KEEP

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Federal Energy Regulatory Commission

Office of Hydropower Licensing

February 1991

FERC/EIS-0059D

DRAFT ENVIRONMENTAL IMPACT STATEMENT



- Present Chars. / Concept of
- Mutually exclusive (impact) chars.
- Historic & Preser - Type Conditions
- Need to develop variable
  Deff of ecosystem restoration
- Summary of pre Summit
  Proposal
- Issues re: preser) proposal
- Concepts in need of add'l study
  - Delta stasoli - after & pretrial dis release
    - annual
    - slow spike
  - Total dis release
  - Dove dam
- ~~Study~~ Needed tech. evaluat.
  - current sed transp. above dams
  - dis fate of Bed mat'l & ASSU on river impacts
  - marine fate of sed. & ASSU - impacts
  - Re-veg conditions/ potential issues

Glines Canyon (FERC No. 588) and Elwha (FERC No. 2683) Hydroelectric Projects, Washington

- Recommended action
  develop plan & process
  to evaluate & select
  tech. proposal. I.P. estab.
  sci. basis for EIS & decision

FEDERAL ENERGY REGULATORY COMMISSION

WASHINGTON, D C. 20426

TO THE PARTY ADDRESSED

Attached is the Draft Environmental Impact Statement (EIS) for the Glines Canyon (FERC No. 588) and Elwha (FERC No. 2683) Hydroelectric Projects, Washington.

The Draft EIS documents the views of the Commission's staff regarding hydroelectric development in the Elwha River Basin. Before the Commission makes a decision on licensing it will take into account all concerns relevant to the public interest. The final EIS will be part of the record from which the Commission will make its decision.

Agencies, organizations, or individuals receiving copies of this Draft EIS are invited to file comments pursuant to the requirements of the National Environmental Policy Act of 1969 and the Commission's Regulations Implementing the National Environmental Policy Act (18 CFR Part 380). Any comments, or conclusion, or recommendations that draw upon studies, reports or other working papers for substance should be supported by appropriate documentation.

Comments should be filed with Lois D. Cashell, Secretary, Federal Energy Regulatory Commission, 825 North Capitol Street NE, Washington, DC 20426. The comments should be filed within 60 days of the notice date in the Federal Register and should reference Project Nos. 588 and 2683. The Draft EIS was sent to the Environmental Protection Agency and made available to the public on or about February 22, 1991.

Attachment


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FEDERAL ENERGY REGULATORY COMMISSION
OFFICE OF HYDROPOWER LICENSING

DRAFT ENVIRONMENTAL IMPACT STATEMENT

PROPOSED ELWHA (FERC NO. 2683) AND GLINES CANYON (FERC NO. 588) HYDROELECTRIC PROJECTS, WASHINGTON

Applicant: James River II, Inc.

Additional copies of this DEIS are available from:

Division of Public Information
Federal Energy Regulatory Commission
825 North Capitol Street NE
Washington, D.C. 20426

February 1991

COVER SHEET

a. Title: The Elwha (FERC No. 2683) and Glines Canyon (FERC No. 588) Hydroelectric Projects on the mainstem of the Elwha River, Washington.

Application for the Federal Energy Regulatory Commission (FERC) licenses to operate and maintain hydropower projects on the mainstream of the Elwha River in the northwest portion of Washington State.

b. Draft Environmental Impact Statement

c. Lead Agency: Federal Energy Regulatory Commission

d. Abstract: James River II (the applicant) seeks a new license for the existing Glines Canyon Hydroelectric Project (13.1 MW) and an original license for the existing Elwha Hydroelectric Project (14.8 MW). Both projects are located on the Elwha River in northwestern Washington. The Glines Canyon Project is situated within the boundaries of Olympic National Park.

In conjunction with receipt of licenses, the applicant proposes facility modifications and operational changes to allow restoration of fish production in the Elwha River based upon natural self-sustaining anadromous populations. Additionally, the applicant proposes project automation improvements and measures related to terrestrial, recreational, and cultural resources.

e. Contact: Mr. S. Ronald McKitrick
Federal Energy Regulatory Commission
825 North Capitol Street NE
Washington, D.C. 20426
(202) 219-2783

f. Transmittal: This draft environmental impact statement prepared by the Commission's staff in connection with an application filed by James River II, Inc. for Project No. 2683 and Project No. 588 is being made available to the public on or about November 21, 1990, as required by the National Environmental Policy Act of 1969 and the Commission's Regulations Implementing the National Environmental Policy Act (18 CFR Part 380).

FOREWORD

The Federal Energy Regulatory Commission (Commission), pursuant to the Federal Power Act (FP Act)[1/] and the U.S. Department of Energy Organization Act[2/] is authorized to issue licenses for terms up to 50 years for the construction and operation of nonfederal hydroelectric developments subject to its jurisdiction, on the necessary conditions:

That the project adopted . . . shall be such as in the judgement of the Commission will be best adapted to a comprehensive plan for improving or developing a waterway or waterways for the use or benefit of interstate or foreign commerce, for the improvement and utilization of water power development, for the adequate protection, mitigation, and enhancement of fish and wildlife (including related spawning grounds and habitat), and for the other beneficial public uses, including irrigation, flood control, water supply, and recreational and other purposes referred to in section 4(e). . . .[3/]

The Commission may require such other conditions not inconsistent with the provisions of the FP Act as may be found necessary to provide for the various public interests to be served by the project.[4/] Compliance with such conditions during the license period is required. Section 385.206 (1987) of the Commission's Rules of Practice and Procedure allows any person objecting to a licensee's compliance or noncompliance with such conditions to file a complaint noting the basis for such objection for the Commission's consideration.[5/]

1/ 16 U.S.C. Sec. 791(a)-825(r), as amended by the Electric Consumers Protection Act of 1986, Public Law 99-495 (1986).

2/ Public Law 95-91, 91 Stat. 556 (1977).

3/ 16 U.S.C. Sec. 803(a).

4/ 16 U.S.C. Sec. 803(g).

5/ 18 CFR Sec. 385.206 (1987).

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GLOSSARY OF TECHNICAL TERMS

Chapter 1

ANADROMOUS FISH
Species, such as salmon, which hatch in freshwater, spend a large part of their lives in the ocean, and return to freshwater rivers and streams to reproduce.

BIOMASS
The total quantity of living organisms of one or more species in a community or per unit of space, often expressed as weight per unit of volume or area.

ECOSYSTEM
A community of living organisms interacting with one another and with their physical environment, such as a rain forest, pond, or estuary. Damage to any part of a complex ecosystem may affect the whole.

GENOTYPES
Genetically distinct organism groups.

GIGAWATTHOUR (GWh)
A quantity of electrical energy equal to 1 million kilowatthours. As a reference, the City of Port Angeles' electrical energy consumption was 686 GWh in 1989.

GREENHOUSE EFFECT
Warming of the earth's atmosphere attributed to an increase in carbon dioxide and other gases in the atmosphere.

MORPHOLOGY
The three-dimensional characteristics or form of a structure such as a river channel.

