. Follow-up diver inspection of these treatment areas one year later found only occasional milfoil sprigs (new plants) in the diver-treated area and approximately one-half acre of live plants in the boat treatment area (Daniel 2002).

Diquat has slight toxicity to most animals and freshwater fish. It is slightly to highly toxic to aquatic invertebrates. It is for this reason that Diquat was not permitted by WDOE for use in Washington State waters from 1992 to 2003. The effectiveness of Diquat on target plants such as Eurasian watermilfoil is found to be heightened through the use of tank mixes with copper containing products (which are not currently approved for use in Washington).

Water use restrictions which would be in force with Diquat applications for milfoil control (two gallons Reward® per surface acre) are three days for drinking, one day for livestock drinking, three days for irrigation to turf and ornamentals and five days for irrigation to food crops. There is no restriction for fishing or swimming in treated water (Syngenta 2008).

Advantages of Diquat:

- effective against many plant species,
- rapid action,
- no fishing or swimming restriction,
- inexpensive.

Disadvantages of Diquat:

- persistent, especially in sediments,
- water use restrictions in place,

- potentially toxic to aquatic organisms,
- repeat applications needed to maintain control
- rapid action may cause oxygen depletion and rapid release of nutrients into water

Costs of Diquat:

- $300.00 per acre applied

Appropriateness for Silver Lake:

- Reward® (Diquat) is considered appropriate for use at Silver Lake. However, due to the lack of systemic action and the lack of target specificity this chemical is not the preferred product.

Endothall

Endothall is a contact herbicide available in the CerexAgri, Inc. products Aquathol K® (a liquid formulation), Aquathol Super K® (a granular formulation), and Hydrothol 191® (both liquid and granular formulations). A product label for Aquathol K® is included in Appendix C as an example of an endothall-containing product.

Endothall compounds are used primarily for short-term (one season) control of a variety of aquatic plants (and algae in the case of Hydrothol 191®). The mode of action of Endothall is not fully understood although the hypotheses indicate that this chemical disrupts biochemical processes at the cellular level (WDOE 2001b). Target plants for Aquathol K® and Aquathol Super K® include milfoil (CerexAgri 2008). Duration of control with Endothall products is dependent upon target species, contact efficiency, lake conditions and regrowth from unaffected root masses. Endothall application has been reported to result in systemic action on milfoil in some cases (Hamel, 2004).

The use of Endothall involves several water use restrictions and it can be toxic to fish although there is a wide margin of safety between allowed application rates and rates that are toxic. At application rates needed to control milfoil (2.0 to 4.0 ppm) the water use restrictions are: do not use fish from treated areas for food for three days and do not use water from treated areas for watering livestock, preparing agricultural sprays for food crops, for irrigation or for domestic purposes for seven to 14 days after application. There is no swimming restriction for Endothall products. Fish toxicity is not a factor, according to the product labels, at doses below 100 ppm (CerexAgri 2008).

Advantages of Endothall:

- fast acting injury to plant tissue which is typically apparent in one to two weeks,
- little or no off-target drift impacts,
- spot treatments possible.

Disadvantages of Endothall:

- only provides temporary reductions in plant growth,
- non-target plant impacts are difficult to mitigate as this is a fairly broad spectrum herbicide,
- water use restrictions in place,
- rapid action may cause oxygen depletion and rapid release of nutrients into water.

Costs of Endothall:

- $650.00 per acre applied

Appropriateness for Silver Lake:

- Endothall products are not considered appropriate for use at Silver Lake due to the lack of systemic action and the lack of target specificity.

2,4-D

2,4-D is a fast-acting systemic herbicide with two formulations approved for freshwater applications in Washington State. The two formulations are the butoxyethyl ester (BEE) formulation found in the granular product Navigate® (marketed by Applied Biochemists); and the dimethylamine (DMA) formulation found in the liquid product DMA4® IVM, produced by Dow AgroSciences LLC. Product labels for Navigate® and DMA4® are included in Appendix C.

The mode of action of this chemical is primarily as a stimulant of plant elongation and cell division (WDOE 2001b). 2,4-D is a post-emergent herbicide that is primarily used to control watermilfoil and water stargrass. Typical submersed monocot plants (i.e. the pondweeds) are not susceptible to 2,4-D so this product can be used for selective plant control.

2,4-D can be effectively used in spot-treatment programs in lakes or ponds. Effectiveness of the treatment is dependent upon the timing of the application and density of the target plant community. Two treatments may be required when targeting dense communities. Susceptible plants will begin to show signs of injury one to two weeks after treatment, followed by plant breakdown and death.

