Lake Tapps

Integrated Aquatic Vegetation Management Plan

CASCADE WATER ALLIANCE

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June 2010

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LAKE TAPPS INTEGRATED AQUATIC VEGETATION MANAGEMENT PLAN

Prepared for:
Cascade Water Alliance
11400 SE 8th Street, Suite 440
Bellevue, WA 98004
(425) 453-0930
www.cascadewater.org

DRAFT

Prepared by:
Tetra Tech
1420 Fifth Avenue, Suite 550
Seattle, WA 98101
(206) 728-9655
www.ttsurfacewater.com

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Project Contacts:

Cascade Water Alliance
Jon Shimada, Capital Projects Director
Joe Mickelson, Operations Manager
Elaine Kraft, Intergovernmental and Communications Director

Lake Tapps Community Council
Charles Romeo, President

Aquatechnex, Inc
Terrance McNabb
Adam Kleven

Tetra Tech, Inc.
Harry Gibbons
Toni Pennington
Robert Plotnikoff
Eugene Welch

DRAFT

EXECUTIVE SUMMARY

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PROBLEM STATEMENT

The presence of the invasive aquatic plant, Eurasian watermilfoil (*Myriophyllum spicatum*), is common to many lakes throughout Washington and the Pacific Northwest. Dense growth of Eurasian watermilfoil in Lake Tapps, as other areas, limits recreation, navigation, disrupts natural water flow and impacts water quality. In particular, boating, swimming, fishing, and aesthetic enjoyment have been severely impacted by dense growth of Eurasian watermilfoil in Lake Tapps. To date, only winter water level drawdowns have been used to control plant growth by exposing weed beds to desiccation and cold conditions. This method of control; however, has resulted in marginal success and is not sufficient to reduce nuisance plant growth throughout the summer recreational season.

Cascade Water Alliance (CWA) acquired Lake Tapps from Puget Sound Energy (PSE) in December 2009. In addition to preserving the lake and maintaining recreational benefits for the community, CWA intends to use Lake Tapps as a municipal supply reservoir.

The purpose of the Lake Tapps Integrated Aquatic Vegetation Management Plan (IAVMP) is to develop a long-term strategy for CWA to eradicate Eurasian watermilfoil from Lake Tapps Reservoir to continue to improve existing beneficial and recreational uses and insure water quality to meet future water demands.

Figure 1. Dense growth of Eurasian watermilfoil in Lake Tapps.

MANAGEMENT GOALS

The primary goal of the Lake Tapps IAVMP is to provide CWA the tools and protocols to efficiently and effectively *eradicate* Eurasian watermilfoil from Lake Tapps. This IAVMP will also provide information to maximize the beneficial uses of Lake Tapps and to maintain long-term water quality for drinking water, recreation, fish and wildlife habitat, and aesthetics.

To achieve these goals, a multi-year, aggressive, and dedicated management strategy must include:

- Community buy-in and ownership of the management goals

- Aggressive treatment protocols in Year 1 with follow-up action in subsequent years as needed
- Diligent monitoring and hand removal of satellite populations
- Enforceable prevention measures
- Regular reviews of management options

PUBLIC INVOLVEMENT

Community Meetings

Public involvement was highly encouraged throughout the development of the Lake Tapps IVAMP. Three public meetings were held between March and June 2010 (Table 1). All meetings were well attended by the Lake Tapps Community Council[1], elected officials, and the media (Figure 2). At the first meeting, Tetra Tech staff provided an overview of the problems associated with invasive aquatic plants along with the pros and cons of various physical, biological, mechanical and chemical control methods. At the second meeting the treatment alternative and approaches were discussed. At the third meeting, the vegetation maps were presented, the technical recommended alternative for eradicating Eurasian watermilfoil from Lake Tapps, as well as strategy for the application of aquatic herbicides was presented. Announcements for public meetings and supporting materials (e.g., PowerPoint slides, newspaper articles) were posted on the CWA website (http://www.cascadewater.org/).

Table 1. Schedule for the Development and Implementation of the Lake Tapps IAVMP

	Feb '10	Mar '10	Apr '10	May '10	June '10	July '10	Aug '10
Vegetation Mapping					x		
Plant index						x	
Public Meetings		31st		11th	10th		
Materials for CWA Website/Newsletter			1st	x	x		
Apply Aquatic Plant & Algae Management Permit				x			
Draft IAVMP					x		
Final IAVMP					x		
Implement Year 1 Recommendations							x

[1] The Lake Tapps Community Council is made of the following property owner Associations: Driftwood Point, Snag Island, Tapps Island, Tacoma Point, Inlet Island, West Tapps Maintenance, and Church Lake.

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Figure 2. Three Public Meetings Were Held and PowerPoint Presentations Posted to CWA Website

WATERSHED AND LAKE FEATURES

Site Description

Lake Tapps is located in the in the Puyallup-White River Watershed near the cities of Bonney Lake and Auburn in eastern Pierce County, Washington. On December 18, 2009 Lake Tapps Reservoir was acquired from Puget Sound Energy (PSE) by Cascade Water Alliance (CWA). CWA represents a consortium of municipalities in the Puget Sound urban area whose objectives include addressing future water supply needs for the area. The acquisition of Lake Tapps includes all water rights, assets and existing facilities that will ultimately provide projected water demand in the Cascade service area for more than 50 years.

Physical Features

Lake Tapps has a surface area of 2,750 acres with the capacity to impound 46,700 acre-feet of water. The maximum depth is 80 feet with a mean depth of roughly 25 feet. The lake has around 45 miles of complex shoreline characterized by numerous islands and peninsulas. To form Lake Tapps, thirteen dikes were constructed around four existing lakes (Tapps, Kirtley, Crawford, and Church Lakes), explaining some of its shoreline complexity. Shoreline jurisdiction around the lake include: Urban, Natural Environment, Rural Residential, and Conservancy (City of Bonney Lake 1975).

Residential development largely surrounds Lake Tapps and the shoreline is characterized by extensive armoring with numerous private boat launches. Much of the littoral zone is characterized by cobble and gravel sediments bars.

Hydrologic Features

The reservoir was created in 1911 by diverting water from nearby White River via an 8 mile diversion flowline into the southeast side of the lake and water is released back to the White River on the northwest side of the lake (Figure 3). The White River is characterized by turbid glacial flour runoff from Mt. Rainier. Prior to 1986, no minimum instream flows were established for the White River, resulting in impacts to fisheries and water quality in the river. After 1986, the minimum instream flow was increased to 130 cfs, resulting in increased water clarity in Lake Tapps, and subsequently more prolific growth of Eurasian watermilfoil. In addition to being a new source of potable water, CWA will continue to improve river flows for endangered fisheries, make improvements to the Lake Tapps facilities, and provide recreational use of the lake.

From 1911 to 2004 the lake operated as a hydropower facility with water released back to the White River on the lake's west side (Figure 3). During much of this time, water flow in the 20.7 miles of White River between the diversion dam and tailrace was often reduced to 30 cfs, resulting in impacts to water quality and the native fisheries. This river reach is located on Muckleshoot Indian Tribe Reservation and, in 1986; PSE and the Tribe established a minimum instream flow of 130 cfs.

CWA continues to divert water from the White River to maintain recreational water levels in Lake Tapps (elevation 541.5 to 543 feet) from April 15 to October 31 per an existing agreement between PSE and the homeowners. During the winter, the lake is drawn down to 530 feet to facilitate control of nuisance vegetation and allow for dike maintenance. White River flows are now primarily determined by operations at Mud Mountain Dam (at RM 29.5) and the diversion dam that runs to Lake Tapps (at RM 24.3).

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In addition to being a new source of potable water, CWA will continue to improve river flows for endangered fisheries, make improvements to the Lake Tapps facilities, and provide recreational use of the lake.

This drawdown period is also used for dike repair work and to ensure that waves from severe winter storms do not overtop the reservoir's dikes.

In the future, CWA intends to divert water from the White River into Lake Tapps to supply municipal water. Operational elements of the Lake Tapps Reservoir Water Rights and Supply Project would require continued enhanced flow in the White River under the 2008 White River Management agreement with the Puyallup and Muckleshoot Indian Tribes and maintenance of recreational water levels consistent with the 2009 agreement with the Lake Tapps Community (CWA 2010).