SPECIES
A group of individual plants or animals (including species, subspecies, and populations) that live in common habitat and interbreed.

TERRESTRIAL COMMUNITY
A land area, including all the organisms and nonliving components that function as a natural interacting system.

WATERSHED
The area drained by a river system.

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GLOSSARY OF TECHNICAL TERMS

Chapter 1

ANADROMOUS FISH
Species, such as salmon, which hatch in freshwater, spend a large part of their lives in the ocean, and return to freshwater rivers and streams to reproduce.

BIOMASS
The total quantity of living organisms of one or more species in a community or per unit of space, often expressed as weight per unit of volume or area.

ECOSYSTEM
A community of living organisms interacting with one another and with their physical environment, such as a rain forest, pond, or estuary. Damage to any part of a complex ecosystem may affect the whole.

GENOTYPES
Genetically distinct organism groups.

GIGAWATTHOUR (GWh)
A quantity of electrical energy equal to 1 million kilowatthours. As a reference, the City of Port Angeles' electrical energy consumption was 686 GWh in 1989.

GREENHOUSE EFFECT
Warming of the earth's atmosphere attributed to an increase in carbon dioxide and other gases in the atmosphere.

MORPHOLOGY
The three-dimensional characteristics or form of a structure such as a river channel.

SPECIES
A group of individual plants or animals (including species, subspecies, and populations) that live in common habitat and interbreed.

TERRESTRIAL COMMUNITY
A land area, including all the organisms and nonliving components that function as a natural interacting system.

WATERSHED
The area drained by a river system.

Chapter 2

BAR RACK
A series of narrowly spaced parallel metal bars across a water intake to prevent entry of debris and/or fish.

COGENERATION
Production of useful electrical energy as a by-product of another type of energy production, such as steam or hot air.

DENIL SECTION
A specific type of fish ladder containing baffles but no pools.

EICHER SCREEN
A fish screen designed to fit within a hydroelectric powerhouse intake penstock that diverts fish away from the turbine flow into a bypass pipe.

GEOTHERMAL
Energy derived from a natural subterranean heat or steam source.

HYDROPHYTIC
Characterizing plants which grow in association with water or in soil too saturated for most plants to survive, e.g., cattails.

HYDROSEEDING
A technique of seeding grass or other plants by broadcasting seeds and nutrients via a water delivery system to speed revegetation and reduce erosion.

OGEE
A spillway crest or other broad-crested weir having a reverse-curve or "roller-coaster" shape.

PENSTOCK
An intake pipe from a water source to a hydroelectric turbine or powerhouse.

RAMPING RATE
The rate at which water levels in a stream or reservoir either rise or fall.

SNAGS
Standing dead trees.

TAILRACE
The region of high velocity water flow below the turbine discharge in a hydroelectric facility.

VERTICAL SLOT FISH LADDER
A fish ladder that contains pools which have walls with narrow, vertical slots between them to allow fish to migrate upstream.

Chapter 3

ACCIPITER
Accipiters are short-winged, long-tailed, forest-dwelling birds of prey. There are three that occur in North America and the project area: Cooper's hawk, sharp-shinned hawk, and goshawk.

ALLUVIAL CHANNELS
Channels formed of clay, silt, sand, and gravel deposited by streams and rivers.

ALLUVIUM
The sediments transported and deposited by streams and rivers, i.e., clay, silt, sand, and gravel.

ARMORING
Progressive removal of finer sediments from a streambed leaving a layer of coarser sediment that is less easily moved.

BASALT
A dark, fine-grained rock produced by fluid lava flows.

BATHYMETRIC CHART
A diagram showing the underwater topography of a pond, lake, bay, or ocean.

BED LOAD
A mobile layer of sediment (sand, gravel, or heavy rock fragments) transported by waves and currents along the bed of a stream.

CREEL SURVEY
A survey of fishermen to determine the type of species and number of fish captured in a specific region (stream or lake) over a specified time (summer or year).

DETRITUS
Finely divided organic debris derived from decomposing plants and animals.

ESTUARY
The region near a river mouth where freshwater and salt water mix.

FORBS
Plants with soft stems that are not grasses.

FRY
An early swimming stage of young fishes.

GAFFED
A method of fish capture using a long-handled, sharp-pointed hook.

INVERTEBRATE
An animal lacking a spinal column including insects, shellfish, and zooplankton.

JUVENILE
Typically refers to any fish not yet an adult. The life stage of salmon and trout that live in fresh water before entering the ocean.

KETTLES
Large concentrations of birds of prey.

LACUSTRINE
Of, or originating within, permanently flooded lakes and reservoirs greater than 20 acres.

LOESS
A windblown silt deposit generally associated with glaciation.

METAMORPHIC ROCK
Rock formed from pre-existing rocks that have been subjected to high pressure or temperature.

OLIGOTROPHIC
A water body with a low nutrient content.

PALUSTRINE
Pertaining to nontidal wetlands dominated by trees, shrubs, persistent emergent vegetation, and emergent mosses or lichens, or nonvegetated wetlands less than 20 acres.

PARR
Young salmonids rearing in freshwater, usually in their first or second year of life prior to becoming outmigrating smolts.

PASSERINE
Songbirds

PAVEMENT
Surface layer of river channel materials consisting (in the case of the Elwha River) of coarse materials such as gravel and cobbles.

PETROGLYPHS
Writing and pictures etched or painted on stone by prehistoric peoples.

PHYLLITE
A relatively fine-grained metamorphic rock with thin layers.

PHYTOPLANKTON
Small to microscopic aquatic organisms which are suspended in water and able to photosynthesize.

RAIN SHADOW
An area downwind of a mountain that has less rainfall than the area on the upwind side of the mountain.

RANNEY COLLECTOR
A method of collecting groundwater in buried perforated pipes, often placed under rivers.

RAPTORS
Birds of prey. Red-tailed hawks and bald eagles are examples of raptors.

REDD
A fish spawning nest in river or stream gravel.

RIFFLE
Shallow, broken water created by an area of sediment deposition in a river channel.

RIPARIAN
Vegetation adapted to moist growing conditions found along waterways and shorelines. Generally adapted to occasional flooding.

RIVERINE
Wetlands and deepwater habitats within a channel that are not dominated by trees, shrubs, persistent emergent vegetation, emergent mosses, or lichens.

SEDIMENTARY ROCKS
Rocks formed by the accumulation of sediment in water or from air.

SERAL STAGES
The stages that follow one another in an ecologic succession.

SINUOSITY
The length of a river channel divided by the length of the reach.

SMOLT
The juvenile life stage of salmon or steelhead trout migrating to the ocean and undergoing physiological changes from a freshwater existence to a saltwater existence.

STANDS
Plant communities, particularly of trees, sufficiently uniform in composition, constitution, age, spatial arrangement, or condition to be distinguishable from adjacent communities.

SUB-PAVEMENT
Layer of river channel materials beneath the surface, or pavement, layer. In the case of the Elwha River, the sub-pavement consists of sand, gravel, and cobbles.

