



DEPARTMENT OF  
**ECOLOGY**  
State of Washington

## **Quality Assurance Project Plan**

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### **Aquatic Plant Monitoring in Washington Lakes and Rivers**

July 2011

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Each study conducted by the Washington State Department of Ecology (Ecology) must have an approved Quality Assurance Project Plan. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completing the study, Ecology will post the final report of the study to the Internet.

The plan for this study is available on Ecology's website at [www.ecy.wa.gov/biblio/1103106.html](http://www.ecy.wa.gov/biblio/1103106.html).

Data for this project will be available on Ecology's website at [www.ecy.wa.gov/programs/eap/lakes/aquaticplants/index.html](http://www.ecy.wa.gov/programs/eap/lakes/aquaticplants/index.html).

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# Quality Assurance Project Plan

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## Aquatic Plant Monitoring in Washington Lakes and Rivers

July 2011

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Signatures are not available on the Internet version.  
EAP: Environmental Assessment Program

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## Abstract

This plan describes the on-going Aquatic Plant Monitoring Program, its objectives, and how those objectives will be achieved.

Objectives of the Aquatic Plant Monitoring Program are to:

- Inventory waterbodies for invasive non-native species, focusing on plants listed by the Washington State Noxious Weed Control Board (Chapter 16-750 WAC), and the Washington Department of Agriculture's list of quarantined plants (Chapter 16-752 WAC).
- Map vegetation populations in lakes and rivers to audit projects funded by the Aquatic Weed Management Fund.
- Quantify the plant community when more detailed studies are undertaken, such as looking at efficacy of weed control methods.
- Inventory waterbodies to determine native plant species.

This Quality Assurance Project Plan details the types of data collected to satisfy the program's requirements and describes methods for data analysis.

## Background

Legislative action in 1991 (RCW 43-21A.660) established the Washington State Department of Ecology (Ecology) Freshwater Aquatic Weed Program. This program provides expertise on aquatic plant issues and a source of grant money for local aquatic weed management projects. To help provide technical expertise, part of the Freshwater Aquatic Weed Program has been used to support the statewide Aquatic Plant Monitoring Program since 1994. A monitoring program was needed to provide baseline information on aquatic plant distribution in Washington. The aquatic plant data aid Ecology, state and local governments, and others with aquatic plant management projects.

Over the years, the main goal of aquatic plant monitoring has evolved to track aquatic plant community changes in lakes and rivers, concentrating on invasive non-native species. In addition, targeted research on invasive aquatic weed control methods is undertaken as required.

The results of the Aquatic Plant Monitoring Program were reported annually from 1994 to 2002. Since 2003 results have been reported on the aquatic plant monitoring web page and online database [www.ecy.wa.gov/programs/eap/lakes/aquaticplants/index.html](http://www.ecy.wa.gov/programs/eap/lakes/aquaticplants/index.html).

This Quality Assurance Project Plan updates a previously published plan and protocol (Parsons, 1995; Parsons, 2001).

## Project Description

The overall goal of the Aquatic Plant Monitoring Program is to improve management of aquatic plant populations in Washington through understanding the distribution of freshwater invasive and native plant populations.

The specific objectives of the Aquatic Plant Monitoring Program are to:

- Find new populations of invasive non-native aquatic and wetland plant species in waterbodies with public boat access throughout Washington.
- Monitor existing known invasive non-native plant populations for expansion or decline.
- Maintain a database of all plant species present in the inventoried waterbodies.
- Monitor the results of weed treatment efforts.

Achieving these goals and objectives improves the use of the Freshwater Aquatic Weed Fund money to target populations of invasive non-native aquatic plants, and improves Ecology's ability to advise federal, state, and local government and other lake managers on the best aquatic weed control methods.

The Environmental Assessment Program conducts all sampling during the growing season, with occasional assistance from other Ecology programs' personnel or from local noxious weed managers, federal agency or other local government personnel, or private citizens. When listed noxious weeds or rare plants are found, we inform the appropriate authorities.

We employ different sampling methods based on the level of detail the particular site requires. All sampling methods require identifying aquatic plants to the lowest taxonomic group possible and, at a minimum, a list of observed species results from all site visits. In addition, we collect data on water clarity, maximum depth of plant growth, and surface water temperature. We record a qualitative estimate of each species' abundance at sites where we inventory the complete waterbody.

