A Citizen's Manual for Developing Integrated Aquatic Vegetation Management Plans

First Edition

WASHINGTON STATE DEPARTMENT OF ECOLOGY

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NEED ASSISTANCE?

For general questions regarding aquatic plant management in inland waters of Washington State, your first point of contact is:

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A CITIZENS MANUAL FOR DEVELOPING *INTEGRATED AQUATIC VEGETATION MANAGEMENT PLANS*

First Edition

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WASHINGTON DEPARTMENT OF ECOLOGY
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A NOTE FROM THE AUTHORS

Since childhood, we have been drawn to the water. In our youth, our fascination with lakes, ponds, reservoirs and rivers was one of joyful recreation and wonder at the life that they offered. The variety of experiences gained early on from enjoyment of the aquatic environment stayed with us throughout the years. We happily recall countless (and endless!) days filled with swimming, wading, water-skiing, fishing or just laying back and enjoying the scenery. Our casual observation of little plants and animals living in different water environments provided a simple sense of peace, yet respect for the power of water.

But our childhood fascination really only skimmed the surface, so to speak, of what aquatic systems are really all about. Over the years, we have dedicated our lives to learning more about the incredibly intricate nature of freshwater ecology. Consistent with the integrated nature of limnology, each of us has obtained two graduate degrees in different but related freshwater disciplines. Maribeth's expertise has been in lake and aquatic plant management, watershed investigations, and algae, zooplankton and macrophyte dynamics. Harry's activities have concentrated on lake and watershed management and restoration, aquatic plant management, and habitat enhancement. Mark's specialty has centered on aquatic ecology with active involvement in lake and aquatic plant management. In our professional pursuits, each new encounter with a freshwater system has helped us to better understand and appreciate the unique and diverse ecology of lakes and rivers. Most importantly, we have come to learn the importance of aquatic plants in the environment.

Plants are part of a balanced ecosystem. The fact that you are reading this manual suggests that your water body may **not** be balanced in a way that maximizes desired beneficial uses. Yet, it is crucial to recognize the uniqueness of each body of water, and that there is no quick fix that covers every situation. We have endeavored in this manual to condense a wealth of material on the topic of aquatic plant management into a practical, working format that has widespread appeal. It is our intent to offer basic tools that you can use to manage your special and unique lake, pond or river. The challenge of management is to be able to achieve desired beneficial uses of a water body within the limits of time, finances and natural capacity of the aquatic system. Such a task is often not easily accomplished without some compromise. Most of all, management of a resource is a continuous learning experience. Conditions will change with time (hopefully for the best), so remember to be flexible. We wish you success in your management endeavor.

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ACKNOWLEDGMENTS

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We extend our gratitude to Kathey Adams for her many thoughtful ideas and comments that had great impact on the format and character of this guide. A special thanks to Tom Clingman and Mark Swartout (Thurston County), who offered their valuable aquatic plant management expertise in review of the manual. In addition to Kathey, Tom and Mark, we also thank other Ecology's Advisory Committee members: Kim McKee, Steve Saunders, Juanita Wilson, and Tom Leonard (Ecology), Connie Iten (Wildlife), Nedda Turner (Tacoma-Pierce County Health Dept.), Shirley Shirley, and Cindy Watt (Wiser Lake). We thank the many individuals, citizens and agency staff alike, who volunteered their time, providing suggestions on content and format of the manual and reviewing the initial draft.

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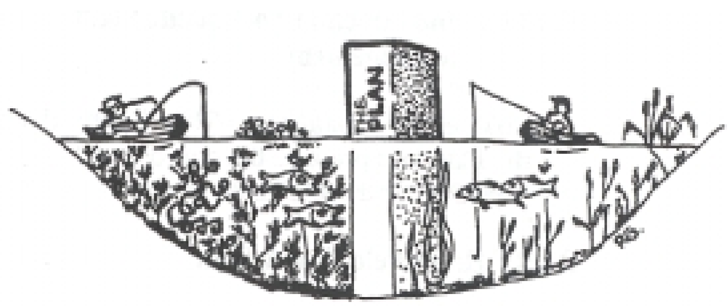
PREFACE

Aquatic plants are an important part of freshwater systems. They perform a wide variety of ecological functions. They provide nesting sites, cover and food for all kinds of aquatic life, including fish, waterfowl and smaller animals. Plants invigorate the water body by increasing oxygen concentrations in the water and sediments. Rooted aquatic plant communities help secure and stabilize shorelines. In some cases aquatic plants help improve water clarity by competing for nutrients with *algae*.[1] These are but a few of the beneficial roles that aquatic plants play.

Under certain conditions, however, aquatic plants can become a problem. Excess growth of aquatic plants can affect beneficial uses of a water body, such as recreational and aesthetic enjoyment, irrigation and water supply uses, and wildlife *habitat*. In addition, invasion by non-native (*exotic*) plant species, such as Eurasian watermilfoil, can seriously damage an aquatic ecosystem. Exotic weeds can choke out native vegetation, and can form dense stands that are a nuisance to humans and create poor habitat for fish and wildlife.

When problem plant populations limit uses of a water body, the solution lies in careful management. Finding a remedy to nuisance aquatic plants that is effective, ecologically sensitive, and economically feasible is the goal of integrated aquatic plant management.



This manual is a citizen's guide to the steps needed to produce an *integrated aquatic vegetation management plan* (herein called the Plan). The process described in this manual represents a major step toward *holistic* (water body and watershed) management of aquatic plants in freshwaters of Washington State.

Material Covered In The Manual

By definition, *integrated* aquatic vegetation management requires incorporating information on many aspects of a water body into a unique planning document. The challenge in preparing this manual involved condensing a wealth of critical information on the topic into a comprehensive but simple format with widespread appeal. The manual is so designed to cover a wide range of situations that might be encountered in aquatic plant management throughout Washington State. It is a step-by-step guide, as the process of planning is broken down into separate but interrelated steps. While the document does refer to freshwater management principles when needed, it is **not**

[1] Italicized words are defined in the Glossary (Appendix A) at the end of the manual.

a primer on *limnology* or lake management. However, appropriate references and resources are presented. Finally, this manual can be used to complete grant applications for the Aquatic Weeds Management Fund administered by the Washington Department of Ecology (see Appendix E).

The manual does the following:

- provides step by step guidelines on how to prepare a Plan.
- explains the critical role of public involvement during the planning process.
- offers guidance on plant mapping methods and collecting water samples.
- describes permits required for aquatic plant management activities.
- defines and explains technical terms.
- includes a basic guide on how to manage aquatic plants.
- describes how to identify six invasive, non-native aquatic plants.
- describes *Ecology's Aquatic Weeds Program*.

A Quick Walk Through The Manual

The manual is divided into four parts:

PART I: Introduction To Aquatic Plant Management

- Chapter 1, *Introduction*. This chapter defines the Plan and presents the purpose and objectives of these Plans.

PART II: Developing A Plan

- Chapters 2-13, *Steps in the Planning Process*. Using flow-diagrams and illustrations, these chapters give step-by-step instructions for putting together a Plan.

PART III: Implementing A Plan

- Chapter 14, *I Have a Plan—What's Next?* In this chapter, the reader is offered guidance on how to use a Plan.

PART IV: Technical References

- Appendix A, *Glossary of Terms,* defines technical terms used in aquatic plant management.
- Appendix B, Invasive, *Non-native Aquatic Plant Fact Sheets (Illustrated),* provides drawings, and features of six non-native (exotic) aquatic plant species that are or could be a threat in Washington State waters.
- Appendix C, *Watershed And Limnological Background Information,* briefly describes physical, chemical and biological features of a water body and its watershed.

- Appendix D, *Aquatic Plant Control Methods,* summarizes aquatic plant control methods available for Washington State waters.
- Appendix E, *Aquatic Weeds Management Fund*, describes the background, objectives, and eligibility criteria of the grant program administered by Ecology that was created as part of the Aquatic Plant Bill.
- Appendix F, *Resources and References*, presents a list of resource agencies and organizations that can provide technical information and assistance on aquatic plant management in Washington State. It also lists technical reference materials that provide more detailed coverage of topics discussed in the manual.

Throughout the manual, you will also find the following special notations:

RED FLAG**:** These alert the reader to the presence of a serious situation in the water body requiring immediate or special action as part of the planning process.

TIP: These give extra information on important points or directions for particular tasks.

References and Resources:

These appear at the end of some chapters and list names of agencies, organizations and titles of literature that can provide more information on topics just discussed. Citations in the quick reference sections, as in the text, are numbered and lettered to correspond with book and organization references, respectively, appearing in Appendix F.

PART I

INTRODUCTION TO AQUATIC PLANT MANAGEMENT

CHAPTER 1

INTRODUCTION

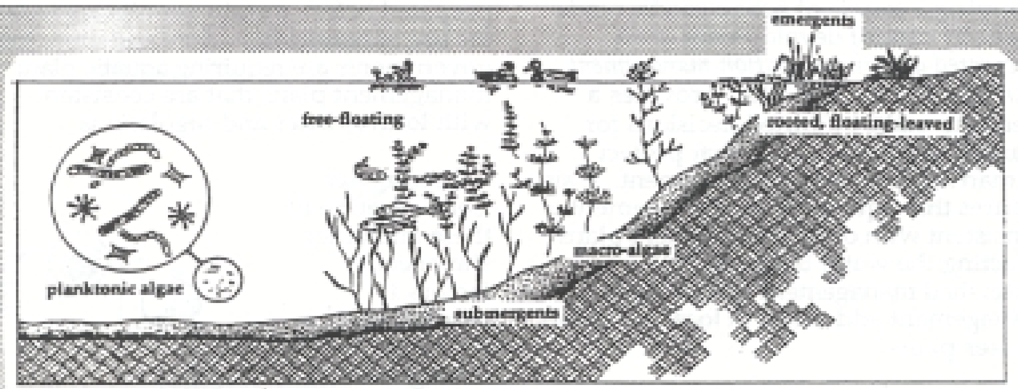
Does Your Water Body Have An Aquatic Plant Or An Algae Problem?

This manual specifically deals with controlling nuisance aquatic plants. To use this manual, it is critical to distinguish between **aquatic plant problems** and **water quality problems** associated with excess algae production (see box).

Managing aquatic plant problems should follow the integrated aquatic vegetation planning route described by this manual.

More specifically, integrated aquatic vegetation management plans focus on controlling aquatic plants, which flourish (often to nuisance levels) on enriched sediments in suitable habitats.

Algae and other water quality problems should follow the lake restoration planning approach. Lake restoration plans deal with correcting water quality problems whose symptoms are seen in water chemistry and algae production.



Aquatic Plants and Algae

Aquatic plants are large *vascular* plants that live in wet conditions. Aquatic plants (also called *macrophytes*) usually possess true roots, stems and leaves, and look like plants in your yard. They can be grouped into four types: emergent plants, rooted floating-leafed plants, submersed plants, and free-floating plants. ***Emergent plants*** have a large portion of stems and leaves growing above (emerging from) the water surface; they are found in shallow water (less than 2 feet deep) or along the shoreline. ***Rooted floating-leafed plants*** have leaves that float on or just above the surface but are connected to the bottom by long, tough stalks. ***Submersed plants*** have most of their leaves and stems below the water surface, often with flowering parts projecting above surface. They may be securely or loosely rooted in the bottom. ***Free-floating plants*** float near the water surface with root systems dangling in the water, but not connected to the sediment.

Algae are simple, primitive plants that do not have true roots, stems or leaves. Many algal species are microscopic forms that float in the water (called *phytoplankton*). Some appear as large, easily seen upright forms, and are called *macro-algae*. Certain types of green algae can form stringy colonies 3 feet or more in length. Nuisance algal growth commonly associated with nutrient problems often appears in the form of surface scums that are greenish or brownish in color.

What Is An Integrated Aquatic Vegetation Management Plan?

Designing a cost-effective and environmentally sound aquatic plant management program is a challenge. Aquatic plant communities vary greatly from one body of water to the next. Likewise, the human uses of each lake, pond or river are unique, as are the activities along its shore. Furthermore, a range of aquatic-plant control methods (physical, mechanical, chemical, biological) are available. These can vary widely in cost, effectiveness and environmental impacts. The critical issue facing those who hope to remedy an aquatic plant problem is selecting methods that are appropriate for the water body.

Mapping a course of action can be made easier by careful development of an *integrated aquatic vegetation management plan* (Plan). The Plan provides a means to make informed decisions for managing aquatic plants that protect human health and the environment. It also assures that aquatic plant management is consistent with other management plans affecting the water body, such as watershed management or shoreline management addressed in local or county master plans.

Development of a Plan uses an approach based on integrated management of land plants that considers such concerns as:

- How bad is the aquatic plant problem?
- At what level will plants become harmful and when should action be taken to control them?
- When is the best time of year to kill, remove, or suppress the nuisance plant species?
- What methods will best deal with the target species, and for how long?
- How will the treatment affect humans, native plants and wildlife?
- Are the costs reasonable and affordable?

When Is A Plan Required?

The State of Washington strongly encourages development of long-term, integrated aquatic plant management strategies to deal with nuisance aquatic plants in lakes, ponds, or rivers. Work spent identifying alternatives early on will save time and money later down the line.

Plans may be required before certain aquatic plant control activities may be initiated. For example, the *Aquatic Weeds management Fund* calls for completion of a Plan before projects can be considered for implementation grants (see Appendix E).

Also, the Environmental Impact Statement for Ecology's "Aquatic Plant Management Program" recommends that a plan be prepared before certain permits are issued for use of herbicides. More and more local governments are requiring aquatic plant management plans that are consistent with local policies and regulations.

Balancing Act: Consideration of these and other site-specific factors is necessary when choosing management methods for a specific water body. There is no magic bullet. For example, no method exists that can completely remove an exotic species infestation and at the same time be inexpensive and have no effect on the local ecology. Thus, the planning process should carefully balance all these concerns to develop a plan that meets the needs of the community while preserving the health of the ecosystem.

Living Document The Plan should be flexible and allow for change. Creating a living document provides for modification of the plan in response to new information of changing circumstances. Factors that could affect the Plan include changes in the aquatic plant problem, water use priorities, and land uses. Also, plant control technologies as well as government policies and regulation may evolve over time and affect the Plan.

Taking the Long View Aquatic plant management is a long-term venture; achieving management goals for a water body can take many years. Even after main goals are attained, some form of management, if only minimal, may be necessary to maintain aquatic plant conditions.

PART II

DEVELOPING A PLAN

PART II, the heart of the manual, is divided into twelve chapters. The first chapter (Chapter 2) describes how a few concerned individuals can start the planning process rolling. Each of the remaining chapters (Chapters 3-13) covers a step in the process of creating an integrated aquatic vegetation management plan (the Plan).

CHAPTER 2

GETTING STARTED

Organization Is Key

You are probably reading this manual because you are concerned about an aquatic-plant problem in your favorite lake or river. Others may share the same perception of an aquatic-plant nuisance. The first step in managing aquatic plants is to get organized. Begin by talking with your neighbors to determine if they have shared concerns about your water body.

The next step is to gather together a core group to talk more about the problem. The gathering might be an informal one, such as a potluck picnic or barbecue, where concerns about aquatic plant problems can be discussed at more length. Important questions that will need to be considered include:

- Is there an aquatic plant problem?
- What is the problem?
- Should anything be done about it?
- Should a community group be formed to address the problems?
- Who will participate in the planning process?

The core group can then plan to meet with the larger lake community to share their concerns in a more formal setting. Posting a notice on the community bulletin-board or in a newsletter, or sending out a one-page flier are simple ways to notify the neighborhood of the location and intent of such a gathering. Often, newspapers are willing to publish a short article for folks organizing neighborhood meetings.

The Steering Committee

With the approval of the larger community, a small *steering committee* should be formed, headed by one or two key individuals. The steering committee should represent the larger community throughout the planning process. This group will be responsible for completing the steps in this manual. It will be important for the steering committee to remain in touch with the community to share information and allow for participation of **all** interested individuals in the planning process. This contact can occur through newsletters or scheduled public meetings and board meetings open to the public.

To begin the process of "learning more about it", the committee should start to assemble available background information on the topic of aquatic plant management. Your first contact should be with staff from Ecology's *Freshwater Aquatic Weeds Management Program.*

The steering committee should also collect any existing information on their project area. *Past studies or reports* can be useful, such as diagnostic investigations called "Phase I" studies, or Reconnaissance Lake Data Reports by the U.S. Geological Survey and Ecology. These reports usually include an aerial photo and depth contour map of the water body.

> ***TIP****: Other lake associations* with established aquatic plant management programs can be contacted to find out about their control experiences (for a directory of Washington lake

associations, contact Washington Water Research Center, Washington State University, 509-335-5531).

Planning Steps Summarized

Supplied with this background information, the steering committee should begin to assess the aquatic plant problem and the need for action by completing the steps described in Chapter 3-13 of this manual. The planning process consists of two phases:

- Phase I (Problem/Site Description)
- Phase II (Control Strategies Development)

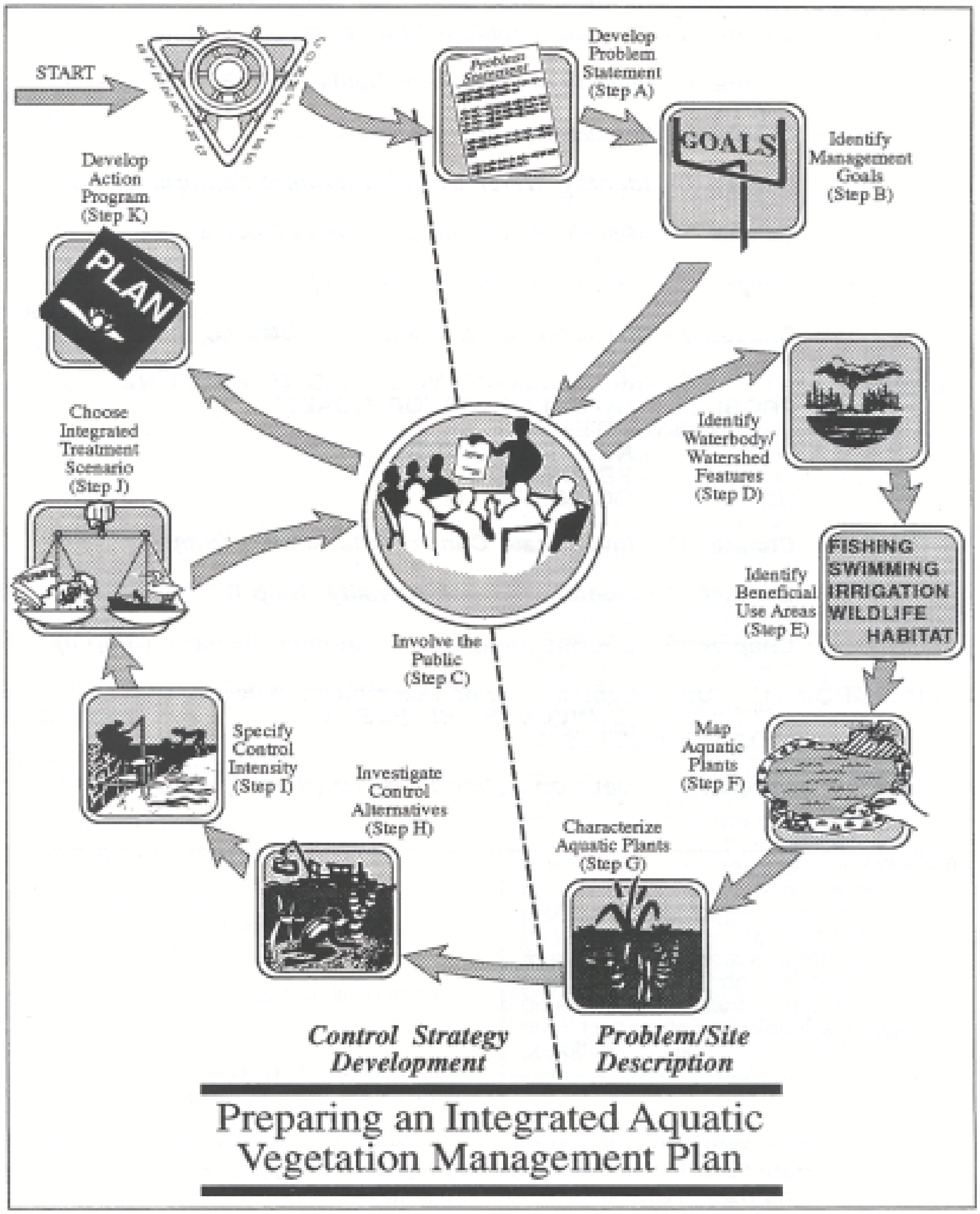
Phase I involves collecting information about aquatic plants and other features of your project area. The right side of the diagram presents the steps of Phase I:

- **Develop Problem Statement (STEP A)**
  This step involves developing a realistic problem statement describing limitations on beneficial uses of water body.
- **Identify Management Goals (STEP B)**
  This step identifies reasonable management goals that maximize beneficial uses yet are compatible with water body's capacity to sustain those uses.
- **Involve the Public (STEP C)**
  This step offers guidance in bringing the community into the planning process.
- **Identify Water Body/Watershed Features (STEP D)**
  This step investigates background characteristics of the water body together with its watershed to understand the whole system.
- **Identify Beneficial Uses (STEP E)**
  This step focuses on identifying beneficial use areas of water body in a Waterbody Use Map.
- **Map Aquatic Plants (STEP F)**
  This step outlines how to perform an aquatic plant survey to identify and map general plant types in a water body.
- **Characterize Aquatic Plants (STEP G)**
  This step translates survey data into a description of beneficial and problem plant zones in a water body.

The left side of diagram depicts Phase II, which investigates aquatic plant control strategies and applies Phase I results to fine-tune a specific plan through the following steps:

- **Investigate Control Alternatives (STEP H)**
  This step investigates available control options in terms of effectiveness, advantages, drawbacks, costs, permits and site specific factors.
- **Specify Control Intensity (STEP I)**
  This step matches up control intensity with appropriate plant zones in a water body, producing a Control Intensity Map.
- **Choose Integrated Treatment Scenario (STEP J)**
  This step identifies critical factors for choosing the combination of controls that best meets the goals of long-term management with the least impacts to the environment.
- **Develop Action Program (STEP K)**
  The final step takes information from preceding steps to formulate a long-term action plan for management of aquatic plants.

For simplicity, the steps are presented in a recommended order. For some water bodies, having information from prior investigations might provide shortcuts through a few of the steps. Certain steps can be covered more generally for water bodies with simpler problems compared to those with more complex matters. Also, as you move through the planning process and more complete information becomes available on your water body, you may need to revisit earlier steps. For instance, you may find it necessary to redefine the original problem statement (Step A) or your initial management goals (Step B). At the end of this chapter, a checklist is provided to help you track your progress through the planning process.



PLAN CHECKLIST

(check here)

( ) Chapter 3 - ***Develop Problem Statement (Step A)***

( ) Chapter 4 - ***Identify Management Goals (Step B)***

( ) Chapter 5 - ***Involve The Public (Step C)***

( ) Chapter 6 - ***Identify Water Body/Watershed Features (Step D)***

( ) Chapter 7 - ***Identify Beneficial Use Areas (Step E)***

( ) Chapter 8 - ***Map Aquatic Plants (Step F)***

( ) Chapter 9 - ***Characterize Aquatic Plants (Step G)***

√CHECKPOINT! New information--DO YOU NEED TO REDEFINE PROBLEM STATEMENT AND/OR GOALS?

YES? GO TO STEP A OR B,
NEXT GO TO STEP C
PROCEED TO STEP H.
NO? GO TO STEP H

( ) Chapter 10 - ***Investigate Control Alternatives (Step H)***

( ) Chapter 11 - ***Specify Control Intensity (Step I)***

( ) Chapter 12 - ***Choose Integrated Treatment Scenario (Step J)***

√CHECKPOINT! Update community on recommended scenario.