SUCCESSION
The changes in vegetation and in animal life that take place as the plant community evolves from bare ground to climax.

SYMPATRIC
Species which arose or occur together in the same geographical area, but do not rely on each other.

TALUS
The accumulation of broken rocks that occurs at the base of cliffs or other steep slopes.

TILL
Unstratified glacial drift composed of clay, sand, rocks, and gravel.

Chapter 4

AGGRADATION
The build-up of sediment by natural deposition.

BENTHIC
Relating to the bottom of a body of water (lake, river, estuary, ocean). For example, benthic invertebrates inhabit the bottom of a river or sea.

CHAR
A group of fish closely related to salmon and trout.

COLIFORM

A type of bacteria that is coil or helix shaped. Fecal coliform bacteria are found in the intestinal tracts of mammals. The presence of high numbers of fecal coliform bacteria in a water body can indicate the recent release of untreated wastewater and/or the presence of animal feces.

DECIDUOUS

Plants that drop their leaves in autumn.

EPHEMERAL STREAM

A stream which occasionally goes dry.

HALOGENATED HYDROCARBONS

Organic compounds which include at least one atom of an element of the halogen series (chlorine, bromine, fluorine, iodine) per molecule. Examples are the refrigerant freon and the cleaning fluid trichloroethylene.

HERBACEOUS

Plants that have soft stems rather than woody.

HYDROGRAPH

A graph of water flow rate over a period of time (e.g., a day, month, year).

HYPOLIMNETIC

Having to do with the deeper waters of a lake or reservoir.

INTERSTICES

The spaces between grains of solid material in a sediment deposit. They may be filled with gas or fluid.

LEVEE

A dike or embankment which protects land from floods.

OXBOW

A curved stretch of a meandering river that has eroded back on itself and then been cut off from the main river flow to form a lake.

PERIPHYTON

Microscopic plants (algae) attached to rocks that live on the bottom of lakes or streams.

PLANKTON

Small plants (phytoplankton) and animals (zooplankton) that are suspended in the water and either drift with the currents or swim weakly.

RAVEL
The progressive disintegration of an exposed slope caused by the grain-by-grain collapse of sediment.

RESIDUALISM
Typically used to refer to salmon or trout juveniles that choose to remain in fresh water instead of migrating to the ocean.

SALMONID
Fish within the family Salmonidae, e.g., salmon and trout.

TRIHALOMETHANE
A chemical carcinogen formed as a byproduct of water supply chlorination.

TSUNAMIS
Large and extremely destructive sea waves produced by earthquakes. The waves can be as high as 50 feet.

TURBIDITY
Visible undissolved solid material suspended in water. Increasing the turbidity of the water decreases amount of light that penetrates the water column. High levels of turbidity are harmful to aquatic life.

WEIR
A man-made blockage across a stream allowing water to pass over.

Appendix A

ADIT
A horizontal shaft or tunnel through rock or concrete.

BIFURCATION
A separation of a single conduit into two branches.

COFFERDAM
A temporary dam allowing dewatering of a portion of a lake or stream for construction activities.

EXECUTIVE SUMMARY

This Draft Environmental Impact Statement (DEIS) evaluates the potential natural resource benefits, the economic costs and the project specific and cumulative environmental impacts associated with relicensing the Glines Canyon Hydroelectric Project and initial licensing of the Elwha Hydroelectric Project in the northwest portion of Washington State. The Federal Energy Regulatory Commission (Commission) is considering a license application submitted by James River II, Inc. proposing initial licensing of the Elwha Project and relicensing of the Glines Canyon Project.

The staff has formulated alternatives and made a comparative evaluation of impacts to respond to concerns raised during the scoping process. The alternatives addressed in this draft EIS include retention of both dams, removal of both dams, removal of only Elwha dam, and removal of only Glines Canyon dam. The DEIS does not consider a no action alternative. Alternatives involving dam retention involve the installation of new facilities and the modification of project operations to encourage fish passage past the dams. Currently, there are no such provisions, and anadromous fish are blocked from accessing the Elwha River above the projects. With the alternatives involving dam removal, the principal issue is reducing uncertainties about the behavior of the large quantities of sediment stored in the two project reservoirs.

Evaluation of these alternatives has been made relative to three primary resource objectives developed on the basis of comment received during the scoping process. These objectives are: 1) the restoration of wild, self-sustaining runs of anadromous fish; 2) restoration of natural conditions within Olympic National Park; and 3) provision of renewable hydroelectric energy. These objectives incorporate the major developmental and nondevelopmental values associated with these licensing or relicensing actions. This DEIS discloses the findings of the Commission staff regarding the performance of the alternatives in relation to these objectives, and it also describes other environmental effects. The DEIS stops short of identifying a preferred alternative. The Final Environmental Impact Statement (FEIS), which will be produced following comment on this draft document, will incorporate the staff's recommended alternative and basis for that recommendation.

The area affected by these licensing and relicensing actions includes the Elwha River Basin on Washington's Olympic Peninsula and the near-shore coastal areas extending east of the Elwha delta to Ediz Hook near the city of Port Angeles, Washington. The upper portions of the Elwha River Basin are contained within Olympic National Park and represent some of the most outstanding scenic and ecological resources in the United States. Olympic National Park has been designated a world biosphere reserve and a World Heritage Park by UNESCO. Within the park boundaries, and upstream of the Glines Canyon Project's

reservoir, Lake Mills, the instream and riparian values of the Elwha River are in completely pristine condition; water quality, fish habitat, riparian habitat and scenic and aesthetic values are now as they were when the first European settlers arrived. The Elwha drainage areas outside of Olympic National Park are relatively undeveloped but effects of road-building, logging, mineral extraction and human settlement are evident. Within the lower portions of the drainage, the Lower Elwha Klallam Tribe reservation is maintained. The Strait of Juan de Fuca shoreline and Ediz Hook are moderately developed shoreline areas.

The primary environmental attribute of the Elwha River drainage system is its historic runs of anadromous fish (salmon and steelhead). Prior to the construction of Elwha dam in 1911, the Elwha harbored runs of chinook salmon, some of which were said to attain weights of up to 100 lbs. The Elwha supported runs of coho, pink, chum and possibly sockeye salmon, which ranked it among Washington's most productive salmon rivers. Steelhead and cutthroat trout and Dolly Varden char also ascended the river. These anadromous fish runs provided biomass for consumption by birds and mammals throughout the basin which depended upon their carcasses. The Elwha River currently has relatively large runs of chinook and coho salmon which are heavily supported by fish hatcheries operated by Washington State and the Lower Elwha Klallam Tribe. Currently, all anadromous fish use is limited to the lower 4.9 river miles, downstream of Elwha dam.

(1) The applicant's proposal (or dam retention alternative) involves the Elwha and Glines Canyon dams and the installation of both upstream and downstream fish passage facilities and other mitigative measures. These fish passage measures include 1) upstream passage facilities, specifically a fish ladder at Elwha dam and a trap-and-haul facility at Glines Canyon dam; 2) downstream passage measures including provision for spill (100 cfs) at Glines Canyon dam during outmigration periods, installation of Eicher screens at the Elwha dam penstocks, and spillway improvements.

