INTERIM AQUATIC PLANT MANAGEMENT PLAN FOR THE PEND OREILLE RIVER (RM 34.4-90.1)

Prepared by:
Pend Oreille County
Newport, Washington

DRAFT

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EXECUTIVE SUMMARY

This document is an Interim Aquatic Plant Management Plan for the Pend Oreille River between River Mile (RM) 34.4 and RM 90.1. Dense and nuisance growth of aquatic plants in this portion of the river, in particular the non-native Eurasian watermilfoil (*Myriophyllum spicatum*) and to some extent, curlyleaf pondweed (*Potomogeton crispus*), can have a negative impact on beneficial uses such as swimming, boating, fish management, and aesthetics. The Plan describes the aquatic plant communities in the river, identifies management goals and objectives, describes beneficial uses in the river and describes the management strategies considered effective in minimizing negative impacts to beneficial uses by reducing overall aquatic plant density and containing Eurasian watermilfoil. The primary management strategy is the continued use of rotovation. At least 200 acres will be rotovated annually, and rotovation will target public boat launches, public swim areas, areas around private docks and developed shorelines. Additionally, private landowner control using hand cutting, weed pulling, weed rolling devices and bottom barrier mats to reduce aquatic macrophyte densities in localized areas will be encouraged. Pend Oreille County (the County) in consultation with the Pend Oreille Public Utility District No.1 of Pend Oreille County (District) prepared this Interim Plan.

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INTRODUCTION

The growth of aquatic plants in the Pend Oreille River between Albeni Falls Dam and the Box Canyon Dam has resulted in impacts to beneficial uses in the Reservoir. Large, dense beds of aquatic plants can impair recreational activities such as boating, fishing, and swimming. In addition the proliferation on non-native species such as Eurasian watermilfoil (*Myriophyllum spicatum*) and curlyleaf pondweed (*Potomogeton crispus*) may negatively impact resident warm water and cold-water fish populations. In populated and popular recreational areas, dense aquatic plant growth also poses an aesthetic concern. Pend Oreille County, the Pend Oreille Public Utility District No.1, and members of the public formed the Box Canyon Water Quality Working Group to address these concerns.

GOAL

The goal of this Interim Aquatic Plant Management Plan is to guide the use of cost effective methods to manage the composition, structure, and distribution of aquatic plant beds and to minimize the expansion of invasive aquatic plant species within portions of the Pend Oreille River and surrounding waters. This management approach reflects multiple resource management objectives and includes public involvement and education activities.

OBJECTIVES

- Define aquatic plant management actions for specific areas within the Pend Oreille River Management Reach that best address the target beneficial uses for that particular site.

- Provide guidance and evaluation of the rotovation program in order to maximize beneficial uses within the Management Reach.

- Identify additional aquatic plant control alternatives that can be initiated at the homeowner and institutional level.

DESCRIPTION OF MANAGEMENT AREA

The Pend Oreille River flows from Lake Pend Oreille into Canada in northeastern Washington. Box Canyon Dam and powerhouse are located near Ione, in Pend Oreille County 17.4 river miles (RM) upstream of Seattle City Light's Boundary Dam. The Box Canyon Reservoir (BCR) extends 55.7 miles along the Pend Oreille River, from Box Canyon Dam at RM 34.4 to Albeni Falls Dam at RM 90.1, in Bonner County, Idaho. Operating as a run-of-the-river facility, inflows to the Box Canyon Dam equal outflow, and the BCR does not store water. River flows in excess of the dam's turbine capacity are spilled.

This Interim Plan is primarily directed towards the Pend Oreille River in the reach between Albeni Falls Dam and Box Canyon Dam. This includes the area between River Mile (RM) 34.4 – RM 90.1. In this Plan, all references to this portion of the Pend Oreille River will be referred to as the Management Reach. Future actions may include areas north of the Box Canyon Dam.

Water Quantity & Quality

The Pend Oreille River flows northwest between Albeni Falls Dam and Box Canyon Dam. The annual flood on the Pend Oreille River generally occurs during April, May and June, fed by snowmelt and precipitation in the headwaters of the Pend Oreille River and Clark Fork River, which originates on the western slopes of the Rocky Mountains in Montana. The highest average weekly flows occur during June, and the average annual flood is 79,445 cfs (based on period of record 1/1/56 - 12/31/95).

The upstream drainage area for the Management Reach is 24,930 square miles. Of this total drainage, about 24,230 square miles are upstream of Albeni Falls Dam (RM 90.1), and the remaining 700 square miles of the drainage area lies between Albeni Falls Dam and Box Canyon Dam (RM 34.4). There are 22 streams that flow into the Management Reach. Two major tributaries are Calispell Creek and the Trimble/Tacoma drainage. Many tributaries flow into the river via shallow sloughs.

The Pend Oreille River in the Management Reach is a cool-water mesotrophic system. Maximum August temperature based on a two-year average from 1989-1990 was 71.2 oF (21.75oC) (Falter et al. 1991). The reservoir is characteristic of a riverine environment with good water quality (Pelletier and Coots 1990; Bennett et al. 1990; Falter et al. 1991; EPA 1993).

Aquatic Plant Community

The majority of the aquatic plant communities within the Pend Oreille River, inclusive of sloughs, consist of mixed beds of native and non-native plants. Nineteen aquatic plant species are known from the Management Reach (Table 1). Of these, the non-native Eurasian watermilfoil (EWM) and curlyleaf pondweed are the most dominant. Eighteen percent of the

vegetated acres are comprised of near monoculture beds of EWM. EWM grows in dense monotypic and mixed-species beds throughout the reservoir, particularly in littoral areas less than 10 feet deep.

Aquatic plant vegetation tends to be greatest in the reach from Riverbend to Furport (RM 60.0-80.0). This reach of river is wide, shallow and tends to have the greatest littoral habitat and substrate suitable for aquatic plant growth. Thirty-five percent of the wetted area within this reach is vegetated, with the majority of the vegetated area classified as having dense/moderate growth.

Table 1. Common Aquatic Plants within the Management Reach

Common Name	Scientific Name	Native to WA?
Eurasian Watermilfoil	*Myriophyllum spicatum*	No
Siberian Watermilfoil	*Myriophyllum sibiricum*	Yes
Curlyleaf Pondweed	*Potamogeton crispus*	No
Coontail	*Ceratophyllum demersum*	Yes
Waterweed	*Elodea canadensis*	Yes
Water star-grass	*Heteranthera dubia*	Yes
Close-leaved pondweed	*Potamogeton foliosus*	Yes
Long-leaved pondweed	*Potamogeton nodusus*	Yes
Fennel-leaved pondweed	*Potamogeton pectinatus*	Yes
Eel-grass pondweed	*Potamogeton zosteriformis*	Yes
Robbins' pondweed	*Potamogeton robbinsii*	Yes
Richardson's pondweed	*Potamogeton richardsonii*	Yes
Incidental species		
(No Common Name)	*Potamogeton natans*	Yes
Nuttall's waterweed	*Elodea nutallii*	Yes
(No Common Name)	*Zannichellia palustris*	Yes
Diverse-leaved pondweed	*Potamogeton diversifolius*	Yes
Large-leaved pondweed	*Potamogeton amplifolius*	Yes
Grass-leaved pondweed	*Potamogeton gramineus*	Yes
Whitewater crowfoot	*Ranunculus aquatilis*	Yes

Aquatic plants tend to be sparse in deeper waters or in areas with coarse gravel or cobble substrate. (See Appendix E2-6 of the FLA, DISTRICT 2000). Plant growth is limited at depths of greater than 13 ft and non-existent at depths greater than 18 ft. Three species dominate the aquatic plant flora found in the BCR. EWM and curlyleaf pondweed are capable of dense growth within 0-13 ft, but growth is particularly limited for EWM at depths greater than 11 ft. The native waterweed (*Elodea canadensis*) is most prevalent within the surf zone at the waters edge where it can form very dense beds. It can also be dominant within shallow sloughs. Additional information on plant species found in the BCR can be found in the FLA (DISTRICT 2000).

No aquatic plants known from the Pend Oreille River Management Reach are state or federally listed as endangered, threatened, sensitive, or species of concern. Although *Heteranthera dubia* (water star-grass) was formerly maintained on the Washington Natural Heritage Program Review list, it was recently downlisted to Watch list status, reserved for those taxa that are more common than previously thought (http://www.dnr.wa.gov/nhp/refdesk/lists/plantrnk.html). *Heteranthera dubia* is common throughout the Management Reach, though rarely dominant.

History of Aquatic Plant Management in the Management Reach

In response to an increasing infestation of EWM in the Pend Oreille River, Pend Oreille County initiated efforts to control EWM in 1982. From 1982 to 1985, the herbicide 2,4-dichlorophenoxyacetic acid (2,4-D DMA) was tested for use in the control of EWM (WATER 1988). However, in 1986 the EPA withdrew the exemption required for the use of this herbicide. In response, Pend Oreille County incorporated rotovation into its EWM control program in 1986. The Pend Oreille River program was the first large-scale operation of its kind in the United States.

Historically the National Aquatic Weeds Program of the US Army Corps of Engineers provided 50% of the funding for the rotovation program. Currently, the Pend Oreille Public Utility District funds 90% of the rotovation program, with the County contributing the remaining 10% (pers. comm., P. Buckley, Pend Oreille County Public Works Dept., August 26, 2003).

Rotovating in the Management Reach has expanded since it first began, while overall treatment costs per area have declined during recent years. The decreased cost reflects increased operator skill and knowledge of treatment areas, removal of underwater obstacles, and increased speed of treatment. Treatment has been completed faster in many areas because of less aquatic plant biomass regrowth. Treatment areas are rotovated, on average, every 18 to 24 months. The County tracks these rotovated areas. Approximately 200 acres per year are being treated, with treatments focusing on high use areas of the river mainstem. The sloughs usually are not rotovated with the exception of Tiger Inlet and other populated areas providing there is adequate water depth to provide access. Rotovating is done year round, weather and river conditions permitting, as high flows and ice restrict operations. Certain areas, such as Tiger Inlet, have seasonal restrictions for rotovating due to bass spawning.

PUBLIC INVOLVEMENT

During the relicensing process for the Box Canyon Dam, the Pend Oreille Public Utility District coordinated a series of meetings of the Box Canyon Water Quality Work Group. The public was invited to attend and contribute to the meetings. In 2000 this group developed and distributed a survey to ratepayers in the District to document public concern on aquatic plant management in the Box Canyon Reservoir. Results of this survey are included in Appendix A.

BENEFICIAL USES

This Interim Aquatic Plant Management Plan was developed in consideration of identified beneficial use resources, ESA regulatory constraints, and cultural resource protection. Other regulations and policy guidelines taken into consideration included county land use planning, FERC operating rules for water level elevations at Cusick, and tribal management plans. Additional tasks included identifying overlaps in multiple resource areas, and balancing needs with program costs and user group interests. Overall, eleven beneficial uses and resource goals in aquatic plant management were identified and are summarized in Table 2 below.

Table 2. Beneficial Uses and Resource Goals for the Management Reach.

Beneficial Use	Goal
Boat Launches	Maximize the reduction and containment of identified problematic macrophytes through rotovation and education.
Swimming	Maximum containment of aquatic plants in public swim areas. For public beaches where swimming is not a primary use, the management goal is guided by other resource concerns. Contain aquatic plant growth near private docks and swim beaches, but priority is on public areas.
Fish Habitat-Salmonids	Provide that the aquatic plant management plan is consistent with fisheries management. Ensure that aquatic plants are not a barrier to tributary spawning.
Fish Habitat-Warm Water Fisheries	Manipulation of identified aquatic beds, mainly in sloughs to favor warm water fisheries as identified by fisheries management.
Shoreline Wetlands	Protect and maintain shoreline wetlands and their functionality with no rotovation within the wetlands. If possible, control the spread of non-native invasive aquatic plants from the reservoir to the adjacent wetlands.
Waterfowl Habitat	Aquatic plant management plan should be consistent with the wildlife management goal of maintaining a healthy great blue heron population, and avoid improving habitat for cormorants.
Shoreline Erosion and Hazard Occurrence	Emphasize emergent native plants in areas of moderate to high hazard bank erosion during the aquatic plant-growing season to reduce erosion caused by wave action.
Bald Eagle/ Osprey Habitat	Aquatic plant management plan should be consistent with the wildlife goal to maintain an abundant and easily acquired food supply.
Cultural	Treatment options will be specified on a confidential site-by-site basis to preserve the cultural integrity of the area. Rotovation will not be conducted at known cultural sites.
Amphibians	Rotovation is considered unlikely to impact amphibian populations.

Beneficial Use and Aquatic Plant Maps

Beneficial use maps were developed in order to understand resource interactions and to assist in the development and implementation of management plans for the Management Reach. These maps are included in the Box Canyon Dam Final License Application (FLA), (DISTRICT, 2000). The complete map sets are available for viewing at the Pend Oreille PUD office in Newport as well as the public library in Newport.

In 1997 the aquatic plant communities within the Management Reach were mapped using a community classification scheme based on biomass, density, and percent species composition. Five plant community categories were used in these efforts; pure Eurasian watermilfoil, mixed beds dominated by milfoil (50-90% milfoil), mixed beds with milfoil (10-49% milfoil), mixed beds with no to minimal milfoil (<10% milfoil) and unvegetated. These categories were further classified to a subjective assessment of plant density. Aerial near-infrared imagery and field mapping data were combined to create a GIS map layer of aquatic plant community distribution. A complete description of the methods and the aquatic plant maps are located in Exhibit E, Water Quantity and Quality, of the Box Canyon Dam FLA. They are also provided in this document as Appendix D.

Aquatic plant maps can be used as a GIS layer in conjunction with beneficial use maps. These can serve as an important management tool to determine the appropriate control methods for particular resource areas, and to highlight those areas that require intensive aquatic plant control. Using a balanced approach to accommodate multiple beneficial use areas, priority areas for immediate aquatic plant control were determined based on the beneficial use maps. These priority areas included public and private boat launches and swimming areas. Containment intensity and control methods were also based on fisheries data which included key salmonid and bass habitat and spawning areas as well as aquatic-dependent wildlife habitat, such as waterfowl feeding areas. In areas of known fish spawning, restrictions were placed on the timing of the aquatic plant control efforts. Cultural areas were also identified and included. The locations of the cultural areas were excluded from the public maps, as the site locations are classified information. Additional factors included shoreline erosion and flooding effects.

Aquatic plant species and bed distributions are known to change annually, e.g. 1997 mapping showed few areas of *R. aquatilius*. This can be attributed to effects from flooding that occurred in 1996. As a result, site-specific assessments may be warranted prior to implementation of significant management actions.

Beneficial Use Resource Goals

Beneficial use resources, and the goals related to aquatic plant management are detailed in Tables 3 through 12 below.

Table 3. Boat Launches

Location	Locations shown on Aquatic Plant Maps
Period	May–September, with some activity year round.
Management Goal	Maximize the reduction and containment of identified problematic macrophytes through rotovation and education.
Management Effects	Current rotovation program concentrates on minimizing aquatic plant beds around public boat launches. Shoreline development for public access is often associated with boat launches.
EWM Impacts	Improper cleaning of boats can spread invasive plants to other waterbodies.
Action	Emphasize education at public boat launches. Public educational signs at boat launches regarding cleaning of aquatic vegetation from watercraft are posted. Focus on areas with dense beds of non-native plants.
Comments	When cleared of plants, swimmers use boat approach areas. Redirect swimming to nearby areas cleared of plants at a safe distance from high-use boat launches.

Table 4. Public Beaches / Swim Areas / Private Swim Areas

Location	Locations shown on Aquatic Plant Maps
Period	May-September, with some activities year round
Management Goal	Maximum containment of all aquatic plants in public swim areas. For public beaches where swimming is not a primary use, the management goal is guided by other resource concerns. Rotovation of aquatic plant growth near private docks and swim with priority on public areas.
Management Effects	Swimmers prefer aesthetics of areas without dense aquatic plant beds. Swimmer safety is enhanced by rotovation.
How is Area Affected	Dense plant beds create a safety hazard and detract from enjoyment for the public and shoreline property owners.
Comments	Safety of swimmers is a concern. Safety at boat launches a concern. Provide shoreline property owners with information on the ecological value of native aquatic plants and alternative treatment methods geared to individuals.

Table 5. Warm Water Fisheries

Location	Primarily sloughs (see FLA, DISTRICT 2000). Bass-spawning habitat was mapped as part of relicensing studies for the Box Canyon Dam.
Period	April 1-July 1.
Management Goal	Manipulation of identified aquatic plant beds to favor warm water fisheries as identified by fisheries management.
Management Effects	Plant beds should be maintained at modest densities to maximize foraging for fish growth and predation success of largemouth bass. Plants support zooplankton population and are cover for small fish. Rotovating is not done in sloughs during spawning periods. Increase structural habitat diversity.
How is Area Affected	Varies by life stage/summer seasonal cover for largemouth bass predation focus.
Comments	Literature review suggests the highest densities of all life stages of bass are achieved by rotovating a cruising lane up the middle of the sloughs parallel with the long axis of the slough. Rotovate beds or provide shading to facilitate forage lanes for predatory fish lake bass. Need baseline information on size structure of predator (bass) and prey (panfish, yellow perch) species and follow-up monitoring to determine if efforts are successful.