There is no fishing or swimming restriction associated with the use of 2,4-D although the WDOE recommends "that due to risk of dermal contact, a swimming advisory shall be posted advising swimmers to wait 24 hours before re-entering directly treated areas to allow time for granules to disperse" (WDOE 2001b). 2,4-D cannot be used in waters used for irrigation, agricultural sprays, watering dairy animals or domestic water supplies (Dow Agrosciences 2008). Silver Lake landowner permission must be obtained for treatments to take place in waters used for irrigation, dairy animals or domestic water supplies. The recent risk assessment prepared for WDOE as part of the 2001 Final Supplemental Environmental Impact Statement for the aquatic plant management program (WDOE 2001b) indicated that "no significant adverse impacts on fish, free swimming invertebrates or benthic invertebrates" should be expected from 2,4-D (either formulation) applications at appropriate label rates. Additional toxicity information from this risk assessment is included in Appendix C following the Navigate® and DMA4® labels.

Advantages of 2,4-D:

- fast-acting systemic herbicide which is effective in removing selected plants with little or no impact on certain non-target plants at labeled rates,
- applications conducted easily with granular or liquid material in a large or small scale applications,
- treated waters can be used for swimming,
- no fish consumption restrictions.

Disadvantages of 2,4-D:

- application must be conducted 0.5 miles or greater from active drinking/domestic water withdrawals (unless approved by WDOE),
- treatment windows apply to areas were Endangered Species Act (ESA) listed salmonids occupy (according to WDFW specifications),
- public perception (equating this with DDT or Agent Orange)

Costs of 2,4-D:

- $770 per acre granular formulation applied, target dose 2 ppm.
- $500 per acre liquid formulation applied, target dose 2 ppm.

Appropriateness for Silver Lake:

- 2,4-D (either of the listed formulations) is appropriate for use in Silver Lake due to the specificity for the target species, the rapid systemic action and dissipation of the herbicide, the demonstrated efficacy in Silver and the general acceptance of this chemical based on past uses. This is the preferred treatment method as described in the Integrated Treatment Action Plan, below.

Fluridone

Fluridone is available in the SePRO Corporation products Sonar AS® (a liquid formulation), Sonar SRP® (a slow release pellet formulation), Sonar Q® (a pellet formulation) and Sonar PR® (a "precision release" pellet formulation). Fluridone is also available in the Griffin LLC liquid product Avast®. Product labels for Sonar AS® and Sonar PR® are included in Appendix C as examples of fluridone products.

Fluridone can show good control of submersed and emergent plants, including milfoil, where there is little water movement and an extended time for the treatment. It is most applicable to whole-lake or isolated bay treatments where dilution can be minimized. Because of the eight- to ten-week recommended contact period, treatments should take place in early spring or fall.

Fluridone interferes with the synthesis of RNA, proteins and carotenoid pigments and thereby affects photosynthesis (WDOE 2001b). Use of fluridone does not pose a threat to human health or to fish and wildlife when used according to the label (SePRO 2008, 2008b). While there is a short term (seven to 30 days) precaution when using treated waters for irrigation, there are no other water use restrictions when using the liquid formulation of fluridone.

Advantages of Fluridone:

- systemic herbicide, will kill entire target plant,
- variety of plants are susceptible, based on treatment rates and program design,
- species specificity with correct application rates,
- non-toxic to humans, pets, fish and wildlife,
- no water use restrictions for fishing, swimming or livestock/pet consumption.

Disadvantages of Fluridone:

- long exposure period required in order to effectively control plants (many times requiring multiple application or minimizing water movement),
- potential for drift from application area, requires whole lake or enclosed area treatments,
- high cost.

Costs of Fluridone:

- Sonar AS: $650 per acre applied*
- Sonar PR: $800 per acre applied*
- Sonar Q: $700 per acre applied*

  * (assuming eight foot average depth in treatment area and three-20 ppb applications)

Appropriateness for Silver Lake:

- Fluridone products are not considered appropriate for use in Silver Lake at this time due to the limited but spread out extent of the Eurasian milfoil infestation (i.e. the need for spot treatments) and the cost. Fluridone products are considered appropriate for treatment of northern milfoil where concentrated at the south end of Silver Lake.

Triclopyr

This is a systemic herbicide produced by SePRO Corporation and also marketed by Vegetation Management, LLC. EPA registration was completed in 2003 for the product Renovate® which is a water soluble triethylamine salt formulation containing three pounds of triclopyr acid equivalent per gallon. An generic liquid product is now available under the trade name Ecotriclopyr. A granular formulation of renovate, the 'OTF' is also available (see product label in Appendix C). Triclopyr was approved for use in Washington by WDOE 2004.

Triclopyr is a product that has been tested extensively and found to be effective on broad-leafed (dicotyledonous) plants such as milfoil. This product is specific for this type of plant and can be used in habitat recovery programs focusing on selective removal of these plant pests. It will not affect plant species in the monocot family, which is the majority of native aquatic and wetland plant types. Renovate® is a liquid product with a contact time requirement of 24 to 48 hours so it has applicability in spot treatments. Susceptible submersed plants exhibit epanasty (bending and twisting of plant tissue) in six to 12 hours after treatment. Treated plants begin to sink slowly three to five days after treatment and one to three weeks later plants should be well below the surface, often near the bottom.