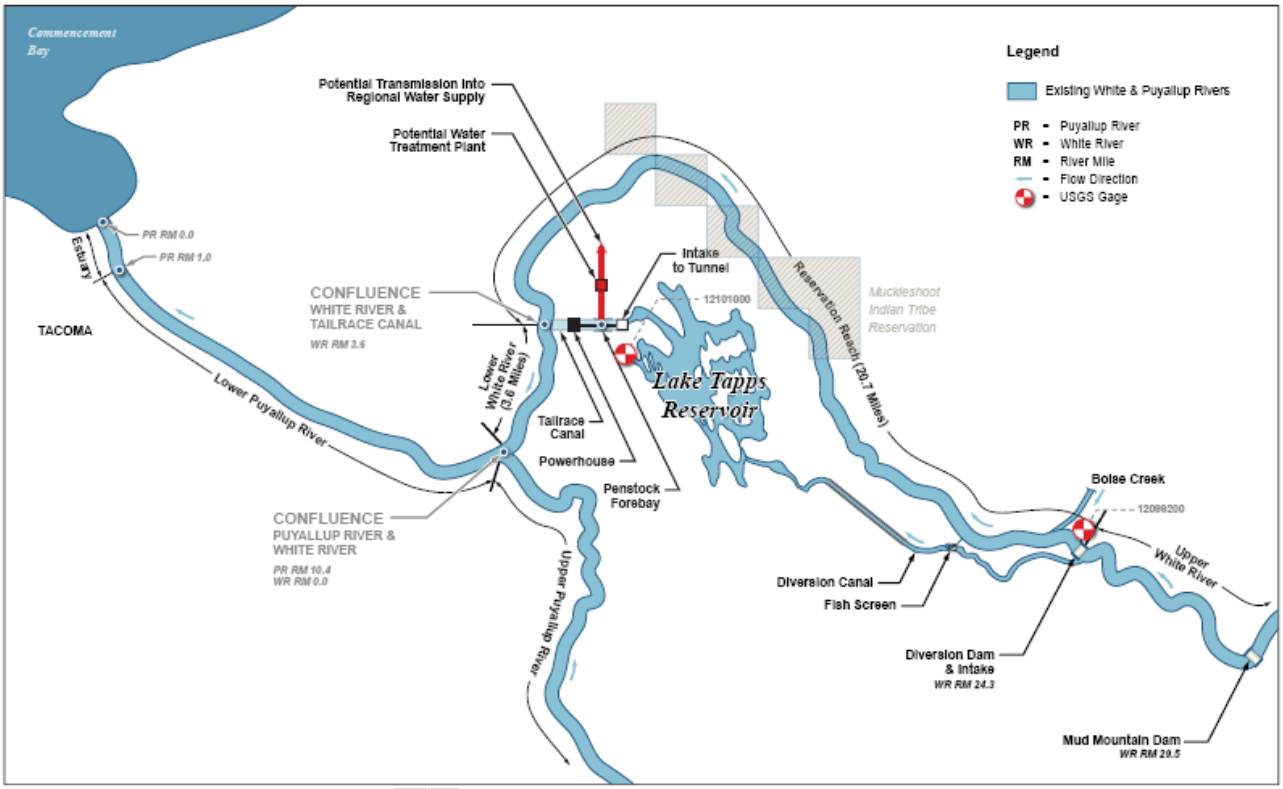

Figure 3. Stream Reaches of the White and Puyallup River (Source: Draft EIS: Lake Tapps Reservoir Water Rights and Supply Project, CWA, January 29, 2010).

Water Quality Features

The lake was intensively sampled by three entities (WDOE, Pierce County and the Muckleshoot Tribe) during 2004-2006. Prior to that there were only four sampling trips by Ecology; two in 1974 and one each in 1981 and 1997. The recent data show the lake to be of high quality and oligotrophic with summer mean concentrations of chlorophyll (chl) and total phosphorus (TP) at 2.3 and 8.4 µg/L, respectively. Boundaries for oligotrophy-mesotrophy are 3.5 and 9 µg/L.

Other constituents were reported by WDOE for 2004 and 2005 (Hallock, 2006). Total nitrogen averaged 65 µg/L and nitrate-N and soluble reactive P (SRP) were usually at or below detection in the epilimnion. Specific conductance ranged from 50 to 60 µS/cm and pH from 7.5 to 8.7.

Historically, Lake Tapps was operated for power production with associated large diversions of around 1,000 cfs from the White River, which carries a high suspended solids load. The average May-September diversion inflow during 1973-2003 was 932 cfs, which resulted in a water residence time of 0.107 years. Mean inflow TP concentration during 2004-2006 was 49 ± 60 µg/L.

Inflows were reduced in 2004-2006, averaging 159 cfs, which produced a residence time of 0.76 years. As a result of much less suspended solids and the nearly sevenfold decrease in residence time, summer Secchi transparency (SD) during 2004-2006 increased from a historical average of 1 m to 3.1 m. In fact, summer SDs in 2005 and 2006 were 3.7 (mean inflows of 108 and 86 cfs), while in 2004, with mean inflow at 284 cfs, summer SD was only 2 m. Thus, the large reduction in diversions, in favor of more water left in the river for salmon, produced much improved lake clarity, with no effect on algae, contrary to previous perceptions of the effects of reduced flushing. Moreover, SD was more dependent on chl than on the high suspended solids concentration, which had caused high non-algal turbidity. Whole lake, volume-weighted TP concentrations were lower, being about 10 µg/L in the two lowest inflow summers. Lower lake TP concentrations, due to longer settling time, were predictable from longer residence times, predicted from an scientifically recognized equation for TP retention.

Plankton algae were limited by P. Light was not limiting, because epilimnetic depth (i.e., mixing depth 6 m) was much less than the calculated depths (11-17 m) necessary to cause light to limit (i.e., critical depth; Welch and Jacoby, 2004). Moreover, algae (chl) did not increase with lower inflow and non-algal suspended matter (light had not limited), but remained at concentrations expected from TP (0.27 chl/TP - typical ratio is ~ 0.35).

The oligotrophic, high quality of Lake Tapps seems ideal for a drinking water supply. As a result of lower inflow volumes, SD was (2004-2006) at an expected depth due mainly to chl, which in turn was dependent on TP, and TP was lower than historical levels. However, there are no data on phytoplankton, which may cause problems at times in water supplies. While nuisance conditions produced by phytoplankton are usually rare in oligotrophic waters, they nonetheless can occur. With several years (at least three) of phytoplankton data, along with other pertinent chemical, physical and climatological data, a cause-effect understanding of the plankton could be developed. That understanding would be valuable to explain why a nuisance problem developed and how it could be controlled.

The water quality of Lake Tapps is largely characterized by the chemical attributes of the White River. Because it originates from the Emmons and Fryingpan Glaciers of Mount Rainier the river contributes significant bedload and suspended sediment load to the lake (Ecology 1999).

Biological Features

Bull and steelhead trout and coho, chum, pink, and Chinook salmon are native to the Puyallup-White River Watershed (NOAA 2003). In 1939, rotating drum fish screens were installed at the diversion dam (see Figure 3) to prevent downstream-migrating fishes from entering Lake Tapps. Fish species known to occur in Lake Tapps are listed in

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Table 2.

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Table 2. Fish Composition (excluding young-of-year) at Lake Tapps (Pierce County) (Sources: Mueller 1997, WDFW 2009).

Common carp (*Cyprinus carpio*)*	Black crappie (*Pomoxis nigromaculatus*)*
Kokanee (*Oncorhynchus nerka*)	Cutthroat trout (*Oncorhynchus clarki*)
Largescale sucker (*Catostomus macroheilus*)	Mountain whitefish (*Prosopium williamsoni*)
Rock bass (*Ambloplites repestris*)*	Rainbow trout (*Oncorhynchus mykiss*)
Smallmouth bass (*Micropterus dolomieu*)	Sculpin (*Cottus* sp.)
Tiger musky (*Esox masquinongy* × *E. lucius*)**	Red-side shiner (*Richarsonius blateatus*)
Yellow perch (*Perca flavescens*)*	Bluegill (*Lepomis macrochirus*)*

*Non-native
**Non-native hybrid

At least four native aquatic plants are present in Lake Tapps: Northern watermilfoil (*Myriophyllum sibiricum*), common elodea (*Elodea canadensis*), coontaill (*Ceratophyllum demersum*), and nitella (*Nitella* sp.). The Washington Department of Natural Resource (WDNR) Natural Heritage Program (WDNR 2010) does not indicate the occurrence of state or federally-listed plant species or high-quality native wetland plant communities within the project area (Appendix A).

Beneficial and Recreational Uses

Lake Tapps supports a variety of beneficial and recreational uses including boating, waterskiing, jet skiing, swimming, fishing, viewscapes of Mount Rainier, and residential development. Warm water fish species (largemouth bass, smallmouth bass, and yellow perch), rainbow trout, and tiger musky are popular sport fisheries at Lake Tapps (

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Table 2). There are two public parks with boat launches on the lake: Lake Tapps North and Allan Yorke Park, with numerous access points for other recreational activities such as picnic facilities, playgrounds, athletic fields, hike/bike trails, and golf (Figure 4). Most lake-users are waterfront property owners, homeowner association members, and residents from the Seattle metro area. The vast majority of the shoreline is developed with residential properties.