When undertaking more intensive studies to monitor effectiveness of aquatic plant control methods, we generally collect plant frequency and biomass data in addition to the above listed parameters. We analyze data for treatment effects using Analysis of Variance for biomass data and Chi-square for plant frequency data.

# Organization and Schedule

Ecology staff involved in this project.

Table 1. Organization of project staff and responsibilities.

Staff (all are EAP except client)	Title	Responsibilities
Kathy Hamel Water Quality Program Headquarters, Lacey Phone: 360-407-6562	EAP Client	Clarifies scopes of the project. Provides internal review of the QAPP and approves the final QAPP.
Jenifer Parsons Eastern Operations Section, EAP Phone: 509-457-7136	Project Manager/ Principal Investigator	Writes the QAPP. Oversees field sampling and lab work. Conducts quality assurance review of data, analyzes and interprets data, and enters data into databases. Writes updates to website and reports.
(various staff) Eastern Operations Section, EAP	Field Assistant	Helps collect samples and records field information.
Gary Arnold Yakima Office Eastern Operations Section, EAP Phone: 509-454-4244	Section Manager for the Project Manager	Provides internal review of the QAPP and approves the budget. Reviews the project scope, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Will Kendra Statewide Coordination Section, EAP Phone: 360-407-6698	Section Manager for the Study Area	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Stuart Magoon Manchester Environmental Laboratory, EAP Phone: 360-871-8801	Director	Approves the final QAPP.
William R. Kammin Phone: 360-407-6964	Ecology Quality Assurance Officer	Reviews the draft QAPP and approves the final QAPP.

EAP: Environmental Assessment Program.

QAPP: Quality Assurance Project Plan.

Table 2. Proposed schedule for completing field and laboratory work, data entry, and reports.

Field and laboratory work	Due date	Lead staff
Field work completed	May to October annually	Jenifer Parsons
Laboratory analyses completed	May to October annually	
Database update		
Product	Due date	Lead staff
Data loaded to project database	December, year of data collection	Jenifer Parsons
Database quality assurance	December, year of data collection	Jenifer Parsons
Data updated to internet version	February following data collection	Steve Barrett
Update website report		
Author lead / Support staff	Jenifer Parsons / Gayla Lord	
Schedule		
Edited and updated version submitted to Gayla Lord	January following data collection	



## Quality Objectives

Aquatic plant identification data will be used to make decisions on aquatic plant management projects, therefore precise identification is important. Because this is not a measured variable, it is not subject to errors in precision and bias that numeric data are. However, accuracy is important because misidentification can lead to inappropriate decisions and actions.

To obtain the most accurate and consistent species identifications possible we collect voucher specimens of all noxious weed sightings and maintain representative samples of all other species in an herbarium. When someone other than the principal investigator collects the data, the principal investigator verifies in the lab the identification of the samples of all species found and collected at the sample site. If the principal investigator is unable to identify a plant with confidence, it is preserved and sent to an expert in that taxonomic group for identification. Members of the *Myriophyllum* genus (milfoils) are sent for DNA analysis when identification to species can not be determined by floral or leaf characteristics and it is a suspected invasive species.

Invasive aquatic plants monitored by this program are listed below. Additional description and distribution data for each species are available on the Aquatic Plant Monitoring website page at [www.ecy.wa.gov/programs/eap/lakes/aquaticplants/index.html](http://www.ecy.wa.gov/programs/eap/lakes/aquaticplants/index.html).

- *Butomus umbellatus* (flowering rush)
- *Cabomba caroliniana* (fanwort)
- *Egeria densa* (Brazilian elodea or egeria)
- *Epilobium hirsutum* (hairy willow herb)
- *Glyceria maxima* (reed sweetgrass)
- *Hydrilla verticillata* (Hydrilla)
- *Hydrocharis morsus-ranae* (Europeans frog-bit)
- *Iris pseudacorus* (yellow flag iris)
- *Ludwigia hexapetala* (water primrose)
- *Ludwigia peploides* (floating primrose willow)
- *Lysimachia vulgaris* (garden loosestrife)
- *Lythrum salicaria* (purple loosestrife)
- *Myriophyllum aquaticum* (parrotfeather)
- *Myriophyllum heterophyllum* (variable leaf milfoil)
- *Myriophyllum spicatum* (Eurasian milfoil)
- *Nymphaea odorata* (fragrant waterlily)
- *Nymphoides peltata* (yellow floating heart)
- *Phalaris arundinacea* (reed canarygrass)
- *Phragmites australis* (common reed)
- *Potamogeton crispus* (curly leaf pondweed)
- *Sagittaria graminea* (grass leaf arrowhead)
- *Schoenoplectus mucronatus* (rice field bulrush)
- *Utricularia inflata* (bladderwort)