The applicant's proposal would result in an increased restoration potential for chinook and coho salmon and steelhead trout. Of these, only steelhead trout (winter run) would have excellent restoration potential in the face of continued passage mortality, harvest pressures, and habitat conditions in the river reaches made available by the fish passage measures. Pink and chum salmon would not be restored in upriver reaches under this alternative because of the inability of young salmon of these species to pass downstream through the project reservoirs. Similarly, anadromous trouts (cutthroat and Dolly Varden) would also be afforded poor prospects for restoration under the applicant's proposal, principally because of passage mortality. Under this dam retention alternative, the reservoirs would continue to store sediment and woody debris from upstream reaches with the

resulting continuation in the armoring and debris depletion which now characterizes the middle and lower river reaches. These conditions result in poor fishery habitat which limits the restoration potential forecasted for this alternative.

Relative to the second objective, restoration of natural conditions in Olympic National Park, the applicant's proposal would only partially restore original conditions in the park. Although at least three anadromous fish species would be restored to the reaches above Lake Mills, their numbers would be reduced by passage mortality. Also, the retention of Glines Canyon dam and Lake Mills would preclude reestablishment of natural conditions in the reservoir and dam area.

Staff-recommended mitigative measures added to the measures already proposed by the applicant would only slightly improve potentials for restoring anadromous fish and restoring natural conditions within Olympic National Park. The staff considered measures directed toward increasing certainty of fish passage survival past the dams in both an upstream and downstream direction. With the addition of staff-recommended measures, the uncertainty associated with the prediction of restoration would be reduced, but the outlook for restoration would not be appreciably improved.

Relative to the third resource objective, provision of renewable hydroelectric energy, the applicant's proposal would provide about 168 GWh of electrical energy, an amount equivalent to about 20 percent of the total electrical energy requirements of the Port Angeles area and about 2 percent less than the current average output of the projects. Capital cost of the applicant's proposal would be about $14.7 million, comprised primarily of costs for fish ladders, trap-and-haul facilities, fish screens, and ancillary features such as road improvements.

Although anadromous fish numbers, particularly for chinook, coho and winter steelhead, could be increased under this alternative, the socioeconomic benefits to commercial fisheries would not necessarily increase because harvest rates on the restored fish populations would be reduced to ensure restoration. Similarly, the value of increased fisheries to the Lower Elwha Klallam tribal fisheries would be minimal, again because of the necessary harvest restrictions. Impacts to recreational activities would be minor, related mostly to construction activities when access to the dam areas would be reduced, and to stream fishing for salmon and steelhead which would likely be reduced during the early period of reestablishment of upstream runs.

(2) The second principal alternative would involve removal of both Elwha and Glines Canyon dams over a period of about 5 years with an additional 2 to 5 years identified for complete sediment stabilization. Under the staff's dam removal scheme, much of the stored sediment would remain in the reservoir and be stabilized after an initial period of downstream transport of sand and finer

sediments. This approach would preclude having to dredge the sediments and dispose of them elsewhere at substantial cost.

Relative to the first resource objective, restoration of anadromous fish runs, this alternative would provide favorable potentials for restoring all anadromous fish species historically present within the basin. In addition to chinook, coho and steelhead trout, which could be restored to certain levels under the applicant's proposal, this alternative would provide restoration potential for pink and chum salmon and anadromous trouts (cutthroat and Dolly Varden). Although all species could be restored with some certainty, only fall chinook and winter steelhead trout are judged to have an excellent potential for restoration.

The dam removal alternative would cause relatively severe impacts to aquatic resources during the construction period and for 2 to 5 years thereafter, because of large quantities of suspended and bed load sediment which would pass through the river system. Anadromous fish restoration measures would not commence during the five-year construction period because of these largely unavoidable sediment impacts.

During the 5-year construction period and for 6 to 10 years thereafter, the Elwha River would be relatively unstable compared to its current condition. Channel morphology and substrate composition would change dramatically, particularly in the middle and lower reaches where the currently large substrate, armored conditions would be replaced by more even distributions of sand, gravel, cobble and boulders. More side-channel habitat would arise, and the increased river meandering would contribute woody debris to the river by undercutting bankside trees and shrubs. Over the long term, the proposed dam removal process would be expected to restore the river to original habitat conditions approximately 10 to 20 years after the end of construction.

In terms of the second major resource objective, establishment of natural conditions in Olympic National Park, the dam removal alternative would be successful in restoring near-natural conditions after a period of 10 to 20 years. This alternative would provide near complete restoration for the 715 acres currently inundated by the Glines Canyon Project facilities and Lake Mills, and it would provide the potential for restoring anadromous biomass within the park boundaries.

The major impact of dam removal would relate to operation at the Daishowa America Mill in Port Angeles. The two hydroelectric projects currently provide nearly 40 percent of the mill's total electrical energy requirements at a cost below the cost of purchasing power from other sources, thus providing a competitive advantage to the mill. Loss of this cost advantage would have negative impacts on mill economics.

The dam retention alternatives, however, also involve costs (for fish passage improvements) which would essentially eliminate any future energy cost advantages over purchasing power from other sources. Commercial, tribal and sport fisheries would benefit more under the dam removal alternative than under the applicant's proposal, primarily because of lower mortality and higher expected harvest rates. Recreational opportunities would increase, particularly for the steelhead and salmon fishery, both in the river and in the Strait of Juan de Fuca.

The capital cost of removing both dams (not including value of lost power) would be approximately $64.3 million. The project's average annual generation of about 172 GWh would be entirely foregone.

Two other alternatives, removal of Glines Canyon dam only and removal of Elwha dam only were also evaluated. These alternatives were of interest because of their potential for providing electrical energy and some environmental benefit. In both cases, the dam removal would be performed as described under the dam removal alternative and the remaining dam would be modified in keeping with the applicant's proposal.

When the Glines Canyon removal alternative was evaluated against the first resource objective, restoration of anadromous fish runs, it provided excellent restoration potential for fall chinook salmon and winter steelhead trout, and good restoration outlook for spring chinook and coho salmon, and summer steelhead. Because of the continued existence of Elwha dam, restoration potential for pink and chum salmon was poor because of downstream passage restrictions. In terms of restoration of natural conditions in Olympic National Park, this alternative was better than the applicant's proposal because of increased chances for restoration of certain salmon species and the removal of Glines Canyon dam. In terms of hydroelectric generation, this alternative would retain the generating capacity of the Elwha Project (68 GWh annually), which is about 40 percent of the projects' current total combined output. Initial capital costs for removing Glines Canyon dam and providing Elwha Project modifications would be $49.1 million.