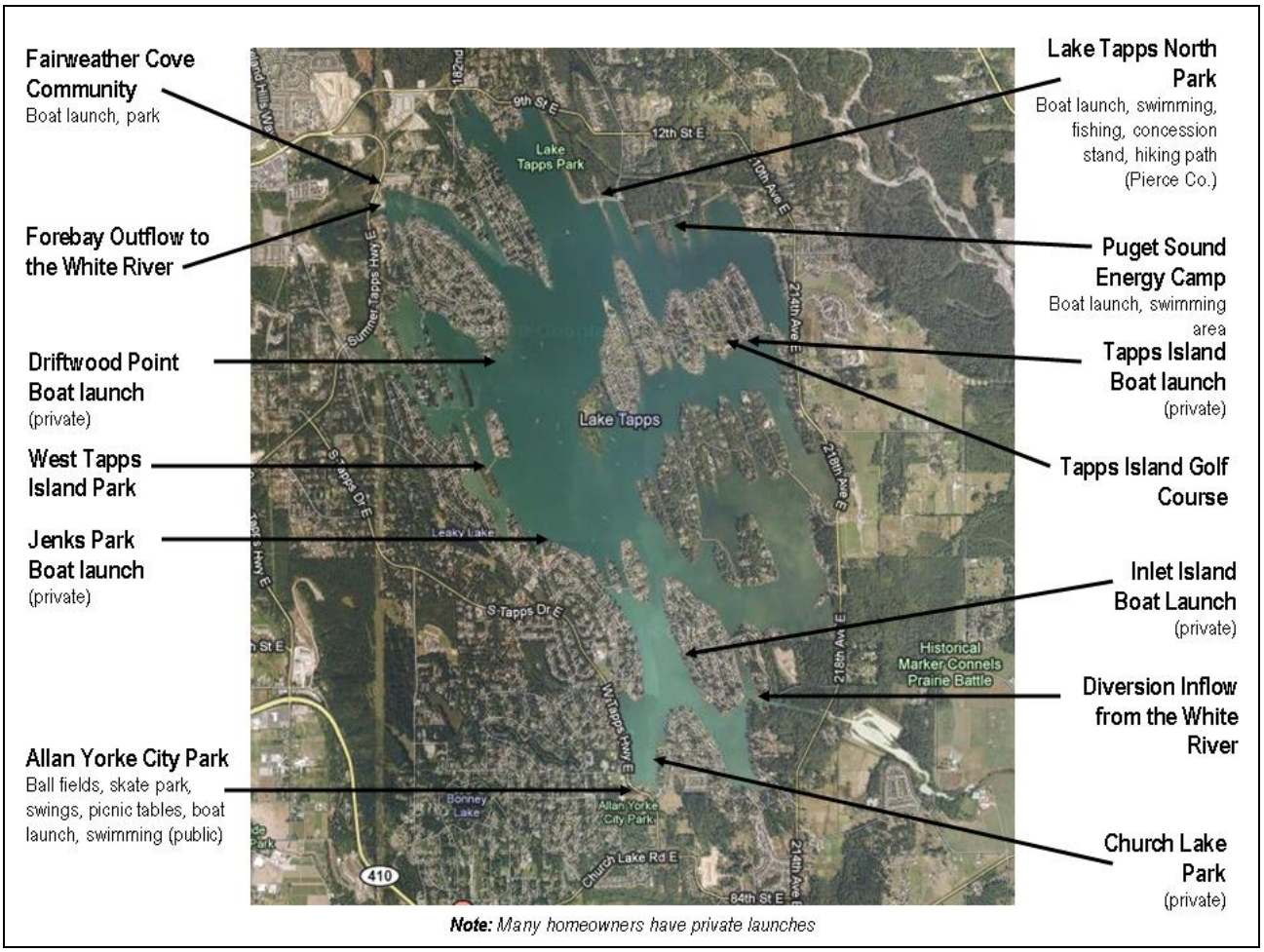

Figure 4. Aerial View of Lake Tapps with Beneficial Uses Identified (Base Map: Google Earth).

AQUATIC PLANT MAP

Dense growth of submersed aquatic plants typically occurs in waters less than approximately 20 feet deep. Lake Tapps is somewhat unique because the water is drawn down during the fall. The result is that, unlike natural lakes where spring plant growth is readily observed along the shoreline, vegetation in Lake Tapps is observed in deeper areas early in the growing season and

in more shallow water as the growth season continues. Figure 5 illustrates the 15 ft. contour at Lake Tapps and was used to estimate the area for potential plant growth. [MORE HERE AFTER PLANT INDEX AND DESCRIBE DISTRIBUTION].

Figure 5. Placeholder until plant index complete.

AQUATIC PLANT CHARACTERISTICS

Eurasian watermilfoil is the dominant aquatic plant species in Lake Tapps. Eurasian watermilfoil is a Class B Noxious Weed in Washington, meaning prevention and containment are the primary goals (WAC 16-750-04). Species are "designated" for control at the local level (by region). Eurasian watermilfoil is non-designated in Region 5 (which includes Pierce County). Eurasian watermilfoil dominates the littoral zone of Lake Tapps. [MORE HERE AFTER SURVEY, INCLUDING INFORMATION ON NATIVE PLANTS]. During a 1997 freshwater fish survey, it was determined that "…little, if any, submersed aquatic vegetation (an important source of food and shelter for most warmwater fish) was detected in Lake Tapps" (Mueller 1997).

Other invasive aquatic plants within the project vicinity that threaten Lake Tapps, include hydrilla *(Hydrilla verticillata*), Brazilian egeria (*Egeria densa*), fanwort (*Cabomba caroliniana*), grass-leaved arrowhead (*Sagittaria graminea*), and variable-leaf milfoil (*Myriophyllum heterophyllum*).

AQUATIC PLANT CONTROL ALTERNATIVES

Information on aquatic plant control alternatives were derived various sources including: Washington Department of Ecology (http://www.ecy.wa.gov/programs/wq/plants/management/index.html), *Biology and Control of Aquatic Plants: Best Management Practices Handbook* (Gettys et al. 2009), field-based experience of the authors, and peer or gray literature otherwise cited in the text.

The following sections outline the various methods to control aquatic plants, including: background information, advantages/disadvantages, permit information, costs, and a discussion of the method's appropriateness to Lake Tapps.

Environmental Manipulation

Water Level Control

Lowering the water level, also known as drawdown, exposes plant stems and other plant propagules to freezing and drying conditions over a prolonged period of time. This may only be used where water levels can be controlled by a dam, siphoning, or pumping and where impacts to native plant and animal species are limited. In same cases, water level controls may already be incorporated into routine maintenance plans (e.g., dock or embankment repair).

Advantages

Provided that the infrastructure exists, water level control it is typically a relatively inexpensive method to control unwanted aquatic vegetation. This is particularly true for species that primarily spread by vegetative propagules that are particularly vulnerable to prolonged desiccation and/or freezing.

Disadvantages

In western Washington, where the temperate climate is buffered by Puget Sound, control of nuisance aquatic plant growth has been less consistent compared to other regions where the winter temperatures are lower and there is less precipitation. Additionally, repeated water level drawdowns can result in sediment compaction that may limit the growth of invasive as well as non-native plant species and can be detrimental to fish spawning habitat. In fact, water level drawdowns can actually promote the growth of invasive plant species due to loss of competitive vigor by native plant species.

Permits

Not Applicable

Costs

Again, provided the infrastructure is in place, the cost of altering water levels is relatively inexpensive. However, where applicable, there may be less direct costs associated with loss of hydropower generation, recreational revenue, or real estate values.

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Appropriateness to Lake Tapps

As previously mentioned (see Hydrologic Features), the existing diversion dam from the White River and former hydropower dam allow for the control of water levels in Lake Tapps. Water level control has been used at Lake Tapps to control Eurasian watermilfoil by reducing from the summer recreational levels (between 542 and 543 feet) to approximately 530 feet during the winter. As with other western Washington reservoirs, this strategy has likely reduced the late spring/early summer growth of Eurasian watermilfoil that may be observed in natural lakes, it has not resulted in substantial declines in milfoil across the lake by the end of summer. The use of water level control in cooperation with other control methods, however, may decrease the cost and time associated controlling invasive aquatic plants.

Biocontrol Methods

Biological control is the intentional use of natural enemies such as fish, insects, or disease-causing pathogens to reduce the biomass of a specific nuisance species. Ideally, the agent will be species-specific, attacking a single organism (Gettys et al. 2009). Biocontrol agents are often imported from its native range after extensive research and after approval by the U.S. Department of Agriculture (USDA). In some circumstances, biocontrol agents are native and shift their feeding preference from a native species to a closely related non-native species. Some factors that determine the success of a biocontrol agent include: environmental conditions, food preference, food quality, and stocking rate.

Grass Carp

Grass carp or white amur (*Ctenopharyngodon idella* Val.) are exotic, plant consuming fish native to large rivers of China and Siberia. Known for their high growth rates and wide range of plant food preference, these fish can control certain nuisance aquatic plants under the right circumstances. Grass carp are most appropriately used for lake-wide, low-intensity control of submersed plants. Stocking rates and control success are dependent on climate, water temperature, salinity, dissolved oxygen content in the water, and type and extent of plant species.

Control Effectiveness and Duration

Effectiveness of grass carp in controlling aquatic weeds depends on feeding preferences, metabolism, temperature, and stocking rates (Sanders et al. 1991, WDOE, 1992; Cooke et. al., 1993). Triploid grass carp exhibit distinct food preferences which can vary from region to region in the U.S. Recent laboratory and field studies in Washington State have shown that some plant species appear to be highly preferred such as the pondweeds, (e.g. *Potamogeton crispus*, *P. pectinatus* and *P. zosteriformis*); others were variably preferred such as coontaill (*Ceratophyllum demersum*) and Brazilian elodea (*Egeria densa*), and some plants not preferred such as watershield (*Brasenia schreberi*) and cattail (*Typha* spp.). The effectiveness and duration of control by grass carp is site-specific. In general, management studies in Washington waters indicate that substantial removal of vegetation by sterile grass carp may not become apparent until 2-5 years after introduction. The duration of aquatic plant control by grass carp is typically 10 years, depending on the age of stocking; however, they are known to survive up to 25 years and are not easily removed after stocking (Gettys et al. 2009).

Advantages

Depending on the problem plant species and other site constraints previously described, proper use of grass carp can achieve long-term reductions in nuisance growth of vegetation. In some cases, introduction of grass carp results in improved water quality conditions (e.g., nitrogen,

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phosphorus, chlorophyll, dissolved oxygen) and biological condition (phytoplankton, zooplankton, benthic invertebrates) (Thomas et. al., 1990, KCM 1997). Compared to other long-term aquatic plant control techniques (e.g., bottom tillage, bottom barriers), costs for grass carp implantation are relatively low.

Disadvantages

Since sterile grass carp exhibit distinct food preferences, they do not graze all plants equally well, limiting their applicability. The fish may avoid areas of the water body experiencing heavy recreational use, resulting in less plant removal. Plant reductions may not become evident for several years. Mature waterlilies (*Nuphar* and *Nymphaea* spp.) do not appear to be effectively grazed by grass carp. While the invasive Eurasian watermilfoil (*Myriophyllum spicatum*) is apparently not a highly preferred food type, especially where other edible native plants are available, effective grazing on milfoil has been demonstrated in the Northwest several years after implantation (Gibbons and Gibbons, unpublished data, 1994). Overstocking of grass carp could result in eradication of beneficial plants and have serious impacts on the overall ecology of the water body. An escape barrier on the outlet (if present) is required to prevent movement of fish out of the system and avoid impacts on downstream aquatic ecosystems. There may be fish loss due to predation, especially by ospreys and otters.