Table 6. Native Salmonids

Location	Cold water tributaries and sloughs
Period	Times to avoid include migration period for bull trout, whitefish, and cutthroat trout, in addition to spawning period for largemouth bass.
Management Goal	Aquatic Management Plan consistent with fisheries management.
Management Effects	Rotovation cleans substrate used by salmonids. Rotovation is not effective in cobble habitats; however, aquatic plants are sparse to non-existent in cobble areas of river.
How is Area Affected	Change in plant density from sparse or absent to dense in areas with gravel or cobble substrate could lead to degradation of spawning/rearing habitat. Flow velocity obstructions would likely be a necessary catalyst to allow plants to become established at dense levels where bed is now coarse gravel/cobble.
Comments	Aquatic plants should not be allowed to be a passage barrier to tributaries. Native salmonids are the priority species and management of macrophytes should avoid negative impacts. Issues: Effective management may require zoning of the reservoir and sloughs as identified for targeted species. Some sloughs may be managed as a migration corridor while others as largemouth bass forage.

Table 7. Cultural Resources

Location	121 Site locations (locations are confidential)
Period	Year round avoid disturbance at cultural sites as they are identified.
Management Goal	Site-specific treatment options will have to be designed on a site-by-site basis, if necessary. Site confidentiality should be preserved to protect cultural sites.
Management Effects	Many inundated sites are not known especially on or adjacent to private lands or areas. Where rotovation is already ongoing, there is reduced potential to cause further damage should unidentified sites exist.
Action	Rotovation not conducted at known sites to avoid bed disturbance.
Comments	Not all archeological sites are known. Develop mechanism or model that identifies areas likely/unlikely to have sites. Shading may be the best option in areas of low velocity, if active management is necessary. Kalispel Tribe is to compare rotovation sites with known submerged archeological sites and notify County if necessary. Protection is through avoidance of rotovation.

Table 8. Shoreline Wetlands

Location	Locations shown on beneficial use maps as semi-permanent to permanently flooded wetlands.
Period	Year round
Management Goal	Protect and maintain shoreline wetlands and their functionality. Control spread of non-native invasive aquatic plants from reservoir to adjacent wetlands.
Management Effects	Spread of non-native invasive plans to surrounding wetlands.
How is Area Affected	Non-issue for seasonal open water wetlands. Flooding and wildlife can transport non-native invasive aquatic plants from the river and sloughs into surrounding open water wetlands, where these invasive plants can out-compete native emergent vegetation. Habitat diversity is degraded and open water within surrounding wetlands is reduced.
Action	Wetlands are not rotovated. Other methods my be employed if necessary.
Comments	Wetland areas may also have important cultural significance as a traditional harvest of native roots (e.g., camas).

Table 9. Colonial Nesting Water Birds (Great Blue Heron and Double Crested Cormorant)

Location	Nest areas are shown on beneficial use maps.
Period	Breeding season: April/May – August
Management Goal	Aquatic Management Plan should be consistent with wildlife goal: Maintain healthy great blue heron population (not at risk by rotovation). Avoid improving habitat for cormorants (perceived as undesirable species).
Management Effects	Unlikely to have any effect on great blue heron, which feed in shallow water. It is unknown what effects plant beds have on cormorants. Presumably they do not feed in dense beds. There are many areas where these birds can feed both in the river and at Calispell Lake.
How is Area Affected	Unclear- probably little effect, however, there is at least some potential to affect food availability.
Comments	

Table 10. Osprey and Bald Eagle Nest Sites and Feeding Areas

Location	Nest sites shown on beneficial uses maps, feeding areas are not shown.
Period	Osprey (April) May – September
Management Goal	Aquatic plant management should be consistent with wildlife goal to maintain an abundant and easily acquired food supply.
Management Effects	Uncertain: There is no evidence that either species is currently limited by food supply. It is possible that these species benefit from dense weed beds that force small to medium size fish to swim above the beds where they are more easily caught. The provision of passageways through dense weed beds might allow fish to swim deeper.
How is Area Affected	Little is known of when Osprey or Bald Eagle feed most heavily – both can travel long distances to feed. There is little likelihood that nesting bald eagles would be disturbed by rotovation. Osprey (more numerous and with many nests on pilings) are presumably unaffected by disturbance from boats, or presumably by rotovation.
Comments	Bottom feeding fish are often stirred up by rotovation and come to the surface. Rotovator operators have observed osprey feeding behind the rotovator.

Table 11. Amphibian

Location	Locations shown on beneficial uses map
Period	May to October
Management Goal	Where bullfrog abundance is documented as a problem, contain surface level aquatic plants to aid in the control of bullfrog populations especially in sloughs. This management goal is secondary to other aquatic plant management goals since the effects are minimal.
Management Effects	The only species of amphibian likely to be affected by aquatic plant control in the river is bullfrog. Bullfrogs are considered an undesirable species so an adverse effect would be anything that could *improve* conditions for this species.
How is Area Affected	Bullfrogs have been observed floating/sitting on aquatic plants, which are at the surface. Clearing plants may reduce this habitat feature. Net effects of rotovation is beneficial (reduction in bullfrog habitat); however activities in the river are not likely to have a major effect (positive or negative) on this species because other habitats (ponds and borrow pits) are abundant in the region.
Comments	

Table 12. Shoreline erosion and hazard occurrence

Location	Moderate to high hazard erosion areas shown on beneficial uses map
Period	From after spring high water in June through October.
Management Goal	Emphasize emergent native plants in areas where moderate to high hazard bank erosion occurs during growing season (June – October).
Management Effects	Areas devoid of shoreline vegetation are most vulnerable to initiation of accelerated erosion processes.
How is Area Affected	Dense aquatic plant beds at the surface can reduce bank undercutting caused by wind and boat generated waves. Spring high flow bank undercutting is not affected since plant beds are not at the surface this early in the growing season.
Comments	As erosion problems occur mostly where banks are steep and currents are swift, areas where aquatic plant beds are minimal.

CONTAINMENT ALTERNATIVES

The Pend Oreille Public Utility District No.1 completed a literature review of control methods for the management of EWM. (DISTRICT 2000). This is included as Appendix C. A review of the effectiveness of rotovation within the Pend Oreille River between Albeni Falls and Box Canyon dams is provided in Appendix B. Control methods reviewed included mechanical methods such as harvest, and rotovation, drawdown, sediment covers and shading methods, manual removal methods (handpulling); dredging; weed rolling; and use of ultrasound. Biological methods reviewed included introduction of herbivorous fish, insect control (including milfoil weevils). Competitive plantings, and plant pathogens were also reviewed for use as EWM control methods. Preventative controls of spread of EWM to other water bodies include boater education with signage at public boat ramps.

Rotovation and Root Ripping

Rotovation involves the tilling of bottom sediments to dislodge plant roots and control aquatic macrophyte growth. Root ripping involves hooking the aquatic plant biomass and pulling the plants out by the roots. The primary goal of rotovation and root ripping in the Management Reach is the physical removal of EWM. Rotovation is done using a boat-mounted Aquamog^{TM} 8-foot long tiller attachment. Root ripping is done using the same Aquamog with a 14-foot rake attachment. The effective operational depth is 16-18 ft, which is capable of reaching virtually all suitable EWM habitat. A two-pass rotovating treatment is typically employed; the first pass is parallel to the shore and the second pass is perpendicular to shore. Additional rotovating may be necessary if post-treatment inspection detects that areas were missed. Root ripping is only appropriate once plant bed growth reaches a high density. It requires multiple passes through the plant beds. It is not as clean as rotovation and cannot clear as close to docks; but, it can make an area usable to water-craft users and swimmers at a more rapid rate during the height of the growing season.

Methods of Limited Use or Not Recommended for Use in the Management Reach

Listed below are the management strategies that are either only appropriate for use on a limited basis or not at all within the Management Reach. These alternatives are either not permitted, interfere with the current management strategies, hold limited applicability for use in flowing water or are ineffective in controlling the aquatic plants in the reservoir. However, it is possible these alternatives may hold greater applicability for aquatic plant management in the future. This management plan is adaptable and encourages the incorporation of new research and new alternatives.

Herbicide Control

Currently, the use of herbicides control is limited by the nature of the river's flowing water and the state DOE for use within the Management Reach. A goal of this plan is to identify areas appropriate for herbicide control, contact the affected landowners and solicit their cooperation in organizing an herbicide application. The County would collect the fees associated with the work and contract out the application.

Herbicide Options

1. Dow DMA 4, 24D. Use of this product has been extensive with excellent results. Cost approximates $225-250 per acre depending on water depth. This product targets Eurasian watermilfoil while having no impact on the other plants.

2. Aquathol Super K. This granular herbicide is very effective with respect to rapid control of both Eurasian Milfoil and Potomogetons such as curly leaf pondweed. It is not very effective on Elodea. It is also a contact herbicide so it is more of a maintenance treatment. This product goes out for about $500.00 per acre.

3. Reward. This broad spectrum liquid herbicide is very effective when targeting most submerged aquatic plants. It also is a contact herbicide, so it would be a maintenance treatment. The cost is $265.00 per acre.

4. Renovate. This product is not yet registered for use in Washington State waters. It is effective at controlling Eurasian watermilfoil while having a lesser effect on native plants. Cost may be prohibitive at up to $1,000 per acre.

Along with greater product availability, application techniques, such as the use of curtain barriers, have been developed to target applications that maximize targeted affect while minimizing non-target damage.

Biological Control

Milfoil Weevil

The milfoil weevil (*Euhrychiopsis lecontei*) has exhibited considerable promise as a biological control agent for EWM. The milfoil weevil is milfoil-specific, native to North America, and associated with declines of EWM both in the lab and the field. Unfortunately, the success of weevils in the Management Reach is most likely limited.

Milfoil-weevil experiments within the Management Reach were conducted in 2001 and 2002 to explore the feasibility and success of using milfoil weevils as a milfoil containment option. Milfoil weevil collection, rearing, and introduction efforts were successful, resulting in the estimated production of nearly 16,000 weevil eggs and larvae over two years. However, these efforts failed to establish substantial weevil populations in a partially enclosed bay in the Pend Oreille River, and Eurasian watermilfoil in the test area appeared unaffected. The recommendation of this study was to terminate milfoil-weevils as a management strategy (Framatome 2003). However, as more information is developed in other areas, revisiting this strategy may be warranted.

Grass Carp

The use of herbivorous fish, such as grass carp (*Ctenopharyngodon idella*) has been limited for EWM control and their introduction and use within the Pend Oreille River is neither recommended nor permitted by the State. The grass carp is an herbivorous fish native to China that has been used in aquatic plant control efforts in the United States since 1963. Control is initiated by stocking pre-determined levels of fish into an area of concern. Due to the expense of trucking, stocking, and monitoring large numbers of imported grass carp, this is a large-scale method not appropriate for homeowner implementation within the river. In addition, fish are mobile and unlikely to remain at their stocking site, diluting any potential benefits for a particular site. Homeowner use in ponds that do not connect to the river would be an individual choice.

Drawdown

When used as a method of aquatic plant control, drawdowns are designed to expose the target plants to drying or freezing conditions (or both) in hopes of killing the plants. Drawdown is widely used elsewhere, in part because it is included in many water management regimes for reasons other than EWM control. This Management Reach-wide control method has been explored as a potential option for aquatic plant control within the shallows of the Pend Oreille River upstream of Box Canyon Dam.

At this time, the use of drawdown is not recommended in the Management Reach. A two-year study to determine the efficacy of drawdown as a management strategy was conducted in Campbell Pond, a 2.32-acre test site near Box Canyon Dam. The drawdown did not affect Eurasian watermilfoil frequency or biomass in Campbell Pond. Although significant increases in the cover of bare ground were observed, it was indicative of a loss of species other than Eurasian watermilfoil. This represented a loss of native plant cover in the two years following drawdown (Framatome 2003).

Commercial Control Options

Both harvesting and hand removal by SCUBA divers have been commercial options available to the waterfront property owner at various times throughout the past 10 years. It is anticipated these options will remain available through the life of this plan. Coordinating with landowner choices and the publicly operated Aquamog will remain a function of the Weed Board.

Bottom Barriers

Although bottom barriers can be effective tools in reducing the aquatic macrophytes, their use in the Management Reach is not recommended on a large-scale. Although homeowners can install bottom barriers with the appropriate permits, the use of bottom barriers throughout the reservoir is not cost-effective and would interfere with rotovation efforts.

INTEGRATED MANAGEMENT STRATEGY

Budget

In 2003, the Pend Oreille Board of County Commissioners charged the Pend Oreille County Noxious Weed Control Board with the fiscal and operational management of the Pend Oreille River milfoil control program. The 2003 budget was set at $99,266. During this year, the DISTRICT has supported the program at 90% of the funding level with a cap of $75,000. The County has made up the remainder from the general fund.

The proposed budget for 2004 is $125,900. Expenses cover 2 vessel operators, a portion of supervisory, support and substitute staff, employee benefits, fuel and supplies to operate and maintain the vessel and vehicle rental fees for crew travel.

Funding strategy

The Weed Board anticipates the DISTRICT's continued commitment to financial support for the river milfoil control program.

The Weed Board sent a proposal to the Board of County Commissioners to provide basic funding for its programs through a fee assessed to the lands of the county benefiting from the county weed control programs. Due to river conditions, such as ice, extremely low temperatures and high water, the vessel cannot operate every day throughout the year. This amounts to 20-25% of the crew time that cannot be charged to the milfoil program. Funding from the other Weed Board programs will support the crew as full-time employees.

In 2003, the County was granted Congressional funding at 50% to purchase a new Aquamog. Currently, DISTRICT and the County are working to secure funds from the State for another 25% of the purchase price. The remaining 25% must be matched at the local level.

Rotovation

It is important to note that although EWM and other aquatic macrophytes are effectively reduced by rotovation, recolonization rates can vary widely. In some cases, re-established macrophytes have exceeded pre-treatment densities although the recolonization may not be dominated by EWM. Therefore when evaluating rotovation effectiveness it is important to evaluate both the total aquatic macrophyte density and EWM density. While rotovation is effective, it is best viewed as a maintenance program for controlling, not eradicating EWM and other invasive aquatic plants.

For the Management Reach, rotovation is the preferred method for controlling EWM densities. A 1997 study which examined pre- and post rotovation aquatic plant densities indicated that the rotovation program is effective at reducing plants in the Management Reach and suggested that the rotovation may contribute to a shift in species composition (Appendix B). Generally, areas

that had been rotovated were revegetated within one year. Beds were composed of mixed species beds dominated by curly leaf pondweed or waterweed. EWM generally was not dominant until the third summer after rotovation and even then most beds were dominated by other species.

This year was the first season of extensively employing root ripping with the rake attachment. Monitoring in successive years will yield information on the effective results.

Promote Homeowner Control

In addition to rotovation, landowners and individuals are encouraged to participate in the process of aquatic plant management. Methods such as hand pulling, hand cutting, weed rakes, or weed rolling are encouraged. These methods can have a localized effect on the density of aquatic weeds in defined swimming or boating beneficial use areas.

Preventative Control and Education

Preventative control measures include improving education of users within the watershed to the effects of introduced, non-native plants to the water body. Although preventative control does not improve the aquatic plant conditions within the Management Reach, it is a key part of this Interim Aquatic Plant Management Plan to promote awareness of reducing EWM and possibly, new exotic plant infestations within BCR and surrounding watersheds. EWM has yet to be eradicated from any large water body to which it has been introduced. Therefore, preventing the spread of EWM into uninfested areas is of great importance.

Current preventative measures include signs at boat launches that warn against the spread of milfoil. Other preventative measures may include educational programs and the distribution of pamphlets with boat licenses or at recreational and commercial facilities.

Research

Research will include follow-up studies to determine the rotovation success in reducing EWM in the Management Reach.

Short term actions

- Continue Aquamog program at current intensity (200 acres/year).
- Promote public outreach for individual and private aquatic plant control management. Hold a public meeting in late 2003 to describe this plan and to solicit/encourage public involvement.
- Incorporate private landowner views in the Aquatic Plant Management Plan.
- Implement new programs and continue current programs to prevent the spread and introduction of EWM through boater education programs, literature, and signs at boat launches.
- Evaluate aquatic plant control funds – including new and additional funding sources.
- Submit plan to Department of Ecology.

Long term objectives

- Reduce EWM in the Pend Oreille River Management Reach.
- Maximize landowner, homeowner, DISTRICT, and county cooperation and participation efforts in aquatic plant control processes.
- Reduce possibility of new, introduced aquatic plants and other species to the Pend Oreille River Management Reach through education.
- Implement and investigate herbicide containment alternatives, as appropriate in the Pend Oreille River Management Reach.
- Incorporate new aquatic plant control methods as they come available within the permitting process.
- Encourage additional research for EWM control.
- Develop Countywide permit system that would extend to individual landowners.
- Evaluate aquatic plant concerns downstream of the Management Reach.

Adaptive Management for Evaluation and Monitoring of Aquatic Plant Management

- Update aquatic plant maps to illustrate changes in the aquatic plant community and possible changes in beneficial uses. The focus of aquatic plant control efforts may need to shift due to changes in beneficial uses at various locations.
- Update beneficial use maps to illustrate changes in beneficial uses
- Evaluate pre- and post rotovation efforts.
- The DISTRICT and Weed Board offices will maintain records of the rotovated areas. Log should include the time, intensity, and location of rotovation and root ripping activities.
- Evaluating plant control methods is beneficial for future aquatic containment. The homeowner, county, and DISTRICT can provide information that can improve the efficacy of the Aquatic Plant Management Plan.
- Incorporate suggestions from landowners for improvements and recommendations to the Aquatic Plant Management Plan.
- Incorporate aquatic plant research and new aquatic plant control techniques to improve control efforts.
- Update aquatic plant control maps to illustrate changes in aquatic plant communities.

Permitting

Rotovation and EWM control activities require local and state permits, whether the activities are carried out by the county or by individual landowners. The County is currently examining the feasibility of obtaining a Management Reach-wide HPA permit for EWM management that would also apply to individual homeowner actions.