Photodegradation is the major route of triclopyr degradation in aquatic environments. The first order half-life for Renovate® is 0.5 - 3.0 days. No accumulation occurs in sediment and no bioconcentration is believed to occur in sport fish or bottom feeding species. Toxicity testing on fish and other non-target organisms performed by or for the manufacturer has indicated that Renovate® has a low toxicity potential (SePRO Corporation 2008).

Renovate® has been used locally under an Experimental Use Permit, particularly in Diamond Lake and in the Pend Oreille River. The observed efficacy of this product was very good in a 1.5 acre bay in Diamond Lake but was poor in a six acre bay above Albeni Falls Dam (this latter most likely due to dilution by the flow in the river). Water use restrictions may be a factor in the use of Renovate®.

Advantages of Triclopyr:

- selective for broad leafed plants,
- short contact time needed,
- systemic action so entire plant is killed.

Disadvantages of Triclopyr:

- Long period of water use restriction for irrigation,
- higher cost.

Costs of Triclopyr:

- $1,700 per acre, applied (water depth of eight feet and target dose of 1.5 ppm).

Appropriateness for Silver Lake:

- Renovate® (triclopyr) is appropriate for use in Silver Lake, due to its short contact time requirement. The current cost of this chemical is substantially higher than the preferred 2,4-D.

Copper Compounds

There are currently two products containing copper that may be used for control of aquatic weeds although copper compounds are not currently allowed in Washington State. They are: Nautique®, manufactured by SePRO Corporation, and Komeen®, manufactured by Griffen. These are both "chelated" or complexed compounds.

Although copper is an essential element for plant growth, high concentrations of copper will inhibit photosynthesis and result in death of plants and algae. Chelated copper complexes where developed to maintain concentrations of the copper ion in water column over a longer period of time. The extended exposure of the copper ion in solution provided improved control plants and algae. Copper products for aquatic weed control are applied by subsurface injection. Effectiveness of applications is enhanced by warm temperatures and sunlight. These conditions stimulate copper uptake by plant cells and increase the rate at which the plants will be controlled.

Given the known toxicity of copper compounds to aquatic life, primarily fish, and given the recent Endangered Species Act listings of several salmonid species in Washington State waters, the WDOE made a policy decision in March 2000 to disallow the use of copper in salmon-bearing waters.

Advantages of Copper:

- relatively low cost treatments,
- no water use restrictions,
- provide effective and rapid control of algae blooms.

Disadvantages of Copper:

- acts as contact herbicide therefore does not kill plant roots,
- not allowed for use in waters discharging to or occupied by salmonid species (requirement of WDOE, not part of EPA label),
- remains bound to sediments and organic over a long period of time,

- limited to treatments in hard water lakes and ponds,
- may require extensive water testing and monitoring in systems with outflow.

Costs of Copper:

- $730 per acre for Nautique®, applied (water depth of 8 feet and target dose of 0.8 ppm).

Appropriateness for Silver Lake:

- Copper compounds are not considered to be appropriate for use in Silver Lake due to their lack of systemic actions, the WDOE restriction on their use and potential environmental concerns over accumulation.

Developing Techniques

There are a number of techniques which are under investigation as possible plant control agents; these being primarily biological agents. These include plant pathogens, herbivorous insects, competitive plants and plant growth regulators. The research with these agents has focused primarily on their effect on noxious submersed plants such as Eurasian watermilfoil and Hydrilla.

Pathogens.

In 1994 a classical pathogen biological control effort was launched by the US Army Corps of Engineers Waterways Experiment Station. Survey work was initiated in Europe for milfoil pathogens (Harvey and Evans, 1997) and in China for milfoil and Hydrilla (Shearer, 1997a). The China survey, in particular, offered the opportunity to search for potential biocontrol agents in temperate areas where climatic conditions more closely match areas in the US where these plants have invaded.

Following the China survey, 200 fungal isolates were collected and returned to the US for testing. Of these, 67 were submitted to the screening using 15 cm milfoil apical segments and 48 were found to induce some damage in the initial screen (Shearer, 1999). The seven isolates which induced the most significant damage were re-tested and of these five produced comparable disease ratings. Only three of the five isolates could be induced to grow before the second screening, and these three were all identified as *Mycoleptodiscus terrestris*, or '*Mt*'. *Mt* is commonly isolated from both hydrilla and milfoil within the US and has been intensively investigated as a biocontrol agent (Shearer 1997b). Interestingly, Mt was not isolated during the European survey work (Harvey and Evans, 1997). Thus *Mt* is one fungal pathogen that is being submitted for additional evaluations.