The final alternative, removal of Elwha dam and modification of Glines Canyon to add dam fish passage features, provided some restoration potential for all species of salmon and anadromous trout. Without the downstream passage impediment provided by Elwha dam, pink and chum salmon would have fair restoration potentials, limited primarily by lack of suitable spawning habitat in the river's middle reach. Chinook and coho salmon would have good restoration potential while winter steelhead, as for all alternatives except the applicant's proposal, would have excellent restoration potential. Among the four alternatives evaluated, Elwha removal ranked second to the dam removal alternative in terms of fish restoration potential. Relative to the objective of restoring the natural ecosystem of Olympia National Park, this alternative was only slightly better than the applicant's proposal because of the retention of Glines Canyon dam and Lake

Mills, and the slightly improved restoration potential for upriver stocks. In terms of hydroelectric generation, the Elwha removal alternative would provide an average annual generation of 100 GWh at an initial capital cost of $30.4 million.

It is clear from the economic and environmental analyses that the three primary objectives are mutually exclusive. For those alternatives providing good restoration potential for both anadromous fish and ecosystem conditions within Olympia National Park, capital costs and energy losses would be severe. For the applicant's proposal, which retains the cost effective utilization of the Elwha River's hydroelectric potential at a substantially lower initial capital cost than all other alternatives, the potentials for restoration of all anadromous species and conditions within the park are significantly worse.

In providing this DEIS without final recommendations for licensing or relicensing, the staff awaits comment on the preliminary findings contained in this DEIS. During the public comment period, the staff invites all relevant information on the technical analyses presented herein.

1.0 PURPOSE AND NEED FOR ACTION

1.1 PURPOSE OF THE ACTION

The Federal Energy Regulatory Commission (Commission) is considering whether to issue or deny licenses for the continued operation of the Elwha and Glines Canyon hydroelectric projects. The need for action is precipitated by James River II, Inc. filing applications for a new license for the Glines Canyon Project (FERC No. 588) and an original license for the constructed but unlicensed Elwha Project (FERC No. 2683). Both projects are located on the Elwha River in the northwest portion of Washington State. The projects are jointly operated and are hydraulically and electrically coordinated. Power from both projects is delivered to a pulp and paper manufacturing plant located in the nearby city of Port Angeles.

1.2 HISTORY OF THE PROCEEDINGS AND JURISDICTION

The Glines Canyon Project was constructed pursuant to a license issued by the Federal Power Commission (FPC) in 1926, under the Federal Water Power Act of 1920 (now the Federal Power Act). The original Glines Canyon Project license expired June 3, 1976; since then, the project has been operating under annual licenses.

The Elwha Project was constructed prior to the Federal Water Power Act, and is not licensed. The Elwha Project has been determined, on the basis of a navigability finding, to be under the Commission's licensing jurisdiction. Applications for license are pending for both projects.

1.2.1 Glines Canyon Project

1.2.1.1 History

On March 23, 1926, the Northwestern Power and Light Company applied for a license for the Glines Canyon Project. A license was issued to the company by the FPC on June 4, 1926, with a 50-year term. The major project works (dam, penstock and powerhouse) and the lowermost portion of the reservoir (about 40 acres) were developed on land owned by the licensee, with the remainder of the project located on United States lands of the Olympic National Forest. At the time of original licensing, FPC jurisdiction was based on the project's use and occupancy of national forest lands.

An FPC order of May 8, 1934 approved a transfer of the license from Northwestern Power and Light Company to Washington Pulp and Paper Corporation, and a subsequent order of February 24, 1937 approved a transfer from the latter corporation to Crown Zellerbach Corporation. Both Northwestern Power and Light and Washington Pulp and Paper were subsidiaries of Crown Zellerbach.

In 1938, Congress established the Olympic National Park (ONP), but by that legislation the federal lands occupied by the Glines Canyon Project were not included in the park and thus remained national forest lands. By Presidential Proclamation of January 2, 1940, however, President Roosevelt added certain national forest lands to the park, and included among those lands was the area where the Glines Canyon Project is principally located. Thus, today the principal project facilities and the lower portion of the reservoir are located on privately owned lands, while much of the reservoir and part of the project's transmission line are on federally owned lands within ONP and another short segment of the transmission line is within Olympic National Forest.

On June 1, 1973, Crown Zellerbach filed an application for a new license for the Glines Canyon Project, and the Commission, after requesting and receiving additional information from the licensee, issued a notice of the application for new license on May 23, 1978. On December 1, 1987, Crown Zellerbach filed a notice of change of the corporation's name to James River Corporation of Nevada, and on April 13, 1988, the Commission approved a transfer of the license from James River Corporation of Nevada to James River II, Inc. Both James River Corporation of Nevada and James River II, Inc. are wholly owned subsidiaries of James River Corporation of Virginia.

1.2.1.2 Licensing Jurisdiction

Research and analysis conducted by the Commission staff do not provide a definitive answer to the question of the Commission's authority to relicense the Glines Canyon Project. The uncertainty arises from the location of the project within the boundaries of a national park.

In 1921, Congress amended the Federal Water Power Act to remove national parks and monuments from the Commission's jurisdiction, as they were constituted as of March 3, 1921, and to retain in Congress the jurisdiction to authorize the construction of dams in those parks and monuments. In 1935, the Federal Water Power Act was further amended to establish that the Commission could not issue a license for a new project on any national park lands. Not expressly addressed in the statute, however, was whether the Commission's lack of authority to issue licenses for new projects on national park lands applied also to relicensing existing projects.

In a filing made on January 27, 1986, the Lower Elwha Klallam Tribe asserted, among other things, a lack of Commission jurisdiction over the Glines Canyon Project. The Department of the Interior, in a letter dated February 13, 1986 and in subsequent filings, also asserted a lack of Commission jurisdiction. The Department of the Interior stated that only Congress can specifically authorize the continued operation of the Glines Canyon Project. Other subsequent pleadings have also addressed the Commission's relicensing jurisdiction, and the General Accounting Office has agreed with the Department of the Interior that Congress must specifically provide relicensing authority.

On March 25, 1988, intervenors Olympic Park Associates, Seattle Audubon Society, Friends of the Earth, and the Sierra Club petitioned the Commission to declare that it does not have jurisdiction to issue a new license for the Glines Canyon Project. In an order dated October 19, 1990, the Commission ruled that it has authority to issue a new license for the project. The Commission noted that, in the absence of a clear Congressional directive, the Commission's retention of regulatory authority over the entire project will provide a centralized forum for considering the future of the entire unit of development in question (both the federal and nonfederal portions of Glines Canyon as well as the downstream private Elwha Project). The record developed before the Commission can form the basis for a comprehensive Commission decision on the projects and can inform any action regarding the project that the Congress may choose to take.

1.2.2 Elwha Project

1.2.2.1 History

Between 1911 and 1913, prior to the passage of the Federal Water Power Act, the Elwha Project was developed by Olympic Power Company. Apparently, due to an inadequate water cutoff between the dam and the river bed, the dam soon failed, and Olympic Power Company went into receivership. Its assets were acquired in 1916 by Northwestern Power and Manufacturing Corporation, which later added to the generating capacity of the project. That corporation became Northwestern Edison Company, which in turn, in 1924, became Northwestern Power and Light Company, the developer of the Glines Canyon Project and a subsidiary of Crown Zellerbach Corporation.