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APPENDIX A

Pend Oreille County PUD Customer Survey
Aquatic Plant Management

total surveys 1320 included in data 942 blank or unreadable 378

1. Where is your primary residence? (Check one)

	Freq.
On the PO between OT and Dam	150
1/2 mile of PO river	120
Somewhere else in PO county	227
In another county or state	210
no response	235
	942

Note: Results tallied by residence category are only inclusive of those surveys reporting primary residence

2. Are you satisfied with the current rotovation program?

	Freq.
Yes	236
No	344
No response/Does not know	362
	942

	Question 2			
	Yes	No	None	
On the PO between OT and Dam	26	115	9	
1/2 mile of PO river	62	32	26	
Somewhere else in PO county	126	70	31	
In another county or state	43	121	46	

3. Rank boat launches in order of importance

Not Important
Slightly less important
Somewhat important
Slightly more important
Extremely important
no opinion

#	Question 3						
	NI	SMI	SI	SMI	EI	NO	No Res
# On the PO between OT and Dam	74	11	19	7	18	3	18
# 1/2 mile of PO river	36	16	7	14	16	17	14
# Somewhere else in PO county	96	24	22	18	28	31	8
# In another county or state	62	12	21	0	1	29	85
#							

4 Rank swimming and public areas

Not Important
Slightly less important
Somewhat important
Slightly more important
Extremely important
no opinion

#	Question 4						
#	NI	SMI	SI	SMI	EI	NO	No Res
# On the PO between OT and Dam	74	45	15	4	8	1	3
# 1/2 mile of PO river	75	16	7	4	6	5	7
# Somewhere else in PO county	85	24	22	32	26	13	25
# In another county or state	153	17	12	10	8	2	8

5 Rank wildlife habitat

Not Important
Slightly less important
Somewhat important
Slightly more important
Extremely important
no opinion

#	Question 5						
#	NI	SMI	SI	SMI	EI	NO	No Res
# On the PO between OT and Dam	56	32	25	19	6	3	9
# 1/2 mile of PO river	68	11	16	18	3	4	9
# Somewhere else in PO county	98	28	37	16	12	9	27
# In another county or state	103	16	20	53	3	6	9

6 Rank fish spawning in order of importance

Not Important
Slightly less important
Somewhat important
Slightly more important
Extremely important
no opinion

#	Question 6						
#	NI	SMI	SI	SMI	EI	NO	No Res
# On the PO between OT and Dam	42	32	31	7	9	3	26
# 1/2 mile of PO river	34	25	18	8	3	24	8
# Somewhere else in PO county	108	31	33	6	9	13	27
# In another county or state	107	21	13	5	26	18	20

7 Rank fishing areas in order of importance

Not Important
Slightly less important
Somewhat important
Slightly more important
Extremely important
no opinion

#	Question 7						
#	NI	SMI	SI	SMI	EI	NO	No Res
# On the PO between OT and Dam	48	31	32	11	18	4	6
# 1/2 mile of PO river	39	42	15	10	3	4	7
# Somewhere else in PO county	107	25	36	8	15	13	23
# In another county or state	134	25	17	32	7	9	11

8. Fish and wildlife habitat can benefit from selective rotovation. If necessary, would you be willing to redirect some of the current rotovation to benefit these resources, even if it meant docks and

	Resp.
Yes	268
No	201
No opinion	289
No response/Does not know	184

	Question 8			
	Yes	No	No Op.	none
On the PO between OT and Dam	40	68	18	24
1/2 mile of PO river	37	66	11	6
Somewhere else in PO county	72	72	54	29
In another county or state	78	93	29	10

9.supplemental and alternative methods

continue with rotovation	165
increase rotovation area	129
winter reservoir drawdown	151
homeowner and rotovation	160
biological treatment	270
no opinion	67

On the PO between OT and Dam	
1/2 mile of PO river	
Somewhere else in PO county	
In another county or state	

Question 09					
CR	IR	WRD	H&R	BT	NO
38	51	52	47	69	9
26	20	18	12	44	9
78	27	23	34	46	46
23	31	31	37	60	13

10. At what level would you be willing to participate in the Aquatic Plant Management Plan

Response Label	
Sorry, not able to participate	395
Attend public meetings	173
Volunteer and participation	145
No response/Does not know	229

On the PO between OT and Dam	
1/2 mile of PO river	
Somewhere else in PO county	
In another county or state	

Question 10			
None	Attend	Volunteer	No Res
69	48	24	9
41	25	6	48
187	18	6	16
167	21	12	10

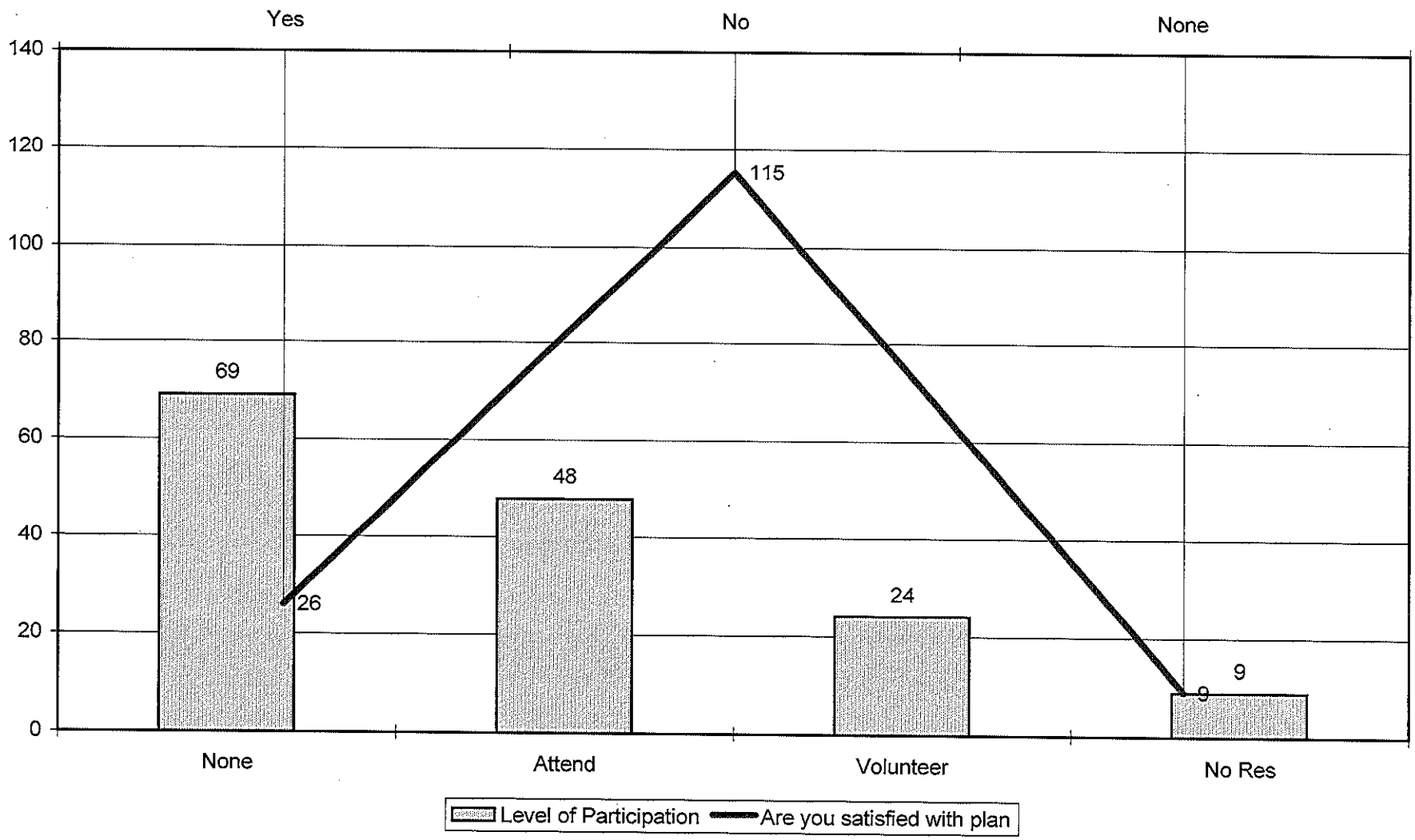
11. As a rate payer how much would you be willing to pay on your monthly utility bill for continued and\or additional aquatic plant management with the Box Canyon Reservoir?

Response Label	
0	203
0.5	106
1	122
2	126
5	175
5.00+	96
No response/Does not know	114

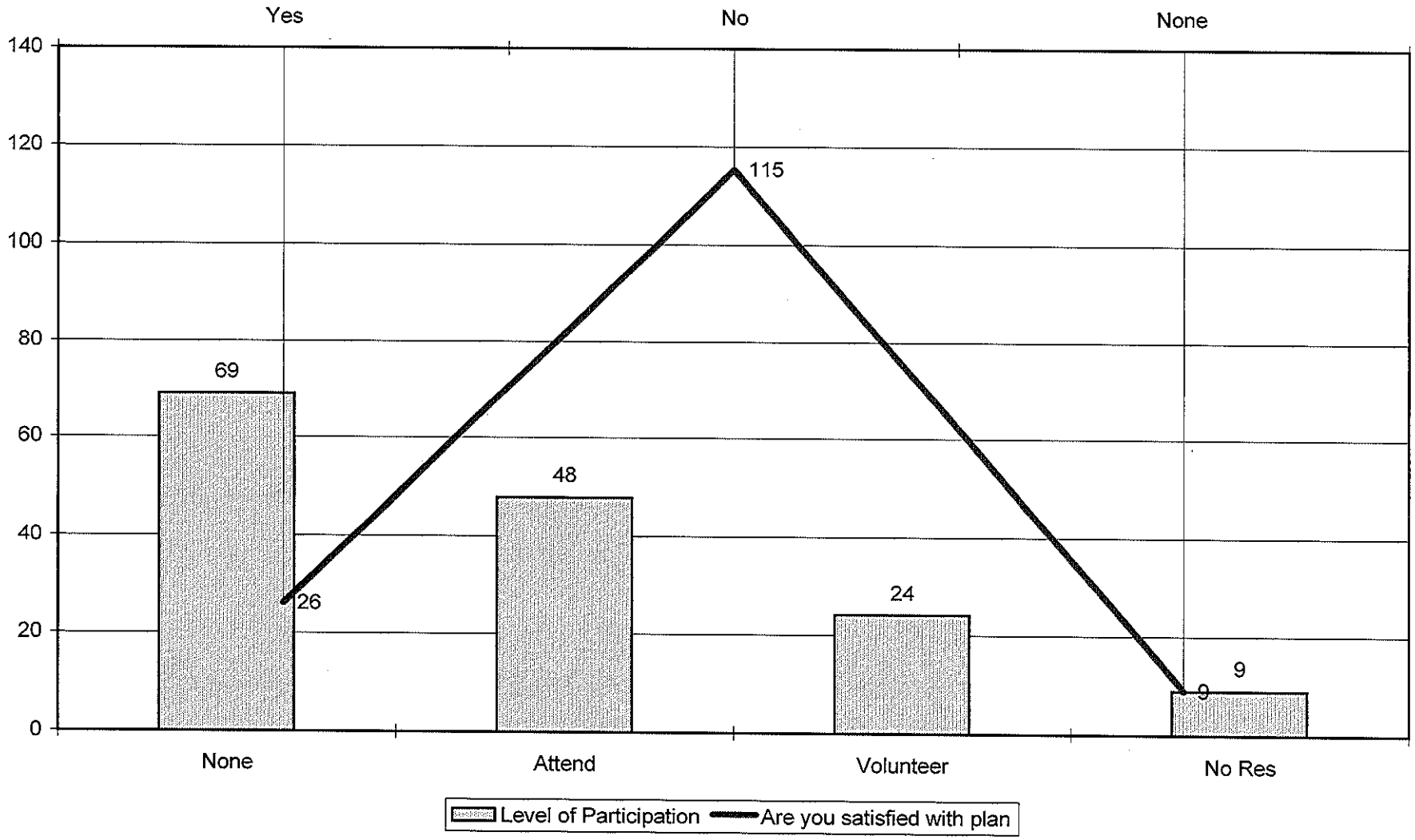
On the PO between OT and Dam	
1/2 mile of PO river	
Somewhere else in PO county	
In another county or state	

Question 11						
$0.00	$0.50	$1.00	$2.00	$5.00	>$5.0	No res.
44	1	20	23	27	16	19
57	6	18	18	15	2	4
95	20	35	34	11	2	30
64	18	23	23	16	18	48

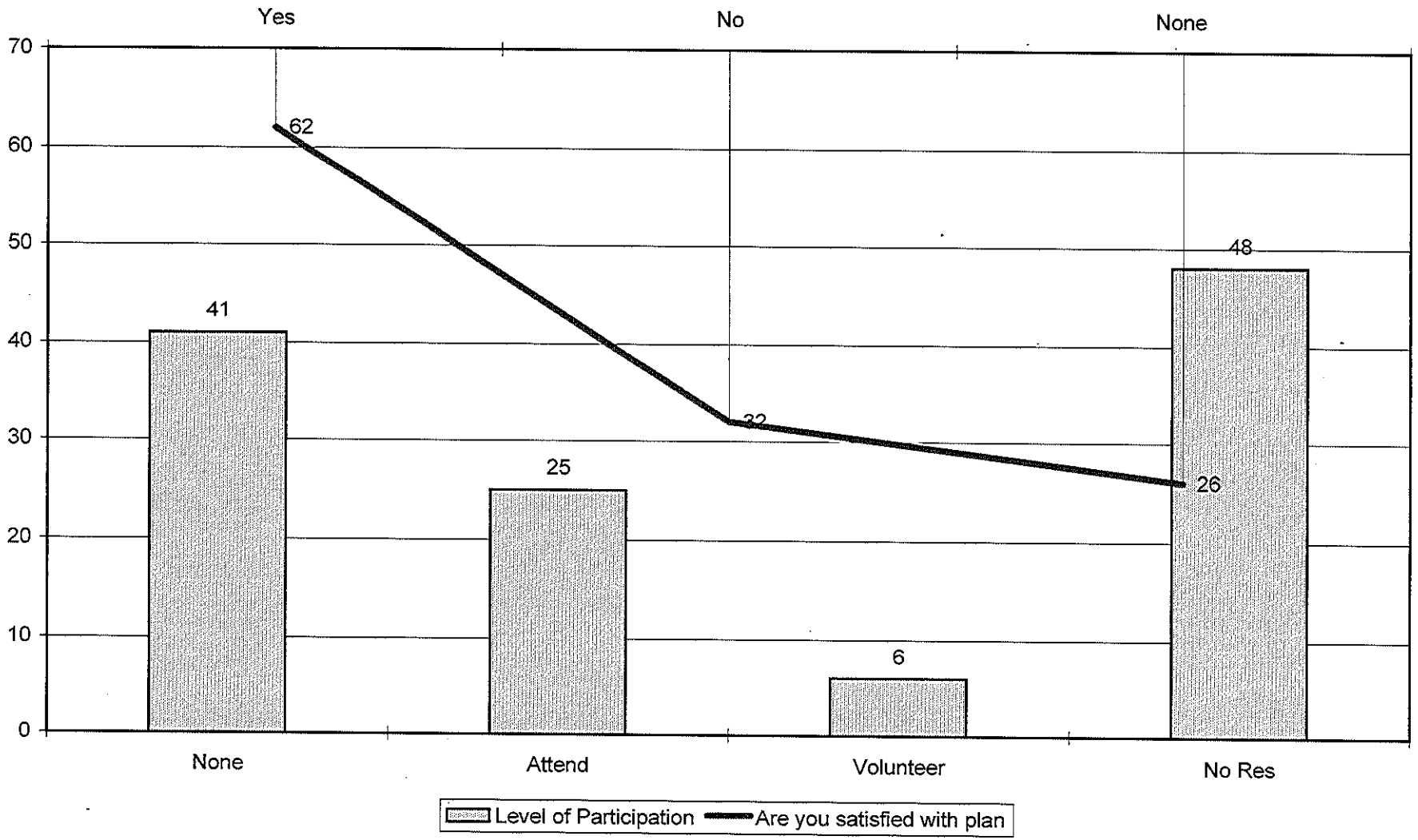
Level of Satisfaction and Participation
Living on the Pend Orielle