Costs

The Washington Department of Fish and Wildlife determines the appropriate stocking rate for each waterbody when they issue the grass carp stocking permit. Stocking rates for Washington lakes generally range from 9 fish per vegetated acre up to 25 fish per vegetated acre (based on 8 to 11 inch fish). This number will depend on the amount and type of plants in the lake as well as spring and summer water temperatures. However, Fish and Wildlife generally err on the side of stocking the least amount of grass carp as possible.

Based on the few large-scale grass carp implantations made in the State of Washington since 1990, costs can range from approximately $50/acre to $2000/acre, depending on stocking rates (range $5/fish to $20/fish, depending on delivery method and quantity purchased).

Permits

Grass carp stocking in a private waterbody requires a stocking permit from the Washington Department of Fish and Wildlife (WDFW). The stocking permit is a two-step process involving the submission of an Application for Planting Triploid Grass Carp and a Fish Transport Application. Department of Natural Resources Natural Heritage Program must be contacted for assessment of threatened or endangered plant species. If requested by WDFW, a State Environmental Policy Act (SEPA) Grass Carp Checklist may be required with the stocking permit. Stocking grass carp in a public waterbody also requires a Washington Department of Ecology (Ecology) – approved Integrated Aquatic Vegetation Management Plan.

If the waterbody (public or private) flows to another body of water, the outflow must be screened which requires Hydraulic Project Approval (HPA) from WDFW. To obtain HPA, a Joint Aquatic Resources Project Approval (JARPA) will need to be completed. These documents may be downloaded at: http://www.wdfw.wa.gov/fish/trnsport.htm

For approval of all grass carp permits, WDFW regulations require that:

1) Only sterile (triploid) fish can be planted
2) All grass carp be certified disease free

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3) Outlets (and possibly inlets) must be screened to prevent fish from getting into other water bodies
4) Stocking rate will be defined by WDFW based on the current planting model.

Appropriateness to Lake Tapps

The use of grass carp is unlikely a viable control method for Lake Tapps due to ESA fisheries issues from both tribe and WDFW.

Watermilfoil Weevil

The milfoil weevil, *Euhrychiopsis lecontei*, is a small, herbivorous aquatic beetle, belonging to the family Curculionidae. It is native to the northern U.S., including Washington, and feeds exclusively on aquatic plants in the genus *Myriophyllum.* It is often associated with the native milfoil (*M. sibericum*), however research indicates that in the presence of both the native and non-native (*M. spicatum*) milfoil, the weevil prefers feeding on the non-native, explaining the interest in using it as a biocontrol agent. Research on the weevil has been conducted in Illinois, Minnesota, Vermont, Washington and Wisconsin as a potential biocontrol for Eurasian watermilfoil. In 1989, state biologists in Vermont reported that Eurasian watermilfoil in Brownington Pond had declined from approximately 10 hectares (in 1986) to less than 0.5 hectares. Studies in Minnesota, Vermont, Ohio and Wisconsin suggest that at least 1.5 to 2 weevils per stem is needed to control Eurasian watermilfoil (Newman and Biesboer 2000).

Advantages

Although a successful biological control agent rarely eradicates a problem species, it can reduce populations substantially, allowing native species to return. Used in an integrated approach with other control techniques, biological agents can stress target plants making them more susceptible to other control methods. Generally agreeable to public,

Disadvantages

To date, there have not been any documented declines of Eurasian watermilfoil in Washington State that can be attributed to 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. Researchers in Minnesota have suggested that sunfish predation may be limiting weevil densities in some lakes (Sutter and Newman 1997). The latter may be true for Washington State as sunfish populations are present in many lakes in the state, including those with weevils. In addition, other environmental factors that may be keeping weevil populations in check in Washington, but have yet to be studied, include over-wintering survival and habitat quality and quantity (Jester et. al. 1997; Tamayo and Grue 2004). Although the milfoil weevil shows potential as a biological control for Eurasian watermilfoil more work is needed to determine which factors limit weevil densities and what lakes are suitable candidates for weevil treatments in order to implement a cost and control effective program.

Permits

The milfoil weevil is native to Washington lakes and rivers (more often in eastern Washington lakes and more alkaline waters; however, it is also present in cooler, wetter western Washington). It is found associated with both native northern milfoil and Eurasian watermilfoil. A company sells milfoil weevils. However, to import these out-of-state weevils into Washington requires a permit from the Washington Department of Agriculture. As of December 2009 no permits have been issued for Washington.

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Costs

The costs for researchers to locate, culture, and test biocontrol agents is high. Once approved for use, insects can sell for $1.00 or more per insect. Sometimes it is possible to establish nurseries where weed specialists can collect insects for reestablishment elsewhere.

Appropriateness to Lake Tapps

The use of milfoil weevils is unlikely a viable control method for Lake Tapps due to permitting issues for importing weevils from out-of-state commercial suppliers and because they will not meet the eradication goal.

Manual Control Methods

Bottom Barrier Application

Barrier material is applied over the lake bottom to prevent plants from growing up through the water column. Bottom covering materials such as sand-gravel, polyethylene, polypropylene, synthetic rubber, burlap, fiberglass screens, woven polyester, or nylon film have all been used with varying degrees of success. Applications can be made up to any depth, with divers often utilized for deeper water treatments. Usually bottom conditions (presence of rocks or debris) do not impede most barrier applications, although pre-treatment clearing of the site is often useful.

Control Effectiveness and Duration

Bottom barriers can provide immediate removal of nuisance plant conditions upon placement. Duration of control is dependent on a variety of factors, including type of material used, application techniques, and sediment composition. Elimination of nuisance plant conditions for at least the season of application has been demonstrated by synthetic materials like Aquascreen and Texel. Where short-term control is desired for the least expense, burlap has been found to provide up to four years of relief from problematic growth before eventually decomposing. After satisfactory control has been achieved (usually several months), some barrier materials can be relocated to other areas to increase benefits.

Advantages

Bottom barriers can usually be easily applied to small, confined areas such as around docks, moorages or beaches. They can be hidden from view and do not interfere with shoreline use. Bottom barriers do not result in significant production of plant fragments (critical for milfoil treatment). Bottom barriers are most appropriately used for localized, small-scale control where exclusion of all plants is desirable; where other control technologies cannot be used; and where intensive control is required regardless of cost. The Washington Department of Fish and Wildlife (WDFW) created a pamphlet to allow for the Hydraulic Project Approval (HPA) and expedite the HPA process for limited control of nuisance aquatic vegetation. A copy of the pamphlet may be found online at: http://www.wdfw.wa.gov/hab/aquaplnt/aquaplnt.pdf

Disadvantages

Depending on the material, substantial drawbacks to the application of bottom barriers include some or all of the following: high materials cost, labor-intensive installation, limited material durability, possible suspension due to water movements or gas accumulation beneath covers, or regrowth of plants from above or below the material. Periodic maintenance of bottom barrier materials is required to remove accumulations of silt and any rooting fragments. In some situations, removal and relocation of barriers may not be possible (e.g., natural fiber burlap

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decomposes over time). Sediment covers can also produce localized depression in populations of bottom-dwelling organisms like aquatic insects.

Costs

Barrier materials cost $0.22 to $1.25 per square foot. The cost of some commercial barriers includes an installation fee. Commercial installation costs vary depending on sediment characteristics and type of bottom screen selected. It costs up to about $750 to have 1,000 square feet of bottom screen installed. Maintenance costs for a waterfront lot are about $120 each year.

Permits

Bottom barrier applications require Hydraulic Project Approval (HPA) from WDFW (no charge).

Hand-Pulling

Hand-pulling and removal of rooted, submerged plants is an intensive treatment option. This method involves digging out the entire plant (stem and roots) with a spade of long knife and disposing residue on shore. In shallow waters less than 3 feet, no specialized gear is required. In deeper waters, hand removal can best be accomplished by divers using SCUBA equipment and Sea Sprints or similar devices to increase mobility.

Control Effectiveness and Duration

Efficacy of plant removal depends on sediment type, visibility, and thoroughness in removing the entire plant, particularly the roots. A high degree of control over more than one season is possible where complete removal has been achieved.

Advantages

The technique results in immediate clearing of the water column of nuisance plants. The technique is very selective in that individual plants are removed. It is most useful in sensitive areas where disruption must be kept to a minimum. Because the technique is highly labor-intensive, it is most appropriate for small-area, low plant density treatments. In these cases, the technique is very useful for aggressive control of sparse or small pockets of Eurasian watermilfoil. This method can also be useful for clearing pondweeds or very small patches of water lilies from areas around docks and beaches.

Disadvantages

The technique is time-consuming and can be costly especially where contract divers are used. Diver visibility may become obscured by turbidity generated by swimming and digging activities. Also, it may be difficult for the laborer to see and dig out all plant roots. Environmental impacts are limited to mostly short-term and localized turbidity increases in the overlying water and some bottom disruption.

Costs

Costs will vary depending on whether contract divers or laborers are used, or if removal activities are the result of volunteer efforts. In the case of contract divers and dive tenders, expenses can run upward of $1,600 to $3,800/day with area covered dependent on height and density of plants.

Permits

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No state permits are currently required for hand-pulling aquatic plants. However, local (King County) shoreline permits may be required.

Hand-Cutting

This technique is also a manual method, but differs from hand-digging in that plants are cut below the water surface (roots generally not removed). Because roots are not removed, this is a less intensive removal technique. Implements used include scythes, rakes, or other specialized devices that can be pulled through the weed beds from shoreline or dock or by boat. Mechanized weed cutters are also available that can be operated from the surface for small-scale control.

Control Effectiveness and Duration

Root systems and lower stems are often left intact. As a result, effectiveness is usually short-term as regrowth is possible from the uncut root masses. Duration of control is limited to the time it takes the plant to grow to the surface

Advantages

The technique results in immediate removal of nuisance submerged plant growth. Costs can be minimal.