In a recent review of plant pathogen issues, Hoagland (1996) stated that although many pathogens have been characterized as bioherbicidal, most lack the aggressiveness to overcome weed defense mechanisms and achieve adequate control. However, some herbicides and plant growth regulators can act to weaken natural plant defense systems making them more susceptible to pathogen attack (Hoagland, 1996). As a result, studies have been performed using *Mt* and various herbicides on both milfoil and hydrilla. A growth chamber study using 2,4-D and *Mt* indicated that herbicide and pathogen combinations provide better control of milfoil than either agent used alone (Nelson and Shearer, 2005). However, a mesocosm study which submitted several plants to combinations of fluridone and *Mt* found that there was no advantage to integrating the two on milfoil (Nelson et al. 1998). Obviously, the use of *Mt* or other fungal pathogens is not ready for field usage.

Herbicide Combinations

There is another realm of developing milfoil control techniques which is receiving some research attention and that is the combining of contact and systemic herbicide chemistries. As described under the 'Currently Available Techniques - Chemical Control' section above, there are two general types of herbicides, 'contact' and 'systemic'. Contact herbicides are fast acting, typically causing extensive cellular damage at the point of uptake but not affecting areas untouched by the herbicide (such as the roots). Contact herbicides generally relieve nuisance problems quickly, but may allow re-growth of nuisance plants. Alternatively, systemic herbicides often will kill the entire plant through translocation of the active ingredient to plant tissue not affected by contact herbicides. Systemic herbicides, although effective in killing the entire plant, are generally slower acting and limited by short contact times.

Studies conducted in small plots and whole lake scenarios have documented the efficacy of a range of rates for the systemic herbicides 2,4-D and triclopyr, as well as selectivity in removing *M. spicatum* populations and leaving native plant communities (Getsinger et al. 1982, Getsinger et al. 1997, Poovey et al. 2004). Similarly, empirical evidence suggests that some selectivity may be achieved when applying the contact herbicide endothall (Skogerboe and Getsinger, 2002, Parsons et al. 2004).

A recent study by Madsen et al (2008 review draft) looked specifically at the effectiveness of mixtures of endothall with 2,4-D and endothall with triclopyr. The objective of this study was to determine whether combinations of a contact and a systemic herbicide might exploit the strengths of each herbicide class, and minimize their weaknesses. This study found that combinations of endothall with either 2,4-D or triclopyr provided the benefits of immediate action and complete control within four weeks. Triclopyr and 2,4-D alone provided 100% control after two to three weeks, but initial control was less than 20%. With endothall alone, there was greater than 60% reduction in milfoil biomass one week after treatment but this dropped to 52% by two weeks after treatment and re-growth was evident. Thus, it appeared from this research that the combinations of these herbicides had additive or synergistic effect with one another and could lead to increased efficacy in large-scale treatments or reduce the amount of herbicide needed to achieve similar control using only one of these products alone. The effect of such combinations on non-target plants has not been determined, however. Thus more research is needed before herbicide combinations can be used in full scale field treatments.

INTEGRATED TREATMENT ACTION PLAN

Overview

Integrated Aquatic Vegetation Management Plans (IAVMPs) are designed to be site specific based on the type of plant problem present and the needs of the waterbody users. An IAVMP reviews all control options available and selects the best mix to apply to the problem over time. An IAVMP is not a one-year management tool; it evolves as conditions in the lake or river system change. For example, if a lake has a major Eurasian watermilfoil infestation, the first years of the program may focus on that problem and select tools to target that plant. In later years, there may still be problematic weed growth, but it could be from native plant communities or from different aquatic weed species. Different tools might be considered in these cases and applied. The management plan should have both short-term and a long-term strategies.

Control Intensity

The current aquatic plant problem at Silver Lake is related to the presence of northern milfoil at nuisance levels and to the presence of Eurasian watermilfoil. Specific problem areas are the littoral zones (i.e. areas with a typical depth of less than 18 feet). As a result, preventative and high intensity controls are recommended for the short term and preventative and low intensity controls are recommended for the long term. These controls (detailed in the Recommended Control Strategy section below) are:

- **Short Term (2009-2012)**: Institute Education / Awareness Program, institute 2,4-D applications for Eurasian milfoil control (or diver directed suction removal if herbicide option is not available), institute 2,4-D treatments for northern milfoil control.
- **Long Term:** Re-evaluate the need for milfoil controls and update IAVMP as necessary. Continue Public Awareness and Involvement Program, institute and continue locally funded milfoil control maintenance activities focusing on non-chemical methods to the extent possible.

Recommended Control Strategies

The management of aquatic plants at Silver and North Silver Lakes must work within the limitations of what is feasible based on the physical, chemical and biological state of the lakes, financial resources and the political and regulatory environment.