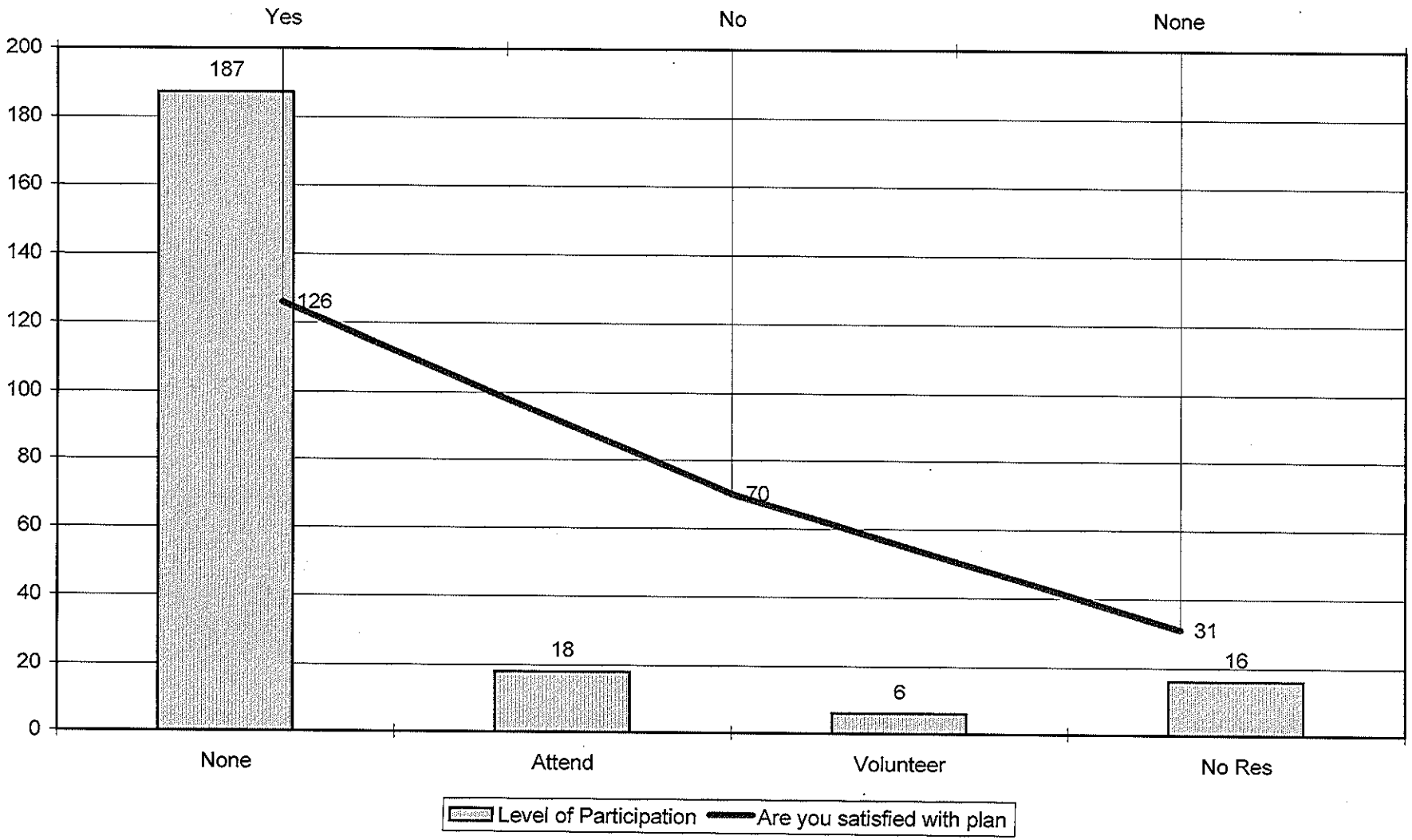
Level of Satisfaction and Participation
Living on the Pend Orielle



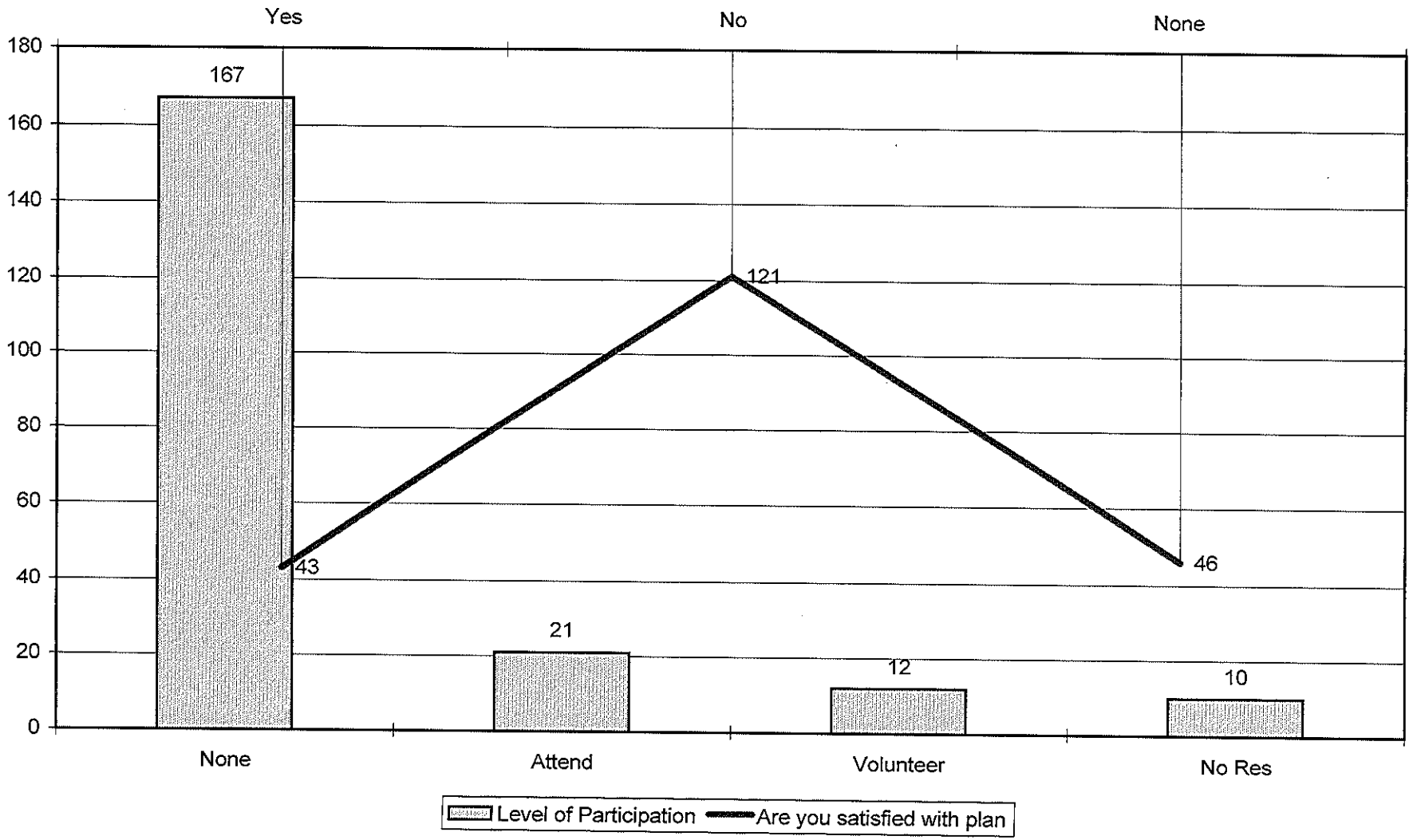
Level of Satisfaction and Participation
Living 1/2 mile of PO



Level of Satisfaction and Participation
Living somewhere else in PO County

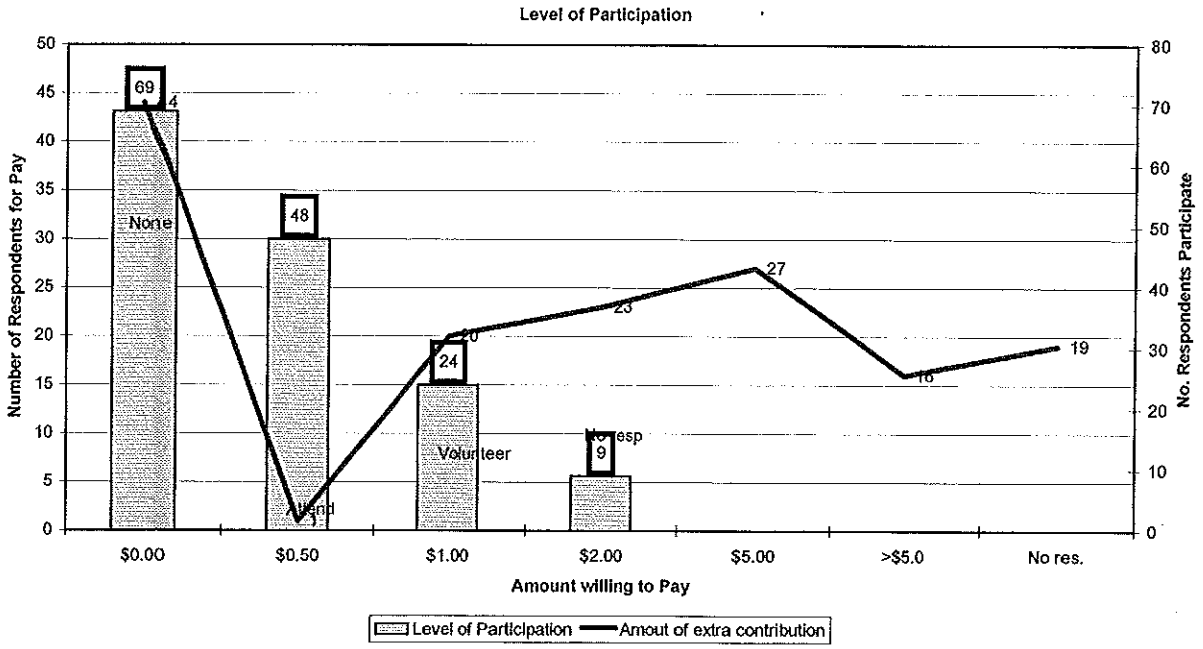


Level of Satisfaction and Participation
Living in another County or State



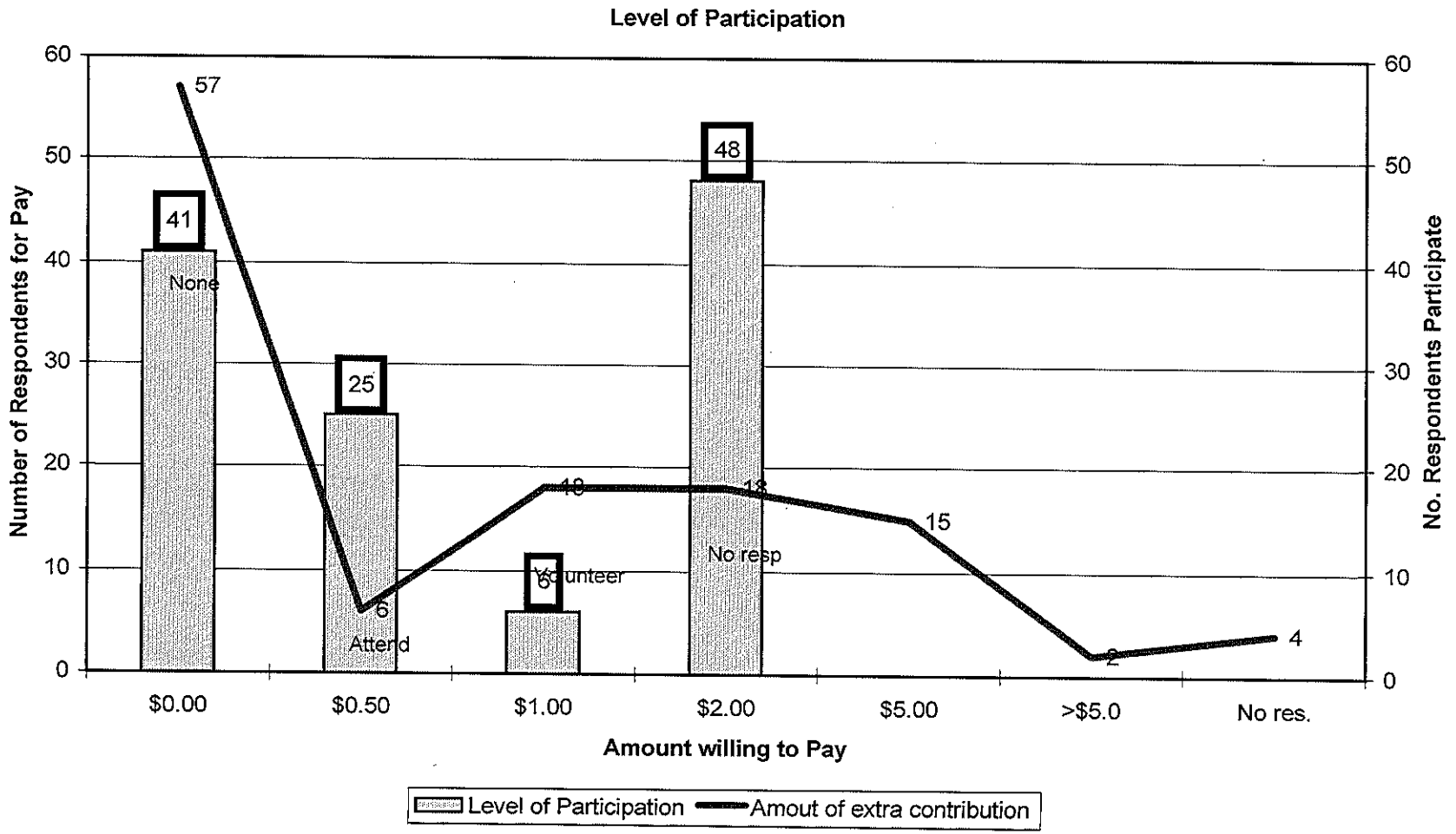
Level of Satisfaction and Amt of Contribution

Living on BCR



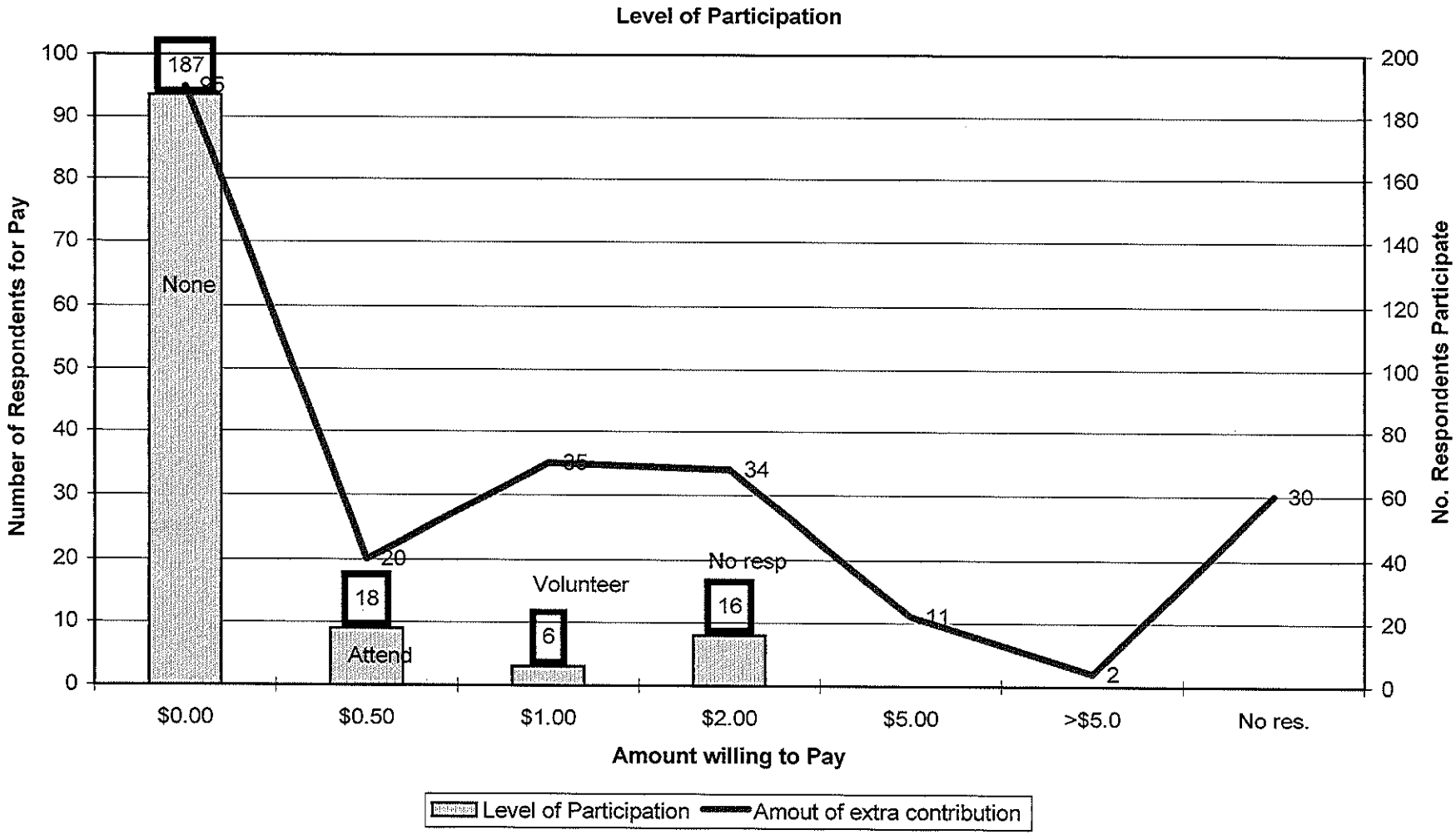
Level of Satisfaction and Amt of Contribution