Disadvantages

Like hand-pulling, the technique is time-consuming. Visibility may become obscured by turbidity generated by cutting activities. Also, since the entire plant is usually not removed, this technique does not result in long-term reductions in growth. Environmental impacts are limited to mostly short-term and localized turbidity increases in the overlying water and some bottom disruption. Cut plants must be removed from the water.

Costs

Where volunteer efforts are employed, costs are mostly limited to purchase of a cutting implement. This can vary from under $200 for the Aqua Wee Cutter (Sunrise Corp.) to over $1000 for the mechanized Swordfish (Redwing Products).

Permits

No permits are required for hand-cutting. It is advisable to check with the local jurisdiction before beginning any aquatic plant-cutting activities.

Raking

Raking is an effective aquatic plant removal technique that tears plants from the sediment, breaking some plants off and removing some roots as well. Attaching a rope to the rake allows a greater reach of plant removal in the waterbody. The rake should be pulled toward the shore to collect and dispose of plants, as weeds left in the waterbody could potentially reseed and gives off nutrients in the lake.

Advantages

The technique results in immediate removal of nuisance submerged plant growth. Costs can be minimal.

Disadvantages

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Similar to other manual plant removal methods, the raking method is time consuming and labor intensive. Another disadvantage of this method is that as the cleared plants regrow this method may have to be implemented several times throughout the summer.

Permits

No permits are required for raking of aquatic plants. It is advisable to check with the local jurisdiction (e.g. King County) before beginning any aquatic plant-cutting activities.

Costs

A commercial rake costs about $95 to $125 and a homemade weed rake costs about $85 (asphalt rake is about $75 and the rope costs 35-75 cents per foot). (Aquatic Plant Management, Dept. of Ecology)

Mechanical Control Methods

Rotovation

This mechanical removal technique involves highly specialized large aquatic rototillers which uproot Eurasian watermilfoil plants. The rotovation blades reach seven to nine inches deep into the lake or river bottom and uproot plants and roots which are removed by weed raking.

Control Effectiveness and Duration

Rotovation can be used year-round as a mechanical control in certain waterbodies, but is most effective in winter and spring when the plants have died back. Rotovation can remove two to three acres of plant material per day and studies have shown effective control up to two growing seasons after a rotovation.

Advantages

This mechanical control method effectively removes the entire plant and treatments decrease/control plant density for two growing seasons. Rotovation can also be used year-round in certain waterbodies if the permit allows and rotovation can stimulate the growth of native aquatic plants.

Disadvantages

Disadvantages of this mechanical control method is its difficulty to maneuver, high cost for maintenance and operation, labor intensive effort and it may increase the spread of invasive weeds such as milfoil. Underwater utilities, such as gas, water, sewer, telephone or water intake pipes, need to be located before rotovation begins

Costs

Costs for a private contractor to harvest plants, remove obstacles, rototill, and collect and dispose of plants range from $1,500 to $2,000 per acre. As plant density decreases and obstacles are removed, costs and time needed to rotovate each acre will decrease.

Permits

Requires a hydraulic approval from the Washington Department of Fish and Wildlife, a shoreline permit from the local jurisdiction (city/county) may be needed and this could take up to six months to acquire, and a Section 404 permit from the Army Corp of Engineers may be required.

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Mechanical Harvesting

Mechanical harvesting use large machines that cut and collect aquatic plant and remove plants by a conveyer belt system for plant disposal. Harvesting occurs in late spring, summer, and early fall when plants are close to the water's surface. This machinery can remove several acres of plants per day and the typical speeds range from 0.5 to 1.5 acres per hour. Due to the large size and high cost of the harvester this type of aquatic plant removal system is ideal for lakes larger than a few acres. Conventional single-stage harvesters combine cutting, collecting, storing and transporting cut vegetation into one piece of machinery. Cutting machines are also available which perform only the cutting function. Maximum cutting depths for harvesters and cutting machines range from 5 to 8.2 ft with a swath width of 6.5 to 12.1 ft. Cooke et al. (1993) summarizes aquatic plant cutters and harvesters available in North America.

Advantages

Since harvesting involves physical removal and disposal of vegetation from the water, the immediate effectiveness in creating open water areas is quite apparent. Harvesting immediately clears aquatic plants and creates open areas of water for recreation and fishing access. Harvesting also has the added benefit that removal of in-lake plant biomass also eliminates a possible source of nutrients often released during fall dieback and decay. This is important in those water bodies with extensive plant beds and low nutrient inputs from outside sources. Furthermore, harvesting can reduce sediment accumulation by removing plant organic matter that would typically decay and add to the bottom sediments. Depending on species content, harvested vegetation can be easily composted and used as a soil amendment. Mechanical harvesting costs can be relatively low compared to other physical/mechanical techniques.

Disadvantages

Mechanical harvesting is essentially a mowing operation removing upper stem material, and duration of control is variable. Factors such as target plant type, frequency and timing of harvest, water depth, and depth of cut can influence duration of control. Harvesting has not proven to be an effective means of sustaining long-term reductions in growth of milfoil. Regrowth of milfoil to pre-harvest levels typically occurs within 30 to 60 days (Perkins and Sytsma, 1987), depending on water depth and the depth of cut. Significant disadvantages of harvesting are the high cost for the equipment as well as the cost to operate and maintain the harvester. Harvesting needs to occur several times during the growing season and plant fragments left behind by the harvester may increase the spread of invasive species in the lake. Another drawback of the harvester is the collection of many small fish, invertebrates, and amphibians. Harvesters should be used in large lakes greater than a few acres and are not suitable for smaller or very shallow lakes (3-5 feet of water). Harvesting is not appropriate for smaller waterbodies or those with man surface obstructions. There is usually little interference with use of water body during harvesting operations. Cut plant material requires collection and removal from the water. Harvesting creates plant fragments. Eurasian watermilfoil can rapidly disperse and regrow by stem breakage. Thus, if plant control program objectives involve reduction of milfoil spread in the system, harvesting would not be an appropriate large-scale technique. Harvesting can be detrimental to non-target plants and animals (e.g., fish, invertebrates) associated with plant beds, which are removed indiscriminately by the process. Harvesting can lead to enhancement of growth of opportunistic plant species that may invade treated areas.

Permits

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Harvesting in Washington requires hydraulic approval from the Department of Fish and Wildlife. Because harvesting collects fish along with aquatic plants, some additional monitoring may be required when harvesting in salmon bearing waters, or a permit may be denied.

Costs

Harvesting program costs depend on factors such as program scale, composition and density of vegetation, equipment used, skill of personnel, and site-specific constraints. Detailed costs are not uniformly reported, so comparing projects costs of one program with another can be difficult. Costs as low as $250 per acre have been reported. Private contractors generally charge $500 to $800 per acre. The purchase price of harvesters ranges from $35,000 to $110,000. There are several harvester manufacturers in the United States and some lake groups may choose to operate and purchase their own machinery rather than contracting for these services.

Appropriateness to Lake Tapps

Because eradication of Eurasian watermilfoil is the objective at Lake Tapps, use of mechanical harvesting is not considered an appropriate control method.

Driver-Assisted Suction

Diver-assisted suction is specifically used for the removal of Eurasian watermilfoil. SCUBA divers use hoses that are attached to small dredges to suck up plant material which are pumped to the water surface for disposal. The suction dredging removes all parts of the plant including the roots. This method will remove approximately 0.25 to 1 acre per day depending on the plant density, sediment type and the efficiency of the diver.

Control Effectiveness and Duration

An exemplary diver suction dredging of Eurasian watermilfoil in Western Washington's Silver Lake, Everett removed 80 percent of the plant population over two years. Diver dredging is an effective control method for Eurasian watermilfoil but less effective for plants where seeds, turions, or tubers remain in the sediments to sprout in the next growing season.

Advantages

Diver dredging is an effective aquatic plant removal method around docks and other difficult areas to reach by large equipment and is safe for the environment.

Disadvantages

Some disadvantages of the diver dredging method include its expensive cost and permitting may take years to acquire. Also this method stirs up sediment, which can lead to the release of nutrients or toxins in the sediment to enter the water column

Costs

Depending on the density of the plants, specific equipment used, and disposal requirements, costs can range from a minimum of $1,500 to $2,000 per day.

Permits

Diver dredging requires hydraulic approval from the Department of Fish and Wildlife and may require a Section 404 permit from the U.S. Army Corps of Engineers. Check with your city or county for any local requirements before proceeding with a diver dredging project.

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Hydraulic (Suction Dredging)

This is an intensive technique that involves removal of littoral sediments and associated rooted aquatic plants using hydraulic dredging equipment. Lake sediment removal is most often performed by means of a cutter-head hydraulic pipeline dredge (Cooke et. Al., 1993). In terms of operation, plants/sediment loosened by the cutter head travels to the pickup head. The slurry is then suctioned up and carried back to the dredge barge through hoses. The sediment slurry is then piped off-site for disposal.

Control Effectiveness and Duration

Large-scale sediment removal techniques can often provide multiple benefits to an aquatic system (Cooke et. al., 1993). Depending on the waterbody, possible enhancements include not only rooted macrophyte control, but also increased depth, and removal of nutrients or toxic substances. Efficiency of removal is dependent on equipment, sediment type and condition, with conventional dredges performing well on harder sediment. However, various types of portable hydraulic dredges are available in the U.S. that are more effective for small lakes with softer, flocculent substrate. Longevity of control is dependent on a number of factors including sedimentation rate (the lower the better), watershed-to-surface-area ratios (nominally 10:1), and hydraulic residence time (the longer the better).