GO TO STEP C ***INVOLVE THE PUBLIC***
NEXT GO TO STEP K

( ) Chapter 13 - ***Develop Action Program (Step K)***

Notes:

CHAPTER 3

DEVELOP PROBLEM STATEMENT STEP A)

What Is The Problem?

Before a group of interested people can make good decisions about managing aquatic plants, they have to agree on the problem. The important uses of the water body that are being limited because of aquatic plants should be described in a *problem statement*.

Preparing a problem statement is the first step the steering committee should take. The committee's first-draft version should be presented to the rest of the community for further discussion and refinement. The initial problem statement might be modified several times before the Plan is completed.

How To Write A Clear Problem Statement

The following steps can help you develop a realistic problem statement:

1. Make a list of users of the water body.
2. Find out what users consider to be the problem.
3. Group the problems into categories
4. Condense the main categories into a problem statement.

Let's examine each of these tasks in more detail.

1. Make a list of users of the water body It is important to identify everyone who has an interest in the water body. The steering committee itself may represent a variety of users and can start with its own membership for ideas on who uses or has an interest in the water body. Efforts should be made to include as many different users as possible. (Read more about how to reach out to other concerned users of the water body in Chapter 5-Involve the Public.)

When is a Plant a Weed?

Determining whether a plant is a problem is not always easy. A plant is considered a pest or a weed when it grows where it is not wanted. Sometimes the reasons for not wanting it are purely aesthetic (the plant is considered unsightly or smelly); sometimes they are economic (as when presence of the plant affects the value of property); and sometimes they are ecological (as when a species, such as the non-native invader milfoil, threatens the well-being of an aquatic ecosystem). In addition, attitudes toward the plant can vary depending on how each person uses the water body. Surface mats of shoreline water lilies may be pleasing to some, but not to those who swim in the area. Dense growth of submersed vegetation may be a problem to the angler using a motor-boat but not to the pilot of a float plane that skims the surface of the water. It is important to recognize these differences in attitudes about aquatic plants when determining if a nuisance condition exists.

2. Find out what users consider to be the problem Different users will have different points of view about the water body's problem. Therefore, it is important to get a broad section of the public involved. Only then can you consider the full variety of perspectives and see to it that they are included in the problem statement.

3. Group the problems into categories This task involves grouping problem descriptions according to what uses they affect. Some uses of a water body that can be affected by excessive aquatic plant growth are:

- fishing
- swimming
- motorboat access/passage
- visual enjoyment
- wildlife habitat.

Problems are often associated with the amount of vegetation as well as its location in the water body. Thick growths of submersed or floating plants in beach or shoreline areas may pose a serious safety risk to swimmers or waders. Dense, surfacing plants can be a hazard to those using non-motorized craft (rowers, rafters, sail boarders). Launch, marina and dock areas clogged by weeds can hinder motorboat access. Most importantly, the presence of any **invasive, non-native plant species** in a water body is a serious situation (See box). Left unchecked, non-native weed species such as Eurasian watermilfoil are aggressive competitors. They can rapidly crowd out native vegetation, creating nuisance conditions affecting many beneficial uses.

4. Condense main categories into a problem statement The final task in Step A is to shorten the major categories into a brief description of the main problems posed by aquatic plants in the water body. Describe the specific locations of problem plant communities. Use numbers, if available, to describe how the problems affect beneficial uses of the water body. For example, "The

Native vs. Non-native Plants: What Differences Does It Make?

Our lakes, ponds and streams have been involved in a long, continuous process of evolution. As each system evolved and achieved a natural balance all its own, native species of aquatic plants and animals became uniquely connected. Native plant communities serve a variety of important functions in aquatic systems. These range from providing food, shelter and nesting sites for fish, waterfowl and other animals to protecting water quality and quantity and shoreline stability. Invasion of a system by a foreign species, however, can quickly destroy the fine balance that took so many years to develop. Away from the diseases and insects that serve as natural controls in their native regions, invader plants can grow and spread quickly. In doing so, they can damage the structure and function of ecosystems by crowding out native plants and changing habitat quality for fish and wildlife.

Introduction of exotic (non-native) plants, threatens the balance of our regional water bodies. Some plants considered invasive and non-native in Washington State include: Eurasian watermilfoil, parrotfeather (milfoil), Brazilian elodea, and purple loosestrife. A common means of introduction of exotic plants is through stem fragments that get caught on boats, trailers, and fishing gear. The plant invader is given a chance to spread from one water body to another if “infected” boating equipment is not properly inspected and all stem fragments removed. Species like Eurasian watermilfoil can reproduce easily by stem fragments. Dense milfoil stands can change water quality, interfere with recreational uses and severely affect fisheries and waterfowl habitat. Sometimes, exotic plants can be purchased from aquatic nurseries and placed in landscapes and home aquaria by the general public. Animals such as waterfowl can also transport seeds or stem fragments from one location to another.

The presence of a non-native, invasive aquatic plant species in your water body is a serious situation. It’s presence should form a primary part of the problem description.

number of serious swimming accidents caused this year by problem plants near the swimming beach was X," or "The community lost Y dollars in revenue this year because the annual rowing event had to be called off due to excessive aquatic plant growth." Statements like these make the problem statement specific for your water body and your community.

Example Of A Problem Statement

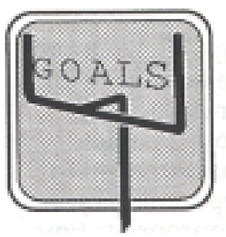
After completing Step A, you will end up with a problem statement that might sound something like this: "In 1985, Eurasian watermilfoil was found in Lake Tranquil. In the following three years, milfoil spread throughout the boat launch area of the 100-acre lake, forming dense shoreline stands out to 12 feet deep. In addition, dense stands of water lilies choke the swimming area at the opposite end of the lake.

Swimming, boating, fishing and other recreational uses have been severely impacted. Local residents are afraid to swim in the lake and are very concerned about the safety of their children. A special rowing tournament held annually since 1975 on the lake in mid-summer can no longer be conducted due to surfacing plant growth. Cancellation of this event resulted in an estimated loss of revenue of X dollars annually. In addition, the average number of fishing days in Lake Tranquil declined from Y days in 1985 to Z days in 1988."

References on Problem Statement Development

- The Lake and Reservoir Restoration Guidance Manual[4]
- Management Guide for Lakes and Reservoirs[5]

CHAPTER 4



IDENTIFY MANAGEMENT GOALS STEP B)

Setting Aquatic Plant Management Goals

Once a problem statement has been drafted for your water body, the next step is to come up with specific *management goals*. Management goals define what the community wants to achieve in response to the aquatic plant problems. Defining goals helps in selecting the best methods which form the heart of the Plan.

It is important to understand the difference between *management goals* and *management methods*. The goals are conditions in the water body that the community wants to achieve, and the methods are the means of attaining those conditions. A goal, for example, might be to reduce aquatic plant growth near a swimming beach so that it is no longer a safety hazard. Mechanical harvesting of the plants or stocking the lake with grass carp that will eat the plants might be methods eventually selected to achieve that goal. But the method selected cannot be chosen before the community establishes its goals and examines other critical aspects of the problem.

Goal-Setting Criteria

Goal-setting begins by identifying an initial set of goals that is reasonable and realistic for the community and the water body. These initial goals must address specific uses and be attainable.

It may be useful early on to set specific criteria to aid in goal-making, such as:

- If an exotic weed is present, give highest priority to reducing its growth.
- Give priority to keeping a particular area clear of weeds, especially where human safety is at risk.
- Limit community outlay to less than x dollars.
- Reduce costs by using volunteer labor where possible.

Matching what's desirable with what's practical Setting goals involves balancing user desire with the natural limitations of the water body and the financial limits of the community. A goal of removing all native plants in a lake is, under most circumstances, a bad choice. A lake is an active, living system, not a sterile swimming pool. Lakes with deep, rich sediments will likely continue to support lots of plants unless aggressive measures are taken in the water body. Furthermore, some control measures are very effective, but may be very costly too.

If the community chooses not to do anything to manage nuisance plants, it is critical to understand the possible consequences. Will there be impacts on human safety, recreational uses, or aquatic life and habitat if problem conditions in the lake are allowed to continue? Consequences of the no action management goal become particularly important when a water body is infested with an invasive, nonnative weed. In a shallow lake, these invaders can wreak havoc on the environment, recreation, and ultimately finances.

The establishment of desirable and acceptable management goals results from conducting well-planned community meetings backed by strong efforts to present all information and gain broad based support.

Example of Aquatic Plant Management Goals

Here is an example of management goals for Lake Tranquil: "The management goals are to maintain recreational and habitat used of the lake by removing milfoil from known locations, and to keep swimming areas clear of weeds for safety reasons". Additional goals are to choose appropriate plant control methods that are environmentally sensitive, and that reduce overall control costs by using volunteer labor when possible.

Tip: As you move through the planning process, you will continue to learn more about your water body and plant problem. With new or more complete information available, you may need to revisit the goal-setting step to refine your management goals. An appropriate time for reviewing initial goals would be after presenting the initial problem statement and goals at a public meeting of the lake community. Another time is after determining beneficial use areas in the water body.

Chapter 5

INVOLVE THE PUBLIC (STEP C)

The Importance of Public Involvement

Once an aquatic-plant growth problem has been recognized, it is crucial to bring all interested and affected parties together early on to participate in planning. Identifying people who have an interest in the water body often requires a bit of searching. The water body may serve a variety of groups with sometimes conflicting interests. Several state, county or local governments and agencies may be involved. Private businesses or other interest groups may have concerns about the water body as well.

Pulling all these parties together is like weaving a piece of fabric, and each group interested in the water body is like a different strand of thread. As the strands are woven into the cloth, it becomes stronger. The end product—achieving consensus among the parties—is like the strongly interwoven cloth. The objective is to encourage cooperation and gather support for the management program, but the benefits of community participation go beyond this. Informed citizens, agencies and other groups who become involved in a water body management project share information about:

- The ecology of the aquatic system
- Whether the system can be managed
- Different government agencies
- Special organizations with an interest in fresh-water management
- Leadership, organization, and cooperation.

Public Involvement Steps

Public involvement means the participation of the entire community. However, it is the role of the steering committee to do the initial leg work — gathering information and developing draft proposals to present to the community. Important elements in the public involvement process are:

1. Identify interested groups
2. Conduct public meetings
3. Keep the community informed

1. Identify interested groups: The steering committee identifies interested groups and compiles a list of appropriate contacts. The committee should already have a good handle on potential user and interest groups, having considered this topic in Step A. Some groups that may have an interest in management of an aquatic system are:

- Residents or property owners around the water body
- Special user groups (e.g., bass anglers, ducks unlimited
- Local government
- State and federal agencies (e.g., State Department of Ecology)
- Native American tribes
- Water-related businesses (e.g., resorts, tackle & bait shops, dive shops)
- Elected officials
- Environmental groups (e.g., Audubon).

2. Conduct public meetings: One of the best ways to reach the public is a meeting sponsored by an existing lake association or community club. These are usually made up of property owners around the water body. If no lake association exists, it is worthwhile to form one. State and national management organizations can offer additional information contacts. Public meetings are a good way to attract individuals from within and outside the association. Local government officials, state agency personnel, local tribes, business people, and environmental and other user groups should all be invited to participate in these meetings.

Tip: Many of the identified groups consist of volunteers who may have limited time to participate in public meetings. It is a good idea to contact these people well in advance of the event so they can plan their time accordingly. Meetings will most likely need to be scheduled for evenings or weekends.

Timing is critical. Public meetings should be conducted at strategic stages in the planning process. critical points are:

1. At the formative stages, following completion of Steps A and B
2. When possible plant control alternatives have been identified by the steering committee (after Step H)
3. After a control scenario has been selected, but before it is carried out (after Step J)
4. During implementation of the control scenario
5. During post-treatment evaluation.

Obtaining widespread support is crucial. It is crucial that the interested parties support and accept proposed aquatic-plant management actions. it is a good idea to collect written documentation of this support to have on record. later on, the supportive documentation can be useful for purposes of clarification or emphasis.

3. Keep the community informed

Newsletters sent to association members and other interest groups and agencies are a good way to keep the public informed. The organization initiating the planning process needs to stay in personal contact with these other interest groups. Members of the steering committee or other association members, for example, could accept invitations to participate in meetings of groups interested in the lake and present information on aquatic-plant management.

Notes on Consensus Building

Consensus building in a diverse group can be a most challenging task. It may be difficult to get people with different interests to agree 100 percent on an issue. But it is critical to bring all groups together in the planning process to constructively discuss the issues and work toward achieving a consensus. To lead the effort, it will be helpful to identify individuals with strong, steadying leadership qualities. The following are some practical suggestions for achieving a common goal in a group:

1. Acknowledge that each person's opinion is important.
2. Emphasize that this is a group endeavor.
3. Use expert advice to clarify misconceptions.
4. Emphasize the community benefits of management actions.

References on Public Involvement/Lake Management Organizations

- Starting and Building an Effective Lake Association[26]
- The Lake and Reservoir Restoration Guidance Manual (appendix 3a)[4]
- Management Guide for Lakes and Reservoirs, Chapter 3.1[5]
- Washington State Lake Protection Association[H]
- North American Lake Management Society[I]

CHAPTER 6

IDENTIFY WATER BODY/ WATERSHED FEATURES (STEP D)

Water Body-Watershed Connection

A lake or river is a dynamic, living system, teeming with all sorts of physical, chemical and biological activity. The system extends beyond its shores to include surrounding land whose waters drain into the water body (the *watershed*). A water body and its watershed are inseparable. In fact, water body conditions are very much influenced by what occurs in the watershed.

For instance, a watershed contributes *nutrients* to a water body that are necessary for aquatic plant growth. These nutrients—especially phosphorus and nitrogen—flow to the lake from all parts of the watershed by way of streams, ground water, and stormwater runoff. In addition, activities in the watershed, such as agriculture and forestry, road maintenance and construction can all contribute silt, debris, chemicals, and other pollutants to the water body. These potential sources of contaminants are examples of *nonpoint pollutant sources*. Nonpoint sources arise from more widespread, dispersed sources, in contrast to point sources such as pipes or outfalls that dump directly into the water body.

A Plan should consider these possible sources of nutrient inputs and identify long-term measures to reduce them. Controlling watershed inputs from these sources can potentially enhance the effectiveness of primary in-lake control measures.

Because of these important land-water connections, integrated aquatic-plant management has to take a look at the entire picture. A water body can't be managed without understanding what makes the whole system tick. Learning about the features of both the watershed and water body aids in understanding problems in the water body and in designing an effective management program.

How To Describe The Watershed And Water Body

This planning step is composed of two tasks:

1. Describe the Watershed
2. Describe the Water Body

This step is really a fact-finding endeavor, which is conducted by the steering committee. The committee may have already uncovered some of the background information recommended below in its preliminary search for data (See Getting Started, Chapter 1).

1. Describe the watershed: To understand a water body's problem, you first need to identify features of the watershed. It is important to note characteristics of the watershed such as:

- Size and boundaries of the watershed
- Tributaries, wetlands and sensitive areas

- Land use activities in the watershed
- Nonpoint pollutant sources
- Existing watershed management, monitoring or enhancement programs
- The presence of rare, endangered or sensitive animals and plants

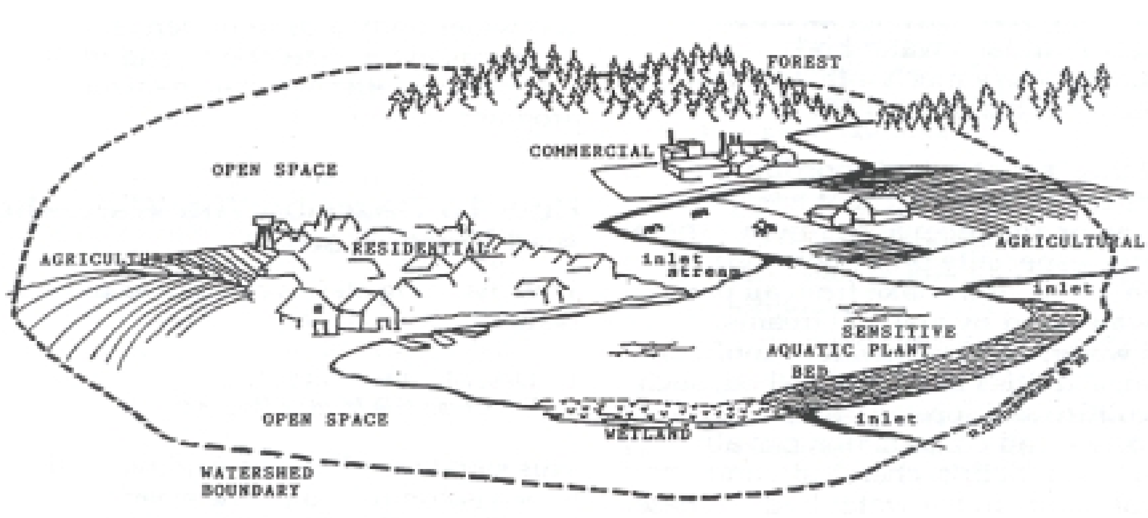
Much of this information is readily available as documents, maps or data that can be obtained from local planning or public works departments and state agencies. *Appendix C --Watershed and Limnological Background Information* offers a more detailed discussion on these topics and how and where to collect information on your watershed.

Most of the watershed information can be presented pictorially in a watershed snapshot. The following illustration depicts such a snapshot showing unique features of a hypothetical watershed.

The description of your lake that is required for a Plan is really no different from how you would describe your lake to a friend. However, where your description to a friend might include observations and information on how to avoid obstacles and where to catch fish, the observations required for a Plan describe what it is about the water body that can affect the growth of plants. Understanding the factors that influence weed growth is an important step in controlling a nuisance weed situation.

Water body features that are important to identify are:

- location
- Size, shape, and depth
- Water sources
- Physical and chemical characteristics (water quality)
- Biological characteristics (animals and plants)
- Shoreline uses
- Outlet control and water rights.



"WATERSHED SNAPSHOT"

2. Describe the water body

You probably know more about your lake than just about anyone else. You can probably easily describe your lake in general terms - you know where the weeds are thickest, where the snags are that can snap your prop or tangle your fishing line, and where the big, hungry fish like to hang out.

Because our state has such diverse climates, ranging from inland desert to coastal plains to high elevation mountain areas, the **location** of your water body within the state can explain unique aspects of the problem and what might work best in your situation. The **size, shape and depth** of a water body determines where aquatic plants can grow, and other biological and chemical processes occurring in the waters. A water body is influenced by types and quantity of **inflowing and outflowing water sources**. In addition, understanding **water quality characteristics,** such as temperature, light, dissolved oxygen levels and nutrient concentrations in the water, helps explain the overall health and limitations of the system. Finally, there are important cultural factors on the shoreline **(land use, regulating flow through the outlet)** that further define the water body. These physical, chemical, and biological features of freshwater ecosystems are described in more detail in *Appendix C-Watershed and Limnological Background Information.*

Getting Started In Your Search Of The Water Body

Many lakes in Washington have been mapped by the U.S. Geological Survey and the Department of Ecology. The results were published in *Reconnaissance Data on Lakes in Washington and Data on Selected Lakes in Washington.* The information in these surveys may be out of date, especially with respect to land use, but they can provide much of the basic background information required for planning.

Sampling/Monitoring To Fill Data Gaps

Some of the information you need to describe your water body and develop a Plan may not be available. In that case, an organized information gathering program might be necessary to fill in background data gaps. The information can be collected by lake-area residents. Special sampling equipment is often necessary to obtain some information.

Also, certain types of water samples require analyses by approved analytical or biological laboratories. See *A Citizen's Guide to Understanding and Monitoring Lakes and Streams, Volunteer Lake Monitoring: A Methods Manual,* or *The Lake and Reservoir Restoration Guidance Manual* for descriptions of sampling methods and equipment.

Ecology's Citizen Lakes Monitoring Program or local monitoring programs may be sources of training and assistance in setting up a sampling program for your water body. Examples of small-scale monitoring projects on the local level are King County/METRO's small lakes program, Snohomish County's volunteer lake monitoring program, Pierce County Cooperative Extension Office's program for stream monitoring, and local Adopt-A-Stream programs.

References and Resources on Lake, River and Reservoir Monitoring and Ecology

- Appendix C-Watershed and Limnological Background Information
- Reconnaissance Data on Lakes in Washington[28]
- Data on Selected Lakes in Washington[29]
- The Lake and Reservoir Restoration Guidance Manual[4]
- Ecology's Citizen Monitoring Project[E]
- Volunteer Lake Monitoring: A Methods Manual[9]
- A Citizen's Guide to Understanding and Monitoring Lakes and Streams[6]
- Limnology[23]
- Ecology staff
- Local governments
- Freshwater limnologists/chemists

CHAPTER 7

IDENTIFY BENEFICIAL USE AREAS (STEP E)

In terms of human enjoyment, freshwater systems are popular outdoor recreational places for swimming, boating, and fishing. They also offer a variety of economic benefits such as tourism, food supply, and transportation. Their capacity to provide aesthetic enjoyment can be immeasurable. Freshwater bodies perform vital functions such as flood protection, providing drinking water, and generating electricity. More importantly, freshwater systems provide habitat and food for all kinds of aquatic life, including fish, waterfowl and other animals.

Beneficial uses are protected Beneficial uses of water bodies are protected by Washington State statute. Under the State Surface Water Quality Standards (Chapter 173-201 WAC), protected beneficial uses include fish and shellfish rearing; spawning and harvesting; swimming; boating; navigation; irrigation; wildlife habitat; and domestic, industrial, and agricultural water supply.

Balancing multiple uses Desired uses of a water body must be compatible with it's capacity to sustain those uses, both human and natural. Unfortunately, a single water body often supports many different desirable uses, which sometimes conflict with each other. The management challenge involves identifying and agreeing on uses that complement each other, and realistically managing for these uses.

How To Determine Beneficial Use Areas Of Your Water Body

This step focuses on identifying zones for each beneficial use on a map of the lake. Often, the process of defining these areas reveals the potential for conflict. Step E consists of two tasks:

1. Identify present water body use areas.
2. Produce a water body usage map.

1. Identify present water body use areas

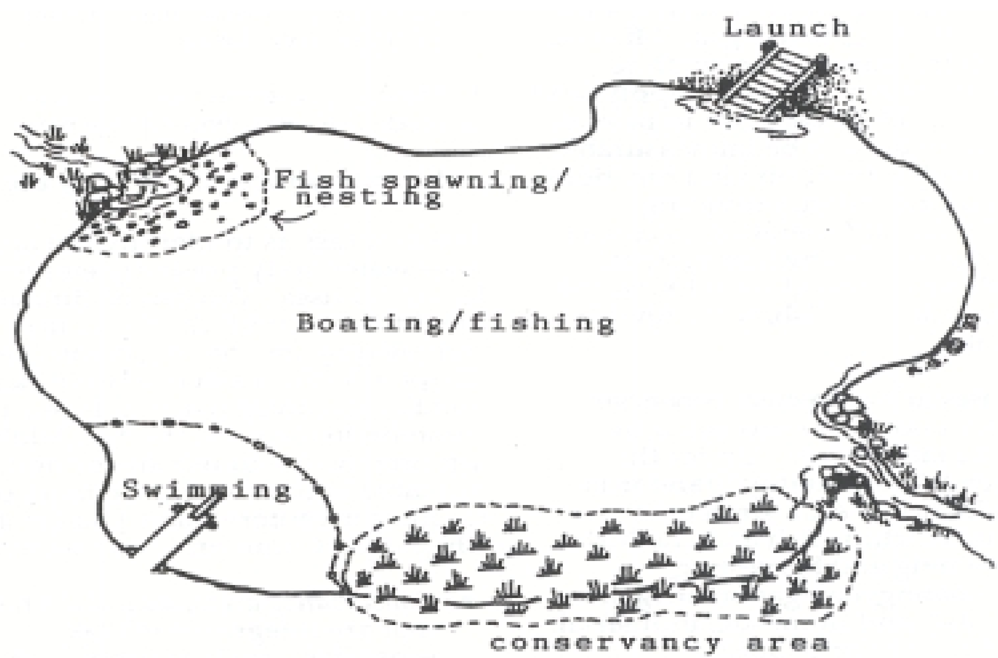
The first task is to identify the areas of your water body presently employed for beneficial uses. You can begin this identification with the list of uses compiled by the steering committee in Chapter 3. For each use from that list, identify the areas where it is most common in the water body. Additional information about use areas might be available in the zoning, wetland, or resource inventory maps you created in Chapter 5. Common use areas include:

- *Conservancy areas,* including habitats that are integral to the lake ecosystem, such as nesting sites, fish rearing or spawning areas, or locations of rare plant communities.
- Boating and boat access areas (launches, ramps)
- Water skiing zones
- Beaches and swimming areas (public, private)
- Fishing areas
- Areas for special aquatic events (e.g., sailing, rowing, mini hydroplane races)
- Parks, picnic areas, nature trails, scenic overlooks
- Irrigation/water supply intakes
- Other shoreline uses (e.g., residential, commercial).