Living within 1/2 Mile of BCR



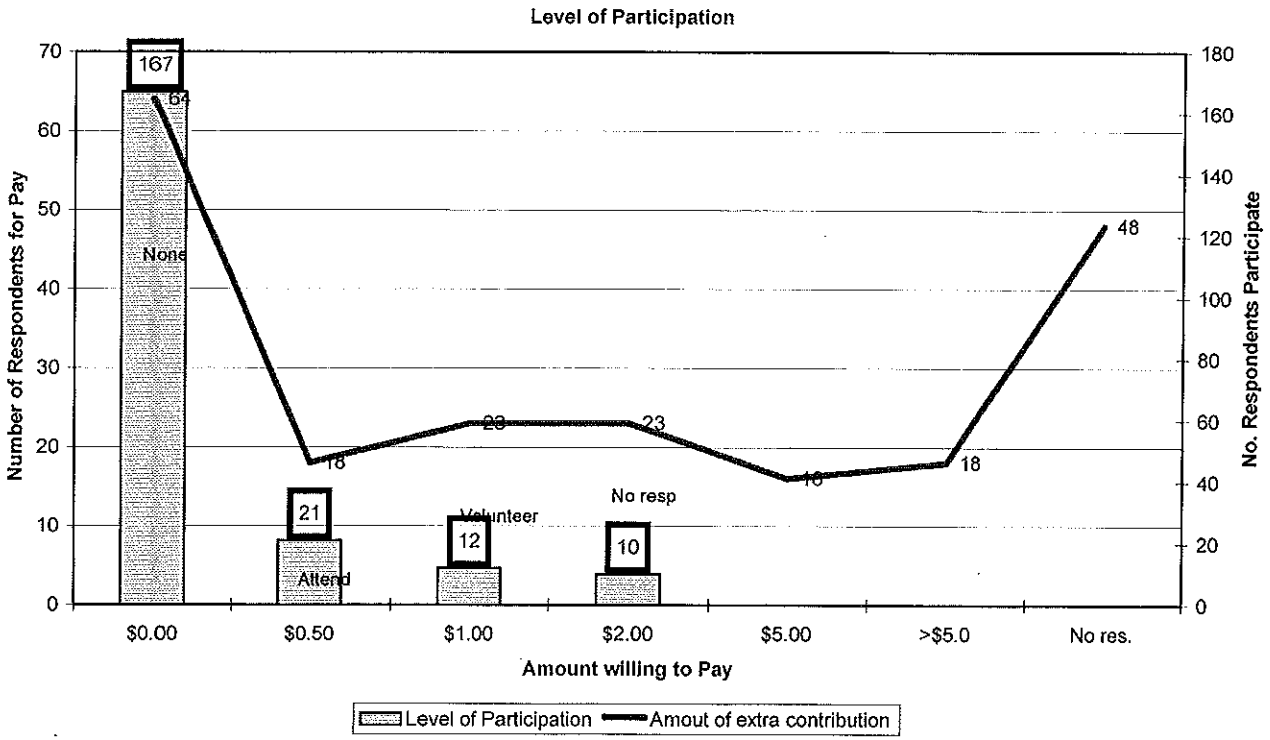
Level of Satisfaction and Amt of Contribution

Living somewhere else in PO County

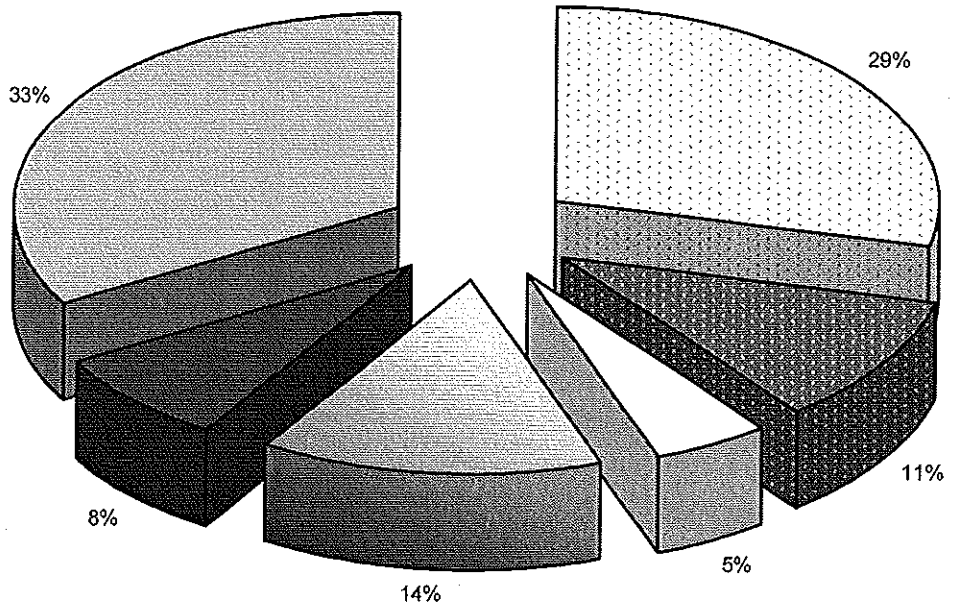


Level of Satisfaction and Amt of Contribution

Living in Another County or State

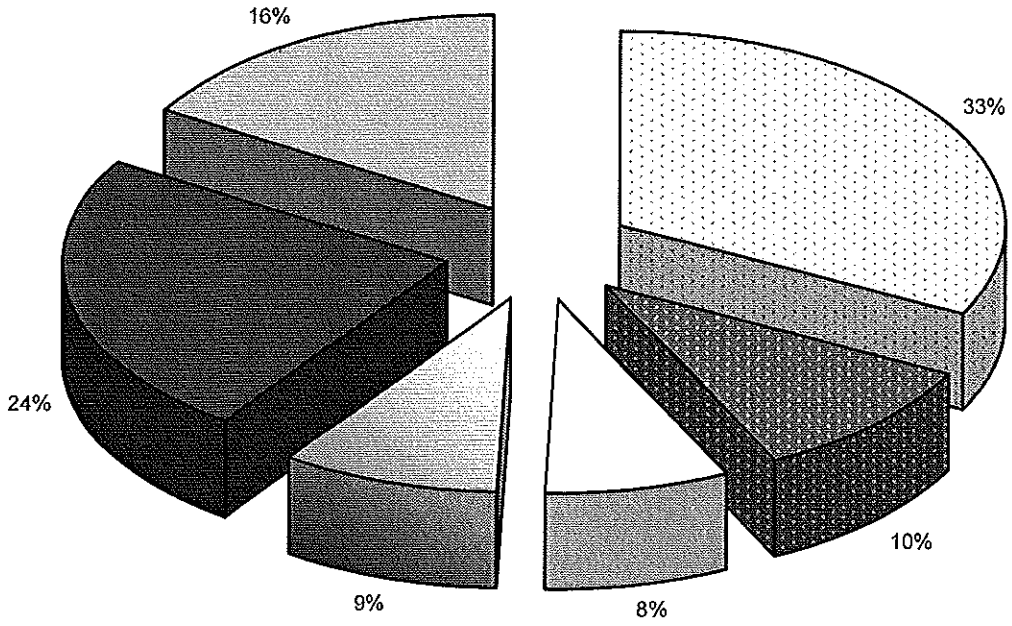


Overall Rank Boat Launches

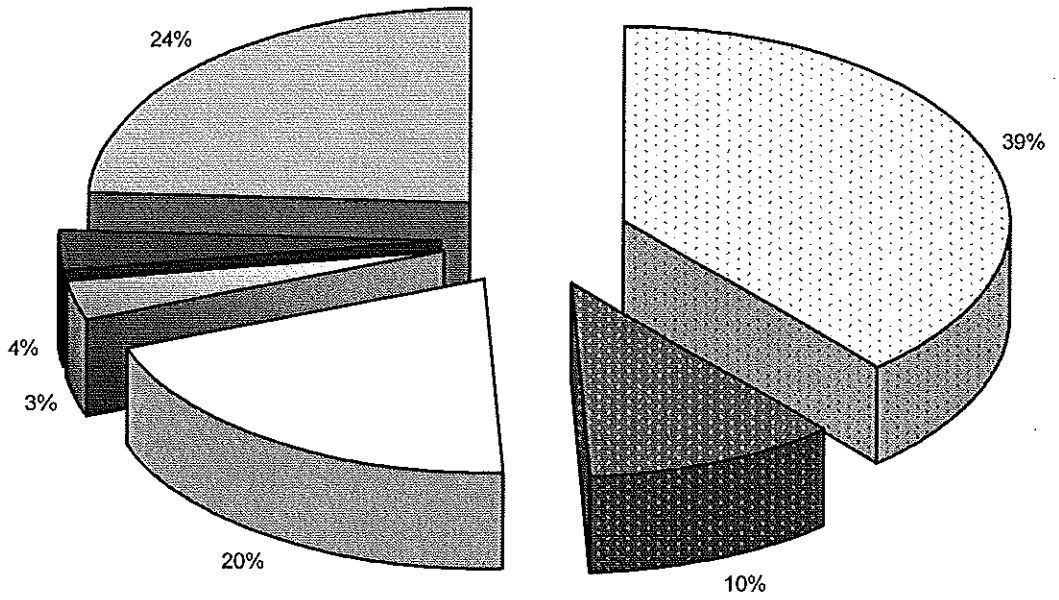


Not Important	Slightly less important
Somewhat important	Slightly more important
Extremely important	no opinion