Advantages

Dredging removes entire plants, including root systems, so regrowth is minimized. Plant pieces are collected and retained, and fragmentation spread is minimized (very important for control of milfoil). It can be used to cover areas larger than practicable for diver-operated dredging or diver hand removal, or where herbicides cannot be used. Human health and safety concerns are negligible where operations are conducted prudently.

Disadvantages

Hydraulic dredging is very expensive and highly disruptive to the local environment. A major problem often involves finding suitable offsite disposal areas and transporting dredged materials to these sites. As a result, more specialized equipment and materials are required and the process can be much more costly. Short-term environmental effects include resuspension of sediments and localized turbidity increases in the area of treatment. Release of nutrients and other contaminants from enriched sediments can also be a problem. In addition, some non-target aquatic organisms and vegetation may be inadvertently removed during the process. However, if only a portion of the lake bed is dredged, impacts on benthic aquatic life should be short-lived (Cooke et. al., 1993).

Costs

Dredging costs can be very variable, depending on density and volume of sediment removed, equipment condition, transport requirements of dredged material, and eventual use of dredged material (Cook et. al., 1993) Hydraulic dredging costs typically range from a minimum of $\$2.25/m^3$ to $\$6/m^3$, although figures as high as $\$20$ to $\$50/m^3$ have been reported for special cases.

Permits

Use of suction dredging does require hydraulic approval from the Washington State Department of Fish and Wildlife. Its use also requires a temporary modification of water quality standards from Ecology for increased turbidity. A local shoreline management permit may be needed. In addition,

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it will be necessary to obtain a letter of approval from the Washington State Department of Natural Resources.

Chemical Control Methods

Chemical control of invasive aquatic plants involves the application of U.S. Environmental Protection Agency (EPA) and Washington Department of Ecology (Ecology) - approved products specifically formulated for applications in or around water. Aquatic herbicides are sprayed directly onto floating or emergent aquatic plants or are applied to the water in either a liquid or granular form. Systemic herbicides are capable of killing the entire plant. Contact herbicides cause the parts of the plant in contact with the herbicide to die back, leaving the roots alive and able to regrow. Non-selective, broad spectrum herbicides will generally affect all plants that they come in contact with. Selective herbicides will affect only some plants (often dicots - broad leafed plants like Eurasian watermilfoil will be affected by selective herbicides whereas monocots like Brazilian elodea (*Egeria densa*) may not be affected). Most aquatic plants are monocots.

Approved Herbicides

Table 3 lists some of the aquatic herbicides approved by the U.S. EPA and Ecology for use in controlling Eurasian watermilfoil in Washington. Also included are the trade names under which these products are sold, its mode of action (e.g., systemic or contact), information about its selectivity, some considerations, and water use restrictions. See Appendix B to view the herbicide specimen labels.

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Table 3. Aquatic Herbicides Approved for Use in Washington to Control Eurasian Watermilfoil

Active Ingredient	Trade Names (G) = granular (L) = liquid	Systemic/ Contact	Selectivity	Management Uses and Considerations	Label Water Use Restrictions and Advisories (Ecology)			
					Drinking	Swimming	Fish	Irrigation
2,4-D (butoxy-ethyl-ester [BEE])	Navigate® (G) Aqua-Kleen® (G)	Systemic	Selective for broad-leaved plants (e.g., milfoil); fast-acting; destroys entire plant	Appropriate for spot treatments; may selectively control native plants at label rate; liquid formulation more effective	2,4-D concentration must be < 70 ppb	Restriction (Ecology) during treatment and 24 hr post-treatment	Granular may not be used in waters with threatened/ endangered salmon	2,4-D concentration must be < 100 ppb
2,4-D (dimethylamine salt [DMA])	DMA*4IVM® (L)	Systemic	Selective for broad-leaved plants (e.g., milfoil); fast-acting; destroys entire plant	Appropriate for spot treatments; may selectively control native plants at label rate; liquid formulation more effective		Advisory (Ecology) during treatment and 24 hr post-treatment		
Endothall (dipotassium salt)	Aquathol® K (L) Aquathol® Super K (G)	Contact	Non-selective; fast-acting; destroys vegetative portion of plant	Short-term control; appropriate for spot treatment	7-25 days	Advisory (Ecology) during treatment and 24 hr post-treatment	3-days	14 days
Fluridone	Sonar® AS (L) Avast!® (L) Sonar®PR (G) Sonar®QR (G)	Systemic	Non-selective; slow acting	Appropriate for areas of low water exchange; used for whole-lake treatment or in isolated bays; not appropriate for spot treatment < 5 acres		No		30 days
Triclopyr (triethylamine [TEA] salt)*	Renovate® 3 (L)	Systemic	Selective for broad-leaved plants; fast acting; destroys entire plant	Appropriate for spot and whole-lake treatments		Advisory (Ecology) during treatment and 12 hr post-treatment		Not for irrigation for 120 days or until <1 ppb (Label^)
Diquat	Reward® (L)	Contact	Non-selective; fast-acting; destroys vegetative portion of plant	Short-term control; appropriate for spot treatment; efficacy limited in turbid water/dense algae	1-3 days** (human); 1 day livestock/ domestic animal consumption	Advisory (Ecology) during treatment and 24 hr post-treatment		1-5 days depending on crop

* Ground water monitoring protocols shall be used if a permittee is applying triclopyr for the third time in a three year period (Appendix C).
** Ranges in days determined by application rate, see label for details.
^ Irrigation restrictions dependant upon specific use and season.

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Advantages

Aquatic herbicides are easily applied around docks and underwater obstructions. Aquatic herbicide application can be less expensive than other aquatic plant control methods, especially when used in controlling wide-spread infestations of state-listed noxious aquatic weeds.

Disadvantages

- Some herbicides have swimming, drinking, fishing, irrigation, and water use restrictions (check the label and general permit)
- Herbicide use may have unwanted impacts to people who use the water and to the environment.
- Non-targeted plants as well as nuisance plants may be controlled or killed by some herbicides
- Depending on the herbicide used, it may take several days to weeks or several treatments during a growing season before the herbicide controls or kills treated plants
- Rapid-acting herbicides like endothall and diquat may cause low oxygen conditions to develop as plants decompose. Low oxygen can cause fish kills
- To be most effective, generally herbicides must be applied to rapidly-growing plants, although sometimes fall applications of perennial plants can also be effective
- Some expertise in using herbicides is necessary in order to be successful and to avoid unwanted impacts
- Public perception to the application of chemicals to water can be unfavorable

Permits

Because of environmental risks from improper application, aquatic herbicide application in Washington state waters is regulated and has the following restrictions:

- Applicators must be licensed by the Washington State Department of Agriculture
- Applicants must obtain coverage under a National Pollutant Elimination Discharge (NPDES) permit before they can legally apply aquatic herbicides to waters of the state
- Ecology requires notification and posting before treatment and, if applicable, there are additional mitigations to protect rare plants or threatened and endangered species.

Ecology issued a "lake" NPDES general permit March 1, 2006 to cover the management of in-lake noxious weeds and native aquatic plants and algae. For in-lake projects applicators and/or the state or local government sponsoring the project must obtain coverage under Ecology's Aquatic Plant and Algae Management General Permit (the Permit)[2] before applying herbicides. The process for obtaining NPDES coverage and follow-up actions includes:

1. Submit a Notice of Intent application form to Ecology requesting coverage under this permit at least 60 days prior to the planned activity resulting in the discharge to waters of

[2] To view the Permit: http://www.ecy.wa.gov/programs/wq/pesticides/permit_documents/APAMfinalpermitrevised011509.pdf

the state. The application shall contain a copy of the public notice and the expected date of the second publication.

2. Complete a SEPA Checklist and submit to Ecology
3. Adhere to all Notification and Posting Requirements (Appendix D) as identified in the Permit, including:
    a. Ecology Notification
    b. Residential and Business Notification
    c. Camp Notification
    d. Posting Requirements (templates provided in Appendix E)

Costs

These costs are estimates and will vary from site to site depending on treatment rates, water depths, amount of notification needed, difficulty of access to the site, and other factors. Approximate costs for one acre herbicide treatment: Fluridone: $900 to $1,000, Endothall: $650, 2,4-D: $300-600, Diquat: $300 to $400.

Appropriateness to Lake Tapps

The application of aquatic herbicides, in combination with other aquatic plant control methods, substantially increases the likelihood of eradicating Eurasian watermilfoil from Lake Tapps. Aquatic herbicides are particularly beneficial at Lake Tapps where submersed trees limit the deployment of benthic barriers. In situations where eradication is the goal, the application of aquatic herbicides is the most aggressive method to rapidly reduce vegetation coverage and allow for other methods such as benthic barriers and diver-assisted hand pulling.

No Action Alternative

The No Action Alternative acknowledges the presence of invasive aquatic plants but not does call for any control or even planning activities.

Advantages

There are few advantages to “doing nothing” to control or prevent the further spread of invasive aquatic plants; however, there may be a perception of saving money by not investing in activities such as herbicide application, mechanical harvesting, or boat washing stations.

Disadvantages

The No Action Alternative can result in long-term deleterious effects on the ecology, recreational uses and aesthetics of a lake. Invasive aquatic plants disrupt dissolved oxygen patterns, displace native plant species, and impair navigation. While changes to water quality may be less obvious to the casual observer, their seasonal and long-term impacts can seriously threaten features that attract homeowners, outdoor enthusiasts, anglers, and boaters to a waterbody.

Appropriateness to Lake Tapps

The current distribution of milfoil at Lake Tapps is already at nuisance levels and will likely only increase, particularly if CWA decreases the magnitude of the winter water level drawdowns. Based on the goal of eradication, the No Action Alternative is not appropriate for Lake Tapps.