On July 22, 1968, Crown Zellerbach filed an application for original license for the Elwha Project. At the direction of FPC staff, the applicant filed additional project details and resource information in 1968, 1969, and 1976. On January 16, 1976, FPC issued a public notice of the application for an original license for the Elwha Project. In an order issued on March 16, 1979, the Commission required the filing of an updated, self-contained application for license. The updated license application for the Elwha Project was filed by Crown Zellerbach on May 23, 1979. On November 30, 1987, Crown Zellerbach filed notice of a name change, and on March 17, 1988, James River Corporation of Nevada filed to be replaced as applicant by James River II, Inc. Approval of the change was granted by the Commission on April 13, 1988.

1.2.2.2 Licensing Jurisdiction

Subsequent to the FPC's public notice of the Elwha Project license application, the applicant, Crown Zellerbach, filed a request for a declaratory order that the FPC was without jurisdiction to license the project. The issue of licensing jurisdiction was tried before an administrative law judge who issued an initial decision on December 11, 1978. The judge's finding stated that the Elwha River, from a point above the Elwha dam to its mouth at the Strait of Juan de Fuca, is navigable

within the meaning of the FPA. Accordingly, the Elwha Project was determined to be under the licensing jurisdiction of the Commission. On March 16, 1979, the Commission issued an order affirming the finding of jurisdiction, and additionally, finding the Elwha and Glines Canyon projects to be hydraulically, electrically, and operationally interconnected. From this point on in the proceedings, the Commission staff processed the license applications for the two projects together.

1.3 SCOPE OF THE ENVIRONMENTAL IMPACT STATEMENT

Upon review of the applications and submissions by intervenors, the Commission staff determined that the issuance of licenses for the Glines Canyon and Elwha projects would constitute a major federal action that could significantly affect the quality of the human environment. Accordingly, the Commission issued a notice on August 17, 1989, indicating its intent to prepare an EIS evaluating the probable project-specific and cumulative impacts of the applicant's proposal for the two projects and of alternative courses of action.

To determine the issues to be addressed in the EIS, the staff initiated a formal scoping process in December 1989. The staff contacted intervenors, state and federal agencies, Native American organizations and members of the public who were potential sources of information that could be used in the EIS; held three public scoping meetings in Washington State to identify issues and solicit comment; and reviewed public, tribal and agency comments relating to the EIS scope.

Based on the results of the scoping process, the staff distributed a document entitled, "Scoping Document 2," which identified the principal developmental and nondevelopmental objectives for the Elwha River and described the issues to be addressed in the EIS. The principal issues included potential effects on: (1) fish resources; (2) Native Americans and their culture; (3) channel morphology and flooding; (4) water quality; (5) wildlife and botanical resources; and (6) regional power supplies. Additional issues included potential socioeconomic, land use, recreational and aesthetic impacts, consistency with comprehensive plans, and issues associated with implementing the various alternatives.

The scoping process also identified dam retention and dam removal as the two principal alternatives to be considered in the EIS. It established that there was no reasonable "no action" alternative, since all parties to the proceeding were dedicated to modification of the existing projects for restoring anadromous fish to the upper Elwha River watershed.

1.4 RESOURCE OBJECTIVES

In considering the issuance of a license, the Commission accounts for multiple aspects of the public interest: (1) potential benefits to interstate or foreign commerce; (2) utilization of the site's hydroelectric potential; (3) adequate protection, mitigation, and enhancement of fish and wildlife (including their

spawning grounds and habitat); and (4) other beneficial public uses, including energy conservation, irrigation, flood control, water supply, recreational opportunities, and other aspects of environmental quality. In weighing the relative importance of these various factors, the Commission is required by law to give equal consideration to both developmental and nondevelopmental values.

The Commission staff has concluded, based on public, agency, and intervenor comment during EIS scoping, that there are three principal resource objectives relevant to the licensing of the Glines Canyon and Elwha projects: (1) restoration of anadromous fish production throughout the Elwha River Basin; (2) restoration of natural environmental conditions within ONP; and (3) provision of renewable hydroelectric energy. These objectives, while each desirable in its own right, may not be fully achievable. Further, greater achievement of one objective may result in less achievement of another. Accordingly, tradeoffs must be made in the course of achieving an appropriate balance.

Each of these resource objectives is discussed further in the subsections that follow.

1.4.1 Anadromous Fish Restoration

The restoration of wild, self-sustaining runs of anadromous fish is a principal resource objective, because the Elwha River watershed provides unique opportunities for such restoration and because restoration of anadromous stocks is a regional priority.

Considerable potential exists for improving anadromous fish production throughout the Elwha River Basin. Historically, the Elwha River was a major wild salmon and trout producing stream. As late as 1930, chinook salmon returning to the river were very abundant and some exceeded 100 pounds (Section 3.4). Verbal records and evidence for comparable streams on the Strait of Juan de Fuca indicate that the river supported runs of spring, summer and fall chinook, chum, pink and coho salmon; summer and winter steelhead; and possibly sockeye salmon. Steelhead and certain salmon stocks could have traveled as many as 43 miles upstream from the Elwha River mouth.

Salmon and steelhead as biological, commercial, and cultural resources are of considerable regional importance in the Pacific Northwest. Columbia River salmon and steelhead runs, for example, continue to be the focus of major restoration efforts under the Northwest Power Planning Council's (NPPC) Columbia River Basin Fish and Wildlife Program (NPPC, 1987). Pacific Northwest Native Americans place extreme importance on salmon and steelhead as key elements of their cultural and religious heritage, as well as their livelihood and subsistence (e.g., Meyer Resources, Inc., The Importance of Salmon and Steelhead of the Columbia River to the Confederated Tribes of the Colville, Nez Perce, Umatilla, Warm Springs and Yakima Indian Reservations - with Particular Reference to Dams of the Mid-Columbia Area, Davis, California, April 1983).

Salmon and steelhead run size and harvest are a focus of resource management planning at state, federal and international levels.

Three management entities provide policy focus within this region. The Northwest Power Planning Council (Council) is congressionally mandated to protect fish and wildlife in the Columbia River Basin and to restore diminished resources, particularly anadromous fish. The Pacific Fishery Management Council (PFMC), established under the Magnusen Act of 1976, provides management guidance for salmon stocks in California, Oregon, and Washington. The Pacific Salmon Commission (PSC) provides management guidance for the Canadian-American Treaty regarding international allocation of salmon. In addition, the Washington Departments of Fisheries and Wildlife, the U.S. Fish and Wildlife Service, and National Marine Fisheries Service play roles in management policy implementation, habitat preservation, enforcement, and fishway specifications.

The anadromous fish restoration objective is interpreted in this document in light of policy positions of the Council, PFMC, and PSC. The bodies have consistently stressed the need for re-establishing wild, self-sustaining salmon and stocks as a first priority. This wild stock emphasis is accepted despite the potential of reduced commercial or sport harvest, because wild, naturally spawning and rearing salmon cannot usually sustain harvest rates as high as hatchery-produced fish.