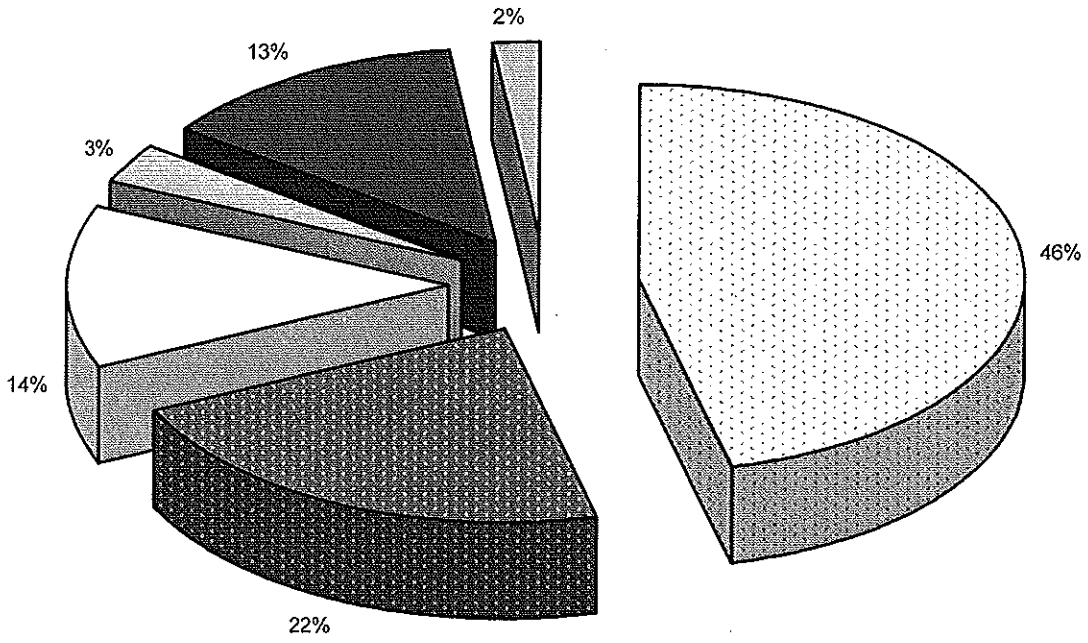
Overall rank swimming and public areas



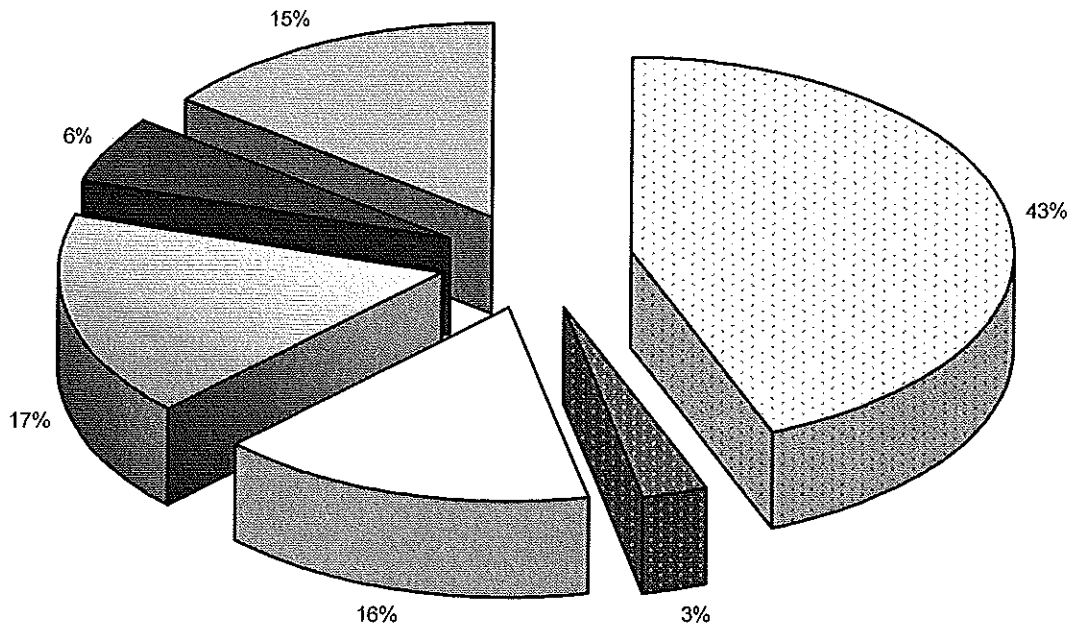
Overall rank wildlife



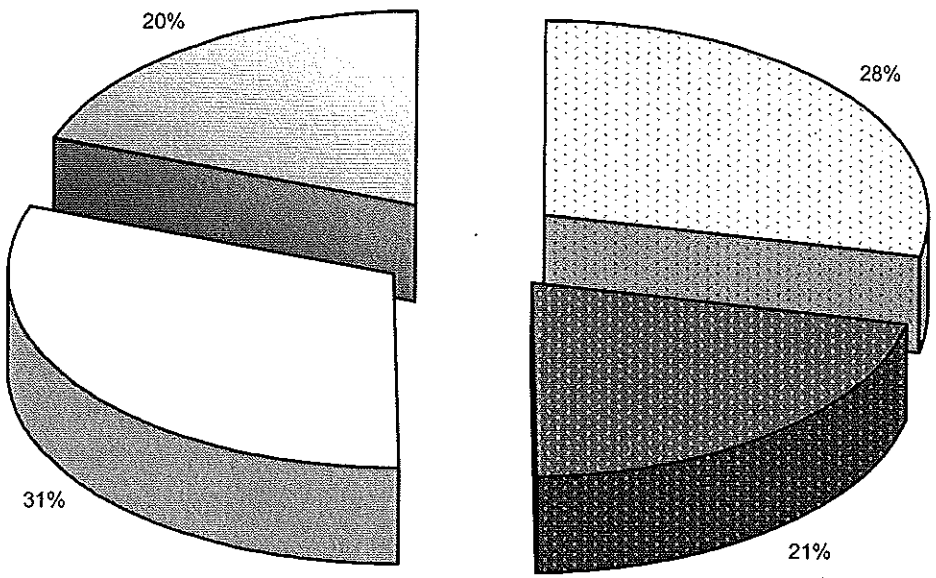
Overall rank fish spawning



Overall rank fishing areas

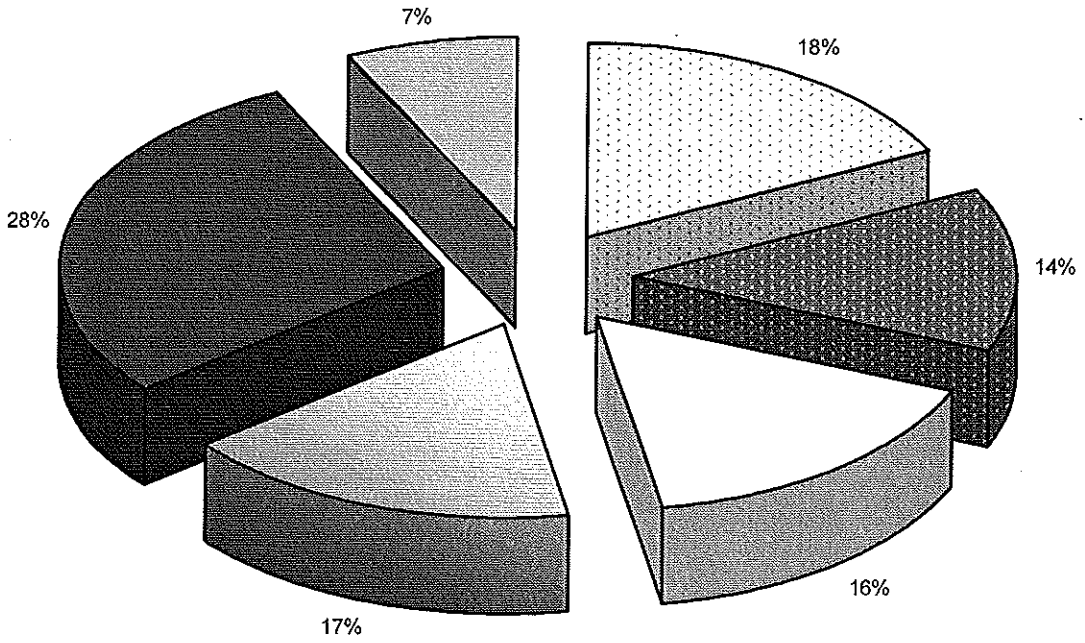


Redirect Rotovation

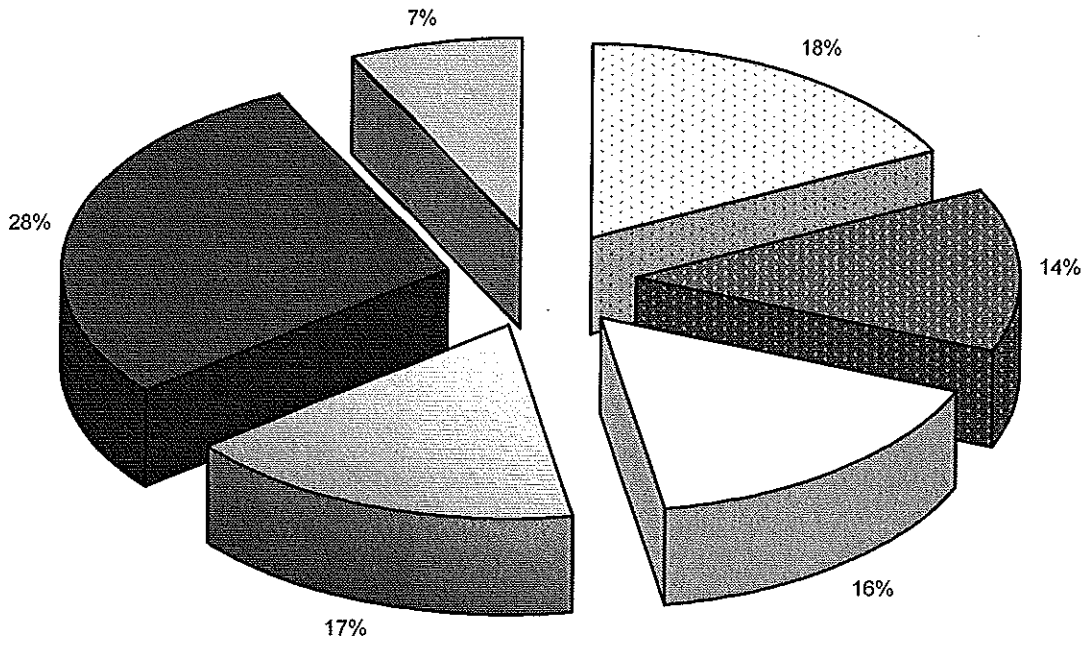


☐ Yes ▩ No ☐ No opinion ▩ No response/Does not know

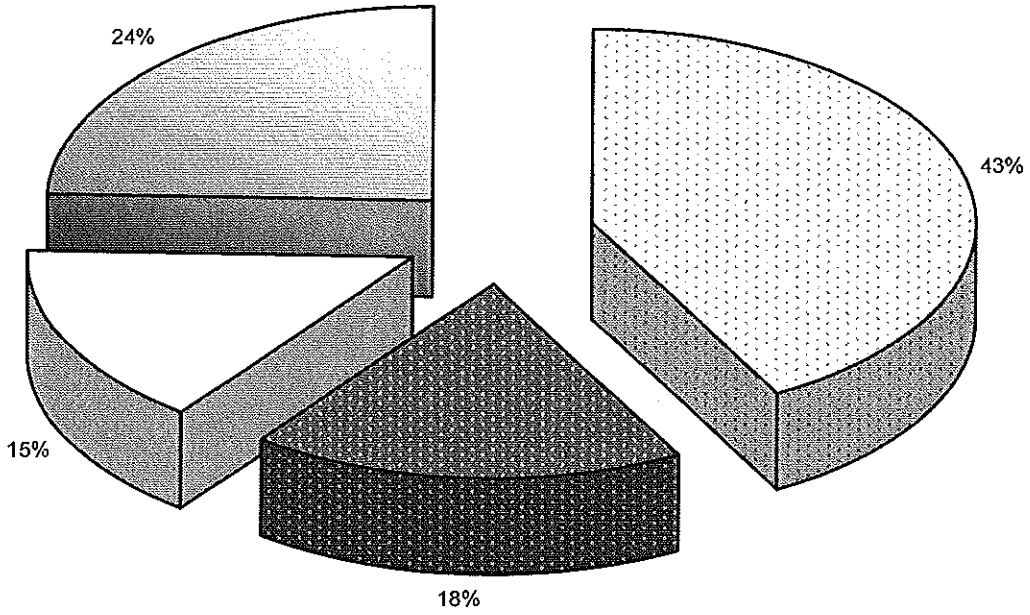
Overall alternative methods



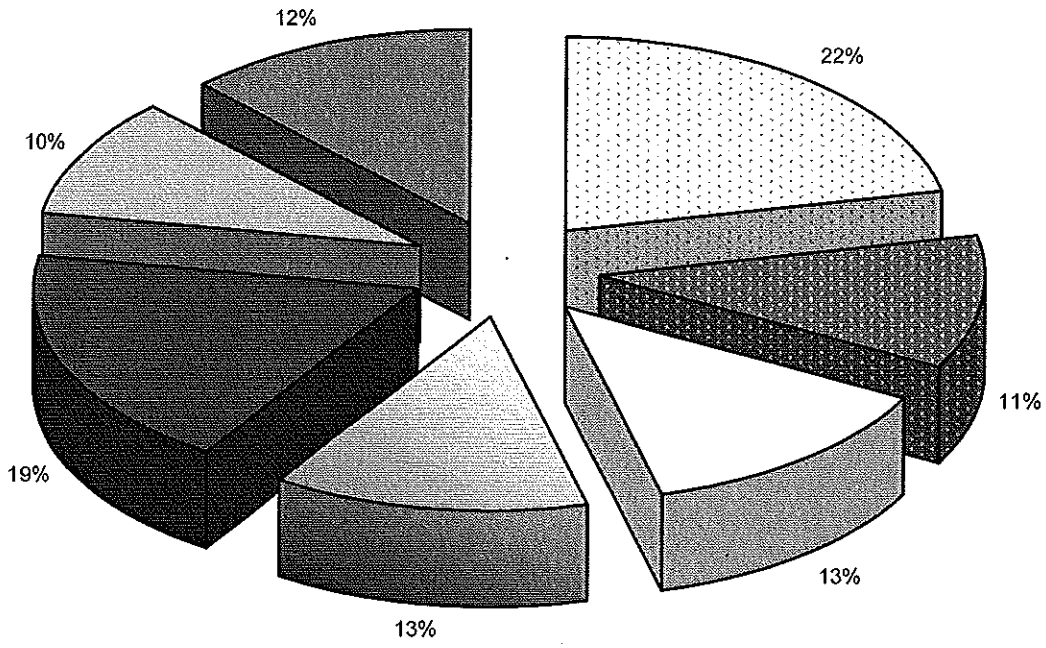
Overall alternative methods



Overall Participation



Overall additional expense



APPENDIX B

REVIEW OF ROTOVATION EFFECTIVENESS STUDIES FOR THE PEND OREILLE RIVER

REVIEW OF ROTOVATION EFFECTIVENESS STUDIES FOR THE PEND OREILLE RIVER

INTRODUCTION

Rotovation, the tilling of bottom sediments to dislodge plant roots, has been used to control aquatic macrophyte growth in the Box Canyon Reservoir since 1986. The primary goal of rotovation in the Box Canyon Hydroelectric Project area is the physical removal of Eurasian watermilfoil (*Myriophyllum spicatum spicatum*) (EWM), an invasive, non-native aquatic macrophyte. Rotovation also removes other plant species, including the non-native curled pondweed (*Potamogeton crispus*), which is probably the most abundant and widely distributed aquatic plant in the project area (CES/DES Relicensing Study Update, February 1998).

EWM grows in dense monotypic and mixed-species beds throughout the reservoir, particularly in littoral areas less than 10 feet deep. There is limited plant growth on substrates between 10 and 18 feet in depth; no plants root in substrates greater than 18 feet deep. The majority of aquatic plant communities within the reservoir are mixed beds of native and non-native plants. In general, the densest beds have a high percentage of EWM.

From 1987 to1988 the aerial distribution of total aquatic plants did not change significantly between Box Canyon Dam and Usk. However, EWM increasingly dominated the plant community. During this period, EWM occupied nearly all available littoral habitat between Box Canyon Dam and River Bend, and continued to invade upstream areas. Between 1986 and 1988, the distribution of EWM expanded 11 miles upstream, from the Calispell River tributary (RM 69.5) to Indian Island (RM 80.5). In 1989, EWM was found upstream to RM 85.7. Apparently, the upstream dispersal of EWM occurs primarily through boating activity. Today, EWM distribution extends upstream to Albeni Falls although plant communities are limited upstream of the Newport bridge due to riverine, high velocity conditions.

EWM is a nuisance to recreational activities such as boating, fishing and swimming. In response to an increasing infestation of EWM in the Pend Oreille River, Pend Oreille County initiated efforts to control EWM in 1982. From 1982 to 1985, the herbicide 2,4-dichlorophenoxyacetic acid (2,4-D DMA) was used to slow the rate of advance of EWM (WATER 1985). However, in 1986 the EPA withdrew the exemption required for the use of this herbicide. In response, Pend Oreille County incorporated rotovation into its EWM control program in 1986. The British Columbia Ministry of Environment, Lands, and Parks pioneered this control technology and have successfully employed rotovation in the Okanagan Lakes Chain (Cooke et al. 1986). The Pend Oreille River program in 1986 was the first large-scale operation of its kind in the United States. The following discussion describes the effectiveness of rotovation efforts in selected areas of the Pend Oreille River.

ROTOVATION PROGRAM

Most studies report rotovation effectiveness as a percent reduction in stem density of EWM per unit area of substrate. Post-rotovation stem densities are compared to pre-rotovation densities. Some studies have reported *carryover effectiveness* in the season or year following rotovation by comparing stem density in rotovated plots after a prescribed period of time (usually one year) to stem density in control plots that did not receive rotovation treatment.

1986 rotovation. In 1986, 38 acres of monotypic EWM and multi-species beds of aquatic plants were rotovated in the Pend Oreille River. Concurrent testing of the herbicide Sonar and planting of dwarf spike-rush were evaluated. Stem density of EWM decreased from 63-90 percent immediately following rotovation. Other aquatic species were removed at similar rates, with the exception of *Elodea canadensis,* which dominated shallow areas that were tilled less completely by the rotovator. One year later, carryover effectiveness ranged from 10-25 percent reduction in EWM stem density. The stem densities of all aquatic macrophytes were reduced from 7-25 percent after one year. Notably, the stem density of Elodea *canadensis* increased 500 percent after one year in one rotovation plot. These results indicate that carryover control was attained for EWM but not necessarily for aquatic plants in general. Immediately after rotovation, EWM stem densities were effectively reduced, but by the second year the results were variable and total stem densities of all aquatic plants were similar to pre-rotovation levels (WATER 1988).

1987 rotovation. In 1987, 80 acres of EWM beds were rotovated, including dense EWM beds located in embayments near Ione and pioneer colonies near Usk. One year after rotovation, the EWM stem density was reduced by 90 percent in the Ione Park Swim bay. However, stem density of *Potamogeton* spp. increased by 20-fold in the Ione swim bay and *Elodea canadensis* also demonstrated increased stem densities. Apparently, tillage may enhance the growth of certain non-target plant species. In two adjacent rotovation plots in the main river channel, one plot had a 44 percent increase in EWM stem density, while another plot had a 25 percent decrease after one year (WATER Environmental Services 1988, 1990).

1988 rotovation. In 1988, approximately 55 acres were rotovated. Rotovation efforts were concentrated in the Dalkena-Furport area (RM 77-80) where new colonies of EWM were identified in 1987. Due to excessive plant biomass in EWM beds, the control program utilized a three-step system in 1988. First, plant stems were cut close to the substrate using a T-bar cutter. Then the plant fragments were gathered using a clam rake tool. After initial removal of this material, the substrate was tilled using the rototiller head to dislodge plant roots (WATER Environmental Services 1988: Pend Oreille River Eurasian watermilfoil Control Program 1988).

Immediately after rotovation, stem density was reduced from 85-94 percent. After one year, stem density in one rotovation plot increased by 44 percent over pretreatment density. This increase was mainly due to small root systems resulting from reinfestation

by fragments from outside the plot. Another plot had 25 percent lower stem density than pre-treatment levels after one year (WATER 1990).

1992 rotovation. In 1992, rotovation treatment significantly reduced macrophyte biomass in four months following rotovation (Falter et al. 1991)

Current program. Approximately 200 acres per year were being rotovated in the Pend Oreille River as of 1995. The rotovator is a boat-mounted Aquamog 8-foot long tiller with an effective operational depth of 16-18 feet. In each site two passes are made with the rotovator; the first pass is parallel to the shore and the second pass is perpendicular to the shore. Fragments are not typically collected except in areas of heavy infestation where plant material can be rolled onto the tiller blade and deposited on shore. Most of the plant material washes up on the shore downstream of the treatment site. Rotovation treatments focus on high use areas in the main river channel. The only slough rotovated is Tiger Inlet.

RE-ESTABLISHMENT OF MACROPHYTES FOLLOWING ROTOVATION

Studies show that EWM will re-establish in rotovated sites, either from EWM fragments or remaining root crowns (WDOE 1998, Cooke et al. 1993). After rotovation, dislodged EWM root crowns and stems float to the surface and are either collected or left to wash to shore (Cooke et al. 1993). Since EWM reproduces mainly by fragmentation and dispersal, rotovation may intensify EWM infestations by creation of fragments. While it is generally believed that the fragments released by harvest are fewer than those that would have been released by the intact bed, no research has addressed this question specifically in Box Canyon Reservoir or similar systems (Cooke et al. 1993). Certainly, collection of plant biomass after rotovation would decrease the likelihood of re-establishment of EWM fragments. However, this control method would be extremely labor and time-intensive, and appropriate disposal options would have to be found for the harvested plant biomass.

In addition to fragment dispersal, EWM will readily recolonize rotovated sites if the substrate is incompletely tilled. In the Pend Oreille River, more substrate area was missed by the rotovator with parallel tilling sweeps than with two perpendicular sweeps (WATER 1988). Areas of the substrate tend to be missed more often when the operator guides the rotovator using visual tracking. Aquatic resource managers in British Columbia have used a portable surface buoy system to improve machine tracking and reduce the occurrence of missed areas. In dense macrophyte beds, successive annual treatments are recommended to attain a reduction in root masses, especially during the initial treatment years (WATER 1988).

In addition to EWM, other species of aquatic plants will invade sites after rotovation (Maxnuk 1979, Bryan and Armour 1982, Gibbons and Gibbons 1988, Cooke et al. 1993). In particular, the non-native *Potamogeton crispus* invades readily (Maxnuk 1979).

The eventual re-establishment of macrophytes in rotovated sites is inevitable without continued preventatives such as herbicides or repeat rotovation. Thus, the objective of rotovation programs should be to maximize the benefits of each rotovation treatment.

Newroth (1986) suggests conducting rotovation treatments in the winter or spring, when EWM biomass is reduced and fragments are less viable. To minimize reinvasion by EWM and other species, WATER (1988) recommends rotovation in the fall, followed by a subsequent rotovation treatment in the spring.

ECOLOGICAL EFFECTS OF ROTOVATION

Most rotovation studies concentrate on rates of plant removal and recolonization. Very few studies have addressed the ecological effects of rotovation. In Box Canyon Reservoir, aquatic macrophytes provide aquatic habitat complexity. The distribution of macrophytes likely influences the density, diversity and distribution of aquatic animals.

Removal of macrophyte biomass by rotovation has dramatic effects on fish and invertebrate habitat. Rotovation can affect fish cover, water temperature, light penetration, sedimentation patterns, and DO levels, which in turn may affect primary and secondary productivity (Falter et al. 1991). Macrophytes act as Anutrient pumps@ via growth and senescence, translocating nutrients from the sediments into the water column. Removal of macrophytes eliminates this important function. Falter et al. (1991) investigated the effects of rotovation on phytoplankton and zooplankton communities. Phytoplankton density and biomass and zooplankton density, biomass and diversity decreased in rotovated areas. They concluded that extensive rotovation may be detrimental to the zooplankton food base of juvenile sport fishes. Their recommendation, from a fisheries management perspective, was that Aclear cut@ and widespread rotovation treatments be cautiously evaluated.