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Table 4. Permits/Documents Required for Aquatic Weed Control Activities in Washington (Source: Washington Department of Ecology)

Permit/document	Agency	Description	Control Activities	Minimum Process Time
State Environmental Policy Act (SEPA)	Local or state agency	Requires complete disclosure of proposed actions; SEPA checklist required for herbicide use and grass carp stocking	Herbicides, grass carp stocking	60 days
Short-term Modification of Water Quality Standards (STM)	Ecology	Allows modification of Water Quality Standards (Chap. 173-201 WAC) - administered through regional offices	Herbicides, rotovation, dredging	90 days
State Shoreline Management Act	Ecology and local jurisdiction	Permit ensures that proposed activity complies with the local Shoreline Master Program. Includes lakes 20-acres or more, and can include associated wetland and some floodplains.	Bottom barriers (based on area/cost), rotovation, harvesting, diver dredging	75 days
Hydraulic Project Approval (HPA - State Hydraulic Code)	Fish and Wildlife	HPA required for work below the ordinary high water line.	All aquatic plant control activities need an HPA, but many activities are permitted by obtaining publication #APF-1-98 - Aquatic Plants and Fish	45 days
Natural Heritage Program Letter (confirming search of date for critical plant species)	Department of Natural Resources	Natural Heritage Program is the state repository of data on endangered, threatened and sensitive species, native wetland communities, aquatic and nonvegetated wetlands.	Search should be conducted for any control activity	3-7 days
Fish Planting Permit	Fish and Wildlife	A permit is required for stocking of triploid (sterile) grass carp in Washington waters for control of aquatic vegetation.	Grass carp stocking	45 days
Local Permits	Local jurisdictions	Permits may be required on the local level for various activities. Permits may include Shoreline Management, Growth Management Act/Sensitive Area Ordinance.	Variable	Variable

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TREATMENT/CONTROL INTENSITY

The objective for the Lake Tapps IAVMP is to *eradicate* Eurasian watermilfoil. Eradication implies the complete and permanent elimination of all viable plant propagules (reproductive structures, including stem fragments, tubers, and seeds) (Gettys et al. 2009). Eradication will require a multi-year, aggressive, and dedicated effort to control and survey by CWA and the entire Lake Tapps community. In addition, enforced prevention efforts will be necessary to ensure new populations of milfoil (or other invasive plant or animal species) are not introduced and established. Eradication of Eurasian watermilfoil has been achieved in Washington, for example: Long Lake and Lake Shoecraft. In both instances, eradication was the goal and fluridone was used, followed by "bump" applications to maintain sufficient exposure of the herbicide.

The approach to eradicating aquatic plants depends on numerous factors including plant distribution and density, Specimen Label restrictions for aquatic herbicides (Appendix A), existing beneficial uses, public perception, and available funding. The following are three possible approaches for eradicating Eurasian watermilfoil from Lake Tapps.

Whole Lake Approach

As the name implies, a whole lake approach involves aggressively treating the entire volume of the lake, typically with an aquatic herbicide. This approach is practical for waterbodies with nearly complete coverage by invasive plants and where the water depth averages about 25 ft. or less. Aquatic herbicides appropriate for whole lake treatment include fluridone and triclopyr. A whole lake treatment approach is not recommended for Lake Tapps.

Partial Lake Approach

Partial lake treatment means that a large area is uniformly treated, typically with an aquatic herbicide or by physical methods (i.e., water level draw down), but not the entire volume of the lake. For example, if an invasive aquatic plant infestation is only known to occur on one end of a waterbody, then there is no need to treat the entire lake. Instead, the infestation and some reasonable buffer around the infestation could be treated. In lakes with deep water areas and a measureable summer thermocline (depth where the water feels much colder than the surface), invasive plants are typically found along the shoreline during late summer. Fragments may be observed elsewhere, but distribution will likely be limited by water depth. In these situations, such as in Lake Tapps, then only the shoreline or areas where water depth is less than about 20 ft. is treated. Aquatic herbicides appropriate for partial lake treatment include fluridone and triclopyr. Water level drawdown has been used in Lake Tapps, in part to control Eurasian watermilfoil. While this approach may help alleviate some shoreline growth early in the summer, water level drawdown alone clearly has not and will not eradicate Eurasian watermilfoil from Lake Tapps.

Targeted Area Approach

Using a targeted area approach to control invasive aquatic plants allows for the use of a variety of control methods, including physical removal or aquatic herbicides. Examples of targeted areas include bays, specific shorelines and navigation lanes. These areas are prioritized for treatment based on factors such as plant density, role as a source of propagules, feasibility of treatment tools (e.g., benthic barriers near docks, but diver hand-pulling in areas with dense tree stumps), and cost. This approach is practical for smaller infestations, for example areas less

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than 5 acres, boat launches, along navigation routes, or swimming beaches. Where eradication is the goal, this approach should be employed after more aggressive methods are used.

Where eradication is the goal, appropriate physical methods for managing aquatic weeds in targeted areas should only rely on methods that *remove or kill all viable plant parts*. These methods may include diver hand-pulling (then removing the plants from the lake) and benthic barriers. Aquatic herbicides appropriate for spot treatments include fluridone, triclopyr, endothall, and 2,4-D. Granular formulations of fluridone are more commonly used for spot treatments than the liquid formulations because the latter typically cannot provide sufficient contact time. Ecology reports more success using 2,4-D or triclopyr for spot treatments of milfoil in the littoral zone. Endothall is routinely used to spot treat Eurasian watermilfoil along shorelines. At higher concentrations (2 to 3 ppb), shorter contact time is required for more complete control; however, at lower concentrations (1 to 1.5 ppb) impacts to native vegetation are lessened, increasing the likelihood of a more robust and diverse plant community.

LAKE TAPPS INTEGRATED TREATMENT SCENARIOS

A multi-year, aggressive, and integrated treatment approach will be necessary to eradicate Eurasian watermilfoil from Lake Tapps. Two scenarios are provided to accomplish this goal. Both scenarios integrate multiple management tools, use both partial-lake and targeted-area approaches, and emphasize prevention and surveys. Where they differ are in the use of control tools and their anticipated results over time. Both treatment scenarios assume that the 550 acres between the shoreline at full recreational level (between 542 and 543 feet) out to the 15 ft. contour will be treated in Year 1 (Figure 6).

Figure 6. Aerial of Lake Tapps including 15 ft. contour (red) and area identified for partial lake treatment (blue hash lines). Source: AquaTechnex, LLC.

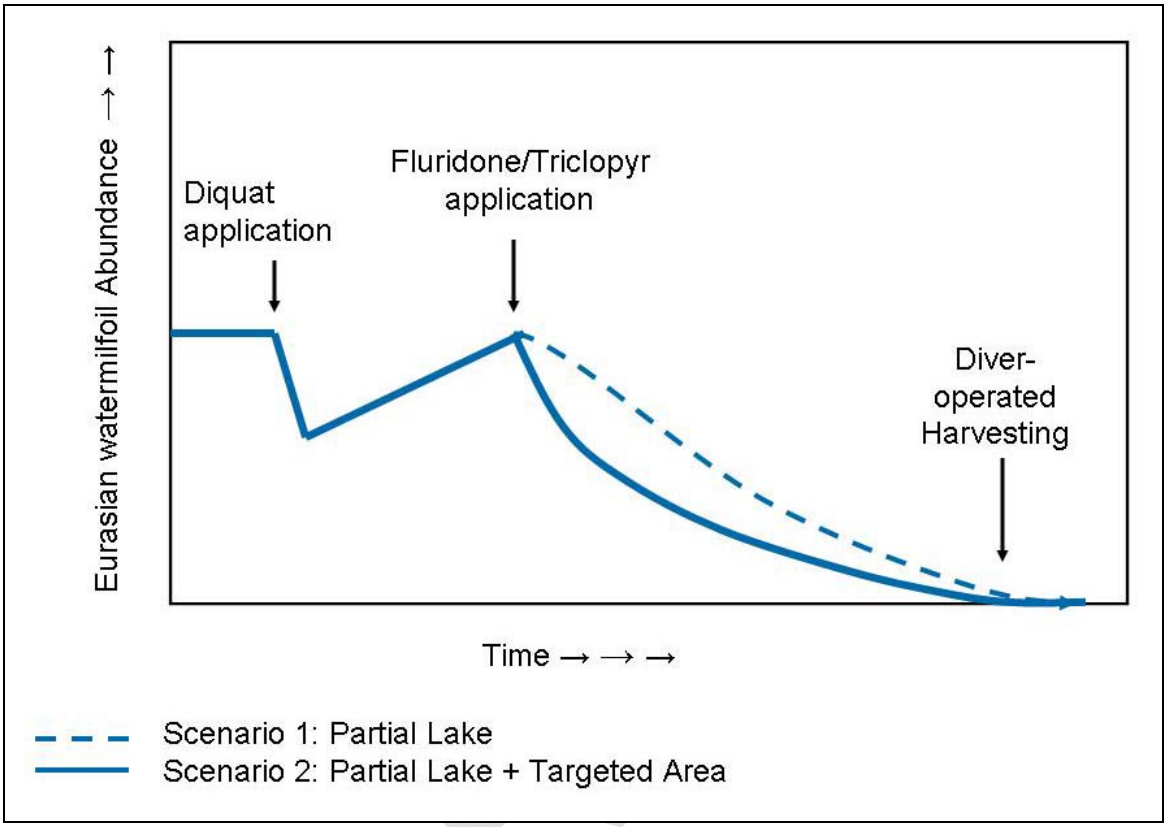

Figure 7. Temporal Selection of Management (Modified from Madsen 2005 using terms from the Lake Tapps IAVMP).

Scenario 1: Partial Lake (Five-year Program)

Scenario 1 (Table 5) involves a partial lake application of liquid fluridone in combination with intensive surveys and diver hand-pulling. Fluridone has no drinking, fishing, swimming, or livestock/pet consumption restrictions[3] and may be applied under whole lake, partial, or target area approaches (Appendix B).