2. Develop a water body usage map: The next task is to draw the current water body use areas on a map of the lake. This water body usage map shows primary human uses, as well as habitat areas for fish, waterfowl, and other wildlife utilizing the water body. As you develop this map, look for potential conflicts in use, such as a water-skiing zone coinciding with a swimming area.

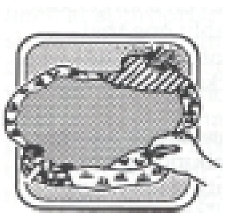
Example Of Water Body Usage Map

The following is a water body usage map drawn for Lake Tranquil.



WATER BODY USAGE MAP

CHAPTER 8



Map Aquatic Plants (Step F)

What is An Aquatic Plant Survey?

Depending on a water body's size, depth, and other characteristics, aquatic plant growth can be extensive or occur in small localized areas. In order to design an effective management program specific to your water body, the types of aquatic plants growing there, their location and the extent of growth must first be determined. This can be accomplished by performing an *aquatic plant survey*. A survey involves systematically traveling around the water body and shoreline and noting aquatic plant conditions. An important part of the survey is collecting samples of aquatic plants to verify the species. This is especially important if invasive, nonnative macrophytes are suspected to be present.

> ***Tip:*** Staff with Ecology's Freshwater Aquatic Weeds Management Program can guide you in designing a survey of your water body. In addition, grants are available for aquatic plant surveying projects through Ecology's Aquatic Weeds Management Fund.

How to Map Aquatic Plants

Mapping aquatic plants in your water body involves the following tasks:

1. Conduct a systematic survey of the water body.
2. Produce an aquatic plant survey map.

1. Conduct a systematic survey of the water body Aquatic plant surveys are usually conducted in critical stages in the growth cycle of plants. Ideally, surveys should be performed early in the growth season (spring), at mid-season (summer), and late in the growth season (fall). But this often can't be done because of time and financial limitations. A survey at the height of the growth season (August), when plants are most obvious, provides a practical and valid alternative. A simple aquatic plant survey consists of:

A. Identifying major types of aquatic plants.
B. Drawing a map of aquatic plant types and locations in the water body.
C. Estimating relative abundance of aquatic plant types.
D. Collecting samples of plant species.
E. Identifying sediment types.

A. Identifying major types of aquatic plants Before you start your survey, you will need to become familiar with various types of aquatic plants. There are generally four kinds of aquatic plants that inhabit freshwater. The types are characterized according to how they are attached to the sediments. The four groups are *emergent* (such as cattails), *freely-floating* (such as duckweed), *rooted floating-leaved* (such as water lilies), and *submersed* forms (such as milfoil). The four plant types may occupy different regions of the lake, with emergents and floating-leaved plants confined to shoreline margins, while submersed and free-floating plants can extend to deeper, open water areas. In general aquatic plants tend to inhabit shallow, near-shore areas of the water body. In shallow water bodies, profuse aquatic plant growth may occur throughout the system.

B. Drawing a map of aquatic plant types and locations in the water body You will need the following basic supplies and equipment for your survey:

- √ A map of your water body
- √ A rope marked off in feet to measure water depth
- √ A weighted rake with rope attached for collecting samples
- √ A notebook, pencils, and waterproof marker
- √ Plastic bags for samples, with labels
- √ An anchor

Keeping the four basic plant types in mind, tour the entire water body by boat, noting where plants are near or at the water surface. You may also find it helpful to walk around the shoreline, especially if near-shore areas are clogged by weeds and make boat passage difficult. Sketch the locations of plant growth for the four types on a large-scale map of the lake, preferably one that indicates water depth intervals and includes major landmarks for reference.

C. Estimating relative abundance of aquatic plant types The relative abundance or prominence of the aquatic plant types often indicates how well the system is in balance. A healthy aquatic system usually has a variety of types and species of plants. The presence of only a few species of plants in a water body may occur where shoreline areas have been disturbed (by an influx of sediments or other contaminants) or have been invaded by exotic species.

In order to determine relative amounts of aquatic plants, you will need to look at the plant beds at representative points within the water body. Before leaving shore, establish

How to Recognize the Four Types of Aquatic Plants

Emergent aquatic plants grow rooted in saturated soils around the shoreline or in water up to about 2 feet deep. Mature emergents' stems, leaves, and flowers extend well above the water surface. Many look like terrestrial plants. Soft rushes, bulrushes, cattails, and iris are typical emergent species.

Freely-floating aquatic plants float on or under the water surface. Their root systems, if present, generally hang beneath the plant and are not attached to the bottom. This diverse group ranges from large plants like coontail and water hyacinth to very small surface-floating plants like duckweed. They are usually found in protected areas or where water currents are very slow. Since they absorb nutrients entirely from the water column, these aquatic plants are frequently found where nutrient content is high.

Rooted floating-leaved aquatic plants grow attached to the sediments in water depths from 1.5 to 10 feet. They are recognized by oval or circular leaves that float on or project just above the water surface. The floating leaves are connected to the bottom by long, flexible, fairly rigid stems. Water lilies are common floating-leaved plants.

Rooted submersed aquatic plants grow at water depths where light is sufficient. Submersed plants grow with stems and leaves underwater, although some forms also have differently-shaped floating leaves (e.g., broad-leafed pondweed). Submersed species usually have long, thin, flexible stems that are supported by the water. Submersed plants show a variety of leaf forms, from long ribbons (long-leaf pondweed) to feathery whorls (milfoil). Most submersed aquatic plants produce flowers above the water surface.

survey lines, called *transect lines*, at appropriate points along the shoreline. For a small lake, you can mark off transects, say every 300 feet, all the way around the shoreline. Draw these lines on the lake map extending them perpendicularly from shore out to where the water is about 20 feet deep (typically the outer limit of growth).

In a boat, follow each of these lines looking at the submersed plants through an *underwater viewer*. These can be obtained at diving shops or recreational supply stores or built (contact Ecology staff for ideas on constructing your own viewer). At regular points along the transect (e.g. at increments of 3 feet of water depth), make an estimate of plant abundance by counting the number of plants per unit area of lake bottom. Estimate plant abundance as sparse (a few plants per square yard), moderate (5-10 plants per square yard), or dense (more than 10 plants per square yard).

D. Collecting samples of plant species. Identifying aquatic plant species is important for several reasons. For one thing, different species often respond differently to the same control techniques. A technique that is very effective on one species may not work at all on a different species. It is also important to determine whether any rare or sensitive plants are present. These species are protected and some control technologies are prohibited. Finally, it is crucial to find out whether any invasive, nonnative plant pests are present, because the presence of these plants calls for fast, aggressive action. To help acquaint you with some important exotic plant invaders, an illustrated plant identification key in Appendix B portrays six exotic species of concern in Washington waters.

> RED FLAG **- If an invasive, exotic species is present in your water body, notify staff at Ecology's Freshwater Aquatic Weeds Management Program.** A more intensive survey should be conducted to determine the precise locations of the exotic plant populations. In addition, special measurements should be taken to deter the status of the infestation, regardless of whether it is in a beginning or advanced stage.

> RED FLAG -- **If an endangered, rare, or sensitive aquatic plant is present in your waterbody,** a more intensive survey is recommended to determine the precise locations. See the discussion on the DNR Natural Heritage Program in Appendix C.

Samples of aquatic plants should be collected at points along the survey transects. From the boat or shoreline you can cast a weighted rake to the lake bottom and pull up aquatic plants. Be sure to note the transect line number, the location on the transect, and the depth from which the sample was taken (use your calibrated rope to measure depth). Specimens collected in this manner can be bagged and sealed for later shipment to a specialist for identification.

It is also advisable that you preserve a sample of the important plant species in your water body for permanent record. Staff with Ecology's Aquatic Weeds Management Program can help you with ideas on preserving plant specimens.

> ***Tip:*** Be sure to keep all plant fragments on the boat for proper disposal later on, as many problem plant species can reproduce and spread by fragments.

E. Identify sediment types. Sediment types are generally classified as:

- mucky, organic
- sandy
- compact, clayey
- gravely

Sediments in the water body can be identified by either collecting a bottom sample with a small sampling dredge, by shoving a PVC pipe into the bottom, or by examining sediment brought up with an aquatic plant sample.

2. Produce an aquatic plant survey map of the water body Using field notes and maps from the aquatic plant survey, construct and aquatic plant map of the water body. The aquatic plant map should show:

- Water depth contours, in feet or meters (this type of data is presented on bathymetric maps).
- Approximate locations of each of the four types of macrophytes.
  - emergents
  - free-floating types
  - rooted, floating-leaved types
  - submersed types
- Highlighted locations of exotic, invasive aquatic plant species, if present.
- Highlighted locations of rare, sensitive, or endangered aquatic plant species, if present.
- Locations of wetlands/conservancy areas.
- General sediment types
  - mucky, organic
  - sandy
  - compact, clayey
  - gravely
- Tributaries/outlets
- Open areas

Tip: Preparing an aquatic plant map for your water body will save you valuable time later in the planning process as you explore certain recommended treatment options. The above information and aquatic plant map can be used when completing an Application for Stocking Grass Carp with Fish and Wildlife.

How to Collect and Prepare an Aquatic Plant Sample for Verification

Step 1. Obtain an aquatic plant sample by dropping a weighted rake to the lake bottom and pulling up the vegetation snagged by the rake. Remove the plants from the rake, sorting out the different plant types. To keep the plants from drying out, sort them in a shallow pan filled with water.

Step 2. Rinse a few healthy specimens of the plant types of concern with water from the lake. Carefully lay the plants between two pieces of damp paper towel, place them in a plastic bag and seal the bag securely. Label the bag clearly with the date, name of the water body, location and depth of sample, and your name and telephone number.

Step 3. Mail the samples to a recognized aquatic botanist for identification as soon as possible. Damp plant specimens in a plastic bag can easily be mailed in a regular envelope.

Step 4. If delivering a fresh (wet) sample in person, store it in a plastic jar filled with lake water in the refrigerator in the interim, and then transfer it to a small cooler with an ice pack for transport to an aquatic plant expert. Plant samples can usually be kept fresh in this way for up to five days.

*****To whom do I send an aquatic plant sample for identification?***

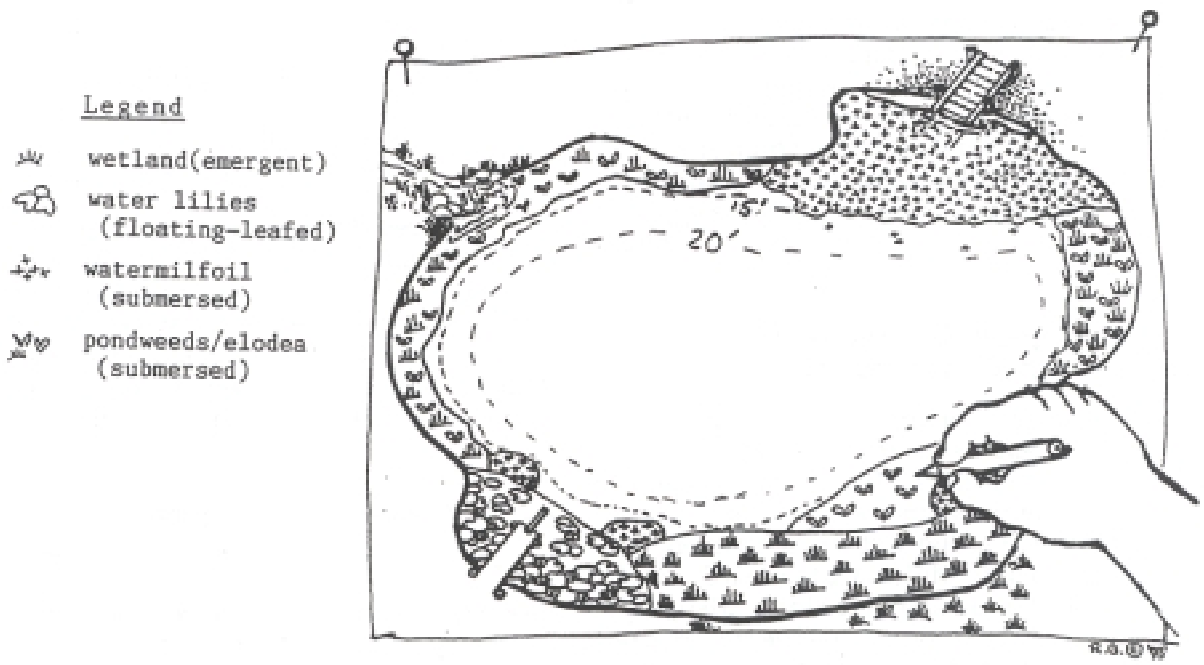
It is critical that the plant sample be accurately identified by an aquatic botanist or a trained freshwater management professional. Your first contact should be the Department of Ecology Aquatic Weeds Management Program Coordinator (Tel: 206-407-6562) who can refer you to recognized aquatic plant experts to aid in determining species identification.

Example of an Aquatic Plant Map

The following is an example of an aquatic plant survey map produced for Lake Tranquil.

Reference and Resources on Aquatic Plant Identification

- Ecology's Freshwater Aquatic Weeds Management Program Coordinator[A]
- Aquatic plant Identification and Herbicide Use Guide[10]
- Wetland Plants of the Pacific Northwest[17]
- Common Marsh, Underwater, and Floating-leaved Plants[2]
- County Noxious Weed Control Boards



AQUATIC PLANT MAP

CHAPTER 9

CHARACTERIZE AQUATIC PLANTS (STEP G)

Once you have mapped the aquatic plants in your water body, the next step is to use that information to write a description of beneficial and problem plant zones. Characterizing the aquatic plant zones allows you to determine where special control actions are required. Step G consists of the following tasks:

1. Describe Plant Types
2. Determine Problem Areas and Beneficial Plant Zones
3. Determine Need for Special Action

1. Describe general plant types The purpose of this task is to write a description of the main types of aquatic plants occurring in the water body. Give the general locations of plant beds and the maximum depth of growth. Also estimate how much of the surface area is occupied by plants.

2. Determine problem areas and beneficial plant zones

Problem plant areas Identify what parts of the water body are affected by the following problems:

- The presence of invasive exotic species
- Excessive native plant growth that interferes with such important water body uses as swimming or boating.

Beneficial plant zones Identify conservation areas, fish rearing habitat or native vegetation considered beneficial to fish, waterfowl, and other wildlife currently utilizing the water body. In addition, locate endangered, rare or sensitive plant zones. The highest priority is given to preserving these plant communities. Their presence may also limit use of certain aquatic plant control methods in and near the water body.

3. Determine special need for action in water body The presence of any non-native, invasive aquatic plant species signals an urgent situation. Because of the nuisance potential posed by these invaders, immediate action is necessary. Special funding is available for new infestations of non-native species through Ecology's Aquatic Weeds Management Fund.

Example Of Written Description Characterizing Aquatic Plants

A description of the aquatic plants in Lake Tranquil might read like this: "Aquatic plant growth in this lake is confined to a narrow band around most of the shoreline, extending out to 12 feet in depth. The total area of the lake occupied by aquatic plants is estimated to be about 40 acres (or 40% of the entire lake area). Some isolated patches of emergent, plants such as iris, cattails, and other reeds and rushes occur along the shoreline. A large water lily bed occupies the end of the lake where the swim beach is located. The submersed plant community is composed of sparse stands of naiad, common elodea and small-leaf pondweed in the shallows, and moderately-dense beds of big-leaf pondweed occurring throughout the deeper water areas. A large, surfacing stand of milfoil also occurs near the boat launch.

In addition, a few scattered stands of milfoil plants are present at the opposite end of the lake (near the swim beach), intermingled with the other submersed plants.

The entire bay with the boat launch as well as the near-shore region at the opposite end of the lake are highest priority **problem zones** because of the presence of the exotic weed milfoil. These milfoil areas require special control action. Another problem zone is the swim beach area which is heavily populated with water lilies; these surfacing beds make shoreline access as well as actual swimming most difficult and dangerous. Lake Tranquil supports a planted trout fishery and nesting blue herons, and the native beds of pondweed, elodea, and naiad form an important source of food and refuge for these and other aquatic wildlife. Also, the wetland stands near the swim beach are classified as a conservation area, and are recognized as beneficial zones and protected as part of the overall aquatic-plant management plan."

√! In completing the planning steps to this point, you may have uncovered new and critical information on the nature and type of aquatic weed problems in your water body. This new information may affect some of your initial objectives. For instance, you may have discovered the existence of exotic plants or sensitive plants in your water body. These conditions will affect your choice of management goals and control options. If this information wasn't available to you as you started the planning process, it may be necessary to revisit STEP A and STEP B and refine the Problem Statement and Management Goals. Once the necessary revisions are made, they should be presented to the larger community for approval through the public process. Now it is time to look at available control options.

CHAPTER 10

INVESTIGATE CONTROL ALTERNATIVES (STEP H)

Control Alternatives Available in Washington

A variety of methods are currently available for controlling nuisance aquatic plants. The following is a list of aquatic plant control alternatives currently available in the State of Washington:

Physical Methods

- Hand-pulling/cutting
- Bottom barrier application/ sediment covers
- Water-level drawdown
- Watershed controls
- Water column dyes

Mechanical Methods

- Harvesting and cutting
- Bottom tillage (rotovation)
- Diver-operated dredging

Biological Methods

- Grass Carp

Chemical Methods

- Fluridone
- Glyphosate
- Endothall
- Copper compounds

Control Alternatives Summarized

With so many techniques to choose from, how do you sort out the options? First, you'll have to become familiar with the advantages and disadvantages of each control alternative. Table 10-1 summarizes the management techniques in terms of important economic, environmental, and logistical factors. Having a basic understanding of the capabilities of each option will help you choose the best combination of treatment methods.

More complete and in-depth information on these control methods is available from other sources. Appendix D of this manual describes each option's mode of action, effectiveness and duration of control, advantages, drawbacks, costs, and permits, and provides other comments. Factsheets on aquatic plant control methods are available from Ecology. Other references and resources are listed below in the Quick References section.

No action alternative: Aquatic plant management usually involves "doing something" in the water body to correct the problem. Sometimes, however, control options may not be as appealing as simply "doing nothing". It is important to consider possible consequences to the water body if no action is taken against problem aquatic plants. The choice of no action may have serious impacts on the aquatic ecosystem and related human uses when problem infestations are due to non-native, invasive species.

In particular, it's important to consider the potential for nuisance plants to alter habitat and impact aquatic organisms. Water quality effects should be evaluated. Dense weed beds can produce changes in the water's dissolved oxygen levels, temperature and pH that can be harmful to aquatic life. In addition to reducing recreational enjoyment, excessive weed growth could negatively affect tourism and even commercial activities associated with use of the water body.

TABLE 10-1.
SUMMARY OF AQUATIC PLANT MANAGEMENT TECHNIQUES AVAILABLE IN WASHINGTON
Effectiveness and duration of control depend upon correct implementation for most techniques.

Method	Appropriate Scale (area of extent)	Duration of Control	Intensity of Control	Cost	Advantages	Disadvantages	Permit Required?
Physical							
Hand-pulling	Small scale	Season or longer	Moderate to High (with complete removal)	$0 with volunteer labor $500 to $2400/day for contract divers	• Site specific • Species specific • Minimum impact on native plants • Use near obstructions	• Slow, labor intensive, expensive • short-term turbidity increase • Diver visibility can restrict effectiveness	No
Hand-cutting	Small-scale	< One season	Moderate	$100 to $1000 for equipment + labor	• Immediate plant removal	• Slow • Fragments generated • Short-term increase in turbidity	Yes
Bottom Barriers	Small-scale	2 to 3 years	High	$0.15 to $0.75/sq.ft. for material $0.25 to $0.50/sq.ft. for installation	• Immediate plant removal • Materials reusable • Site specific • Useful around obstructions	• Not species specific • Benthic organism impacts • Material costs • Maintenance required	Yes
Drawdown	Large-scale	None	Low	Variable	• Useful for repair/ maintenance of shorelines and structures • May enhance growth of emergents (waterfowl habitat)	• Not species specific • May impact wetlands • Loss of recreation • Dissolved oxygen decrease • Benthic invertebrate impacts	Yes
Watershed Controls	Small-scale	None – long-term	Low	Low	• Long-term improvement in water quality • May encourage rooted and discourage non-rooted species	• Does not address nutrient sources used by most aquatic plants • May encourage rooted/discourage non-rooted species • Sometimes difficult to implement	No

SUMMARY OF AQUATIC PLANT MANAGEMENT TECHNIQUES AVAILABLE IN WASHINGTON (Continued)

Method	Appropriate Scale (area of extent)	Duration of Control	Intensity of Control	Cost	Advantages	Disadvantages	Permit Required?
Water column dye	Weeks to months	Weeks to months	Low	$12.50/acre-ft.	• Non-toxic • No special equipment needed • Colors water blue	• Shallow, closed systems only • Repeat treatments through growing season required • Not effective when plants near surface • No use in potable, flowing, or chlorinated water • Some classified as herbicides	Yes/No (Those classified as herbicides require a permit)
Mechanical							
Harvesting	Large-scale	Less than one season	Low-Mod	$600/acre (May vary with transport costs)	• Immediate plant removal to cutting depth (4 to 8 ft.) • Minimal bottom disturbance • Materials may be composted • Reduces internal loading of nutrients	• Plant disposal • Fragments produced • Fish and invertebrate impacts • Slow • High initial capital costs • Operating depth limited • Operations depend on weather • Not species specific	Yes
Rotovation/ Cultivation	Large-scale	2 to 3 years	Mod-High	$1000 to $1700/acre (depends on plant density and area of treatment)	• Winter treatment minimizes summer season recreation impacts • May increase species diversity	• Bottom disturbance/ increased turbidity • Long-term efficacy only on perennials • Bottom obstructions limit use • Not species specific	Yes
Diver-operated dredge	Small-scale	Potentially long (Depends on availability of propagules for recolonization)	Mod-High	$1100-2000/day (coverage depends on plant density)	• Site specific • Species specific • No depth constraints • Used near obstacles	• Labor intensive • Slow • Potential fragment production • Temporary bottom disturbance and increased turbidity	Yes

SUMMARY OF AQUATIC PLANT MANAGEMENT TECHNIQUES AVAILABLE IN WASHINGTON (Continued)

Method	Appropriate Scale (area of extent)	Duration of Control	Intensity of Control	Cost	Advantages	Disadvantages	Permit Required?
Biological							
Grass carp	Large-scale	Potentially long	Low-High	$50 to $200/acre (depending on stocking density)	• Low maintenance • Large area covered • Triploid fish are sterile	• Stocking densities not well established • Difficult to fine-tune control • Preference for native species over exotics • Containment structures required • Ecological impacts unknown • Not site specific • Recapture problems • Susceptible to predation by wildlife or humans	Yes
Chemical							
Fluridone	Large-scale	> 1 year (depends on availability of propagules for recolonization)	High	$700 to $1000/acre	• Systemic herbicide • Some species specificity with correct application rates • Non-toxic	• Requires long contact time • Off-site movement possible • Nutrient release and dissolved oxygen	Yes
Glyphosate	Large-scale	> 1 year (depends on availability of propagules for recolonization)	High	$250/acre	• Systemic herbicide • Non-toxic • No label restrictions on swimming and fishing	• Non-selective herbicide • Emergent plants only	Yes
Endothall	Large-scale	Weeks to months	Moderate	$500 to $700/acre	• Short contact time required • Low toxicity • Low cost • Fast dissipation	• Contact herbicide • Temporary effect • Some label restrictions for swimming and domestic water use	Yes
Copper chelates	Large-scale	Weeks to months	Mod to High (depends on species present	$120 to $340/acre (depends on species present)	• No use restrictions • Short contact time required	• Potential toxic effects • Persistent in environment • Species susceptibility varies	Yes

In summary, before a decision is made to "do nothing" to control nuisance plants, the potential consequences of that decision on beneficial uses of a water body must be carefully considered.