ROTOVATION EFFECTIVENESS

Cooke et al. (1993) provide a recent review of rotovation effectiveness, particularly for the removal of EWM. In British Columbia, rotovation reduced EWM by 80-97 percent and carryover benefits were documented to persist for a year or more. They found that two tillage passes were required to provide acceptable standards of control, particularly in silt and clay substrates. They recommend significant overlap in rototilled strips to avoid missing areas of substrate. According to Cooke et al. (1993) regrowth of EWM in rotovated areas is dependent on the following factors:

- The time and care taken by the equipment operator, and operator experience
- The condition of the rotovation equipment
- The physical conditions of the treatment site (including presence of obstacles and rocks, slope, substrate type)
- The proximity and density of untreated sources of viable EWM fragments to aid reinfestation
- The frequency of previous derooting treatments of the area and the pretreatment density of the target plants

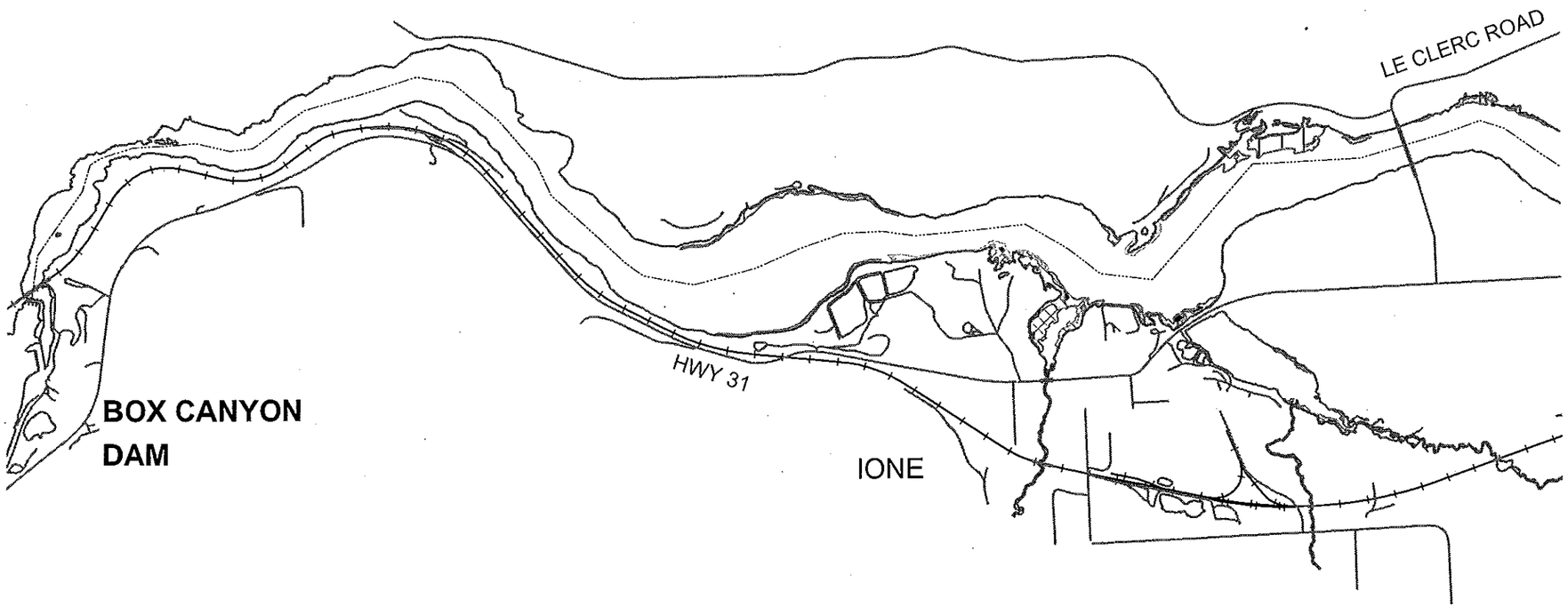
Rotovation effectiveness in the Pend Oreille River has been variable. While stem density of EWM and other aquatic macrophytes are effectively reduced by rotovation, recolonization rates vary widely. Carryover effectiveness has been observed, however in some cases density of re-established macrophytes exceeds pre-treatment densities. This highlights the fact that in evaluating the effects of rotovation, it is important to note the total aquatic macrophyte stem density in studies, not simply EWM stem density, as other species may invade at increased rates rotovation treatment.

APPENDIX C
A Literature Review of Control Methods for Management of Eurasian Watermilfoil

A Literature Review of Control Methods for Management of Eurasian Watermilfoil

November 1999

APPENDIX D
AQUATIC PLANT MAPS



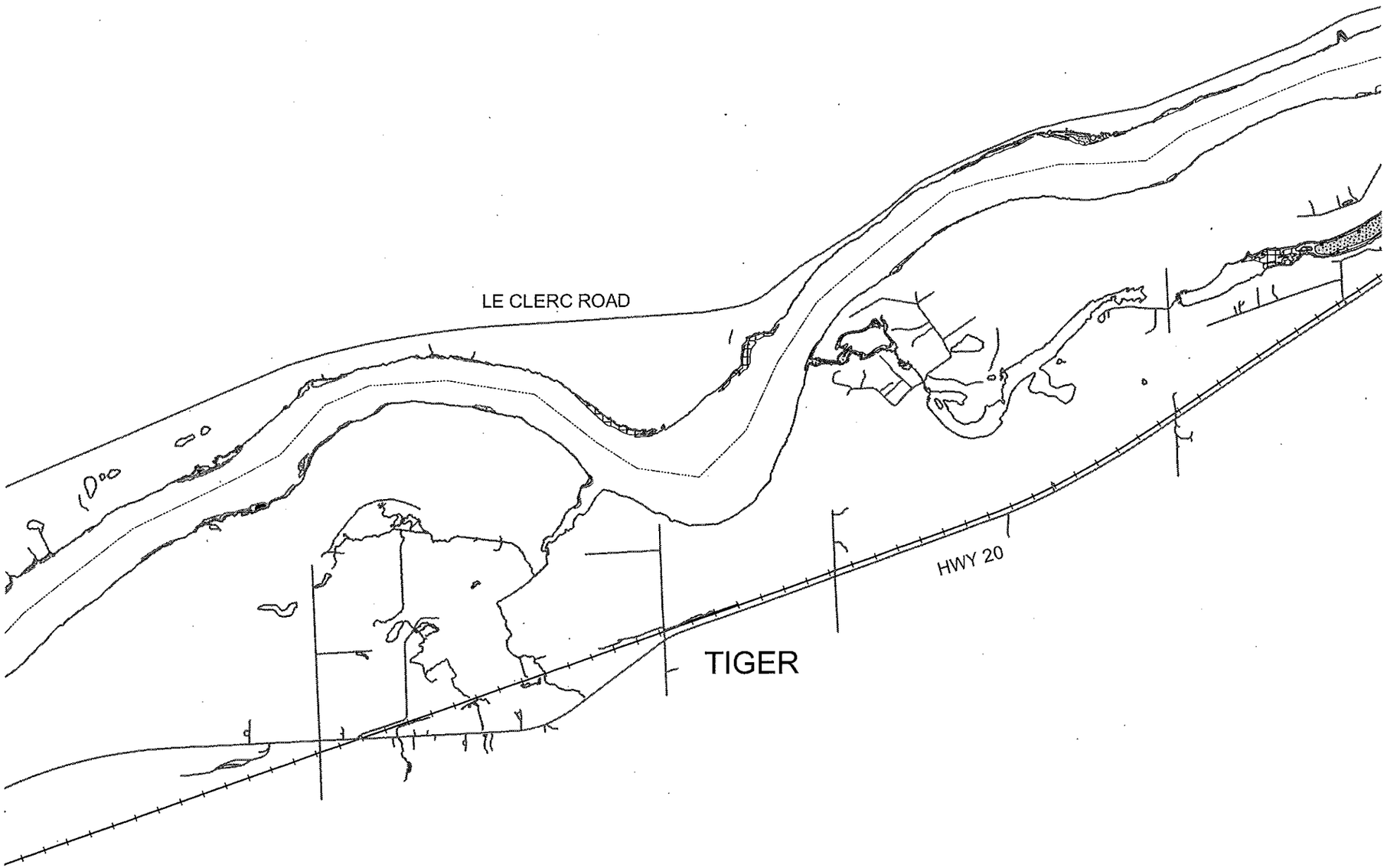
N

Legend

- 1D EWM>90%, dense
- 1M EWM>90%, moderate
- 1S EWM>90%, sparse
- 2D Mixed, EWM 50-89%, dense
- 2M Mixed, EWM 50-89%, moderate
- 2S Mixed, EWM 50-89%, sparse
- 3D Mixed, EWM 10-49%, dense
- 3M Mixed, EWM 10-49%, moderate
- 3S Mixed, EWM 10-49%, sparse
- 4D Native, EWM<10%, dense
- 4M Native, EWM<10%, moderate
- 4S Native, EWM<10%, sparse
- Island or Emergent Vegetation
- No Vegetation

Scale: 1" = 2000'

Aquatic Macrophytes Maps
1997
Box Canyon Hydroelectric Project
Sheet 1 of 11



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- 2D Mixed, EWM 50-89%, dense
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- 3D Mixed, EWM 10-49%, dense
- 3M Mixed, EWM 10-49%, moderate
- 3S Mixed, EWM 10-49%, sparse
- 4D Native, EWM<10%, dense
- 4M Native, EWM<10%, moderate
- 4S Native, EWM<10%, sparse
- Island or Emegent Vegetation
- No Vegetation

Scale: 1" = 2000'

Aquatic Macrophytes Maps
1997
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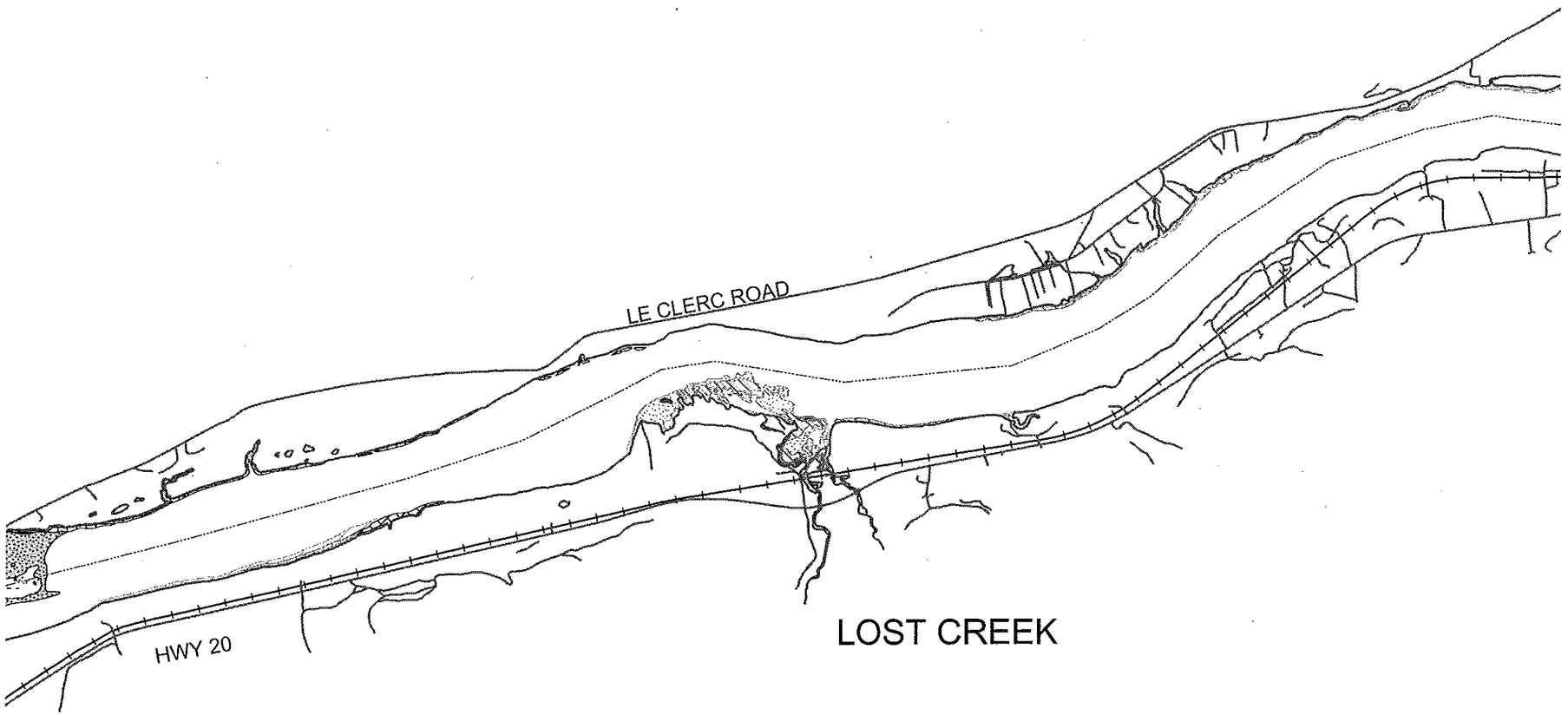

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- 3M Mixed, EWM 10-49%, moderate
- 3S Mixed, EWM 10-49%, sparse
- 4D Native, EWM<10%, dense
- 4M Native, EWM<10%, moderate
- 4S Native, EWM<10%, sparse
- Island or Emergent Vegetation
- No Vegetation

Scale: 1" = 2000'

Aquatic Macrophytes Maps
1997
Box Canyon Hydroelectric Project
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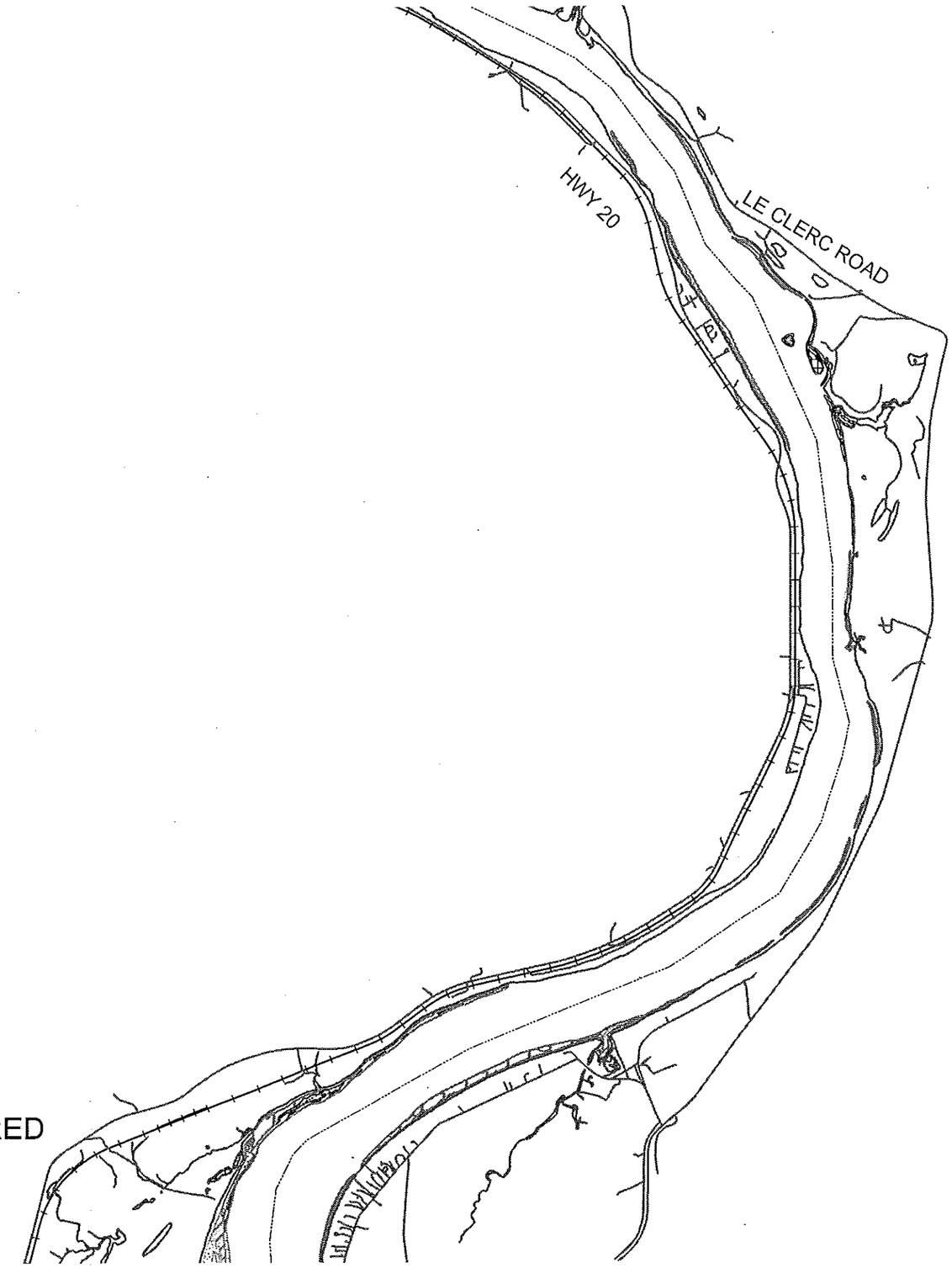

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- 3M Mixed, EWM 10-49%, moderate
- 3S Mixed, EWM 10-49%, sparse
- 4D Native, EWM<10%, dense
- 4M Native, EWM<10%, moderate
- 4S Native, EWM<10%, sparse
- Island or Emergent Vegetation
- No Vegetation

Scale: 1" = 2000'