The PSC, the agency most involved in current Washington State chinook salmon management, has specified a phased program of reducing chinook salmon harvest to increase wild fish spawning escapement (PSC, 1989). The Council, in its Columbia Basin subbasin planning process, has consistently emphasized wild fish production unless intended run size cannot be obtained (NPPC, 1987). The PFMC specifies intended coastal harvest levels to protect wild stock fish in the commercial harvest. The state fisheries agencies set specific regulations and address habitat concerns from the perspective of protecting and enhancing wild stocks, often at the expense of commercial or sport harvest (PFMC, 1978).

Collectively, these actions strongly indicate region-wide emphasis on wild fish production, and they acknowledge that some reduction in harvest may ensue in the pursuit of the principal goal.

Therefore, when evaluating the alternatives in this EIS, we have emphasized wild anadromous fish restoration as a major objective, and have evaluated harvest-related impacts on tribal, commercial, and sport fisheries as a lesser consideration.

1.4.2 Restoration of Natural Conditions Within Olympic National Park

The restoration of anadromous fish production throughout the Elwha River is directly tied to the concept of restoring natural environmental conditions ONP. Restoration of the Elwha River Basin's natural ecosystem within the boundaries of the park is considered a principal resource objective, because of the substantial potential for restoring natural processes and the prominence of National Park Service (NPS) policies and goals relating to ecological integrity.

Salmon species play a major role in carrying nutrients from the ocean back to the freshwater ecosystem, enhancing productivity in aquatic and terrestrial communities. For example, recent studies have demonstrated that at least 22 bird and mammal species feed on the carcasses of coho salmon (Cederholm et al., 1989). Restoring anadromous fish runs in the upper Elwha River would result in an increase in total biomass and the total number and diversity of species within the park watershed, thereby enhancing the productivity of the ecosystem. Each anadromous fish stock, if restored, would use a distinct portion of the watershed, and each stock would enter the system at a distinct time of the year. Thus, full natural ecosystem restoration would require the restoration of all species and stocks native to the watershed.

In addition to the missing anadromous fish component of the natural ecosystem, the Glines Canyon Project and its Lake Mills reservoir represent other non-natural aspects of ONP. The presently inundated reservoir area, if drained and successfully revegetated, could represent an opportunity for restoration of lowland wildlife habitat for a variety of species and for cross-valley migratory routes for wildlife, including resident and migratory elk.

As described in park enabling legislation, ONP contains the finest sample of primeval forests of Sitka spruce, western hemlock, Douglas-fir, and western red cedar in the United States. The presence of lowland temperate rain forest located in the park is unique to North America and represents one of the largest intact natural areas in the Pacific Northwest. Owing to its large size, abundance of natural features, and multiple entrances, ONP is the most visited national park in Washington State.

The basis for adopting natural conditions restoration within ONP as a principal resource objective is found in the NPS program goals and policies. The primary goal of the NPS in managing national parks and monuments is to preserve or, where necessary, recreate the environment as viewed by the first European visitors (Leopold et al., 1963).

U.S. Department of Interior Management Policies (NPS, 1988a) call for the NPS to manage the natural resources of the national park system to maintain, rehabilitate, and perpetuate their inherent integrity. Specifically, the NPS is to strive to protect the full range of genetic resources (genotypes) native to plant and animal popula-tions in the parks by perpetuating natural evolutionary processes

and minimizing human interference with evolving genetic diversity. Furthermore, the NPS is to restore native species to parks when adequate habitat exists, when the species can be self-perpetuating, and when the species loss to the park was a result of human-induced change.

Further, the ONP Statement for Management includes as a management objective:

> "to conserve, maintain, and restore, where possible, the primary natural resources of the park and those ecological relationships and processes that would prevail if not for the advent of modern civilization" (NPS, 1989a).

1.4.3 Provision of Renewable Hydroelectric Energy

The Elwha River's hydroelectric potential represents the third principal resource value identified during EIS scoping. The cost-effective utilization of the Elwha River's hydroelectric potential is a principal resource objective, because the continued use of this renewable resource would contribute to meeting the region's long-term power requirements and to forestalling increased adverse environmental effects of fossil fuel burning.

1.4.3.1 Reliability Considerations

A need for additional power is likely to exist in the Pacific Northwest sometime during the 1990's. Firm energy provided by the Glines Canyon and Elwha hydroelectric projects would, depending on cost, continue to be useful in meeting a portion of the projected need for power.

The combined effect of electrical load growth and fixed or declining level of existing generation necessitates the addition of conservation and/or generating resources if reliability levels are to be maintained. The timing of the need for additional resources is determined largely by the rate of load growth, load characteristics, the age and condition of existing resources, and system reliability criteria.

Pursuant to the Pacific Northwest Electric Power Planning and Conservation Act of 1980, the Council adopted a Northwest Conservation and Electric Power Plan (Power Plan) in 1983, amended the plan in 1986, and supplemented the plan in May 1989. The Power Plan includes, but is not limited to, a 20-year demand forecast and estimates of resources available to meet future demand.

The Power Plan recognizes as a basic tenet that the future is uncertain and that it is not possible to accurately forecast electrical energy needs. To deal with this uncertainty, the Council developed a range of high, medium-high, medium, medium-low, and low electrical growth scenarios.

For resource planning purposes, the Council assumes a probability distribution to describe the likelihood that any given level of future electricity demand will occur. The demand levels between the medium-low and medium-high forecasts are most likely and are considered equally probable. The demand levels outside the low and high forecasts are considered by the Council to be of sufficiently low probability that they are not formally considered in resource planning. The probability of future demand being equal to or above the medium-low forecast is considered to be about 76 percent. The probability of future demand being equal to or above the medium-high forecast is about 23 percent.

While forecast levels were developed cooperatively with the Bonneville Power Administration (BPA), BPA places a relatively higher probability on the medium forecast than does the Council.

Since hydroelectric power predominates in the Pacific Northwest and the power system is energy limited rather than capacity limited, the Council's forecasts focus on firm energy requirements for power planning purposes (Table 1-1).

Regional firm sales of electrical energy are forecast to change from 15,618 average megawatts (MW) in 1987 to a level between 15,442 and 29,223 average MW by 2010. The medium forecast is 21,344 average MW in 2010, which represents an average annual growth rate of 1.4 percent.

Table 1-1. Firm sales of electricity (average MW).[1/]

	Actual	Forecasts			Growth Rate (% per year)
	1987	1990	2005	2010	1987-2010
High	15,618	17,751	25,979	29,223	2.8
Medium-High	15,618	17,934	21,915	24,026	1.9
Medium	15,618	16,456	19,853	21,344	1.4
Medium-Low	15,618	15,835	17,897	19,124	0.9
Low	15,618	15,170	14,913	15,442	-0.1

[1/] Source: NPPC, 1989a.