References and Resources on Aquatic Plant Control Alternatives

- Aquatic Weeds Management Program Coordinator, Department of Ecology[A]
- Aquatic Plant Management Program, FSEIS[1]
- Restoration and Management of Lakes and Reservoirs[13]
- Lake and Reservoir Restoration Guidance Manual[4]
- Aquatic Plant Identification and Herbicide Use Guide, Vol II[10]

CHAPTER 11

SPECIFY CONTROL INTENSITY (STEP I)

This step of the Plan development involves determining how much control is needed for particular plant problems. Are there plant zones around the lake that should be left alone (*no control)*? Where should a *low level of control* be applied to preserve some intermediate level of plant growth? And under what circumstances would a *high level of control* be necessary, such as where a minimal amount of nuisance plants can be tolerated.

What Are The Different Levels Of Control?

No Control It may be best to leave special habitat areas untouched, such as shoreline wildlife conservancy areas that serve as nesting and forage sites for waterfowl and other animals. Sometimes these sanctuary areas are islands within the water body system. Native plant beds that function as fish spawning sites might best be left alone or subjected to minimal treatment. In some cases, the presence of native plants may have aesthetic value to the surrounding community.

Low Level of Control Low levels of control might be all that is needed to attain your management goals. This usually involves a partial removal of vegetation. For instance, in lakes where a warm-water fishery is important, using mechanical means to develop fish lanes through vegetation can be quite valuable. Low-intensity control efforts are also important in shoreline treatments where emergent vegetation is to be protected. Low-level control maximizes enjoyment of a water body while minimizing plant removal. A benefit of low-level control using mechanical means is the low treatment cost per acre because less plant material is removed.

High Level of Control Certain situations may require aggressive control. For safety reasons it may be necessary to clear all vegetation from swimming or wading areas. Other areas requiring intensive removal may include areas around docks or boat ramps. The presence of invasive non-native plants may justify aggressive measures to remove plants. Lake-wide control efforts affecting 100 percent of aquatic plants are not appropriate, except in lakes where invasive, non-native plants have been identified.

How To Determine Levels Of Control In Water Body

To determine appropriate levels of plant control in your water body, refer to: the *water body usage map* and the *aquatic plant map*. The following tasks describe how to use these maps to produce a ***control intensity map***.

> ***TIP:*** If the maps are the same size and scale, they can be overlaid. A blank map of the water body showing just the shoreline outline can be placed over these to produce the control intensity map.

Task 1. On the usage map, identify use areas of the water body that are not impacted by existing aquatic vegetation growth. Make a list of these use areas under the heading NO CONTROL.

Task 2. Next, locate areas around the water body that are or have the potential to be designated conservancy zones or confirmed endangered, rare, or sensitive plant populations. Add these areas to NO CONTROL list, if not already included.

Task 3. On the usage map, identify use areas of the water body that require some control of existing aquatic vegetation growth. Make a list of these use areas under the heading LOW CONTROL.

Task 4. Referring to the aquatic plant map, recheck that low control areas do not contain endangered, rare, or sensitive plant populations. If they do, REMOVE from low control list.

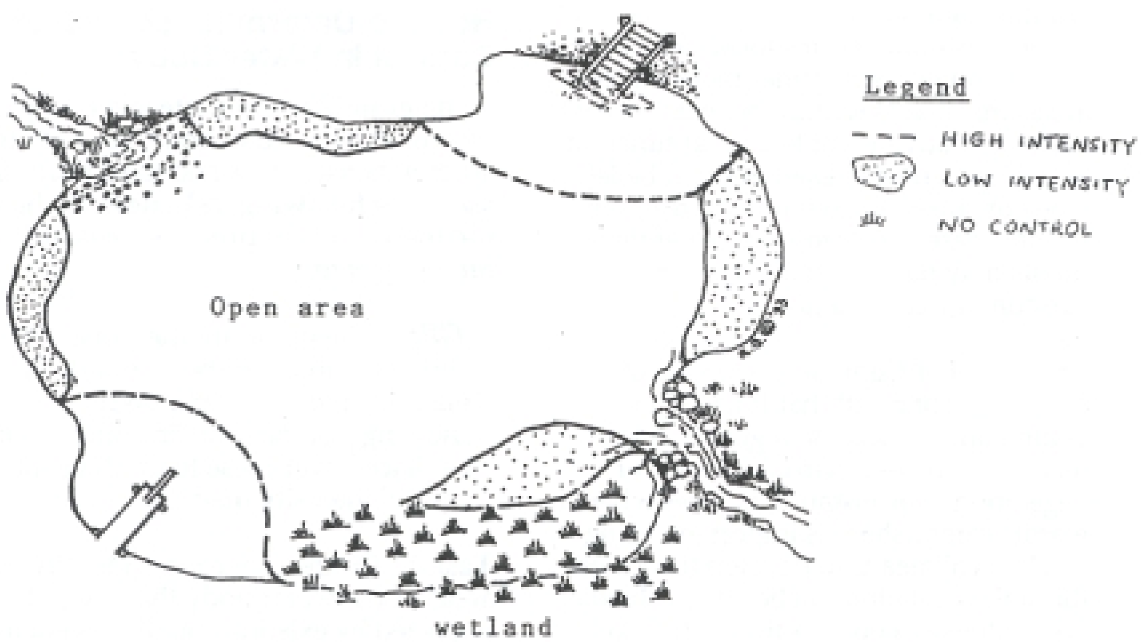
Task 5. On the usage map, identify use areas that require maximal removal of aquatic plant growth. Make a list of these areas under the heading HIGH CONTROL.

Task 6. Referring to the aquatic plant map, locate areas with invasive, non-native plant populations (like Eurasian watermilfoil or Brazilian Elodea). Include these areas on the list of HIGH CONTROL if not included.

References and Resources on Sensitive Plants
- Appendix C, Endangered, Rare and Sensitive Plants--DNR Natural Heritage Program

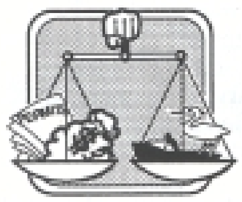
Example Of Control Intensity Map

The end product is a map clearly showing zones of all three control intensities (See control intensity map for Lake Tranquil). Construction of a control intensity map will aid in choosing appropriate treatment options for each area of the lake (Chapter 12).



CONTROL INTENSITY MAP

CHAPTER 12



CHOOSE INTEGRATED TREATMENT SCENARIO (STEP J)

The Integrated Approach—A Juggling Act

This step involves choosing the combination of control efforts that best meets the needs of water body users with the least impacts to the environment. The procedure consists of evaluating each control option listed in Chapter 10 using an *integrated vegetation management approach*. This approach involves examining the alternatives with regard to such factors as:

- The extent of problem plant(s) infestation
- Scale, intensity, and timing of treatment
- Effectiveness against target plant(s),
- Duration of control (short-term vs. long-term)
- Human health concerns
- Environmental impacts and mitigation, if needed
- Program costs
- Permit requirements (Federal, state, local).

Reviewing control alternatives in light of these and other site-specific factors provides a means of narrowing down your options into an appropriate management package. No management program, however, is without some impacts. Choosing a management program will require you to carefully weigh all the factors. The trick in deciding a course of action is to achieve a balance between expected management goals at a reasonable cost and acceptable environmental disruption.

A Procedure For Choosing An Appropriate Treatment Scenario

Using the *Control Intensity Map*, match each control zone (no control, low control, high control) with an appropriate control method. The following considerations are important:

- **The type and extent of plant growth and timing of treatment.**
  In reviewing control options, it is important to understand both the extent and the life cycle of the problem plant species. What is the area of problem growth? If the infested area is small (say, 0.25 acre), then large-scale methods, like mechanical harvesting, would be inappropriate. The same is true for large-scale problems treated with small-scale methods. What is the plant's typical life cycle? Some plant species with early-season growth are more susceptible to treatment in the springtime. In other situations, winter treatment may be most effective.

- **Probable duration of control.**
  How long will the plant be controlled? Is duration of control short-term (a month, a growing season) or longer term (one year, two years, more)?

- **Site-specific constraints that might affect use of control method.**
  Does the site have a lot of submerged logs or bottom debris or water intake pipes that would hamper bottom treatments like rotovation or bottom

barrier application? Are there many surface obstacles such as docks or buoyed areas that could interfere with surface operations of mechanical cutting or harvesting?

- **Capital costs and operation/maintenance costs.** If specialized equipment is to be purchased for the control project, determine the cost of buying, operating and maintaining it, including staff wages and replacement costs.
- **Human safety and health concerns.** Will the control option restrict use of the water body after treatment by banning water contact or ingestion (swimming, fishing, drinking or irrigation use)? Does the operation of large machinery or equipment occur at a peak time of recreational use? Does this control option represent a severe safety hazard or interfere significantly with normal use?
- **Fisheries, waterfowl or wildlife status and general *ecology* of water body.** Does the aquatic system have important spawning sites? If so, control activities that disturb the bottom would be prohibited during certain critical periods. The presence of endangered, rare, or sensitive plants or animals utilizing aquatic plant beds could also limit the use of certain control methodologies.
- **Balancing enhancement of beneficial uses with environmental protection.** What are the projected short-term and long-term impacts? Is there a risk that control for the sake of maximizing human use can seriously jeopardize an important segment of the native aquatic plant or animal community?
- **Possible *mitigation* techniques and costs, including replacement of untargeted plants that are removed.** Some aquatic plant control techniques pose higher risks of removing non-target organisms, particularly emergent vegetation along the shoreline. Estimates should be made of the types and areas of plant species that may be affected by the control techniques. Lost areas can be mitigated by replanting with nursery stock plants or plants harvested from local areas (check on local harvesting restrictions). Volunteers can often help with revegetation efforts, if needed.
- **Local, county, state or Federal permit requirements.** Find out what permits are necessary, whether a fee is required, and the expected time it takes to process the permit application(s). The length of time involved in processing different permit applications can vary enormously (See Table 12-1.). While most permits for aquatic plant control work in freshwater are free, some have an assessed fee (for example, a shoreline management permit has a cost that depends on the value of bottom barrier material applied).

Example Of Recommended Treatment Scenario

The following is an example of a recommended treatment scenario produced for Lake Tranquil :

LAKE TRANQUIL RECOMMENDED TREATMENT SCENARIO

- Whole-lake diver surveillance for milfoil locations (spring).
- In-lake treatment
  - First-year milfoil treatment: *Systemic herbicide application* in boat launch embayment with *bottom barrier application* in swimming areas (spring).
  - Second-year milfoil treatment: *Diver hand removal/bottom barrier application* on residual populations (spring).
  - Water lily treatment: *Systemic herbicide/bottom barrier* (Spring).
- Watershed controls.

√ ! You have come a long way in gathering critical information and evaluating plant control options with regard to the specifics of your water body and user needs. Now is a good time to update the community on the status of the emerging plan. The information can be presented to the community for discussion and approval through the public process. After obtaining group consensus on a treatment scenario, the steering committee can finalize the long-term action program.

Table 12-1. Who Permits What?
Permits/Documents Required for Aquatic Weed Control Activities in Washington

Permit/Document	Agency	Description	Control Activities Affected	Minimum Process Time*
State Environmental Policy Act (SEPA)	local or state agency	Requires complete disclosure of potential adverse environmental effects 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)	Dept. of Ecology	Permit allows modification of Water Quality Standards (Chap 173-201WAC); administered through regional offices.	herbicides, rotovation, dredging	45 days
State Shoreline Management Act	Dept. of Ecology (Shorelands) and local jurisdiction	Permit insures that proposed activity complies with local Shoreline Master Program; includes lakes 20 acres or more, rivers 20 cfs or greater, and can include associated wetlands and some floodplains.	bottom barrier(based on area/cost), rotovation, harvesting	75 days
Hydraulic Project Approval (HPA)(State) Hydraulic Code)	Dept. of Fisheries or Dept. of Wildlife	HPA required for work below ordinary high water line that can use, divert, or change natural flow or bed of waters of State; Fisheries jurisdiction applies to all salmon (& other food fish species) bearing water; Wildlife has jurisdiction over all game fish species.	some bottom barrier projects, rotovation, dredging	30 days
Natural Heritage Program Letter confirming search of data for critical plant species	Dept. of Natural Resources Division of Land & Water Conservation	Natural Heritage Program is State repository of data on Endangered, Threatened, & Sensitive plant species, native wetland plant communities, aquatic & non-vegetated wetland systems.	search should be conducted for any control activity	3-7 days
Fish Planting Permit	Dept. of Wildlife	A permit is required for stocking of triploid (sterile) grass carp in Washington waters for control of aquatic vegetation.	grass carp stocking	30 days
Local Permits	Local jurisdictions	Permits may be required on the local level for various activities, such as Shoreline Management or Growth Management Act/Sensitive Area ordinance	variable	variable

*For complete applications

CHAPTER 13

DEVELOP ACTION PROGRAM (STEP K)

Putting All The Pieces Together

The final task is to take all the information and formulate a *long-term action program (plan)* for aquatic plant management. This Plan provides the community with guidance and direction for aquatic plant management. The decision to proceed with aquatic plant control in your water body is just the beginning. Follow-through is critical. ***Aquatic plant control is an ongoing concern that requires long-term commitment.*** This is particularly true of water bodies with exotic plants or with nuisance plant growth that has developed over many years. In these situations, achieving management goals could take many years. The Plan should be flexible and evolving. It should provide for regular checking of how well the actions are working and allow for modification as conditions change.

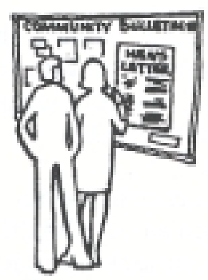
Components Of The Action Plan

While the integrated treatment scenario forms the heart of the Plan, there are other activities that are also essential components of the management program. These include program budgeting, evaluating program effectiveness, organizing public outreach and exotic weed prevention programs, developing funding strategies, and identifying short-term and long-term actions. These components are all linked together by the critical element of time. Appropriate start-up time and duration of each of these activities can vary widely. For these reasons, it is important to divide the action plan into short-term and long-term program elements.

1. **Review and recheck the recommended integrated treatment scenario.** The following factors need to be determined:
   - Costs
   - Permit requirements
   - Human safety/health and environmental impacts
   - Mitigation, if needed
   - Acceptability to water body property owners, users and other interested parties
2. **Compute costs and a budget to implement the overall program.** In particular, identify:
   - Planning costs
   - Contracted treatment costs
   - Capital costs (for equipment or materials)
   - Operation and maintenance costs
   - Equipment replacement costs
   - Program monitoring/evaluation costs
   - Mitigation costs
   - Permit costs
3. **Determine monitoring and evaluation strategies to evaluate the program's success.** In particular, you will need to:
   a. Determine methods to track short- and long-term nuisance plant growth trends.

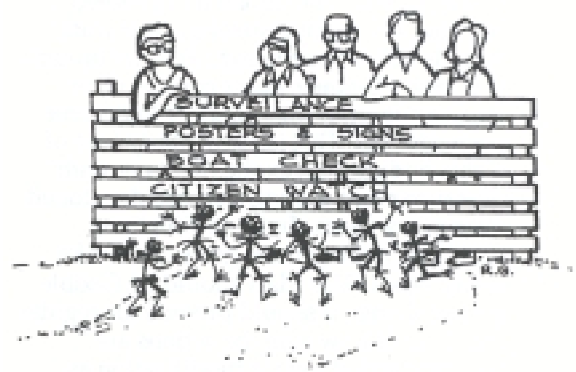
   b. Evaluate the effectiveness of your annual program with respect to meeting management goals.

4. **Plan a public outreach program.** Educational information about the aquatic plant management program can be disseminated through:
   - Public meetings
   - Newsletters and media coverage
   - Posted signs around the water body
   - Special events highlighting management activities on the water body such as workshops or lake fairs.



5. **Plan an exotic weed prevention program.** The old adage "an ounce of prevention saves a pound of cure" really holds true when it comes to exotic weed invaders. The Plan should contain an exotic (non-native) weed prevention component to limit introduction of non-native weeds to the water body and to provide a means of quick response if exotic weeds are sighted. Exotic weed invaders such as Eurasian watermilfoil, Brazilian elodea and hydrilla spread primarily by fragmentation (breaking off of stem pieces) and transport on boating equipment. Efforts to halt the spread through educational means, by a citizen watch for these invaders in the water body, and by visual inspection of boats entering and leaving the water body are recommended.

6. **Develop funding strategies.**
   a. Identify community groups with an interest in the water body.
   b. Identify the level and duration of needed funding.
   c. Assess all funding options, including
      - Voluntary donations for aquatic plant control work
      - Formation of a lake or property owner association with the ability to collect revenue
      - Establishment of a lake management district (LMD) or other taxing district
      - Grants or loans from public agencies or other outside sources (e.g., Ecology's Aquatic Weeds Management Grant Program).
   d. Identify an action plan based on optimal short and long-term funding sources to accomplish the Plan. Incorporate into points 7 and 8.



7. **Construct a short-term action plan.** Some elements of the Plan can be initiated immediately. Control methods like hand digging are usually small scale and have no permit requirements, so they can be implemented as soon as plants begin to show growth in early spring. Since mechanical harvesting is usually performed later in the season when plant growth is at its peak, preparing appropriate permit applications in the winter allows sufficient time to process permits prior to summer treatment. Volunteer efforts can be used for some activities. Many home

or property owner watershed controls can be implemented right away. Public outreach programs on scheduled management activities can be started immediately with little or no cost.

8. **Construct a long-term action plan.** Other elements of the Plan may require more time for completion or to procure funding or to handle complex permit issues. Certain techniques require repeat treatments over several years for optimal effectiveness (e.g., diver dredging, rotovation). The time-frame for processing permits may be extended if multiple permits are required or several agencies are involved in the review process. It may take time to advertise for specialized contract services such as diver dredging.

√ ! The planning process results in a *written* Plan that summarizes all the information that you have gathered. The written document provides the basis for annual review of short-term and long-term elements of the Plan. It is recommended that a three ring binder with tabs for each planning step be used to organize your planning document. In this way, any new information, monitoring results and necessary changes in the program can be easily documented for future use. Your plan should have the following written components:

√ Problem statement
√ Management goals
√ A list of water body and watershed characteristics from previous studies or current sampling work
√ A map showing beneficial and recreational use areas of the water body
√ A map showing types and locations of aquatic plants
√ A written characterization of aquatic plants
√ A discussion of aquatic plant controls, examining pros and cons of use in the water body (results can be presented in a matrix format)
√ A control intensity map showing proposed control areas in water body
√ Description of public involvement program, including specific examples.
√ A list of action strategies, both short- and long-term, and time frames
√ A description of the monitoring and evaluation process to be used.

A written plan containing these elements will serve you well in overall management of aquatic plants, as well as in meeting requirements of certain public funding sources. For example, an application for Aquatic Weeds Management Fund grant monies administered by Ecology requires written presentation of planning information using the format described in this manual (see Appendix E).

The Road Well Traveled

Congratulations on completing your Plan! Throughout the planning process, you have learned about the workings of the water body and its watershed, as well as aquatic plant management in Washington State and its applicability to your water body. You have learned how to organize and work together, and most of all, how to compromise. Now you can begin the process of initiating the aquatic plant management program.

PART III

IMPLEMENTING A PLAN

Part III offers guidance on how to use an integrated aquatic vegetation management plan (the Plan).

CHAPTER 14

I HAVE A PLAN—WHAT'S NEXT?

The period between development of an integrated aquatic plant management plan and implementation of the plan is a time for excitement, paperwork and patience! It involves scheduling, public outreach, securing permits and funding, and arranging for volunteer and contracted services. The duration of this period largely depends on the scale, intensity and complexity of the plant control program. Once these necessary items have been taken care of, you are indeed off and running!

Permits And Other Requirements

After the Plan has been approved and adopted, steps can be taken to secure required *permits* for control measures. The role of the permit process in the protection and management of our State's freshwater resources is a necessary and important one (See box below). The permits, fees, and notification procedures depend on the control methods to be used and the size, type or other special features of water body. (See Chapter 12 for summary information on permits necessary for certain control activities conducted in Washington State.) Often, several jurisdictions may be involved in the permitting process for a project. As a result, you may need to make a few phone calls to secure information and application forms.

Why Are Permits Needed?

Anyone planning aquatic plant management activities in their water body should be aware of the various State and local regulations protecting freshwater resources and aquatic life. There is no single regulation governing aquatic resources in our State, nor a single agency wholly responsible for overseeing freshwater activities. However, there are a number of laws regarding water quality, fisheries, wildlife, and habitat, and many different agencies responsible for administering these laws. In most cases, authorities overlap on both the local and State levels, and sometimes the Federal level, especially if navigable waters are affected. You should check with local and county public works or planning departments on what permits are required for a particular control activity in your lake or stream. Personnel with Ecology's Regional Offices or the Aquatic Weeds Program can assist you with information on permits required by State agencies.

Funding

Finding the right mechanisms for *collecting funds* is important. If major costs of the program are being funded by private contributions, outline a schedule for collecting committed donations. Local funds may be provided by financing through special community club or lake association assessments. It is best to start such an assessment process well in advance of the need for initial outlay of funds. Forming a lake management district (LMD) is a way to procure funds through special tax assessments. Timely completion of grant applications is critical if funding has been secured through competitive, cost-sharing grant programs such as the Aquatic Weeds Management Fund (Appendix E) or the

Centennial Grant Fund (both administered by Department of Ecology).

Implementation Needs Management

Once the plan is approved by the community, start lining up volunteers for parts of the program where citizen labor can be used. It may be beneficial for your association or club to expand the functions of the steering committee or establish a special aquatic plant management committee to oversee the long-term management program. Whether the project is large and complex or small and simple, each facet of the program will need to be managed.

Monitoring Program Effectiveness

A carefully designed aquatic plant management program can be successful and satisfying. But it also requires long-term commitment and flexibility. Depending on the severity of problems in the water body, it can take many years to achieve specific management goals. Furthermore, conditions in the water body or community needs may change over time. As a result, an aquatic plant management program must include a monitoring element to regularly evaluate treatment effectiveness and recommend program adjustments as needed. The effectiveness of the overall program should be assessed on an annual basis at a minimum. Progress in meeting management goals can be quantitatively tracked by directly sampling/measuring problem plant populations at strategic times during the year. Staff with Ecology's Freshwater Aquatic Weeds Management Program can provide assistance in planning a monitoring project for your water body.

TIP: An example of monitoring protocols currently used by Thurston County to assess aquatic plant management program effectiveness is presented at the end of Appendix C of this Manual.

On a more informal note, it may also be helpful to conduct periodic surveys of the community to gain their impressions of effectiveness of the program. During the implementation phase, it's important to be patient, be realistic in your expectations, and keep the lines of communication open!