For the variables that are measured and numeric, Table 3 indicates the quality of results.

Table 3. Measurement Quality Objectives.

Parameter	Bias	Precision	Accuracy	Reporting Limit
Secchi Depth	N/A	±0.1 m	N/A	N/A
Temperature	N/A	±2 °C	N/A	N/A
Maximum depth of plant growth	N/A	±0.5 m	N/A	N/A
Plant biomass	N/A	±0.1 g	N/A	N/A

To ensure precision targets are being met, 10% of field-collected samples will be duplicated in the field. Plant biomass is measured in the lab, and 10% of those samples will also be duplicated to ensure accurate weight measurements.

Additional information on each measurement is provided below.

- *Secchi depth* is compared to the maximum depth of macrophyte growth to ascertain if water clarity on the day of sampling is close to normal for that lake. Generally, submersed macrophytes will grow to a depth of 2-3 times the Secchi depth (Aquatic Plant Management in Lakes and Reservoirs 1997). The procedure for measuring Secchi depth is detailed in the *Sampling Procedures* section of this report.
- *Temperature* of surface water is measured with a hand-held thermometer just below the water surface.
- *Maximum depth of plant growth* is attained through a combination of best professional judgement and multiple samples taken at what seems to be the maximum depth boundary with the sampling rake. Because we are estimating this parameter from the water surface rather than by direct observation by SCUBA diving, it is inherently imprecise. However, with our situation it is the best we can do.
- *Biomass and frequency* are calculated from repeated measurements. Aquatic plant distribution and abundance within a lake are inherently variable, as is the response to treatment. Because of this, we collect as many samples of each parameter as is practical for existing time constraints and lake size. Usually we have between 30 and 50 biomass samples, and between 90 and 300 frequency samples per sampling event.

Using data from completed studies, a power analysis was run to test how adequate the sampling has been. The typical response of the target species' biomass has ranged from 90-99% reduction. When the power analysis is performed, the sample size used was large enough to detect about a 75% reduction of the more common species, and less than a 25% reduction in dominant species such as Eurasian watermilfoil (*Myriophyllum spicatum*) (Figure 1, Table 4).

Figure 1. Formula for calculating power and required sample size.

Formula for calculating power and sample size from Zar (1984)

$$n = \frac{s^2}{\delta^2} (t_{\alpha,v} + t_{\beta(1),v})^2$$

where n = required sample size

$s^2$  = sample variance

$\delta^2$  = difference we want to detect

$t_{\alpha,v}$  = value from t-table for  $\alpha$  (0.05) and v degrees of freedom

$t_{\beta(1),v}$  = value from t-table for the chosen  $\beta$  (i.e. 90%) and v degrees of freedom

Table 4. Required sample size (n) to detect the percent reduction in biomass indicated. Log transformed variance data were used in the calculation.

Lake studied	Plant species	n to detect a 90% biomass reduction	n to detect a 75% biomass reduction
Kress Lake	<i>M. spicatum</i>	2	2
	<i>Elodea canadensis</i>	11	30
	<i>Potamogeton amplifolius</i>	12	33
Loon Lake	<i>M. spicatum</i>	12	34
	<i>P. robbinsii</i>	12	34
	<i>E. canadensis</i>	11	30
	<i>Megalodonta beckii</i>	2	5

# Sampling Process Design (Experimental Design)

## Locations and Schedule

All Washington waterbodies that support aquatic plants are potential sampling sites. However, because the program is funded with boat trailer license fees, we concentrate our efforts on waterbodies with public boat launch facilities. Private lakes, or lakes without boat launches, are visited when requested and when we believe there is a valid concern regarding invasive or rare plant species. Because the number of potential sampling sites is much greater than the time available to visit them, the following criteria are used to select waterbodies to be inventoried:

- Those requested by Ecology, local government, or weed district personnel.
- Those known to host invasive non-native species in order to assess plant population changes.
- Those considered to be at high risk for a non-native plant invasion.
- Those with on-going plant monitoring projects.
- Those with special intensive projects.