Aquatic Macrophytes Maps
1997
Box Canyon Hydroelectric Project
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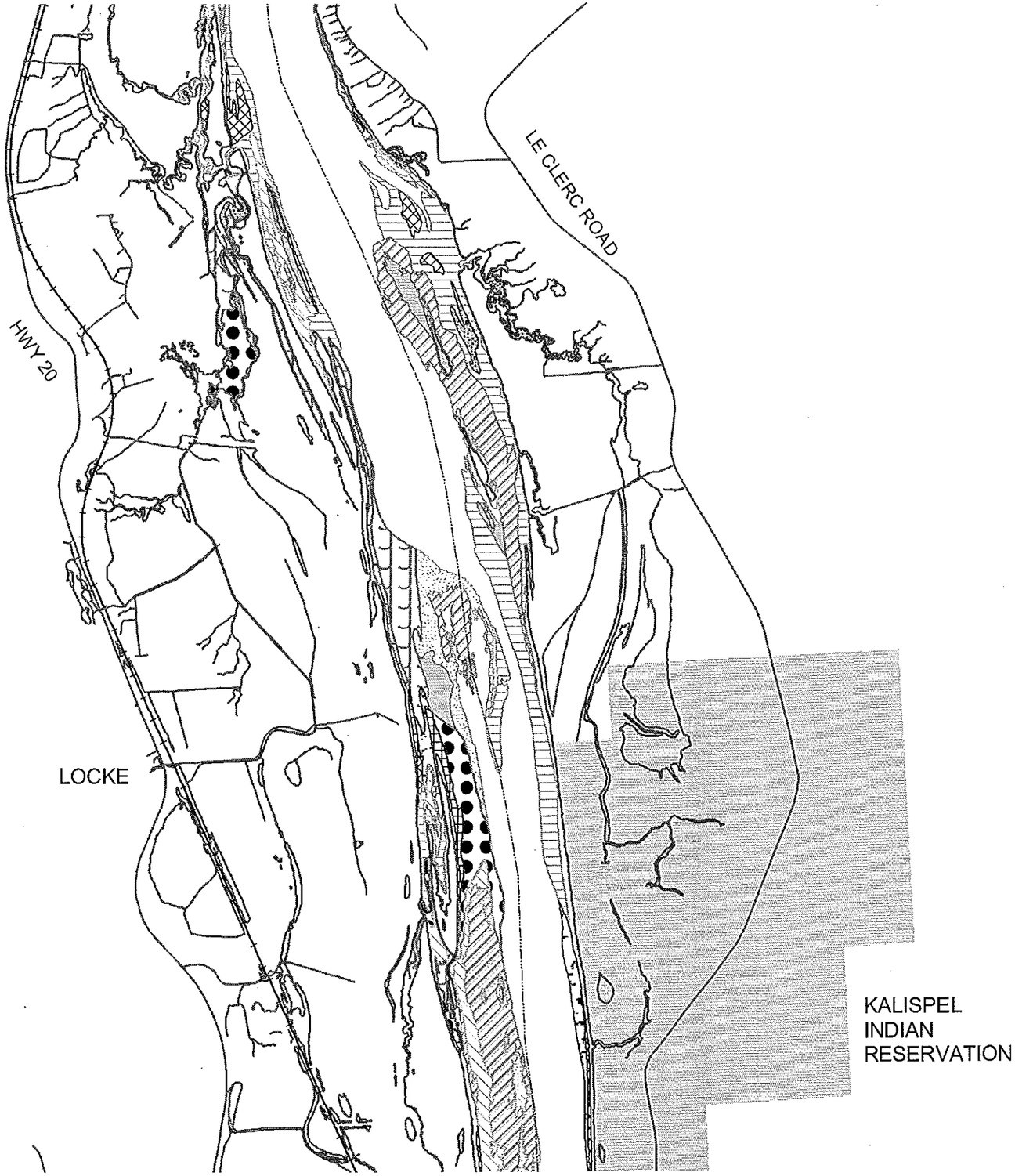

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- 3D Mixed, EWM 10-49%, dense
- 3M Mixed, EWM 10-49%, moderate
- 3S Mixed, EWM 10-49%, sparse
- 4D Native, EWM<10%, dense
- 4M Native, EWM<10%, moderate
- 4S Native, EWM<10%, sparse
- Island or Emergent Vegetation
- No Vegetation

Scale: 1" = 2000'

Aquatic Macrophytes Maps
1997
Box Canyon Hydroelectric Project
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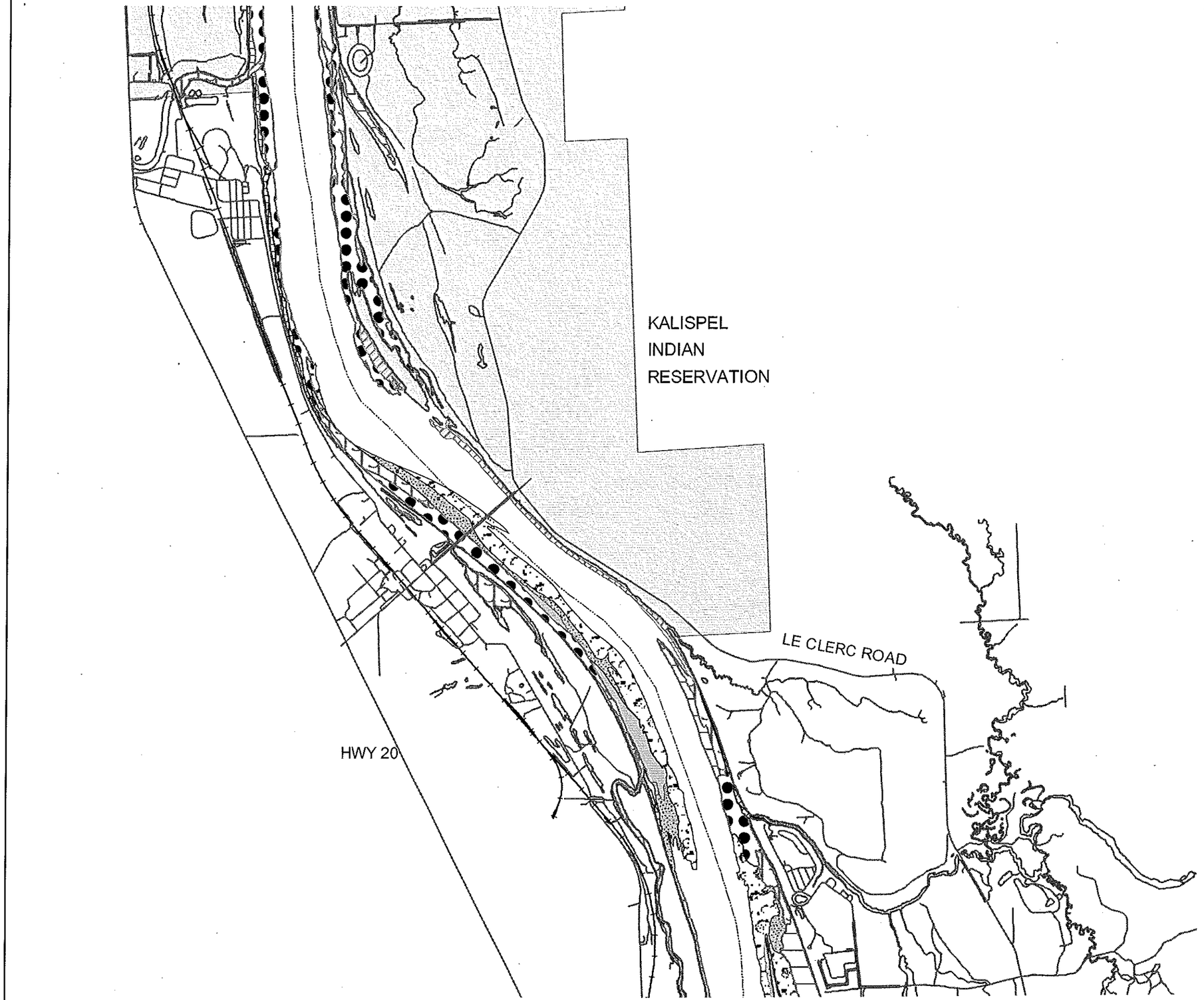

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- 3S Mixed, EWM 10-49%, sparse
- Text 4D Native, EWM<10%, dense
- 4M Native, EWM<10%, moderate
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- Island or Emergent Vegetation
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Scale: 1" = 2000'

Aquatic Macrophytes Maps
1997
Box Canyon Hydroelectric Project
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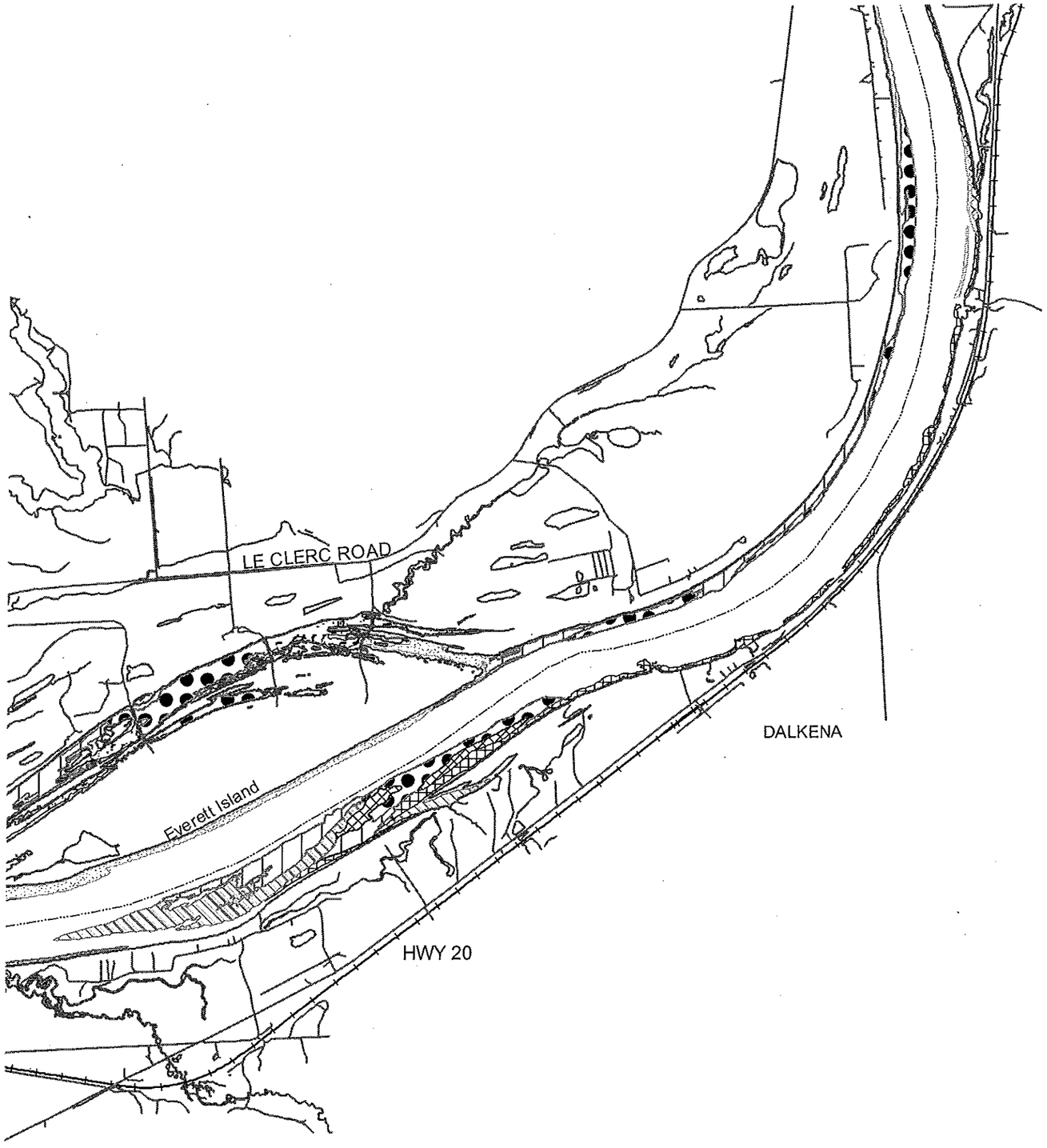

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- 3S Mixed, EWM 10-49%, sparse
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- 4M Native, EWM<10%, moderate
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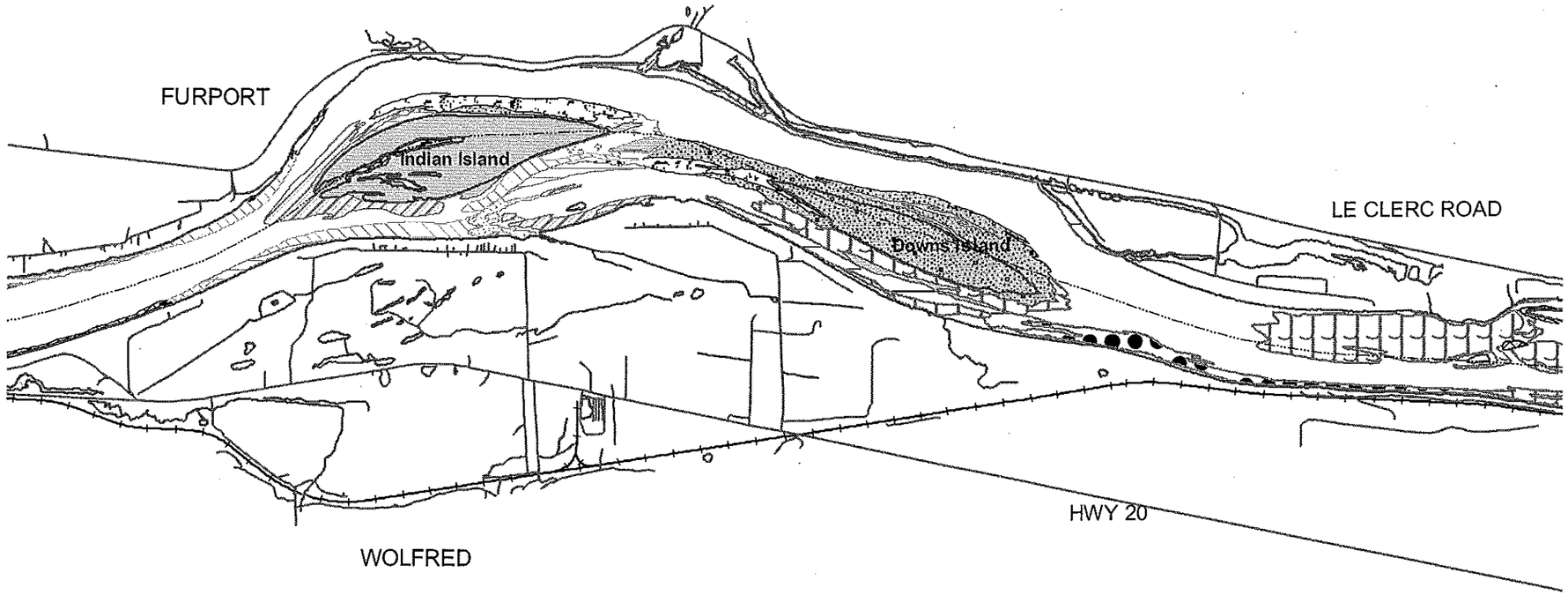
Scale: 1" = 2000'

Aquatic Macrophytes Maps
1997
Box Canyon Hydroelectric Project
Sheet 9 of 11



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- 3S Mixed, EWM 10-49%, sparse
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Aquatic Macrophytes Maps
1997
Box Canyon Hydroelectric Project
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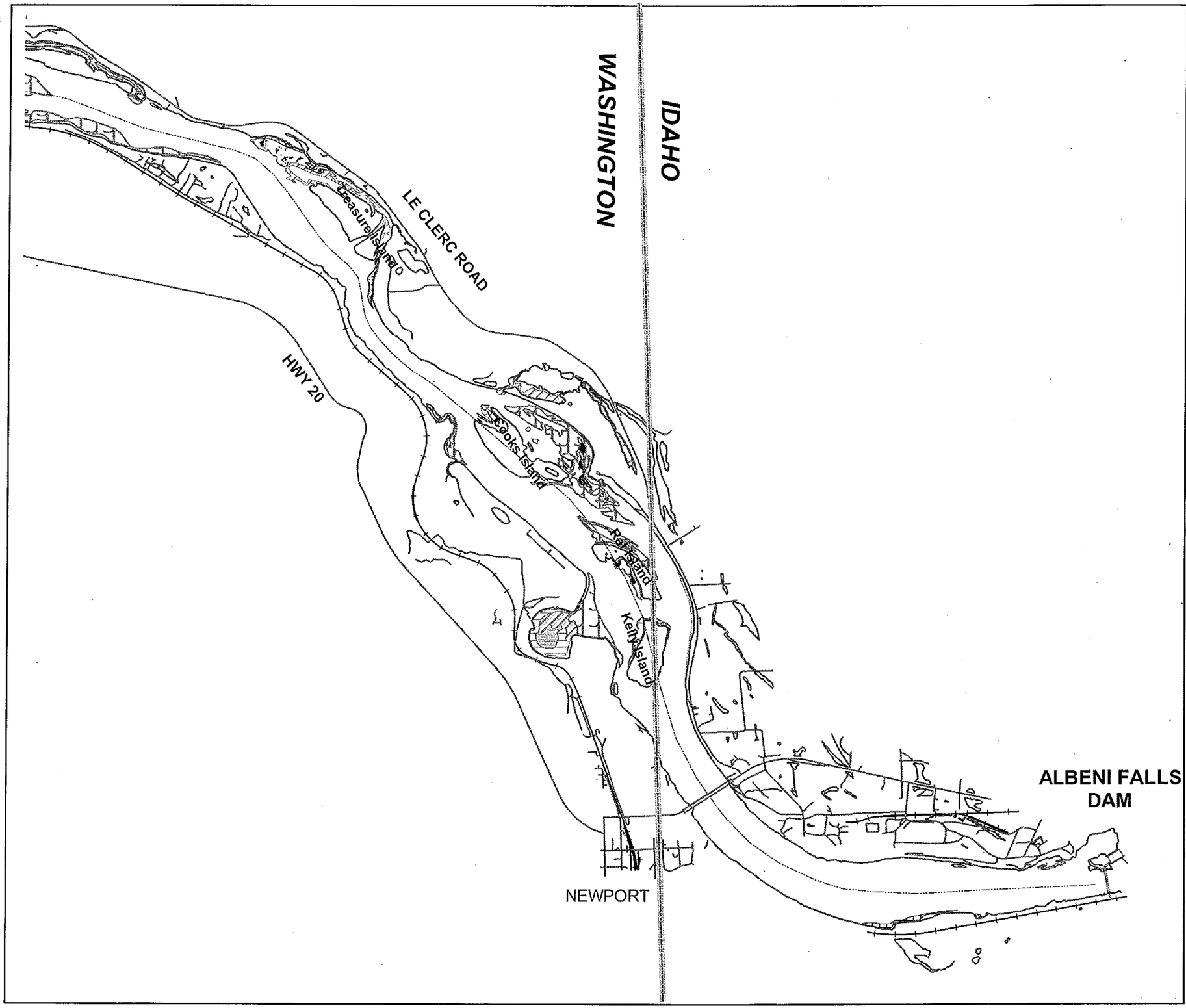

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