Keeping Everyone Informed

It is critical to keep the community informed about the progress of the control project. In particular, give advance notice of any inconveniences that might be experienced by users of the water body as a consequence of in-lake activities. The community will want to know about the findings of post-treatment monitoring and evaluation of the control effectiveness. In going through the planning process described in this manual, you have already started the educational ball rolling. Through public meetings, newsletters, barbecues, and local media coverage, you've gotten word out that a problem exists in your water body but there’s a way to tackle it. Continue to use informational avenues that have worked for you to update the community on important aspects or results of the control program.

IN following the planning steps in this Manual, you have created a unique document—your ***PLAN***. The Plan describes the best path to integrated aquatic plant management in your water body. Good luck in your aquatic plant management efforts!

PART IV

TECHNICAL REFERENCES

APPENDIX A

Glossary of Terms

GLOSSARY OF TERMS

Algae — Small aquatic plants containing chlorophyll and without roots that occur as single cells or multi-celled colonies. Algae form the base of the food chain in aquatic environments.

Algal bloom — Heavy growth of algae in and on a body of water as a result of high nutrient concentrations.

Alkalinity — The acid combining capacity of a (carbonate) solution, also describes its buffering capacity.

Aquatic plant survey — a systematic mapping of types and location of aquatic plants in a water body, usually conducted by means of a boat. Survey information is presented on an **aquatic plant map**.

BMP's (Best Management Practices) — practices or methods used to prevent or reduce amounts of nutrients, sediments, chemicals or other pollutants from entering water bodies from human activities. BMP's have been developed for agricultural, silvacultural, construction, and urban activities.

Bathymetric map — a map showing depth contours in a water body. Bottom contours are usually presented as lines of equal depth, in meters or feet.

Benthal — Bottom area of the lake (Gr. *benthos* depth).

Biocontrol — management using biological organisms, such as fish, insects or micro-organisms like fungus.

Biomass — The total organic matter present (Gr. *bios* life).

Bottom barriers — synthetic or natural fiber sheets of material used to cover and kill plants growing on the bottom of a water body; also called sediment covers.

Chlorophyll — The green pigments of plants (Gr. *chloros* green, *phyllon* leaf).

Consumers — Organisms that nourish themselves on particulate organic matter (Lat. *consumere* to take wholly).

Contact herbicide -— An herbicide that causes localized injury or death to plant tissues with which it contacts. Contact herbicides do not kill the entire plant.

Control intensity map -— A map of a water body showing areas requiring no, low or high levels of aquatic plant control. See Chapter 11.

Decomposers — Organisms, mostly bacteria or fungi, that break down complex organic material into its inorganic constituents.

Detritus — Settleable material suspended in the water: organic detritus, from the decomposition of the broken down remains of organisms; inorganic detritus, settleable mineral materials.

Dissolved oxygen — A measure of the amount of oxygen gas dissolved in water and available for use by microorganisms and fish.

Drainage basin — The area drained by, or contributing to, a stream, lake, or other water body (see watershed).

Drawdown — Decreasing the level of standing water in a water body to expose bottom sediments and rooted plants. Water level drawdown can be accomplished by physically releasing a volume of water through a controlled outlet structure or by preventing recharge of a system from a primary external source.

Dredging — Physical methods of digging into the bottom of a water body to remove sediment, plants or other material. Dredging can be performed using mechanical or hydraulic equipment.

Ecology — Scientific study of relationships between organisms and their surroundings (environment).

Ecosystems — Any complex of living organisms together with all the other biotic and abiotic (non-living) factors which affect them.

Emergent plants — Aquatic plants that are rooted or anchored in the sediment around shorelines, but have stems and leaves extending well above the water surface. Cattails and bulrushes are examples of emergent plants.

Endothall — The active chemical ingredient of the aquatic contact herbicide Aquathol®.

Epilimnion — The uppermost, warm, well-mixed layer of a lake (Gr. *epi* on, *limne* lake).

Eradication — Complete removal of a specific organism from a specified location, usually refers to a noxious, invasive species. Under most circumstances, eradication of a population is very difficult to achieve.

Euphotic zone — That part of a water body where light penetration is sufficient to maintain photosynthesis.

Eutrophic — Waters with a good supply of nutrients and hence a rich organic production (Gr. *eu* well, *trophein* to nourish).

Exotic — Refers to species of plants or animals that are not native to a particular region into which they have moved or invaded. Eurasian watermilfoil is an exotic plant invader.

Floating-leafed plant — Plants with oval or circular leaves floating on the water surface, but are rooted or attached to sediments by long, flexible stems. Waterlilies are examples of rooted floating-leafed plants.

Fluridone — The active chemical ingredient of the systemic aquatic herbicide SONAR®.

Flushing rate — Term describing rate of water volume replacement of a water body, usually expressed as basin volume per unit time needed to replace the water body volume with inflowing water. The inverse of the flushing rate is the (hydraulic) detention time. A lake with a flushing rate of 1 lake volume per year has a detention time of 1 year.

Freely-floating plants — Plants that float on or under the water surface, unattached by roots to the bottom. Some have small root systems that simply hang beneath the plant. Water hyacinth and tiny duckweed are examples of freely-floating plants.

Glyphosate — The active chemical ingredient of the systemic herbicide RODEO®.

Grass carp — Also known as white amur, grass carp is a large, vegetation-eating member of the minnow family (*Ctenopharyngodon idella*). Originally from Russia and China, these plant grazers are sometimes used as biological agents to control growth of certain aquatic plants. Regulated use of sterile (non-reproducing) grass carp has been recently permitted in Washington State for aquatic plant control.

Herbicide — A chemical used to suppress the growth of or kill plants.

Habitat — The physical place where an organism lives.

Hydraulic detention time — The period of detention of water in a basin. The inverse of detention time is flushing rate. A lake with a detention time of one year has a flushing rate of 1 lake volume per year.

Hypolimnion — The cold, deepest layer of a lake that is removed from surface influences (Gr. *hypo* under, *limne* lake).

Integrated aquatic plant management — Management using the best combination of plant control methods that maximizes beneficial uses, minimizes environmental impacts and optimizes overall costs.

Limiting nutrient — Essential nutrient needed for growth of plant organism which is the most scarce in the environment. Oftentimes, in freshwater systems, either phosphorus or nitrogen may be the limiting nutrient for plant growth.

Limnology — The study of inland waters (Gr. *limne* lake).

Littoral — The region of a body of water extending from shoreline outward to the greatest depth occupied by rooted aquatic plants.

Macro-algae — Large, easily seen (macroscopic) algae. The macro-algae *Nitella* sp. sometimes forms dense plant beds and can be a conspicuous member of the aquatic plant community.

Macrophyte — Large, rooted or floating aquatic plants that may bear flowers and seeds. Some plants, like duckweed and coontail, are free-floating and are not attached to the bottom. Occasionally, filamentous algae like *Nitella* sp. can form large, extensive populations and be an important member of the aquatic macrophyte community.

Mitigation — Actions taken to replace or restore animals or plants that may have been damaged or removed by certain prior activities.

Morphology — Study of shape, configuration or form (Gr. *morphe* form, *logos* discourse).

Niche — The position or role of an organism within its community and ecosystem.

Nitrogen — A chemical constituent (nutrient) essential for life. Nitrogen is a primary nutrient necessary for plant growth.

Non point (pollutant) source — A diffuse source of water pollution that does not discharge through a pipe or other readily identifiable structure. Non point pollution typically originates from activities on land and the water. Examples of non point sources are agricultural, forest, and construction sites, marinas, urban streets and properties.

Non-target species — A species not intentionally targeted for control by a pesticide or herbicide.

Noxious weed — Non-native plant species that, because of aggressive growth habits, can threaten native plant communities, wetlands or agricultural lands. The Washington State Noxious Weed Board has the authority to designate certain plants as "noxious" in the state. Eurasian watermilfoil (*Myriophyllum spicatum)* is a noxious weed in Washington.

Nutrient — Any chemical element, ion, or compound required by an organism for the continuation of growth, reproduction, and other life processes.

Oligotrophic — Waters that are nutrient poor and have little organic production (Gr. *oligos* small, *trophein* to nourish).

Oxidation — A chemical process that can occur in the uptake of oxygen.

pH — The negative logarithm of the hydrogen ion activity. pH values range from 1-10 (low pH values are acidic and high pH levels are alkaline).

Phosphorus — A chemical constituent (nutrient) essential for life. Phosphorus is a primary nutrient necessary for plant growth.

Photosynthesis — Production of organic matter (carbohydrate) from inorganic carbon and water in the presence of light (Gr. *phos*, *photos* light, *synthesis* placing together).

Phytoplankton — Free floating microscopic plants (algae) (Gr. *phyton* plant).

Point (pollutant) source — A source of pollutants or contaminants that discharges through a pipe or culvert. Point sources, such as an industrial or sewage outfall, are usually readily identified.

Pollutant — A contaminant, a substance that is not naturally present in water or occurs in unnatural amounts that can degrade the physical, chemical, or biological properties of the water. Pollutants can be chemicals, disease-producing organisms, silt, toxic metals, oxygen-demanding materials, to name a few.

Primary production — The rate of formation of organic matter or sugars in plant cells from light, water and carbon dioxide (Lat. *primus* first, *producere* to bring forward). Algae are primary producers.

Problem statement — A written description of important uses of a water body that are being affected by the presence of problem aquatic plants. See Chapter 3.

Producers — Organisms that are able to build up their body substance from inorganic materials (Lat. *producere* to bring forward).

Public Awareness/Outreach — Programs designed to share technical information and data on a particular topic, usually associated with activities (such as management) on or around a water body.

Residence time — The average length of time that water or a chemical constituent remains in a lake.

Rotovation — A mechanical control method of tilling lake or river sediments to physically dislodge rooted plants. Also known as bottom tillage or derooting.

Secchi disc — A 20-cm (8-inch) diameter disc painted white and black in alternating quadrants. It is used to measure light transparency in lakes.

Sediment — Solid material deposited in the bottom of a basin.

Sensitive areas — Critical areas in the landscape, such as wetlands, aquifer recharge areas, and fish and wildlife habitat conservation areas, that are protected by state law (Growth Management Act of 1990).

Standing crop — The biomass present in a body of water at a particular time.

Steering committee — A small group of people organized to represent the larger community of individuals, businesses and organizations who have an interest in management of a particular water body. The steering committee is responsible for following the planning steps outlined in this manual.

Stratification — Horizontal layering of water in a lake caused by temperature-related differences in density. A thermally stratified lake is generally divided into the epilimnion (uppermost, warm, mixed layer), metalimnion (middle layer of rapid change in temperature and density) and hypolimnion (lowest, cool, least mixed layer).

Submersed plants — An aquatic plant that grows with all or most of its stems and leaves below the water surface. Submersed plants usually grow rooted in the bottom and have thin, flexible stems supported by the water. Common submersed plants are milfoil and pondweeds.

Susceptibility — The sensitivity or level of injury demonstrated by a plant to effects of an herbicide.

Systemic herbicide — An herbicide in which the active chemicals are absorbed and translocated within the entire plant system, including roots. Depending on the active ingredient, systemic herbicides affect certain biochemical reactions in the plant that can cause plant death. SONAR® and RODEO® are systemic herbicides.

Thermal stratification — Horizontal layering of water in a lake caused by temperature-related differences in density. A thermally stratified lake is generally divided into the epilimnion (uppermost, warm, mixed layer), metalimnion (middle layer of rapid change in temperature and density) and hypolimnion (lowest, cool, least mixed layer).

Thermocline — (Gr. *therme* heat, *klinein* to slope.) Zone (horizontal layer) in water body in which there is a rapid rate of temperature decrease with depth. Also called metalimnion, it lies below the epilimnion.

Topographic map — A map showing elevation of the landscape in contours of equal height (elevation) above sea level. This can be used to identify boundaries of a watershed.

Transect lines — Straight lines extending across an area to be surveyed.

Tributaries — Rivers, streams or other channels that flow into a water body.

Triclopyr — The active ingredient of a systemic herbicide being evaluated in Washington for aquatic plant control.

Triploid — A genetic term referring to non-reproducing (sterile) forms of grass carp induced by manipulating reproductive genes. Reproducing grass carp have two pairs of chromosomes and are termed diploid. Triploid fish have three sets of chromosomes.

Trophic state — Term used to describe the productivity of the lake ecosystem and classify it as oligotrophic (low productivity, "good" water quality), mesotrophic (moderate productivity), or eutrophic (high productivity; "poor" water quality).

Vascular plant— A vascular plant possesses specialized cells that conduct fluids and nutrients throughout the plant. The xylem conducts water and the phloem transports food.

Water body usage map — A map of a water body showing important human use areas or zones (such as swimming, boating, fishing) and habitat areas for fish, wildlife and waterfowl. See Chapter 7.

Watershed — The entire surface landscape that contributes water to a lake or river. See drainage area.

Watershed snapshot — A simple drawing of a water body and its watershed showing important identifying features such as watershed boundary lines, inlet and outlet streams, wetlands, landuse zones and other site-specific characteristics. This is a simple way of condensing background data and information on a project area and displaying selected features in a picture.

Watershed management — The management of the natural resources of a drainage basin for the production and protection of water supplies and water-based resources.

Wetland — A generalized term for a broad group of wet habitats. Wetlands are areas of vegetation that are transitional between land and water bodies and range from being permanently wet to intermittently water covered.

Zooplankton — Microscopic animal plankton in water (Gr. *zoion* animal). *Daphnia* sp. or water fleas are freshwater zooplankton.

APPENDIX B

Invasive, Non-native Aquatic Plant Fact Sheets

INVASIVE, NON-NATIVE AQUATIC PLANT FACT SHEETS

Introduction

Correct identification of aquatic plants is important. Control strategies that are effective on one may not be effective on another. The following fact sheets will help in identifying the most common nuisance aquatic plants.

Only a few aquatic plants create nuisance conditions in Washington. Usually there are key features that easily differentiate aquatic plant species, but in some cases plants require careful scrutiny for correct identification. Hydrilla, Brazilian elodea, and common elodea, which are plants of concern in Washington State, are perhaps the most difficult species to correctly identify. The importance of accurate identification is aptly illustrated by this trio of plants. Hydrilla is one of the most damaging of the aquatic plants. It is present in only one lake system in Washington, so early detection is important. Care must be taken not to mistake Hydrilla for one of the other plants in the trio because it requires special, rapid action to control its spread. Brazilian elodea is a common nuisance aquatic weed in Washington, while common elodea is a native species. If in doubt–call an expert!

Myriophyllum (milfoil) species may also require careful observation for correct identification. There are two weedy milfoils in Washington: Eurasian watermilfoil and Parrotfeather. Parrotfeather has distinctive emergent leaves, while Eurasian watermilfoil and the native milfoils are mostly submersed (except for the flower stalks). In addition to the native milfoils, several other aquatic plants are commonly mistaken for Eurasian watermilfoil.

Plants are amazingly adaptable organisms. Since they are usually rooted and can't move around to search out hospitable environments like animals do, plants adjust their growth to match the environment that they find themselves in. The form of an aquatic plant, like all plants, is determined by an intricate interaction between its environment and biology. Photos and drawings cannot convey the rich variation possible as individual plants respond to their unique environment. The illustrations shown here represent the general features of the plant. The plants you find in your lake should be compared to the illustrations with special consideration of the key features mentioned in the text. If identification is in doubt contact an expert (see Appendix F for a list of people who can answer your questions).

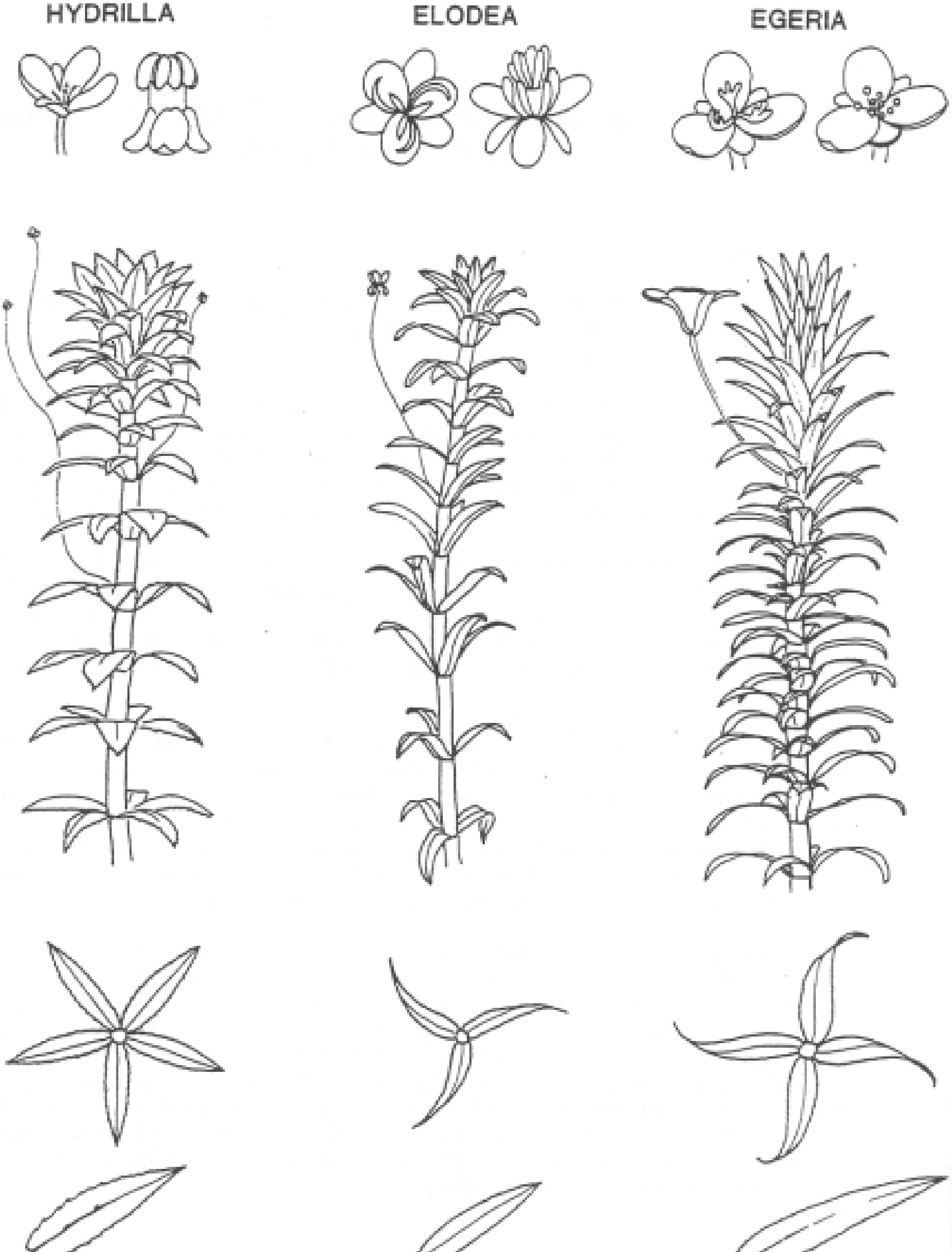


illustration provided by:
IFAS, Center for Aquatic Plants
University of Florida, Gainesville, 1990

Eurasian watermilfoil

(*Myriophyllum spicatum* L.)

Description

Milfoil has finely dissected leaves that form in whorls of four on the stem. Milfoil leaves fall off as they age, so occasionally you may find less than four leaves in a whorl, especially near the bottom of the plant. Leaves near the surface are often a reddish or brown color. Eurasian watermilfoil generally has 12-16 pairs of leaflets on each leaf. It's often difficult to separate Eurasian watermilfoil from its native cousins: northern watermilfoil and whorled watermilfoil. Calling an expert at Ecology may be the best way to positively identify your milfoil.

Growth Habit

Eurasian watermilfoil is the culprit in many nuisance aquatic plant cases in Washington. It has been the subject of much research, and its growth habits are well known. Milfoil overwinters as short bright green stems from a few inches to a few feet long - rooted in the sediments. Milfoil stores energy and nutrients in its roots over the winter. In early spring, plants grow rapidly to the surface where they can form a mat or canopy of branches. Rapid spring growth and canopy formation allows milfoil to outgrow and shade out other, more desirable native plants.

Propagation

Milfoil is spread primarily by stem fragments. Fragments are formed when pieces of the plant are cut off of the main plant body, such as by a boat propeller or during harvesting operations. These stems fragments can root and produce new plants. Milfoil also fragments naturally. In the late summer, the stems of milfoil become quite brittle and roots begin to form on the stem. Wave action or a duck paddling though a milfoil bed can cause stems to break.

Control

Prevention of Eurasian watermilfoil invasion requires control of fragment spread. Some management techniques, harvesting for example, can create fragments and contribute to the spread of milfoil. Milfoil is susceptible to several herbicides, including endothall and fluridone. With the proper herbicide and application rate, milfoil can be selectively removed from an aquatic system, leaving more desirable aquatic plant species. Other intensive methods, such as bottom barrier placement and diver-dredging are effective against small-scale infestations of milfoil. Milfoil is relatively unpalatable and is low on the grass carp preference scale. Other biological controls of milfoil are under intensive investigation, although none are likely to be available soon.

Eurasian watermilfoil
(Myriophyllum spicatum L.)

Key features:

- 12 to 16 leaflets on each leaf
- Emergent flower stalks sometimes are present during the summer
- Milfoil leaflets look like feathers
- No emergent leaves
- Leaves near surface may be reddish or brown

Parrotfeather

(*Myriophyllum aquaticum* (Vell.) Verdc.)

Description

Parrotfeather has both emergent and submersed leaves. The submersed leaves are finely-dissected, and feathery, often with a reddish color. The submersed growth form of parrotfeather is easily mistaken for Eurasian watermilfoil (*Myriophyllum spicatum* L.). The emergent stems can be from a few inches to over a foot high and are the most distinctive feature of parrotfeather. Emergent leaves form in whorls on the stem. Leaves are bright green and finely divided. In spring, very small, white, tuft-like flowers form where the emergent leaves attach to the stem.