Waterbodies selected for more intense studies of aquatic plant management techniques are chosen by collaborating with personnel managing the Freshwater Weed Fund from the Water Quality Program. Waterbodies generally must satisfy the following criteria:

- They contain nuisance levels of the target study plant (thus far, this has always been an aquatic invasive species listed with the State Noxious Weed Board).
- They have the cooperation and support of the surrounding community and local government.
- They are located where public benefit will be high and where logistical problems are kept to a minimum.

The schedule was covered in the *Organization and Schedule* section of this report and is repeated here:

- February to May – Plan for the field season, select sites to visit, plan any special projects that require more detailed sampling.
- May to October – Conduct field sampling.
- October to December – Complete data entry and quality control checks.
- December to February – Update web page, post data to the online database.

This schedule allows us to collect plants when they are actively growing or at their peak abundance, facilitating a relatively complete species list and easier detection of invasive non-native species.

## Measurements Taken, Samples Collected

These have been discussed in the *Quality Objectives* section, but a brief list is provided here:

- Aquatic plant species present (list of names identified to the lowest taxonomic group possible).
- Plant density estimate value between 1 – 5 for each plant species (see *Field Procedures* section for definitions).
- Maximum depth of plant growth.
- Secchi Depth.
- Surface water temperature.
- Biomass on lakes with special studies.
- Plant frequency on lakes with special studies.

All of the values for these parameters are obtained in the field except for biomass samples which are sorted, dried, and weighed in the lab at Ecology's Central Regional Office in Yakima.

## Representativeness

Each waterbody we sample is generally visited once during the year and not revisited for several subsequent years. As such, our data represent the state of the waterbody on that day, to the best of our ability to measure it. If something atypical affects water clarity on the sampling date, the species list may lack plants that are difficult to collect with the rake we use as a sampler. Also, if we do not visit the waterbody during its period of abundance, the species list may lack plants with a narrow window of growth and presence.

Similar caveats exist for the other parameters collected, especially for Secchi depth, plant density estimates, and biomass which fluctuate seasonally.

## Comparability

The most critical product resulting from this project is the species list (except in the case of the special studies). These results can be compared to similar studies only to the limit of the researcher's ability to correctly identify plant species. This is a variable that must be determined subjectively, based on the personal knowledge or reputation of the people doing the work.

The other values collected are comparable to other work based on the caveats discussed under the *Representativeness* section above.

## Sampling Procedures

Please refer to the *Aquatic Plant Sampling Protocols* document for details on aquatic plant sampling procedures and data analysis conducted by this program (Parsons, 2001). Other measured variables collected are outlined below.

The qualitative plant density estimate will be recorded at specific sampling sites around the lake when such sites are deemed necessary. The definition of the values to be used are:

- 1 – few plants of this species (<5% cover)
- 2 – plants common but not dominating the site (5-20% cover)
- 3 – plants form dense patches (20-50% cover)
- 4 – plant species dominates, but not at the exclusion of other species (50-80% cover)
- 5 – plant species dominates to the exclusion of other species (80-100% cover)

The cover values are difficult to assess in situations of poor water clarity. In this case, estimates are based on the relative quantity of plants retrieved with the rake.

After the waterbody has been surveyed, a summary species list is created and each species is assigned a whole lake distribution value based on the following similar criteria:

- 1 – plant species is rare in the waterbody, only observed in 1 or a few places.
- 2 – plant species common, though not dominant.
- 3 – plant species in scattered, sometimes dense patches, co-dominant with other plants.
- 4 – plant species dominates the lake in thick, nearly monospecific patches.
- 5 – plant species growing very densely at the exclusion of other species, a pattern usually restricted to invasive non-native species.

The maximum depth of plant growth is ascertained by using a sampling rake with the rope marked in 1 meter increments. At sites to be determined on the day of sampling (based on plant communities observed and the lake bathymetry) the rake is used to determine the deepest point at which macrophytes are retrieved. The value is recorded to 0.1 m.