Public Awareness and Involvement Program

The Silver Lake residents have indicated their concern for the protection of the beneficial uses of "their" lake and also their willingness to be involved in lake management efforts at various levels. As a result, it is highly recommended that residents be given as many options as possible to continue and/or increase their involvement. These options should include training in aquatic vegetation identification, milfoil survey and removal techniques, involvement in actual survey and removal efforts and also involvement in monitoring and data collection. More specifically, volunteers will be needed for participation in diver removal efforts and boat operators will likely be needed for both the diver removal work and surveying efforts. It is expected that most property owners around the lake will have the greatest interest in their own shoreline area, so individual or small group efforts with this local focus should be fostered. Much of the property owner participation is also expected to be simply attendance at meetings and training sessions so these sessions should be made as interesting and focused as possible to maintain or expand this level of participation as well.

The Public awareness program should be addressed to the general public as well as the lake residents. This could take the form of information signs and brochures placed at public access points, articles written for publication in newspapers of wider local distribution (the Spokane Spokesman Review for instance, in addition to the Cheney Free Press). Programs brought to the schools can also have a great impact on public awareness.

The Public Awareness and Involvement Program can be initially designed and implemented by lake residents. However, it is anticipated that at some point professional services will be needed to help with the development of informational materials and activities.

Annual Surveillance and Mapping

The annual milfoil surveillance efforts performed at Silver Lake in 2008 should be continued into perpetuity. This program includes two or three people in a boat with a weed rake, a hand-held GPS unit and a data sheet.

The preferred schedule for the annual surveillance work is early in the growing season, typically during June. This timing will usually allow the surveyors to see the milfoil at a time when it is actively growing; the particular green color of the leaves and reddish stems are fairly distinctive and noticeable. This time is also usually early enough to allow planning for treatments that same growing season (i.e. in July). In years that control treatments are performed, it may be advantageous to also perform a post-treatment survey during August or September to determine treatment efficacy. While late-season surveys can be used to plan the next season's treatments, it should be noted that milfoil will continue to fragment and become established to some extent during the fall, winter and early spring months. Thus, spring surveys will give a more accurate and current picture of the presence of the target plant.

Past surveys have included the use of Global Positioning System (GPS) equipment to help document the locations of the milfoil infestations, either individual plants or dense patches of plants. The GPS data is typically imported into a Geographic Information System computer program and milfoil distribution map prepared. This can also be done using Google Earth®. It is recommended that GPS mapping be performed as a regular component of the annual surveillance. The GIS map produced and an explanatory report should be prepared and provided to the Silver Lake residents as part of the Public Awareness and Involvement program.

Herbicide Applications

Based on past milfoil control efforts at a number of Eastern Washington and Northern Idaho lakes, as well as the information presented in the CONTROL ALTERNATIVES section of this Plan, it appears that spot applications of fast-acting systemic herbicide combined with surveys and diver suction removal, present the greatest opportunity to break the current milfoil growth cycle and meet the Management Goals stated above. The herbicide active ingredients that present the greatest chance of controlling the milfoil growths in silver and North Silver Lakes are 2,4-D (found in products Navigate® and DMA 4 IVM®) and triclopyr (found in the Renovate® line of products). The liquid formulation of 2,4-D, DMA 4 IVM®, is the recommended chemical to be used initially at Silver Lake. It should be noted, however, that the Goals presented in this IAVMP indicate that it is desirable that milfoil control does not involve chemical applications every year.

2,4-D was first registered for use in the United States in 1947 and it was used for water hyacinth at that time. The approval to use 2,4-D in Washington came in 1999 through RCW 90.48.448. This chemical has been used throughout Washington with good success and this is the preferred product for Silver Lake's initial milfoil control treatments. There have been no adverse impacts noted due to 2,4- D use in any local lakes; this agrees with the conclusions stated in the WDOE Risk Assessment information included in Appendix C.

The 2,4-D treatments performed in the area to date used primarily the granular formulation of the chemical (Navigate®). The typical application rate of this product for Eurasian milfoil control is 100 pounds per acre; the maximum allowed for this plant by the product label is 200 pounds per acre. Water monitoring of herbicide residues performed in other area lakes (Sacheen Lake in Pend Oreille County and Coeur d'Alene Lake), however, seems to indicate that the target concentration of 2,4-D (2 ppm) was not always achieved by the 100 pounds per acre application rate (Lamb 2008). This might be the result

of sediment absorption of the chemical, when the granules fall to the lake bottom in sparsely infested areas. In any event, it appears that the liquid formulation of 2,4-D (DMA 4 IVM®) might have a greater efficacy because it is immediately mixed through the water column and perhaps more completely available for absorption by the milfoil. The label for the liquid 2,4-D also allows a somewhat higher maximum application rate than the granular does and the higher does is expected to be needed to control the northern milfoil.