Growth Habit

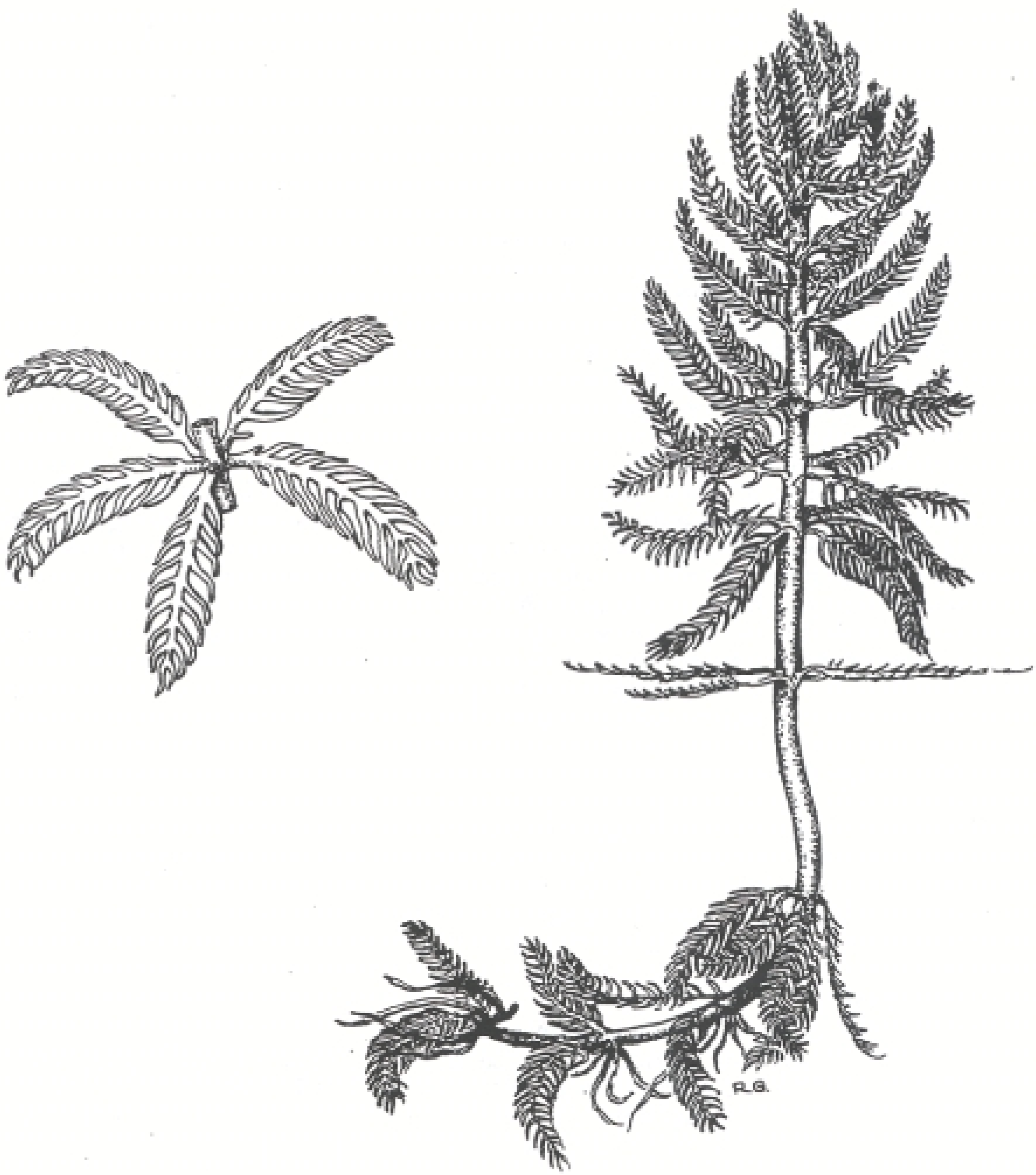
Parrotfeather grows best when rooted in shallow water. In nutrient-enriched lakes parrotfeather can grow as a floating plant in deep water. The emergent stems can survive on wet banks of rivers and lake shores, so it is well adapted to moderate water level fluctuations. Parrotfeather invasion of lakes and streams severely changes the physical and chemical characteristics of the aquatic ecosystem. The emergent stems shade the water column eliminating algae growth, which is the basis of the aquatic food web. Parrotfeather is also excellent habitat for mosquito larvae.

Propagation: Parrotfeather spreads only by plant fragments. All the parrotfeather plants in Washington are female. In fact, there are no male plants anywhere outside of its native range in South America. Consequently, there is no sexual reproduction and no seeds are formed. Parrotfeather rhizomes are quite tough and can be transported long distances on boat trailers. Parrotfeather's attractive green foliage make it a popular aquascaping plant, which has contributed to its spread.

Control

Parrotfeather has a high tannin content, which makes it unpalatable for most grazers, including grass carp. Parrotfeather is sensitive to many herbicides, but a thick cuticle, which forms a waxy cover on the emergent leaves, hampers aerial application of herbicides. Research has shown that parrotfeather growing in water deeper than about 20 inches may be particularly sensitive to reduction in phosphorus concentrations in the water column.

Parrotfeather
(Myriophyllum aquaticum (Vell.) Verdc.)



Key features:

- Bright green, christmas-tree like emergent stems
- Dense mat of intertwined rhizomes in the water with abundant, long roots
- Reddish feathery-leaved, very limp submersed leaves may be present

Brazilian elodea

(*Egeria densa* Planch.)

Description

Brazilian elodea is often confused with Hydrilla and Common elodea. Since Common elodea is a native species and Hydrilla an extremely aggressive invader, it is important that the plants be correctly identified. Common elodea has three leaves per whorl, Brazilian elodea four (sometimes eight) leaves per whorl, and Hydrilla five leaves per whorl. Common elodea leaves are usually less than $^1/2$ inch long and about $^1/4$ inch wide. Brazilian elodea leaves are greater than $^1/2$ inch long and less than $^1/4$ inch wide. Hydrilla has small "prickle hairs" on the leaf edges and spines on the midvein of the leaf that gives the plants a rough feeling. Hydrilla also forms small ($^1/4$ to $^1/2$ inch long) tubers in the sediment, which are not formed by the other two species. Brazilian elodea has three-petaled, white flowers, less than an inch in diameter, that float on the water surface.

Growth Habit

Brazilian elodea is rooted in the sediment and grows rapidly in the spring, forming a canopy of intertwined stems at the surface that shades out native aquatic plants. It is a popular aquarium plant, once commonly sold in tropical fish stores, but no longer legally for sale in Washington. The characteristics that make Brazilian elodea a popular aquarium plant: rapid growth under low light levels, easy propagation, and tolerance of a wide range of water and sediment types, also makes it a nuisance aquatic plant. when it escapes and grows in lakes and streams.

Propagation

Plant fragments are the primary mode of spread of Brazilian elodea. Fragments are formed when pieces of the plant are cut off of the main plant body, such as by a boat propeller or during harvesting operations. These stems fragments can root and produce new plants.

Control

As with other aquatic plants that are spread by stem fragments, prevention of Brazilian elodea fragment spread is critical to preventing the invasion of new lakes. Some management techniques, harvesting for example, can create fragments and contribute to the spread of Brazilian elodea. Once established, Brazilian elodea can be controlled by several herbicides and appears to be a preferred species grazed by grass carp. Other methods, such as bottom barrier placement and diver-dredging are effective against small-scale infestations of Brazilian elodea.

Brazilian Elodea
(Egeria densa Planch.)

Key features:

- Submersed, sometimes with white floating flowers
- Leaves in whorls of four or eight
- Leaves greater than one-half inch long and less than one-quarter inch wide
- **No tubers** attached to roots in sediment

Hydrilla

(Hydrilla verticillata (L.F.) Royle)

Description

Hydrilla closely resembles its cousins Brazilian elodea (*Egeria densa*) and common elodea (*Elodea canadensis*), both widespread in Washington. The primary distinguishing feature of Hydrilla is the presence of tubers that form on the roots. Tubers are small potato-like structures $^{1}/_{4}$ to $^{1}/_{2}$ inch long. Hydrilla also has small prickles on its leaves that give the plant a rough feel. Hydrilla typically has 3 to 8 leaves in a whorl around the stem that are $^{1}/_{10}$ to $^{1}/_{8}$ inch wide and $^{1}/_{4}$ to $^{3}/_{4}$ inches long. Hydrilla also forms turions (small, hard buds) on the stem and has small ($^{1}/_{2}$ inch diameter) white, floating flowers.

Growth Habit

Hydrilla is a submersed plant that is rooted in the sediment. Hydrilla is probably the most troublesome submersed aquatic plant in North America. It grows rapidly under very low light levels, in a variety of aquatic habitats from static to flowing water and at depths from an inch to 50 feet. The stem branches in the upper parts of the water column, forming a canopy that inhibits growth of native species and interferes with recreational use of lakes.

Propagation

Hydrilla has three primary means of spread: Stem fragments, tubers, and turions. Stem fragments are formed by harvesting operations and by boat props. Each stem piece can root and form a new plant. Tubers form on the roots in the sediment, and turions form on the stem in the water column. Tubers are produced in the sediment by the thousands, and sprout in the spring. Turions are smaller and are easily carried by water currents, providing a mechanism for long distance transport. Some strains of Hydrilla can set very small seeds.

Control

Hydrilla is found in one lake system in western Washington where an eradication program has been underway since 1995. Tubers and turions complicate control strategies. There is currently no technique, short of dredging, to remove tubers from the sediment once they are formed. Herbicide treatments can kill vegetative parts of the plant but do not affect the tubers. Therefore repeated herbicide treatments are needed to eradicate hydrilla from a lake. Grass carp will readily eat leaves and stems of Hydrilla, but do not eat the tubers. No biocontrol agent has been found that can effectively attack tubers in areas with even mild winters.

Hydrilla

(Hydrilla verticillata (L.F.) Royle)

Key features:

- Tubers (one-quarter to one-half inch long potato-like propagules) attached to roots in the sediment
- Tiny spines and "prickle hairs" on the leaves give hydrilla a rough feel

Fanwort

(*Cabomba caroliniana* Gray)

Description

Fanwort has distinctive fan-shaped submersed leaves arranged in pairs on the stem. In the water, fanwort has a "tubular" look because leaves are quite dense on the stem and there is little branching. Submersed leaves resemble those of water buttercup (*Ranunculus aquatilus*). Buttercup leaves, however, are arranged alternately (one per node) on the stem. Distinctive, but small, floating leaves may also be present. Floating leaves are long (less than one-half inch) and narrow (less than one-quarter inch). The stem attaches to the floating leaf blade at the center where there is a slight constriction. Small (less than one-half inch diameter), white flowers float on the water surface.

Growth Habit

Fanwort is a rooted aquatic plant with a limited distribution in the Northwest. In Washington it is restricted to side-channels of the Columbia River near Longview. In contrast to other rooted aquatic plants, fanwort is reported to obtain nutrients important for growth from the water column rather than the sediment. Fanwort has been in Cullaby Lake, on the north coast of Oregon, for at least 10 years where it creates severe nuisance conditions. Fanwort is a serious aquatic weed as far north as upstate New York and Michigan. It clearly has the ability to grow and create serious weed problems in Washington.

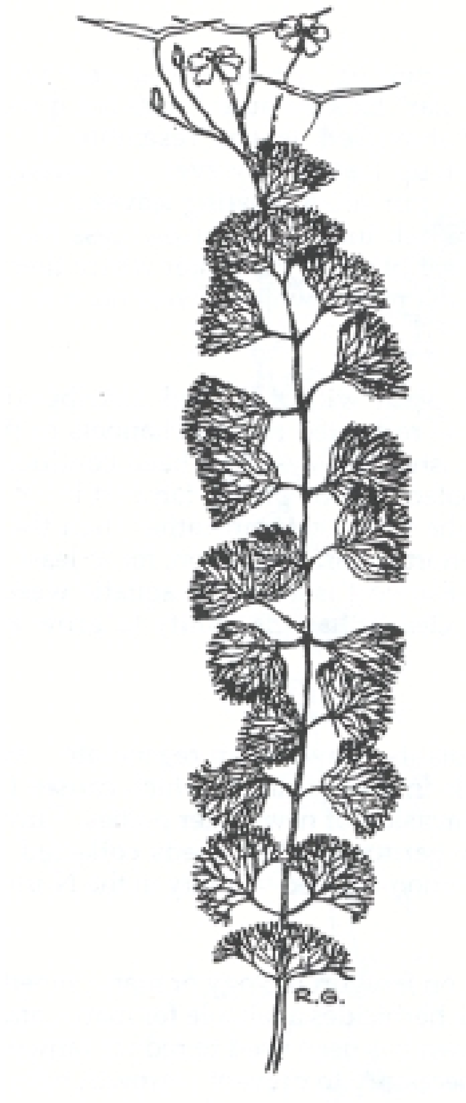
Propagation

Like many problem aquatic plants, fanwort can regenerate from small stem fragments. Fanwort stems become brittle in late summer, which causes the plant to break apart, facilitating distribution and invasion of new water bodies. Fanwort is self-pollinating in the South and seeds readily germinate. Yet, seeds collected in New Jersey failed to germinate. There is no information on seed viability in the Northwest.

Control

There has been little research on fanwort biology or management. There are reports that fanwort is less sensitive to the herbicides available for management in Washington than other aquatic plants. Drawdown has been used to reduce fanwort growth in the South, however, extreme drying is necessary to prevent regrowth from seeds. Grass carp eat fanwort but there has been no research on other biocontrol agents. Because it may obtain most of its important nutrients from the water, fanwort may be sensitive to reduction in nutrients in the water. The fanwort invasion in Washington is in a pioneering stage. Prompt action and vigilant monitoring of our lakes, may prevent further spread and increased management costs in the future.

Fanwort
(Cabomba caroliniana Gray)



Key features:

- Fan-shaped leaves in pairs on the submersed stem
- Submersed stems have a "tubular" appearance
- Small (less than one inch long), oval floating leaves with stem attached in the center

Water hyacinth

(*Eichhornia crassipes* (Mart.) Solms)

Description

Water hyacinth is a floating plant with round to oval leaves up to 10 inches in diameter, although smaller leaves are common. Leaves are bright green and shiny and held upright so they act like sails, which facilitates distribution of the plant. The leaf stalk is spongy and thick and helps to keep the plant buoyant. A mass of fine roots hang in the water column. Flowers are large (2-3 inches) and attractive. They are blue-ish purple or lilac colored with a yellow spot.

Growth Habit

Water hyacinth can form impenetrable mats of floating vegetation. Water hyacinth has not been found in the wild in Washington but it is sold as an ornamental plant in garden stores in the state. Although it is thought that water hyacinth cannot survive Washington's winters, its presence as an ornamental makes it possible for escape and growth in the wild under the right conditions.

Propagation

Water hyacinth reproduces by seeds and vegetatively. Daughter plants form on rhizomes forming dense beds of water hyacinth. In one study, two plants produced 1200 daughter plants in four months. Individual plants break off of the mat and are dispersed by water currents. As many as 5000 seeds can be produced by a single plant. Seeds are eaten and transported by water fowl. The seeds sink to the bottom and may remain viable for 15 years. Seedlings are common on mud banks exposed by low water levels.

Control

The best way to manage water hyacinth is to keep it from becoming established in Washington. Grass carp will eat water hyacinth and the plant can be managed with herbicides. All management options are very expensive and require an ongoing commitment. Be aware of the threat of water hyacinth and report any sitings to your local weed board and/or the Department of Ecology!

Water hyacinth
(Eichhornia crassipes (Mart.) Solms)

Key features:

- Floating bunches of oval leaves that form a dense surface mat
- Long roots dangling in the water
- Attractive hyacinth-colored (purplish) flowers

APPENDIX C

Watershed and Limnological Background Information

WATERSHED AND LIMNOLOGICAL BACKGROUND INFORMATION

I. Watershed Features

Watershed Size/Boundaries

The size and topography of the watershed can significantly influence the water body. Watershed boundaries are marked by ridges and hilltops. The most obvious sources of drainage to a water body are inflowing rivers and streams (called tributaries). Other sources of inflow include surface flow or overland wash (often evident as water running over the ground, such as after a rainstorm). Water inflow below the surface of the ground to a lake or river is called groundwater. In cases where no streams flow into the water body, the watershed is the area from which groundwater is captured to supply the water body along with rainfall runoff.

Tributaries, Wetlands And Sensitive Areas

Tributaries: Identifying tributaries (rivers, streams, creeks) flowing into your water body can help you locate major sources of incoming waters. Land uses near these streams may also be important in controlling long-term water quality. Streams are "great sculptors", cutting into and scouring channels and creating sediment along the way. They are also "great collectors", carrying and eventually depositing nutrients, sediments, and other materials washed from the watershed. Streams are shown on USGS quad maps and other general maps. The best source for stream mapping is the *Water Resource Areas Inventories***,** available from your regional Department of Fish and Wildlife. These maps classify streams according to size and duration of flow, even down to seasonal streams that only flow in winter months. These maps also indicate waterbody use by salmon and obstacles to fish passage.

How to Determine Boundaries of a Watershed

A map showing the watershed boundaries (usually the area from which surface water flows toward the water body) is a very useful tool. Often a watershed map already exists for your lake or river. Watershed maps are sometimes available from Public Works or Planning Department of your county or city.

If a watershed map does not exist for your particular water body, you can construct one by using a topographic map. A topographic map shows a series of concentric circles called contour lines. Each contour line represents points on the surface that are the same elevation. The scale on topographic maps usually is presented in feet (or meters) above mean sea level (MSL). USGS quad maps also show contours, usually in 20 foot increments. Topographic or USGS quad maps can be obtained from local Public Works or Planning Departments, Department of Natural Resources, National Wetlands Inventory (US Fish & Wildlife), map stores or outdoor recreation stores. U.S. Geological Survey sometimes has regional groundwater maps, which would be useful for seepage lakes (groundwater-fed).

To find the watershed boundaries, read from the water body shoreline (the low point) outward on all sides to the highest elevation. Stop at the point before elevation readings begin to decrease. Once you have an initial boundary, check again to see you didn't stop too soon at a dip on the map. Often, local or county staff can assist you in checking watershed boundaries.

Wetlands and Sensitive Areas It is important to determine if there are any wetlands or sensitive areas adjacent to the problem water body. Certain aquatic plant control actions could impact these special, often fragile areas. National Wetland Inventory Maps (based on USGS quad series) can be obtained from Ecology, Wetlands Section. Check with your local or county Planning Department for a map of sensitive areas as defined by local Sensitive Areas Ordinances.

Land Use Activities In the Watershed

Human activities around a water body can have a significant influence on the aquatic system. Reducing pollutant inputs from livestock, croplands, forestry, residential properties and other sources can help protect the quality of the water body in the long term. These pollution sources, left unchecked, could make the water quality worse over time. Yet, while controlling these inputs helps reduce contamination, control of these sources alone is unlikely to provide a short-term solution to aquatic-plant problems. In most cases, in-lake management efforts form the primary means of dealing with the immediate problem of nuisance plants.

You can view recent aerial photos, if available, to get "the big picture" of the area around the water body. These may be obtained from your local or county Public Works or Planning Departments. The Department of Natural Resources in Olympia also has aerial photos in black and white and sometimes in color. Looking at aerial photos gives an important bird's-eye view of the watershed, but it may not be enough. For more detail on land uses, zoning maps and land use maps can help define the now as well as what the future may bring. Contact your local Planning Department for zoning maps and information on development trends in the region.

Point And Nonpoint Pollutant Source Locations

The watershed not only contributes water to maintain the water body, but also sediment, nutrients, organic matter and contaminants that can wash into the lake or river. Pollutants can originate from two types of sources: point and nonpoint. Point sources arise from a distinct source that can be easily traced; they typically discharge through a pipe, conduit or outfall structure. Sources of nutrients and contaminants that do not originate from a pipe are commonly referred to as nonpoint sources. These sources are more diffuse in nature and may not be as obvious as piped discharges. Nonpoint sources include runoff from agricultural areas, forests, urban runoff (lawns, driveways, roadways), construction sites, seepage from septic tanks, discharges from marina and recreational boating and other widespread sources. While nonpoint source loadings can originate from anywhere in the watershed, certain land use practices such as agriculture, construction, and city streets contribute greater inputs than other land uses such as forests and well-vegetated areas. Small quantities of pollutants from many sources in a watershed can have a cumulative effect, and can severely impact the quality of the receiving waters.

Since seeping or failing septic systems are often found to be sources of nonpoint pollution, areas with on-site waste treatment/disposal systems should be identified. A quick means of identifying potential nonpoint sources of pollution from septic systems around a water body can be accomplished by reviewing zoning maps from the Planning Department or as-built plans of developed communities. You can also contact local Public Health Department for more information.

Existing Watershed Management, Monitoring, Or Enhancement Programs

Integrated aquatic-plant management takes the holistic view, working in cooperation with other management efforts in the watershed. Certainly, there are things that everyone can do in the watershed to limit point and nonpoint inputs to lakes, rivers and streams. Use of Best Management Practices (BMPs) in agriculture, construction, home and yard practices are methods designed to prevent or reduce loadings of nutrients, sediments, pesticides, and other contaminants to receiving waters. In addition to zoning (information supplied by your local Planning Department), there may be watershed management programs such as agricultural BMP activities through your Conservation District or septic tank maintenance programs through your local Health Department or County Cooperative Extension Service.

The Presence Of Rare, Endangered, Or Sensitive Animals And Plants

Washington has a program called the Natural Heritage Information System, that maintains a database on endangered or high quality native plant and animal species. The Natural Heritage Information System is a administered jointly by Natural Resources" Washington Natural Heritage Program and Wildlife's Nongame Program. The Washington Natural Heritage Program is responsible for information on the state's endangered, threatened, and sensitive plants as well as high quality native plant communities and wetlands. Similarly, the Nongame Program manages and interprets data on wildlife species of concern in the state. Although the Natural Heritage Information System does not contain a complete inventory of all natural features in Washington, the database is continually updated.

The presence of rare, endangered or other state sensitive animal or plants species in the immediate area being considered for aquatic plant treatment may pose certain limitations on those activities. This is particularly true for use of certain aquatic plant control techniques, such as aquatic herbicides.

II. Water Body Features

Location, Size, Depth, And Shape Of Water Body

Location: A thorough description of where your lake is located is an important element in a Plan. A complete description should include the County, Township, Range, Section, and coordinates of your lake. This information can be obtained from topographic maps published by the U.S. Geological Survey, or from soils maps consulted in your characterization of the watershed.

Size: The size, depth, and shape of a lake determines the area colonizable by aquatic plants and also influences the mixing that occurs in the lake. The timing and degree of mixing of lake water is a characteristic feature for each lake and is a key determinant of the productivity of the ecosystem. Size can vary from less than an acre to thousands of acres. Aquatic plants can typically cover a larger percentage of the lake area in small lakes and consequently play a larger role in the overall functioning of the ecosystem in small lakes than in large lakes.

Depth: The depth of a lake tells us much about the biology and productivity of the lake. In deep lakes, surface waters warm during the summer while bottom waters remain cool. This thermal stratification in deep lakes affects mixing of water in the lake. Deep waters do not mix with the surface waters. This can have profound impacts on the amount of nutrients entering the lake, the growth of algae, water clarity, and the area colonizable by nuisance aquatic plants. Shallow water bodies typically support more aquatic plant growth than deeper, steeper-sided basins.

The measurement of the shape of the lake basin is called bathymetry. Bathymetric lake maps are based on a series of depth measurements. Typically, depth is measured at intervals along transects. These measurements are plotted on a map of the lake and contours drawn to provide a topographic map of the basin. The depth and size (area) of a lake determine the lake volume, which, in turn, determines the *hydrology* of the system (see below).

Shape: The shape of the shoreline can also provide information about the lake's biology and physical/chemical characteristics. Lakes with many embayments and an irregular shoreline have more shallow areas, and are consequently more susceptible to nuisance plant growth. Similarly, a long narrow lake has a greater shoreline length, i.e., more shallow areas, than a more circular lake with the same area.

Water Sources (Tributaries, Groundwater) And Hydrology

A water body is defined by characteristics of water flow. As water is impounded in a basin, i.e., water is detained, a stream or river becomes a reservoir or lake. The period of detention of water in a basin is called the *hydraulic detention time*. The detention time can vary from days to years, depending upon the volume and flow through a particular water body. The inverse of detention time is the flushing rate, which is how fast the water in a lake is replaced. A lake with a detention time of 1 year has a water replacement, or flushing rate, of 1 lake volume/year. A lake with a $^1/_2$ year detention time has a flushing rate of 2 lake volumes/year, a 2 year detention time gives a flushing rate of $^1/_2$ lake volumes/year, etc. A short detention time (high water flow rates and low lake volume) results in a flushing rate that is so high that algal cells produced in the water column are washed out of the system faster than they can be replaced. Consequently, high flushing rates lead to low algal biomass, clear water, better and deeper light penetration into the lake, and better aquatic plant growth conditions.

Since water flow defines a water body and also influences its biological characteristics, it is important to consider the sources and volumes of water entering and leaving your lake. Are streams flowing in and out of the lake? Do they flow all year or seasonally? Is more water entering the lake than is flowing out? If so, the lake may be recharging the groundwater. If more is flowing out than is flowing in groundwater may be moving into the lake. Streams are also important in terms of fisheries support as well as possibly contributing to downstream movement of aquatic plant problems.

Physical, Chemical And Biological Characteristics Of The Water Body And Tributaries

Rooted aquatic plants compete with algae for light and nutrients in the water column. Removal of the aquatic plants may increase light availability and result in enhanced algae growth. If water column nutrient levels are high enough nuisance algae blooms may occur. Therefore, in order to prevent exchanging a nuisance aquatic plant problem for a nuisance algae problem you must consider whether the light, temperature, and nutrient environment of the lake and its tributaries may support nuisance algae growth. Some of the required information may be available from the sources listed at the beginning of this section. If the data are incomplete or inadequate a sampling program may be required to fill in the gaps.