The Secchi depth is measured at the deepest part of the lake if the lake bathymetry is known. If the bathymetry is not known, best professional judgement is used to determine the sampling location. The measurement is obtained by lowering the Secchi disk from the shaded side of the boat to reduce surface glare. It is lowered until the disk can no longer be seen, then raised until it can be seen. This measurement is then recorded. Sunglasses should be removed during the procedure. If the Secchi depth is greater than the deepest part of the lake, that is noted.

Surface water temperature is obtained by holding a hand-held thermometer just below the water surface for several minutes until a constant temperature is attained.

All data are recorded on data forms developed for this purpose.

At the end of each field visit, boats and other gear are cleaned in accordance with the Standard Operating Procedure for Minimizing the Spread of Invasive Species for Areas of Moderate Concern and Extreme Concern available at [www.ecy.wa.gov/programs/eap/InvasiveSpecies/AIS-PublicVersion.html](http://www.ecy.wa.gov/programs/eap/InvasiveSpecies/AIS-PublicVersion.html).

## Measurement Procedures

All measurements are collected in the field and described above except for plant weights for calculating biomass.

Plant biomass is measured as follows:

- Empty paper bags are numbered, placed in a forced-air drying oven for at least 4 hours at 70° C to dry completely, and weighed to the nearest 0.01 g directly from the oven.
- Weights are recorded on the data form.
- Collected plant samples are separated by species and placed into the numbered paper bags, the bag number and species name is written on a data form.
- The bags are placed in a forced-air drying oven set at 70° C until dry. Dryness is determined by feel (dry aquatic plants are very brittle).
- The bags plus dry plant material are weighed to the nearest 0.01 g directly from the oven. The weights are recorded on the data form.

Weight and species information is entered into a spreadsheet to obtain the plant dry biomass.

## Quality Control Procedures

### Field

The aquatic plant species identification data are not variable. Thus they are not subject to quality control procedures. Sampling methods listed in this document and the Aquatic Plant Sampling Protocols (Parsons, 2001) are followed to maintain quality control of other parameters, including field and lab duplicates where applicable.

### Laboratory

No samples are sent for analysis.

## **Data Management Procedures**

The data are entered in an Access® database at the end of the field season. As data are entered, the plant species list is checked against any existing data for the waterbody to check for consistency. After the data are entered a report is produced in Access and checked for errors. All numeric values resulting from biomass and frequency data collection are also checked for accuracy.

## **Audits and Reports**

Previously unknown locations of listed noxious weeds that are designated for control are reported to local noxious weed control coordinators or land management personnel as they are found. All locations of plants listed as rare by the Washington Natural Heritage Program are reported to that program. When the database is updated and verified at the end of the field season, the online database is updated and individual project reports are updated on the aquatic plant internet page. Upon completion, selected projects are prepared as manuscripts and submitted to a peer-review journal and are also available as Ecology publications.

## **Data Verification and Validation**

### **Data Verification**

The field QC procedures will be followed. The data will be checked prior to entry into the database.

### **Data Validation**

Data will be checked after entry into the database using a combination of queries and reports. The results of computations and statistics will be checked for reasonableness.

## **Data Quality (Usability) Assessment**

Aside from biomass data, all data analysis is conducted in the field. So long as field quality control methods are followed, additional data quality assessment is not necessary.

For the biomass data, power analysis will be run after samples have been analyzed to ensure enough samples have been collected to detect a change in the plant community within the acceptable error limits. See the *Precision* section for additional information on the power analysis used.



## References

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# Appendix. Glossary, Acronyms, and Abbreviations

## Glossary

**Chi-square:** A statistical test that determines if an observed frequency distribution is different from a theoretical distribution.

**Parameter:** A physical chemical or biological property whose values determine environmental characteristics or behavior.

**Secchi depth:** A measurement of water clarity attained using a Secchi disk.

## Acronyms and Abbreviations

Ecology	Washington State Department of Ecology
et al.	And others
GIS	Geographic Information System software
GPS	Global Positioning System
SOP	Standard operating procedures
WAC	Washington Administrative Code

### *Units of Measurement*

°C	degrees centigrade
g	gram, a unit of mass
m	meter