Due to the need for the herbicide treatments to be performed by experienced and State licensed (and insured) personnel, it will be necessary for the LMD (or any other lake management group) to contract with a lake management contractor for this work. Due to the expected annual treatment cost, it will be necessary to advertise for Statements of Qualification / Proposals. It is acknowledged that at the time of this writing, there are few firms in Washington that are set up to perform both the survey and treatment work. For this reason, and because of the cost and effort involved in going through a competitive bid process, this is recommended to be undertaken on an infrequent basis (i.e. every three to five years). In order to ensure that a true competitive process is followed, it is recommended that a public notice be placed in a newspaper of fairly wide distribution, at a minimum, the Spokane Spokesman Review. The Statement of Qualifications / Proposal solicitation process should begin as early in the winter as possible (October or November) so that it can be completed and a contractor Agreement finalized well before the following survey / treatment season (i.e. before April). It is recommended that the LMD obtain the assistance of the WDFW or the Spokane County Noxious Weed Control Board in reviewing submitted proposals. It is further recommended that any monitoring that is desired or required relative to the milfoil treatments should be conducted by the LMD with oversight by a qualified water quality or lake management specialist, or by a qualified, independent lake management specialist.

It should be reiterated that there are water use restrictions indicated on the herbicide labels that the lake residents and users must be made aware of. While public and resident notification requirements will be described in the WDOE aquatic weed NPDES permit, the following are applicable to the use of 2,4-D in aquatic systems:

- "Unless an approved assay indicates the 2,4-D concentration is 100 ppb (0.1 ppm) or less … do not use water from treated areas for irrigating plants or mixing sprays for agriculture or ornamental plants."
- "Unless an approved assay indicates the 2,4-D concentration is 70 ppb (0.07 ppm) or less, do not use water from treated areas for potable water (drinking water)."

There are no fishing or swimming restrictions stated on the product labels but, as noted in the 2,4-D section above, the WDOE recommends that "due to risk of dermal contact, a swimming advisory shall be posted advising swimmers to wait 24 hours before re-entering directly treated areas to allow time for the chemical to disperse".

2,4-D is recommended for initial treatments of both Eurasian and northern milfoils in Silver Lake. However, it appears that application rates appropriate for the northern milfoil will need to be higher than those for Eurasian. The cost estimates for Silver Lake treatments are based on using the maximum DMA-4 IVM® label rate for all northern treatments and 80% of the maximum for Eurasian.

Note that herbicide applications should be performed as early in the summer season as possible, when the target plant biomass (size and weight) is low. This helps prevent possible low oxygen levels which can result from the bacterial decomposition of the plants that are killed by the herbicide. Early season treatments can reduce the potential release of nutrients, especially phosphorus, from dying plants which

fosters algae growth. The growth of excessive algae not only clouds the lake water but in some cases algae (particularly the blue-green species) can produce chemicals which are toxic to humans and pets. Thus, the control of potential algae growth is an important concern in lakes such as Silver and North Silver.

Diver Operated Suction Removal

There is a need for a back-up treatment option because of lake resident opinion that treatments should not always rely on a chemical addition to the lake. This back-up method is recommended to be diver operated suction removal. The costs of substituting suction removal for 2,4-D are substantially higher (see below) and it is recommended that a minimum of 40 days of suction dredging be performed per season (assuming one suction unit operating). Disposal of collected milfoil should be arranged for well away from the lake by the LMD.

Note that diver suction removal is recommended as a "search and remove" effort where the treatment crew would be given specific treatment areas and they would search through these and remove any milfoil present. As such, this method is not recommended for native milfoil control, at least at start of control, due to the extreme volume of plants which would need to be removed. Diver suction removal may be appropriate for touch-up in areas previously treated with herbicide.

If diver operated suction removal of milfoil is undertaken it will involve a considerable effort that will span much of the summer. Therefore, it is recommended that a qualified, experienced contractor be hired to manage and implement this work, including providing and operating / maintaining one or more boat-mounted suction units. It is not expected that water monitoring will be required or necessary in conjunction with this milfoil control measure but if it is this should be preformed by the LMD with appropriate oversight and local labor if possible.

Diver Hand Removal

Diver hand removal is recommended to be performed in areas of sparse milfoil infestation such as in North Silver Lake. An effort of five to ten days per season is recommended, based on levels of milfoil infestation. This work could be contracted out (included in herbicide application or diver suction removal contracts for ease of administration) or performed with local labor, if available. If this work is done with local labor, there should be a designated manager who will coordinate and direct this effort following the results of the herbicide or diver suction work. It is not expected that water monitoring will be needed for this effort.

Expected Environmental Impacts of Recommended Control Strategy

The recommended milfoil control efforts are expected to have no significant negative environmental impact on the lake environment, including the wetlands, groundwater or adjacent upland areas. This assumes that all in-lake treatment work will be performed following currently accepted protocols and regulatory requirements.

The herbicides recommended are very target-specific, especially the 2,4-D and triclopyr. This limits the potential impact to beneficial vegetation. The recommended herbicides have been thoroughly tested to determine their potential impact to fish, birds, animals (wildlife and pets) and to humans. At the label-described application , no effects to fish, birds, animals or humans is expected. The use of pre-treatment diver inspections allows for precise placement of herbicides and thus a control on the amount of chemical that is used at any one time. The use of systemic products further limits the amount of

chemical used because susceptible target plants do not re-grow if they receive a lethal dose of the chemical. Finally, each of the recommended herbicides has a limited life in the lake; these chemicals are broken down into harmless compounds by sunlight and microbial action.