Physical/Chemical (Water Quality) Characteristics

Transparency: Water transparency is one of the oldest and easiest methods for describing a lake. Over the years the method of measuring transparency has been standardized to allow comparisons of measurements taken by different people in different lakes. The standard method utilizes a Secchi disk to measure transparency. A Secchi disk is a large diameter, black and white plate that can be lowered into the water on a rope. The depth at which the disk disappears from view (the Secchi depth) is related to the amount of materials (algae, sediment, and dissolved organic material) suspended in the water column. The Secchi depth has been correlated with a number of indices that indicate the overall productivity of the lake, including the maximum depth at which aquatic plants can grow.

Temperature: Temperature profiles are important descriptive information because of the effect of temperature on biology and water density. Most biochemical reactions occur more rapidly at higher temperatures. Water temperature is an important determinant of photosynthesis rate in plants and respiration rates of plants and animals. Temperature determines the rate of growth of aquatic plants, and triggers the onset of growth in the spring and the fall dieback. Temperature also influences the density of water. Surface warming can lead to thermal stratification, as mentioned above, which can have significant impacts on nutrient availability, distribution and concentrations in lakes. In addition, extensive shallow areas (which typically have high aquatic plant densities) may undergo larger night/day temperature fluctuations than deeper, off-shore waters, which can lead to onshore-offshore water currents that can shorten herbicide contact times and effectiveness.

Dissolved Oxygen: Measurement of dissolved oxygen profiles in the lake can provide much information about the overall functioning and productivity of the lake. All of the organisms that are commonly observed in lakes require oxygen to survive. In stratified lakes, oxygen in the cool, dark bottom waters can be used up by the bacteria that decay and decompose the dead algae cells that rain down from the warmer and more well-lit surface waters. Loss of dissolved oxygen in the bottom waters makes those waters inhospitable for fish and many other aquatic organisms. Loss of oxygen also causes chemical changes in the sediment that result in the release of nutrients that can fuel growth of algae and rootless aquatic plants, like coontail (*Ceratophyllum demersum*), in the lake.

Alkalinity: Alkalinity is a measure of the ability of water to resist changes in pH (a measure of acidity). Large fluctuations in pH can occur on a daily basis in lakes with low alkalinity and dense aquatic plant growth because of the chemical reactions of photosynthesis. Plant photosynthesis uses the energy of sunlight to convert the carbon in carbon dioxide and bicarbonate ions into plant tissue. The removal of carbon dioxide from the water causes pH to increase. During the night, respiration of plant tissues releases carbon dioxide into the water, causing pH to decrease. Extreme high and low pH can influence a number of chemical reactions that determine the availability of nutrients in the lake, and can lead to chemical toxicity problems for fish and insects.

Phosphorus: In many lakes the concentration of phosphorus in the water determines the growth rate of algae. Therefore, measurement of the concentration of phosphorus in the water is an indication of the potential productivity of algae in the lake. Two forms of phosphorus are generally measured in lakes. Dissolved, inorganic phosphorus is readily available for plant and algae uptake. Total phosphorus includes dissolved phosphorus and the phosphorus that is associated with algae, zooplankton, and particles in the water.

Phosphorus concentrations can vary considerably with depth in stratified lakes. Low dissolved oxygen concentrations in bottom waters of stratified lakes can result in a chemical reaction that causes phosphorus to be released from the sediment to the water. As a consequence, bottom waters can have much higher phosphorus concentrations than surface waters.

Nitrogen: Nitrogen often limits aquatic plant growth and can occasionally limit algae growth. As with phosphorus, there are inorganic and organic forms of nitrogen. Inorganic nitrogen can exist in three forms in lakes: nitrite, nitrate, and ammonia. Nitrite is usually present in only very small amounts. As with many other chemical constituents, the distribution of inorganic nitrogen varies with depth in stratified lakes. Nitrate is generally most abundant in the surface waters, and ammonia dominates the bottom waters. Presence of nitrates in the bottom waters may indicate that groundwater is entering the lake. High concentrations of ammonia and/or nitrates in the surface waters may suggest that there is septic pollution present.

Biological Characteristics

Your lake is a complex community made up of a variety of interacting plants and animals. Aquatic weeds and algae make up the plant community. Fish, *zooplankton*, insects, and wildlife interact with each other and the plant community to make a functioning aquatic ecosystem. The aquatic plant community is discussed in greater detail in Chapter 8- Map Aquatic Plants. This section describes other characteristics of the biological community that must be considered when developing a Plan.

Algae: The algae, or *phytoplankton*, community forms the foundation of the aquatic ecosystem and are the first link in the aquatic food chain. The algae in your lake can be used as indicators of the overall nutrient status of your lake and the likelihood of nuisance algae blooms. Certain algae, such as the blue-green algae (a.k.a. cyanobacteria), are characteristic of nutrient enrichment. Since algae and some aquatic plants both compete for dissolved nutrients, in certain cases, algae problems may increase if aquatic plants are removed. In other words, fewer weeds allow the algae to have a bigger share of the nutrient pie. As a result, the algae may flourish and create their own problems.

It is important to note that management for nuisance algae and management for nuisance aquatic plants in a waterbody require different tactics. The dominance of algae generally indicates a problem of excessive nutrients in the water column that could come from a variety of in-lake or offshore sources. Algae control usually necessitates both internal and external controls. Aquatic plant control is primarily concerned with in-lake treatment for long-term effectiveness. These may also be supplemented by watershed controls as a secondary aid.

The concentration of chlorophyll *a* in the water column is an index of algae abundance. Chlorophyll *a* is one of a family of pigments that make green plants green. It is the molecule that captures the energy in light and transfers it to a chemical form that provides the fuel for the entire ecosystem. High chlorophyll *a* concentrations in lake water indicate high algae densities, which influences the light available for aquatic plant growth.

Zooplankton: The zooplankton are microscopic aquatic animals that graze on the algae present in the water. Zooplankton graze algae like cows eat grass. High zooplankton densities can reduce algae abundance and result in high water clarity that permits aquatic weeds to proliferate. The efficiency of zooplankton grazing is dependent upon the relative size of the algae and zooplankton. Large zooplankton are the most efficient grazers, but they also look like big juicy steaks to hungry fish.

Fish: There is a fine balance between the algae, zooplankton and fish in your lake. Many small fish depend upon zooplankton for food. If zooplankton populations are reduced by the fish, algae can grow unchecked. Using the cow/grass analogy, if wolves (fish) eat the cows (zooplankton), the grass (algae) grows tall. If the wolves are eliminated by hunting (big fish eat little fish), the cow population increases, and the grass is short. Since algae determines light penetration of the water, changes in the fish community can affect aquatic weed growth in your lake.

Many lakes in Washington are stocked with catchable-size trout. Introduction of many large, fish into your lake can have a ripple effect all the way down the food chain, and can affect aquatic weed distribution and growth. The reverse is also true; changes in the aquatic plant community due to your control and management activities, can affect the fish population. Information on the native and stocked fish in your lake can be obtained from the Department of Wildlife.

Wildlife: Your lake may serve as a resource for a variety of waterfowl and wildlife. Some waterfowl feed on aquatic plants, while birds of prey, like eagles and osprey, may fish in a lake or river. Muskrats, beavers, otters, deer, and other animals may be residents or visitors. Your management activities may alter the habitat quantity or quality available for wildlife. A seasonal census of wildlife utilization of the lake should be included in a Plan. Local residents and the Department of Wildlife are good sources of information on the kinds and numbers of wildlife that depend upon your lake.

Shoreline Use

Your examination and characterization of the watershed will provide some information on land use on the shoreline. A more detailed look at the shoreline is necessary to evaluate the feasibility of some aquatic-plant management techniques. Some herbicides cannot be used near drinking water intakes; others require a waiting period before the water can be used for irrigation purposes. In addition, you may identify areas that could be a source of nutrients to the lake (e.g., failing septic systems and heavily-fertilized lawns) and contribute to water quality problems (See previous section on Point and Nonpoint Pollutant Sources).

Outlet Control And Water Rights

What you do in your lake may effect water users downstream and you must consider their water rights. Lake drawdown and subsequent refilling would affect flow below the outlet. Would altering flow affect someone's water rights or fish habitat downstream? Would herbicide use affect downstream uses? Water level manipulation requires some type of outlet structure. Who controls the outlet structure and lake water level? Are they willing to cooperate in your efforts to manage aquatic vegetation? **It is important to note that certain water rights and established in-stream flow rates are legally protected and must be maintained.**

Salmonids require special consideration. If salmonids migrate through your lake the management plan must accommodate their movements. Use of grass carp for control of aquatic plant growth usually requires containment structures to prevent their movement out of the lake. Because it is difficult and expensive to design a containment system that keeps grass carp contained, but allows free passage for salmon, Fish and Wildlife rarely issue permits for grass carp stocking in waterbodies with salmon. The Department of Fish and Wildlife can provide information about outlet control and information regarding salmon movement into and out of your lake.

References and Resources on Lake, River and Reservoir Monitoring and Ecology

- Nonpoint Source Pollution Assessment and Management Program[7]
- Puget SoundBook[8]
- The Lake and Reservoir Restoration Guidance Manual[4]
- Ecology's Citizen Monitoring Project[E]
- Volunteer Lake Monitoring: A Methods Manual[9]
- A Citizen's Guide to Understanding and Monitoring Lakes and Streams[6]

Ambient Lake Water Quality Monitoring

The following monitoring parameters and schedules were suggested by the Thurston County Lakes Program staff. These parameters and schedule are intended to provide information on the basic nature of a lake system, such as whether stratification occurs, and to track trends in lake water quality.

Required Equipment

Kemmerer bottle
Secchi disk
Haach kit or dissolved oxygen meter
Bottles for laboratory analysis (provided by laboratory)

Field Parameters

Oxygen	Samples taken at four depths - surface, at 1/3 of lake depth, 2/3 of lake depth and near the bottom. Equipment: Haach® dissolved oxygen kit (full range) or a dissolved oxygen meter.
Temperature	Samples taken at four depths - surface, at 1/3 of lake depth, 2/3 of lake depth, and near bottom. Equipment: Thermometer (can be in kemmerer bottle)
Visibility	Secchi disk

Laboratory Analysis

Chlorophyll a	Composite of epilimnion. Can be determined by: 1. Approximation of the photic zone. Calculate by multiplying average secchi depth times 1.5. or by 2. The temperature and dissolved oxygen profile.
Total phosphorus	Samples taken at two depths - surface and near bottom.

Lake Monitoring (continued)

Observations

Weather, algae blooms and other features observed on sampling days.

Sampling Frequency

Minimum lake monitoring: Spring, summer, fall (three sampling events)

More intensive sampling: A more detailed picture of the lake can be obtained through more intensive sampling schedule, emphasizing the spring-fall months (total of eight sampling events): Monthly May through October, two sampling events in winter months.

APPENDIX D

Aquatic Plant Control Methods

AQUATIC PLANT CONTROL METHODS

Physical Control Methods

Physical methods of aquatic plant control include:

- Hand-pulling
- Bottom barrier application (sediment covers/bottom screens)
- Water level drawdown
- Implementing watershed controls to reduce nutrient inputs
- Water column dyes

Each method will be briefly discussed in terms of mode of action, effectiveness and duration of control, advantages, drawbacks, costs, and required permits.

HAND-PULLING

Principle Hand-digging 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 or 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 or snorkeling equipment and carrying collection bags for disposal of plants.

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.

Drawbacks The technique is time-consuming and costly, especially where contract divers may be 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 $500 to $2400/day with area covered dependent on density of plants.

Permits An HPA is required from the Department of Fish and Wildlife. Be sure to also check with your local jurisdiction before beginning any activities.

HANDCUTTING

Principle This technique is also a manual method, but differs from hand-pulling in that plants are cut below the water surface (roots generally not removed). Implements used include scythes, rakes, or other specialized devices that can be pulled through the weed beds by boat or several people. 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 are minimal.

Drawbacks 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 about $100 for the Aqua Weed Cutter (Sunrise Corp.) to over $1000 for the mechanized Swordfish (Redwing Products).

Permits Cutting (including hand-held and battery-operated equipment) does require hydraulic approval by Department of Fish and Wildlife. Be sure to check with your local jurisdiction before beginning any activities.

BOTTOM BARRIER APPLICATION (SEDIMENT COVERS)

Principle Barrier material is applied over the lake bottom to prevent plants from growing, leaving the water clear of rooted plants. Bottom covering materials such as sand-gravel, polyethylene, polypropylene, synthetic rubber, burlap, fiberglass screens, woven polyester, and 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 2-3 years of relief from problematic growth before eventually decomposing (Truelson[14, 15]). 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 are 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.

Drawbacks Depending on the material, major drawbacks to the application of benthic 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 does decompose over time). Sediment covers can also produce localized depression in populations of bottom-dwelling organisms like aquatic insects.

Costs Costs vary from approximately $0.30/sq. ft (Texel) to $0.35/sq. ft (Aquascreen) for materials with an additional $0.25-0.50/sq. ft for installation. Locally, prices for rolled burlap material (available in fabric stores, outlets) average from $0.15 to $0.25/sq. ft for materials only.

Permits Bottom barrier applications require hydraulic approval from Washington Department of Fish and Wildlife (no charge). In addition, barriers costing more than $2500 may need a shoreline permit, so local Shoreline Master Plan should be checked for compliance; contact your local Planning Department for information.

WATER LEVEL DRAWDOWN

Principle: Water level drawdown used for management of aquatic plants involves exposing plants and root systems to prolonged freezing and drying, or hot, dry conditions to kill the plants. Drawdown for plant control is usually performed during winter months, although summertime drawdowns are sometimes conducted.[13] It's use has been more common in management of reservoirs and ponds than in natural lakes.

Control Effectiveness and Duration Aquatic plants vary in terms of susceptibility to drawdown. Some aquatic plants can be permanently damaged after sufficient exposure, while others are unaffected or even enhanced. Therefore, accurate identification of target species is critical before considering this method. A summary of responses of common aquatic plants to water level drawdown is presented in *Restoration and Management of Lakes and Reservoirs.*[13] For Eurasian watermilfoil, effects have been variable, partly because of its ability to withstand low temperatures for short periods of time as well as its resiliency and tenacity. The mild, wet winters typical of Western Washington may not provide adequate freezing/drying conditions to kill certain plants.

Advantages In addition to controlling aquatic plant biomass, drawing down the water level makes it possible to use several other management procedures for restoration or improvement. For instance, it can be used for fish management, to repair structures such as docks or dams, to facilitate localized dredging or bottom barrier placement or to remove stumps or debris. This technique can result in compaction of certain types of sediments, such as mucky substrates and thus improve shoreline use. Decreasing nearshore vegetation through drawdown can reduce potential inputs of nutrients to the water from seasonal dying of aquatic plants. Drawdown can be used to attract waterfowl by enhancing growth of certain emergent plants such as cattails and bulrushes.[13]

Drawbacks This technique is not species-selective; removal of beneficial plant species may occur. Wetlands adjacent to the water body can be exposed with possible negative impacts on both plant and associated animal communities. Prolonged drying and freezing can decrease bottom-dwelling invertebrates that could be important food sources for fish. Dissolved oxygen levels may decline as a result of lowering the water level with possible negative impacts on fish and other aquatic organisms. Fish spawning areas may be affected. Recreational use of the water body may be limited or unavailable during the period of drawdown. Drawdown has not proven effective in Western Washington. If summer or winter drawdown is implemented for plant control, sediments must become completely dry for a prolonged period of time to kill plant roots.

Costs If an outlet structure is located on the water body, expenses should be minimal. Other costs would include recreational losses (perhaps loss in tourism revenue).

Permits Most water level drawdown projects that release through regulated outlet structures require hydraulic approval from Washington Department of Fish and Wildlife (no charge). In addition, you may need a shoreline permit, so local Shoreline Master Plan should be checked for compliance; contact your local Planning Department for information.

WATERSHED CONTROLS

Principle The principle involves reducing sources of external (outside) nutrient and sediment inputs by implementing watershed best management practices (BMPs). The idea is to shut off entry of growth-stimulating nutrients (phosphorus and nitrogen) to the water body by using prudent household and yard care practices, as well as employing agricultural, forestry, construction and road maintenance practices that minimize pollutant loadings in the watershed. Common examples of homeowner BMP's include: maintaining septic systems, using prudent lawn and garden fertilizing practices, and disposing of yard litter by shredding or composting well away from water's edge. Use of watershed controls is often implemented as part of a whole lake/watershed management effort, which may involve other in-lake aquatic weed control and/or nutrient control measures. For a more complete discussion on BMPs, see *The Lake and Reservoir Restoration Guidance Manual*.[4]

Control Effectiveness and Duration If it has been demonstrated that excessive rooted macrophyte growth is due to siltation and external nutrient inputs and not to historically-enriched sediments, then appropriate watershed controls could provide long-term control of nuisance aquatic plant growth. But it will take many years to achieve this because siltation has created suitable habitat for plants to flourish, with an adequate supply of nutrients already contained in sediments.

Advantages Watershed best management practices are wide-ranging and usually easy to perform. Since the watershed and water body are interconnected, any reduction in contaminant loading to a water body as a result of BMPs can maintain or extend effectiveness of in-lake controls.

Drawbacks Employing BMPs to correct nuisance aquatic plant growth will not result in immediate, substantial growth reduction because habitat has already been created that supports aquatic plant growth. Consultation with lake management experts as to underlying causes of poor water quality (nuisance aquatic plant growth is often symptomatic of a larger problem) can aid in avoiding such a mistake.

Costs Initiation of most homeowner BMP's involves very little expense to get started. Most of the effort involves voluntary changes in behavior, such as modifying product buying practices (go for less packaging, more environmentally friendly products), conserving water, energy, and composting where possible, to name a few.

Permits Permits are not usually required for initiation of best management practices around shorelines. This is especially true for property owners utilizing prudent household and yard management practices.

WATER COLUMN DYES

Principle The theory behind this technique is to suppress aquatic plant growth by shading the plants from sunlight needed for photosynthetic growth. Dark-colored dyes are applied to the water, which reduces the amount of light reaching the submersed plants.

Control Effectiveness And Duration Aquashade (Applied Biochemists, Inc.) is a commercial dye product available for applications in closed systems (water bodies with no outflow). According to the manufacturer, Aquashade is apparently effective against Eurasian watermilfoil, Hydrilla, Elodea, and various pond weeds, as well as macroalgae *Chara* sp. and filamentous green algae like *Spirogyra* spp. There are a number of other pond dyes on the market that mimic Aquashade in their shading effects. These products are probably more effective in shallower water bodies where dye concentrations can be kept up and the loss of dye through dilution would be less. Best results are obtained when the product is used early in the growth season.

Advantages Aquashade is reported to be non-toxic to humans, livestock, and aquatic organisms. No special equipment is needed for application; it can be poured into the water by hand from shoreline or boat. It imparts a blue color to the water.

Drawbacks Its use is limited to shallow water bodies with no outflow. According to the manufacturer, Aquashade is less effective when aquatic plant growth is within 2 feet of the surface In this case other methods of removal are recommended prior to dye use. This can increase program costs considerably. Repeat dye treatments may be necessary throughout the growth season. Aquashade should not be used in drinking water supplies, in flowing waters, or in chlorinated waters.

Costs Costs for Aquashade are approximately $50/gallon, which can be used to treat one acre of water at average depth of 4 feet at the recommended dosage of 1 ppm (part per million).

Permits Aquashade is currently the only product on the market that has an EPA herbicide registration because the manufacturer does make that claim. However, other dye products are available that are sold strictly as pond dyes without an herbicide registration. Depending on the circumstances, use of water column dyes may require receiving a short-term modification to state water quality standards from the Dept. of Ecology prior to treatment. However, the permitting process for aquatic dyes allowed for use in State waters is usually much simpler than that for traditional aquatic herbicides.

Mechanical Control Methods

Mechanical methods for aquatic plant control include:

- Mechanical harvesting
- Rotovation/cultivation (underwater bottom tillage)
- Diver-operated suction dredging

MECHANICAL HARVESTING

Principle Mechanical harvesting is considered a short-term technique to temporarily remove plants interfering with recreational or aesthetic enjoyment of a water body. Harvesting involves cutting plants below the water surface, with or without collection of cut fragments for offshore disposal. To achieve maximum removal of plant material, harvesting is usually performed during summer when submersed and floating-leafed plants have grown to the water's surface.

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.[13] summarizes aquatic plant cutters and harvesters available in North America.

Control Effectiveness and Duration Since harvesting involves physical removal and disposal of vegetation from the water, the immediate effectiveness in creating open water areas is quite apparent. The duration of control is variable. Factors such as frequency and timing of harvest, water depth, and depth of cut are suspected to 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,[24] depending on water depth and the depth of cut.

Advantages Harvesting is most appropriately used for large, open areas with few surface obstructions. There is usually little interference with use of water body during harvesting operations. 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 of important consequence in those water bodies with extensive plant beds and low nutrient inputs from outside sources. Furthermore, harvesting can reduce sediment accumulation by removing organic matter that normally decays and adds 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.

Drawbacks Cut plant material requires collection and removal from the water. Harvesting creates plant fragments. This is of great concern with Eurasian watermilfoil, given its ability to rapidly disperse by fragmentation. Harvesting can be detrimental to non-target plants and animals (e.g., fish, invertebrates), which are removed indiscriminately by the process. Harvesting can lead to enhancement of growth of opportunistic plant species that invade treated areas. Capital costs for machine purchase are high and equipment requires considerable maintenance.

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 project costs of one program with another can be difficult. However, average costs of local harvesting operations range from $200/acre to $700/acre.

Permits Mechanical cutting (including battery-operated equipment) does require hydraulic approval from the Department of Fisheries and Wildlife. Also check with your local government to determine if local regulations apply to mechanical cutting operations.

ROTOVATION/CULTIVATION (BOTTOM DEROOTING)

Principle Mechanical rotovation/cultivation are bottom tillage methods that remove aquatic plant root systems. This results in reduced stem development and seriously impairs growth of rooted aquatic plants. Derooting methods were developed by aquatic plant experts with the British Columbia Ministry of Environment as a more effective milfoil control alternative to harvesting. Essentially two types of tillage machinery have been developed. Deep water tillage is performed in water depths of 1.5 to 11.5 ft using a barge-mounted rototiller equipped with a 6-10 ft wide rotating head. Cultivation in shallow water depths up to a few meters is accomplished by means of an amphibious tractor or modified WWII "DUCW" vehicle towing a cultivator. Both methods involve tilling the sediment to a depth of 4-6 in, which dislodges plants including roots. Certain plants like milfoil have roots that are buoyant and float on the surface where they can be collected. Treatments are made in an overlapping swath pattern. Bottom tillage is usually performed in the cold "off-season" months of winter and spring to reduce plant regrowth potential.

Control Effectiveness and Duration
Bottom tillage has been used effectively for long-term control of milfoil where populations are well-established and prevention of stem fragments is not critical. Single treatments using a crisscross pattern have resulted in milfoil stem density reductions of 80-97 percent in bottom tillage treatments.[16, 17] Seasonal rototilling in an area is at least as effective as 3 to 4 harvests, and where repeated treatments have occurred at the same site over several years, carryover effectiveness may extend to greater than a year.

Advantages A high percentage of entire plants (roots and shoots) can be removed by bottom tillage methods. Depending on plant density, carryover effectiveness of rototilling can persist for up to 2 to 3 years without retreatment. Following treatment, rotovated areas in Washington and British Columbia have shown increases in species diversity of native plants, of potential benefit to fisheries. Fish are not removed through rototilling as they are by harvesting operations. Unlike harvesting which is conducted during summertime when plant growth is maximal, rototilling treatments for root removal can be performed during "off season" months of winter and spring. This results in no interference with peak summer-time recreational activities.