During the summer of Year 1, the 550 acres between the shoreline at full recreational level (between 542 and 543 feet) out to the 15 ft. contour will be treated with fluridone at 8-10 ppb (Figure 6). Water samples will be collected every two weeks within the treatment area and analyzed for fluridone concentration using FasTEST® Water Analysis (SePRO Corp., Carmel, IN). "Bump" applications will be made (typically 2 to 4) to ensure the target concentration is maintained for at least 45 days (Ecology suggests up to 10 weeks for eradication projects). While milfoil is capable of growing in water deeper than 15 ft., fluridone is known to disperse to

[3] Fluridone does have irrigation restrictions for up to 30 days.

areas beyond the target area, thus it is anticipated that plants adjacent to the treatment area will be affected.

During the fall of Year 1, divers will hand-pull milfoil from areas less than about 5 acres. At the same time, divers will survey and map infested areas greater than 5 acres. For infestations greater that 5 acres, it is recommended they be targeted for herbicide application the following year. Winter drawdowns will be used to inhibit growth the following spring.

The treatment approach in Year 2 will largely be based on surveys conducted during the fall of Year 1. If only isolated infestations are found during the fall survey from Year 1, then targeted areas should be treated with either granular fluridone (e.g., isolated bays) or granular triclopyr (e.g., along exposed shorelines). If applicable and/or feasible, at least 2 acres surrounding the infestation should also be treated. Although it is unlikely, if large (> 5 acres) nearly contiguous milfoil infestations are found, then a second partial lake treatment with granular fluridone (isolated bays) or granular triclopyr (exposed shorelines) may be needed. In any case, during the fall of Year 2, divers will once again hand-pull milfoil from areas less than about 5 acres and survey and map areas greater than 5 acres. For infestations greater that 5 acres, it is recommended they be targeted for herbicide application the following year. Winter drawdowns will be used to inhibit growth the following spring.

It is assumed that by Year 3, the population of milfoil will be significantly less such that a partial lake treatment will not be necessary. Instead, targeted areas may be treated using wider selection of tools. More specifically, emphasis will be placed on diver hand-pulling, particularly for sites with infestations less than 5 acres while granular formulations of fluridone or triclopyr may be used for areas greater than 5 acres. During the fall of Year 3, divers will once again hand-pull milfoil from areas less than about 5 acres and survey and map areas greater than 5 acres. For infestations greater that 5 acres, it is recommended they be targeted for herbicide application the following year. Winter drawdowns will be used to inhibit growth the following spring.

By Year 4 and beyond, it is expected that diver hand-pulling will be sufficient to control milfoil in Lake Tapps; however, the use of granular triclopyr or granular fluridone will be used for spot treatments of larger areas. Winter drawdowns will be used to inhibit growth the following spring.

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Table 5. Summary of Scenario 1: Partial Lake (Five-year Program)

Year	Action	
1	Summer	Partial lake application with liquid fluridone; apply 2 to 4 “bump” applications to maintain desired concentration for at least 45 days. Implement prevention efforts to eliminate introduction of plant propagules
	Fall	Survey to inform Year 2 treatment; hand-pull areas less than < 5 acres; normal water level drawdown
2	Summer	Application of granular fluridone (isolated bays) or granular triclopyr (exposed shorelines) to 2 acres surrounding infested areas identified in Year 1 fall survey; apply 2 to 4 “bump” applications to maintain desired concentration for at least 45 days. Increase prevention efforts to eliminate introduction of plant propagules
	Fall	Deploy divers for hand removal of plants in areas less than 5 acres and mark areas greater than 5 acres for herbicide application in Year 3; normal water level drawdown
3	Summer	Same as above and increase use of diver hand-pulling to eliminate satellite infestations Further increase and enforce prevention efforts to eliminate introduction of plant propagules
	Fall	Same as above
4	Summer	Spot application of triclopyr to areas greater than 5 acres; deploy divers for hand removal of plants in areas less than 5 acres. Continue to enforce prevention efforts to eliminate introduction of plant propagules
	Fall	Same as above
5	Summer	Same as above Continue to enforce prevention efforts to eliminate introduction of plant propagules
	Fall	Same as above

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Scenario 2: Partial Lake + Targeted Areas (Five-year Program)

Scenario 2 (Table 6. Summary of Scenario 2: Partial Lake + Targeted Areas (Five-year Program)) also involves a partial lake application of liquid fluridone in combination with intensive surveys and diver hand-pulling. More specifically, Scenario 2 also involves application of diquat to quickly open up high priority areas (e.g., boat launches and boat lanes). Again, fluridone has no drinking, fishing, swimming, or livestock/pet consumption restrictions[4] and may be applied under whole lake, partial, or target area approaches (Appendix B). Diquat has drinking water and irrigation restrictions (up to 3 and 5 days, respectively) and 1 day domestic animal consumption; however, there are no fishing or swimming restrictions (Appendix B).

During the summer of Year 1, the 550 acres between the shoreline at full recreational level (between 542 and 543 feet) out to the 15 ft. contour will be treated with fluridone at 8-10 ppb (Figure 6). Water samples will be collected every two weeks within the treatment area and analyzed for fluridone concentration using FasTEST® Water Analysis (SePRO Corp., Carmel, IN). "Bump" applications will be made (typically 2 to 4) to ensure the target concentration is maintained for at least 45 days (Ecology suggests up to 10 weeks for eradication projects). While milfoil is capable of growing in water deeper than 15 ft., fluridone is known to disperse to areas beyond the target area, thus it is anticipated that plants adjacent to the treatment area will be affected.

During the fall of Year 1, divers will hand-pull milfoil from areas less than about 5 acres. At the same time, divers will survey and map infested areas greater than 5 acres. For infestations greater that 5 acres, it is recommended they be targeted for herbicide application the following year. Winter drawdowns will be used to inhibit growth the following spring.

The treatment approach in Year 2 will largely be based on surveys conducted during the fall of Year 1. If only isolated infestations are found during the fall survey from Year 1, then targeted areas should be treated with either granular fluridone (e.g., isolated bays), granular triclopyr (e.g., along exposed shorelines), or diquat (e.g., high use areas such as navigation lanes). Beginning the fall of Year 2, all subsequent monitoring and treatment efforts will follow Scenario 1.

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[4] Fluridone does have irrigation restrictions for up to 30 days.

Table 6. Summary of Scenario 2: Partial Lake + Targeted Areas (Five-year Program)

Year		Action
1	Summer	Partial lake application with liquid fluridone; apply 2 to 4 "bump" applications to maintain desired concentration for at least 45 days; targeted application of diquat to high use areas (e.g. navigation lanes) Implement prevention efforts to eliminate introduction of plant propagules
	Fall	Survey to inform Year 2 treatment; hand-pull areas less than < 5 acres; normal water level drawdown
2	Summer	Application of granular fluridone (isolated bays) or granular triclopyr (exposed shorelines) to 2 acres surrounding infested areas identified in Year 1 fall survey; apply 2 to 4 "bump" applications to maintain desired concentration for at least 45 days; targeted applications to maintain desired concentration for at least 45 days; targeted application of diquat to high use areas (e.g. navigation lanes) Increase prevention efforts to eliminate introduction of plant propagules
	Fall	Deploy divers for hand removal of plants in areas less than 5 acres and mark areas greater than 5 acres for herbicide application in Year 3; normal water level drawdown
3	Summer	Same as above and increase use of diver hand-pulling to eliminate satellite infestations Further increase and enforce prevention efforts to eliminate introduction of plant propagules
	Fall	Same as above
4	Summer	Spot application of triclopyr to areas greater than 5 acres; deploy divers for hand removal of plants in areas less than 5 acres Continue to enforce prevention efforts to eliminate introduction of plant propagules
	Fall	Same as above
5	Summer	Same as above Continue to enforce prevention efforts to eliminate introduction of plant propagules
	Fall	Same as above

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Preferred Scenario

Scenario 1 is preferred as this approach is slightly less costly and has a reduced swimming advisory. Scenario 1 calls for the application of fluridone and triclopyr. Fluridone has no swimming advisory or restriction and triclopyr only has a 12 hour Ecology swimming advisory. In Scenario 2, the additional use of diquat to open up navigation channels would result in added expense and a 24 hour swimming advisory for diquat). The short term benefits provided by Scenario 2 must then be weighed against the added cost and reduced recreation benefit.

MONITORING, RESPONSE, AND PREVENTION

Successful eradication of Eurasian watermilfoil from Lake Tapps will require diligent (annual) monitoring for new Eurasian watermilfoil populations (as well as other invasive plant and animal species) and committed outreach and prevention measures. Eradication will be considered attained when for three consecutive three only new pioneer colonies of EWM are observed and those are removed with hand methods during annual surveys.

Recommendations to CWA: public outreach, (e.g., boat launch signage, public meetings, presentations to landowner associations), inspections at boat launches (including a designated boat washing station), survey adjacent lakes (Leaky, Bonney and Debra Jane Lakes to the west and Bowman and Hille Lakes to the east).

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APPENDIX A KNOWN RARE OR LISTED SPECIES WITHIN THE PROJECT AREA

Figure A-1. Washington Natural Heritage Program Project Area Report (License No.XXX)

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APPENDIX B HERBICIDE SPECIMEN LABELS

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APPENDIX C GROUNDWATER MONITORING PROTOCOLS

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APPENDIX D NOTIFICATION AND POSTING REQUIREMENTS

INSERT FROM PERMIT
http://www.ecy.wa.gov/programs/wq/pesticides/permit_documents/APAMfinalpermitrevised011509.pdf

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APPENDIX E PUBLIC NOTICE TEMPLATES

INSERT TEMPLATES

http://www.ecy.wa.gov/programs/wq/pesticides/permit_documents/APAMfinalpermitrevised011509.pdf

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