Impacts from diver suction removal of milfoil are minimized because the divers direct the suction to individual target plants, avoiding other vegetation. While some sediment materials can be picked up with the suctioning and released with excess water near the lake surface, these materials generally settle fairly quickly back to the lake bottom and do not leave a long-term plume of turbidity. Re-suspension of sediment is also minimized by the fact that the divers actually lift the milfoil root wad up to the suction intake as opposed to placing the intake into the sediments to collect the milfoil roots. Due to the typically high cost of diver suction removal, this is seldom used for large-scale milfoil control, thus minimizing the aerial extent of the intrusion into the aquatic habitat. Diver hand removal of milfoil, as well, is not used for large-scale milfoil removal thereby minimizing lake habitat disruption.

The wetland areas are not expected to be impacted by milfoil control treatments because the treatments are focused on the lake and there are few opportunities for potentially degrading 'elements' (either chemicals or human disruption) to move into the wetlands. As indicated herein, the Silver Lake wetlands are vegetated primarily by grasses and grass-like plants which are not susceptible to either 2,4-D or triclopyr.

SEPA Environmental Checklist

A State Environmental Policy Act (SEPA) Environmental Checklist has been prepared for the recommended control strategies and this is presented in **Appendix D**. This checklist should be reviewed for accuracy and submitted to the appropriate agencies and the public prior to initiating the project.

Monitoring and Evaluation

Continued monitoring of aquatic plant populations and lake quality will be necessary to help guide the implementation of desired control measures and to evaluate the effectiveness of these measures. Monitoring should focus on an annual submersed plant survey and periodic sampling/analysis of basic water quality parameters. The following is a recommended program which should become an integral part of the submersed plant control program. Estimated costs associated with this work are provided in the Costs section below.

In addition to the monitoring of conditions in the lake, a periodic re-evaluation of this IAVMP is recommended. This re-evaluation should include a review of the monitoring results and discussion of possible changes in the methods to be implemented. The discussion should involve participation of all interested groups including LMD Steering Committee, WDFW, WDOE and any other affected parties. Changes in the plan could be desired following changes in funding availability, regulatory changes, new or revised treatment techniques or other factors.

Aquatic Plant Surveillance and Mapping

This should include diver inspection of the lake's littoral area through boat tows (parallel to shore) and snorkeling / surface inspections (in between docks and in shallow areas). The combination of diver and

non-diver methods is necessary to expedite the complete coverage of the littoral areas. Information on milfoil presence and relative density should be collected and a map should be prepared (preferably using GPS / GIS technology due to its greater accuracy) and to build a historical record of conditions and responses. This survey should be performed at least once a year after plants have come up in the early summer (June). Secondary surveys performed late in the summer could provide additional information on the short-term effectiveness of treatments.

It is also recommended that surveys be performed periodically (every three to five years) to document the presence of native aquatic plant species. This effort is important to document the on-going health of the native species and the continued lack of adverse effects of the 2,4-D treatments.

If GPS / GIS mapping is desired (or required) for this surveillance, it will be necessary to contract with a consultant firm that has this capability, in addition to having experienced diver staff who can identify the range of plant species present. Again, due to the expected annual cost of this work, a competitive solicitation process will be necessary. It is recommended that this surveillance and mapping work be included in the solicitation for a treatment contractor but made an option so that applicator/diver only firms may respond as well as surveillance/mapping only firms. This will at least make the most of the cost of the public notices.

Herbicide Treatment Monitoring

Herbicide residue analysis of surface water (lake and stream) samples are only required, currently, for control projects funded by WDOE. For these efforts the monitoring results are reported to the US EPA as part of the NPDES permit compliance. However, monitoring of herbicide residues in the lake is highly recommended to be able to respond to concerns expressed by residents or visitors about the usability of the water or potential non-target impacts of the herbicide.

The minimum recommended program for this is to collect four depth-composited samples following each treatment. The first two samples should be collected the day after treatment, one sample from within a treated area and one sample outside (within 200 feet of) that treated area. Two additional samples should be collected from the same two locations four days after treatment. All samples would be submitted to an accredited laboratory for analysis on the day of collection. If more than one area is treated at the same time, the minimum sampling should be conducted at the largest treatment area.

All samples should be composites of the water column at the sampling location. This requires the use of a device that can determine the depth at a location and also a device that can be lowered into the water to collect samples at desired depths. Separate samples should be collected from the lower, middle and upper third of the water column and equal volumes of each placed in bottles provided by the analytical laboratory.