Drawbacks Bottom tillage is limited to areas with few bottom obstructions and should not be used where water intakes are located. Rototilling does create short-term turbidity increases in the area of operation, but increases are usually temporary with a rapid return to baseline conditions often within 24 hours.[13, 16] Since bottom sediments are disturbed, short-term impacts on water quality and the benthic invertebrate community can occur.[16] Rototilling is not advised where bottom sediments have excessive nutrient and/or metals concentrations, because of potential release of contaminants into the overlying water. Rotovation is not species selective, except by location, and can result in unintentional removal of non-target plants. The method does result in production of plant fragments, and is not recommended for use in water bodies with new or sparse milfoil infestations or where release of fragments is a concern. There are often timing restrictions to avoid interference with fish spawning or juvenile use.

Costs Bottom tillage costs vary according to treatment scale, density of plants, machinery used and other site constraints. Contract costs for rotovation in the State of Washington range from $1200-1700/acre depending on treatment size.

Permits In the State of Washington, bottom tillage methods do require hydraulic approval from Washington Department of Fish and Wildlife. Its use requires temporary modification of water quality standards from Ecology. The Army Corps of Engineers requires a dredging permit. In addition, you may need a shoreline permit, so local Shoreline Master Plan should be checked for compliance; contact your local Planning Department for information. It may also be necessary to obtain a letter of approval from Washington Department of Natural Resources.

DIVER-OPERATED SUCTION DREDGING

Principle Diver dredging was being used in the late 1970s in British Columbia as an improvement to hand removal of sparse colonies of Eurasian watermilfoil.[13] The technique utilizes a small barge or boat carrying portable dredges with suction heads that are operated by scuba divers to remove individual rooted plants (including roots) from the sediment. Divers physically dislodge plants with sharp tools. The plant/sediment slurry is then suctioned up and carried back to the barge through hoses operated by the diver. On the barge, plant parts are sieved out and retained for later off-site disposal. The water sediment slurry can be discharged back to the water or piped off-site for upland disposal.

Control Effectiveness And Duration Diver dredging can be highly effective under appropriate conditions. Efficiency of removal is dependent on sediment condition, density of aquatic plants and underwater visibility.[13] As it is best used for localized infestations of low plant density where fragmentation must be minimized, the technique has great potential for milfoil control. Depending on local conditions, milfoil removal efficiencies of 85-97% can be achieved by diver dredging.[17]

Advantages The method is species-selective and site-specific. Disruption of sediments are 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 hand digging or diver hand removal, or where herbicides cannot be used. Diver-dredging can be conducted in tight places or around obstacles that would preclude use of larger machinery.

Drawbacks Diver-dredging is labor-intensive and expensive. In dense plant beds, the utility of this method may be much reduced and other methods (e.g., bottom barrier) may be more appropriate. Returning dredged residue directly to water may result in some fragment loss through sieves. Where upland disposal of dredged slurry is used, more specialized equipment and materials are required and the process is much more costly. Short-term environmental effects can include 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 sediment and non-target vegetation may be inadvertently removed during the process.

Costs Dredging costs can be very variable, depending on density of plants, equipment condition and transport requirements of dredged material. In addition, the use of contract divers for dredging work is subject to stringent State regulations on certification, safety and hourly wage payment, which can affect total project cost. Costs range from a minimum of $1100/day to upwards of $2000/day (with no dredged material transport).

Permits In the State of Washington, use of suction dredging does require hydraulic approval from Washington Department of Fish and Wildlife. Its use also requires a temporary modification of water quality standards from Ecology for increased turbidity. The Corps of Engineers requires a dredging permit. A shoreline management permit may be needed. In addition, it may be necessary to obtain a letter of approval from Washington Department of Natural Resources.

Biological Control Methods

Interest in using biocontrol agents for nuisance aquatic plant growth has been stimulated by a desire to find more "natural" means of long-term control as well as reduce use of expensive equipment or chemicals. The possibility of integrating biological controls with traditional physical, mechanical, or chemical methods is an appealing concept. While development and use of effective biocontrol agents for aquatic plant management is still in its infancy, potentially useful candidates have been identified such as plant-eating fish or insects, pathogenic organisms, and competitive plants. Except for exotic species infestation, a realistic objective of biocontrol of aquatic vegetation is not the eradication, but the reduction of target plant species to lower, more acceptable levels.[13] More importantly, control of nuisance plants using biological agents will be a gradual process, although the effects should be long-lasting. In the State of Washington, the only biological method currently available for aquatic plant control is the introduction of triploid (sterile) grass carp.

TRIPLOID (STERILE) GRASS CARP

Principle 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 are dependent on climate, water temperature, type and extent of plant species and other site-specific constraints. Grass carp require a permit from the Department of Fish and Wildlife. To avoid problems encountered in other areas of the country, Washington State regulations adopted in 1990 (see box below) require:

1. Only sterile (triploid) fish can be planted;
2. Inlets and outlets must be screened to prevent fish from getting into other waterbodies;
3. Stocking will be defined by Fish and Wildlife based on the current planting model. This is to insure that sufficient vegetation is retained for fishery and other habitat needs.

State fisheries personnel with Fish and Wildlife should be contacted for more information on specific use and stocking of grass carp in State waters.

Control Effectiveness And Duration Effectiveness of grass carp in controlling aquatic weeds depends on feeding preferences and metabolism; rates do appear to be temperature-dependent[1, 13]. Triploid grass carp exhibit distinct food preferences which apparently 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, *Potamogeton crispus*, *P. pectinatus*, and *P. zosteriformis*; others were variably preferred as coontail, *Ceratophyllum demersum*, and some plants not preferred such as watershield, *Brasenia schreberi*. Grass carp control effectiveness and duration are site-specific. In general, management studies in Washington waters indicate that substantial removal of vegetation by sterile grass carp may not become apparent until 3-5 years after introduction.

Advantages Depending on the problem plant species and other site constraints, proper use of grass carp can achieve long-term reductions in nuisance growth of vegetation, although not immediately. In some cases, introduction of grass carp may result in improved water quality conditions, where water quality deterioration is associated with dense aquatic plant growth.[12] Compared to other long-term aquatic plant control techniques (e.g., bottom tillage, bottom barriers), costs for grass carp implantation are relatively low.

Drawbacks 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. Grass carp grazing is not recommended for milfoil control. In fact, use of grass carp could indirectly increase milfoil populations in a water body by selectively removing highly preferred plants.[19] Overstocking of grass carp could result in eradication of beneficial plants and have serious impacts on the overall ecology of the water body. Full ecological impacts of grass carp introductions in Northwest waters are still being determined. An escape barrier on the outlet (if present) is required to prevent movement of fish out of the system and avoid impacts on downstream non-target vegetation. Fish loss due to predation, especially by ospreys and otters is possible.

Department of Fish and Wildlife Grass Carp Planting Policy-POL-5220 (12/14/90).

1. Triploid grass carp may be planted in the State of Washington after required permits and documents are approved.
2. Only triploid grass carp over 8 inches in length may be introduced in Washington waters.
3. A minimum of 25 % of the lake shall remain vegetated with aquatic vegetation.
4. Escapement of non-targeted waters must be prevented.
5. Planting triploid grass carp must not pose a significant threat to rare native plants, or to fish and/or wildlife.
6. The planting rate for triploid grass carp will be based on the current planting model.
7. A lake restoration feasibility assessment meeting Department of Ecology's standards must be completed before planting triploid grass carp into waters with public access.
8. The WDW Exotic Species Policy (POL-4001) must be followed to plant triploid grass carp.

Costs 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, at stocking rates ranging from 5 fish/acre to 200 fish/acre and average cost of $10/fish (range $7.50/fish to $15.00/fish).

Permits Washington Department of Fish and Wildlife requires a game fish planting permit prior to grass carp introduction to a water body. In addition, if outlet screening is necessary, hydraulic approval is required from the Washington Department of Fish and Wildlife. Department of Natural Resources National Heritage Program must be contacted for assessment of threatened or endangered plant species.

Chemical Control Methods

Historically, use of aquatic herbicides was the principal method of controlling nuisance aquatic weeds in Washington. However, in recent years there has been a move away from such a dominant practice and toward more selective herbicide use following thorough review of target effectiveness, as well as other environmental, economic, political and social implications[1].

The State of Washington currently permits use of only four aquatic herbicides to control aquatic weeds. They are the systemic herbicides fluridone and glyphosate, the contact herbicide endothall, and certain copper compounds. Systemic herbicides are absorbed by and translocated throughout the plant, capable of killing the entire plant roots and shoots. In contrast, contact herbicides kill the plant surface with which it comes in contact, leaving roots alive and capable of regrowth. These three herbicides are reviewed in more detail below.

A fourth herbicide, triethylamine salt formulation of triclopyr, has been tested for efficacy against Eurasian watermilfoil in selected waters in Washington State under an Experimental Use Permit (EUP). Triclopyr is a systemic herbicide and is described in more detail by Getsinger et al.[22] and Netherland et al.[21] Preliminary results of 1991 applications in Pend Oreille River (Washington) milfoil beds indicate high selectivity against milfoil, rapid onset of toxicity symptoms, and minimal damage to non-target plant species. This herbicide is still under study and is not permitted for general use at this time in Washington State waters. To learn more about aquatic herbicides, see references *1* and *10* listed in Appendix F.

Table D-1. Common Aquatic Weed Species And Susceptibility To Herbicides (Adapted From Westerdahl And Getsinger, 1988)[10]

	Endothall	Glyphosate	Fluridone	Copper
Emergent species				
Phragmites spp. (reed)		√		
Scirpus spp. (bulrush)		√		
Typha spp (cattail)		√	√	
Lythrum salicaria (purple loosestrife)		√		
Floating species				
Brasenia schreberi (watershield)	√		√	
Eichhornia crassipes (water hyacinth)	√(fair)	√(fair)		
Lemna minor (duckweed)	√(fair)		√	
Nuphar spp. (cow lily)	√	√	√	
Nymphaea spp. (water lily)	√	√	√	
Submersed species				
Ceratophyllum demersum (coontail)	√		√	
Elodea canadensis (common elodea)			√	
Egeria densa (Brazilian elodea)	√?		√	√?
Hydrilla verticillata (hydrilla)	√		√	√
Myriophyllum spicatum (Eurasian watermilfoil)	√		√	
Myriophyllum aquaticum (parrotfeather)	√	√(fair)		
Potamogeton spp. (pond weeds)	√		√*	

***Dependent on species**

FLURIDONE

Principle Fluridone, 1-methyl-3-phenyl-5-[3-trifluoromethyl)phenyl]-4(1H)-pyridinone, is a slow-acting, systemic type herbicide. Fluridone is available as the EPA-registered herbicide SONAR® (SePro) for use in the management of aquatic plants in freshwater ponds, lakes, reservoirs, and irrigation canals. It is formulated as a liquid (SONAR 4AS) sprayed above or below surface, and in controlled release pellets (SONAR SRP) spread on the water surface. Fluridone is effectively absorbed and translocated by both plant roots and shoots.[10]

Control Effectiveness And Duration
Fluridone demonstrates good control of submersed and emergent aquatic plants, especially where there is little water movement. Its use is most applicable for lake-wide or isolated bay treatments to control a variety of exotic and native species. Eurasian watermilfoil is particularly susceptible to the effects of fluridone. Typical fluridone injury symptoms include retarded growth, "whitened" leaves and plant death. Effects of fluridone treatment become noticeable 7-10 days after application, with control of target plants often requiring 60-90 days to become evident.[10] Because of the delayed nature of toxicity, the herbicide is best applied during

the early growth phase of the target plant, usually spring-early summer.

Advantages As a systemic herbicide, fluridone is capable of killing roots and shoots of aquatic plants, thus producing a more long-lasting effect. A variety of emergent and submersed aquatic plants are susceptible to fluridone treatment (See Table on species susceptibility to herbicides). As a result of extensive human health risk studies, it has been determined that use of fluridone according to label instructions does not pose any affect to human health.[1] Fluridone also has a very low order of toxicity to zooplankton, benthic invertebrates, fish, and wildlife.

Drawbacks Fluridone is a very slow-acting herbicide, and its effects can sometimes take up to several months. Because of the long uptake time needed for absorption and herbicidal activity, fluridone is not effective in flowing water situations. Because of the potential for drift out of the treatment zone, fluridone is not suitable for treating a defined area within a large, open lake. The potential exists for release of nutrients to the water column and consumption of dissolved oxygen from the decaying plants. Non-target plants may be affected, as a variety of plants do show degrees of susceptibility to fluridone treatment. Mitigation of lost vegetation may be necessary. As fluridone-treated water may result in injury to irrigated vegetation, there are label recommendations regarding irrigation delays following treatment. To protect drinking water sources, it is recommended that no applications be made within 0.25 miles of a water intake, except for treatments made for milfoil at low initial concentrations.

Costs Treatment costs (materials and application) by private contractor for any of the formulations range from about $700 to $1500/acre, depending on scale of treatment.

Permits The use of aquatic herbicides does require receiving a short-term modification to State water quality standards from the Dept. of Ecology prior to treatment.

GLYPHOSATE

Principle Glyphosate (N-(phosphonomethyl)glycine) is a non-selective, broad spectrum herbicide used primarily for control of emergent or floating-leafed plants like water lilies. Glyphosate is a systemic herbicide that is applied to the foliage of actively growing plants. The herbicide is rapidly absorbed by foliage and translocated throughout plant tissues, affecting the entire plant, including roots. Glyphosate is formulated as RODEO® or Pondmaster® (Monsanto) for aquatic application.

Control Effectiveness And Duration Glyphosate is effective against many emergent and floating-leafed plants, such as water lilies (*Nuphar* spp.) and purple loosestrife (*Lythrum salicaria*). According to the manufacturer, RODEO is not effective on submersed plants or those with most of the foliage below water. The herbicide binds tightly to soil particles on contact and thus is unavailable for root uptake by plants. As a result, proper application to emergent foliage is critical for herbicidal action to occur. Symptoms of herbicidal activity may not be apparent for up to 7 days, and include wilting and yellowing of plants, followed by complete browning and death.

Advantages As a systemic herbicide, glyphosate is capable of killing the entire plant, producing long-term control benefits. Glyphosate carries no swimming, fishing, or irrigation label restrictions. Glyphosate dissipates quickly from natural waters, with an average half-life of 2 weeks in an aquatic system. The herbicide has a low toxicity to benthic invertebrates, fish, birds and other mammals.

Drawbacks As a non-selective herbicide, glyphosate treatment can have an affect on non-target plant species susceptible to its effects. While the possibility of drift through aerial application exists, it is expected to be negligible if application is made according to label instructions and permit instructions.

Costs Treatment costs (materials and application) by private contractor for any of the formulations average approximately $250/acre, depending on scale of treatment. Permits: Use of aquatic herbicides requires receiving a short-term modification to State water quality standards from the Dept. of Ecology prior to treatment.

ENDOTHALL

Principle Endothall is a contact-type herbicide that is not readily translocated in plant tissues. Endothall formulations (active ingredient endothall acid, 7-oxabicyclo[2,2,1]heptane-2 ,3-dicarboxylic acid) are currently registered for aquatic use in Washington in either inorganic or amine salts. Aqueous or granular forms of the dipotassium salt of endothall, Aquathol (Elf Atochem), is permitted in State waters with stringent use restrictions on water contact, irrigation and domestic purposes over and above label restrictions. Due to its toxicity, the liquid amine form Hydrothol-191 is not permitted for use in fish-bearing waters.[1]

Control Effectiveness And Duration As a contact herbicide, endothall kills only plant tissues it contacts, usually the upper stem portions. Thus, the entire plant is not killed. It is therefore used primarily for short-term control of aquatic plants. Duration of control is a function of contact efficiency and regrowth from unaffected root masses. Effective reductions in plant biomass can range from a few weeks to several months. In some circumstances, season-long control can be achieved. Carryover effectiveness of endothall treatments into the following growth season is not typical.

Advantages Contact herbicides like endothall generally act faster than translocating herbicides such as fluridone; evidence of tissue death is often apparent in 1-2 weeks. There is usually little or no drift impact from proper application of this product. Overall costs of treatment are less than fluridone applications over the same area.

Drawbacks Because the entire plant is not killed, endothall causes temporary reductions in aquatic plant growth. As a variety of aquatic plants are susceptible to endothall, non-target plant impacts are possible. Currently, Washington requires an 8 day swimming restriction following treatment[1] There are also label restrictions on fish consumption and non-food crop irrigation.

Costs As with fluridone applications, endothall treatments vary with total area and dosage rate. Average costs for a small to moderate area application can run about $500-700/acre.

Permits Use of aquatic herbicides requires receiving a short-term modification to State water quality standards from the Dept. of Ecology prior to treatment.

COPPER CHELATES

Principle Copper is an essential element for plant growth. High concentrations of copper can lead to inhibition of photosynthesis and plant death. In order to maintain effective concentrations of the copper ion in solution, a number of chelated or complexed forms of copper have been developed. These complexed copper compounds are much more effective herbicides than copper sulfate.

Control Effectiveness and Duration The use of copper for macrophyte control in Washington waters is not encouraged by Ecology. Its use is presently limited to algae control, which Ecology also strongly discourages. The effectiveness of complexed copper compounds is enhanced by warm temperatures and sunlight, conditions that stimulate copper uptake by sensitive plants. In addition, uptake and toxicity is higher in young, rapidly growing plants, although even mature plants such as hydrilla, brazilian elodea, and milfoil can be killed, and complexed copper can effectively reduce large standing crops of these species even in late summer.[27] The effect of treatment can be observed within 10 days, with full effects manifested in 4 to 6 weeks. Depending on timing of the initial treatment and regrowth rates a second treatment, after about 12 weeks, may be necessary for full season control.

Advantages Costs of copper treatment are low relative to other herbicides for submersed plant control. There are no use restriction following treatment; complexed copper can even be used in potable water supplies.

Drawbacks Copper is persistent in the environment. Applied copper eventually becomes bound to organic materials and clay particles and is deposited in the sediment. Yearly application of copper to lakes can result in elevated copper concentrations in sediments. Although the bioavailability and toxic effects of sediment-bound copper is unknown, the toxicity of the copper ion to fish is higher in soft than in hard water.
NOTE: The Department of Ecology strongly discourages use of copper in Washington waters.

Costs As with other herbicides, costs of copper treatment vary with area treated and dosage. Costs generally run between $120 and $340 per acre.

Permits Use of aquatic herbicides requires receiving a short-term modification to State water quality standards from the Dept. of Ecology prior to treatment.

APPENDIX E

Aquatic Weeds Management Fund (Ecology)

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WASHINGTON STATE DEPARTMENT OF ECOLOGY

Focus

Aquatic Weed Management Fund Grants

Background

Invasive, non-native freshwater plants are a serious threat to the health of lakes, rivers, and streams throughout the state. Excessive weed growth impairs fish and wildlife habitat and restricts recreational activities. Traditionally, residents and property owners have borne the high costs of controlling these plants.

In 1991, the legislature established the Freshwater Aquatic Weeds Account to provide financial and technical support to tackle the problem on a statewide level. This Account provides funding for technical assistance, public education, and grants to help control aquatic weeds. Revenue for the Account comes from a $3 increase in annual license fees for boat trailers.

What kind of projects are eligible for grants?

Grant projects must address prevention and/or control of freshwater, invasive, non-native aquatic plants. The types of activities funded include: Planning, education, monitoring, implementation (control), pilot/demonstration projects, surveillance and mapping projects.

Who can receive funding?

Cities, counties and state agencies are eligible to receive grants. Lakes groups and other private organizations must work in conjunction with their local governments to receive funding for projects.

When can I apply for grants?

Grant applications are accepted from October 1 through November 1 of each year during a formal application process (SORRY NO FUNDS AVAILABLE FOR 1998 - EXCEPT FOR EARLY INFESTATION PROJECTS). Grant applications are evaluated by people experienced with aquatic plant management. Funds are offered to selected applicants in the winter. Generally about $300,000 is available during each annual funding cycle.

An additional $100,000 is available on a year-round basis for "early infestation" grants. The purpose of early infestation grants is to provide immediate financial assistance to local or state governments to eradicate or contain an invasion of a non-native freshwater plant like Eurasian watermilfoil.

What are the special requirements of this fund?

- **Local Match**

  Local sponsors are required to provide 25 percent of the eligible project costs as a match to state funds. However, in-kind services can be used for up to one-half of the local share. Grants of up to 87.5 percent of the eligible project costs can be provided for "early infestation" projects and for pilot projects.

- **Planning Before Implementation**

  In waterbodies with well-established populations of non-native, invasive aquatic plants, the development of an integrated aquatic plant management plan is required before grants can be awarded for implementation (control projects). However, grants are available for the development of integrated aquatic plant management plans.

- **Public Boat Launching Facilities**

  Funds awarded for projects to control aquatic weed growth can be used only for waterbodies that have public boat launching facilities.

- **Grant Ceiling Amounts**

  Funds are limited to $30,000 (state share) for planning grants and $75,000 (state share) for other projects. Each public body is limited to $75,000 per annual grant cycle and $75,000 for "early infestation". Early infestation projects are limited to $50,000 per project.

What are the state funding priorities?

Projects that can demonstrate that lake or waterbody residents have a long-term interest and commitment to the project receive funding priority because they are likely to be successful. Other important criteria include: The presence of a nonnative aquatic plant like Eurasian watermilfoil or purple, loosestrife, the environmental and economic impacts of the problem plants on the ecosystem, the degree that the project will benefit the public, the likelihood of the problem plant to spread to other waterbodies, and state wide significance of the project.

For more information

For more information about the Aquatic Weeds Management Fund or to find out how to apply for grant funds, contact Kathy Hamel at (360) 407-6562/SCAN 407-6562, address correspondence to:

Washington State Department of Ecology
Water Quality Financial Assistance Program
Post Office Box 47600
Olympia, Washington 98504-7600
Attention: Kathy Hamel

Washington State Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600

APPENDIX F

Resources and References

Resources And References

Agencies and Organizations

A) Washington Department of Ecology
Freshwater Aquatic Weeds Management Program Coordinator
Kathy Hamel
P.O. Box 47600
Olympia, WA 98504-7600
(206) 407-6562

Provides technical assistance and information on aquatic plant management in freshwaters of the State; administers Freshwater Weeds Management Grant Program.

B) Washington Department of Ecology
Shorelands and Coastal Zone Management Program
Planning and Management
Wetlands Section
Olympia, WA 98504
(206) 407-6665

National Wetland Inventory maps; provides technical assistance and information on wetlands.

C) Washington Department of Ecology
Water Quality Program
Steve Saunders
Olympia, WA 98504
(206) 407-6481

Oversees permitting for activities affecting Water Quality Standards in Washington State waters (e.g., permits for use of aquatic herbicides). Also contact Ecology Regional Offices.

D) Washington Department of Ecology
Shorelands and Coastal Zone Management
Shorelands Management Section
Olympia, WA 98504
(206) 407-6665

Oversees compliance of local shoreline master programs with State Shoreline Management Act. All permits are reviewed by Ecology's Shorelands Section. Also contact local jurisdictions.

E) Washington Department of Ecology
Environmental Investigations and Laboratory Services
Ambient Monitoring Section
Julie Rector
Olympia, WA 98504
(206) 407-6680

Coordinates citizen water quality monitoring projects on lakes in Washington State.

F) Washington Department of Natural Resources
Natural Heritage Program
Mail Stop EX-13
Olympia, WA 98504
(206) 902-1664

Maintains current listing of State endangered, threatened, sensitive plants, as well as high quality native plant communities and wetlands.

G) Washington Department of Fisheries/Wildlife
600 Capitol Way N.
Olympia, WA 98501-1091
(206) 753-5700

Processes fish planting permits; Hydraulics Project Approval permits for game fish species and for salmon and other food fish species in waters of the State. Manages and interprets data on wildlife species of concern in the State. Also contact regional offices.

H) Washington State Lake Protection Association (WALPA)
P.O. Box 1206
Seattle, WA 98111-1206

I) North American Lake Management Society (NALMS)
One Progress Boulevard, Box 27
Alachua, FL 32615
(904) 462-2554

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