Sampling and analytical methods used will conform to the latest revision of the *Guidelines Establishing Test Procedures for the Analysis of Pollutants* contained in 40 CFR Part 136 or to the latest revision of the *Standard Methods for Examining Water and Wastewater* (APHA). In addition, sampling shall be performed by, or with oversight by, a qualified water quality specialist. Volunteer involvement in sampling and monitoring is encouraged and volunteer training is an important aspect of a public awareness program. Water sampling and analysis equipment must be made available; this should be discussed with Sewer District since they have performed monitoring work in the past and a cooperative effort should be investigated.

Water Quality Monitoring

It is strongly recommended that standard, routine water quality analyses be performed annually following treatment implementations. While the recommended control measures are not expected to have negative impacts, water quality data will allow for this to be documented.

This effort should consist of field data collection at regular depth intervals (i.e. every two meters) from the surface to the bottom of the same sites that herbicide residues are collected. Additional sites should be added so that data is obtained from representative areas within and outside of treated areas. Parameters to be determined in the field are temperature, dissolved oxygen, pH and conductivity (specific conductance). The Secchi Disk transparency should be determined at each site. If desired, water samples should be collected and submitted for laboratory analysis of total phosphorus and total nitrogen content. The nutrient testing will provide important indications of the overall productivity of the water bodies.

Project Costs

The milfoil controls described above focus on treating areas infested with Eurasian milfoil for three years and areas dominated by northern milfoil for five years. After that, it will be necessary to re-evaluate the presence of these invasive plants and the need for treatments. A summary of the anticipated costs associated with this survey, treatment, monitoring and public awareness project (2008 dollars) is provided in Table 9. Appendix E provides more detail of these costs. As indicated, the anticipated cost of a three-year Eurasian milfoil control program is $198,530. Assuming that a $75,000 WDOE Aquatic Weeds Management Fund grant would be available, the local cost of this three-year program would be $123,530, of which $19,230 is the estimated in-kind (non-cash) match. The anticipated cost of a five-year northern milfoil control program is $175,800. No grants are available for native nuisance plant control. The extent of these costs indicates that some local funding mechanism must be developed.

Local Funding Strategy

Funding can be a limiting factor in an organization's ability to effectively manage noxious aquatic weeds or other lake-wide problems. At this time, there are no known grant programs, aside from the WDOE Aquatic Weeds Management Fund, which provide financial assistance for the type of project outlined in this Plan. Therefore, it is recommended that the Silver Lake and North Silver Lake residents work together to form a special purpose taxing district. Examples of these include sewer and water districts, flood control districts and lake management districts. It is most likely that formation of a temporary (but renewable) lake management district (LMD) would suit the needs of the Silver Lake residents for milfoil control projects. Lake management districts are formed by local groups for specific, limited term projects and require a vote of all residents in the project area. Any taxing approved by the voters within the LMD operates through the County Auditor's office. Since the Silver Lake property owners have been working to form such an LMD to fund milfoil controls, it should suffice to say that this is a viable option but it can require a considerable effort to organize and educate the voters before a workable program is developed and approved by the voters.

Table 9. Summary of costs associated with initial milfoil control project implementation at Silver and North Silver Lakes, Spokane County, WA.

SUMMARY OF THREE-YEAR EWM CONTROL PROGRAM COSTS:

TOTAL COST FIRST YEAR EWM CONTROLS =	$	72,210.00
Expected 75% WDOE grant =	$	54,157.50
Total In-Kind contributions =	$	6,410.00
Required cash match =	$	11,642.50
TOTAL COST SECOND YEAR EWM CONTROLS =	$	66,310.00
Expected 75% WDOE grant =	$	20,842.50
Total In-Kind contributions =	$	6,410.00
Required cash match =	$	39,057.50
TOTAL COST THIRD YEAR EWM CONTROLS =	$	60,010.00
Expected 75% WDOE grant =	$	-
Total In-Kind contributions =	$	6,410.00
Required cash match =	$	53,600.00

TOTAL COST THREE YEARS =	$	198,530.00
MAX WDOE GRANT =	$	75,000.00
Required Local share =	$	123,530.00
Total In-Kind contributions =	$	19,230.00
TOTAL COST THREE YEARS EURASIAN WATERMILFOIL CONTROLS =	**$**	**104,300.00**

SUMMARY OF FIVE-YEAR NATIVE MILFOIL CONTROL PROGRAM COSTS:

AVERAGE COST PER YEAR NM CONTROLS =	$	35,160.00
Expected 75% WDOE grant =	$	-
Total In-Kind contributions =	$	-
Required funding =	$	35,160.00

TOTAL COST FIVE YEARS =	$	175,800.00
MAX WDOE GRANT =	$	-
Required Local share =	$	175,800.00
Total In-Kind contributions =	$	-

TOTAL COST FIVE YEARS NATIVE MILFOIL CONTROLS =	**$**	**175,800.00**
TOTAL ESTIMATED COST FOR 5-YEAR PROGRAM =	**$**	**280,100.00**

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