To forecast the need for additional resources, the Council subtracted existing resources (adjusted for any known additions or reductions) from the range of future electricity demands (Figure 1-1). The Council predicts that if high load growth occurs, the region will need new resources as early as 1992. At the

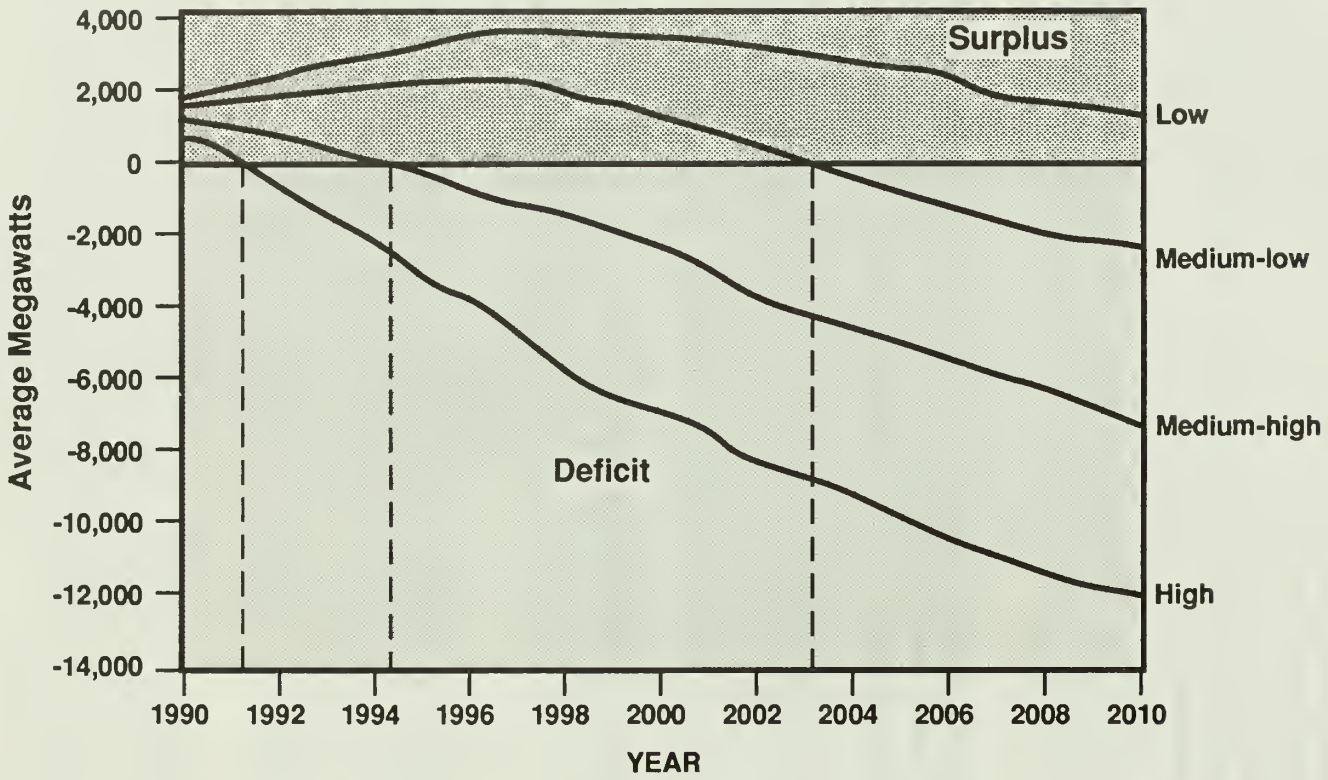


Figure 1-1. Regional load/resource balance. (Source: the staff, modified from Northwest Power Planning Council, 1989a).

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opposite extreme, no new resources will be needed during the planning period if growth follows the low load path. In the more likely medium-high and medium-low scenarios, the region will need new resources sometime between 1995 and 2004. The regional load and resource analysis represents average conditions, not necessarily representative of any particular power supply sector or individual utility. For example, the Council's load/resource analysis for the region's investor-owned utilities shows the need for additional resources about three years earlier than for the region as a whole.

In determining the perceptions of other planning bodies in the region regarding load projections and the need for additional resources, the Commission staff examined the latest load projections and needs analyses of the Pacific Northwest Utilities Conference Committee (PNUCC) that were published in March 1990 (PNUCC, 1990). The PNUCC projections of regional firm energy loads and resources show a need for additional resources beginning in 1992 (PNUCC, 1990). The PNUCC predicts a deficit of over 1,000 average MW by 1997, based on present-day existing and assured resources.

Eliminating the Glines Canyon and Elwha projects, or any decrease in their output due to operational changes, would decrease the region's resource base to a small extent and increase projected deficits.

1.4.3.2 Environmental Effects of Fossil Fuel Use

Given the present and potential future role of coal-fired generation in the Pacific Northwest, hydroelectric generation provides an opportunity to reduce the quantity of atmospheric pollutants associated with the combustion of fossil fuels.

Coal-fired powerplants account for about 6,300 MW, or about 15 percent of the region's installed capacity. The burning of fossil fuels, especially coal, is associated with emission of air pollutants that contribute to adverse environmental effects, including acid rain, global warming (the greenhouse effect), and depletion of the ozone layer. In 1989, the United States portion of the Northwest Power Pool experienced coal-fired powerplant generation totalling 70,714 gigawatthour (GWh), and at least 4,200 GWh were generated from coal plants in every month (personal communication, Chris Elliot, Analyst, Northwest Power Pool, June 29, 1990).

In addition to the existing coal plant resources, the Council recognizes the potential need for as many as 5,425 MW of new coal generation in its planning horizon, but does so with reservations concerning the adverse effects of new coal development. The extent and timing of the need for new coal resources varies according to the load forecast.

2.0 PROPOSED ACTION AND ALTERNATIVES

This section describes the existing Glines Canyon and Elwha projects, the applicant's proposal for these projects, and staff-developed alternatives. It also contains a brief description of sources of replacement power and an economic evaluation of the applicant's proposal and alternatives.

2.1 DESCRIPTION OF THE EXISTING PROJECTS

The Elwha dam is located about 5 miles from the mouth of the Elwha River and forms Lake Aldwell. The Glines Canyon dam is located about 7 miles upstream of the Elwha Project and forms Lake Mills (Figure 2-1).

2.1.1 Glines Canyon Project

2.1.1.1 Facilities

Constructed in 1927, the Glines Canyon dam is a varied radius, single arch concrete dam, 210 feet high (Figure 2-2). The base of the dam is 55 feet wide, and the length at its crest is 270 feet. A concrete thrust block, concrete gravity section and embankment section complete the dam on the right abutment. The spillway consists of a 120-foot-long section on the dam's left abutment, containing five 18- by 20-foot radial gates. There is also an uncontrolled spillway section in the center of the dam with a crest at El. 610 mean sea level (msl).

The reservoir, Lake Mills, has a total storage capacity of about 40,000 acre-feet at El. 610 msl, the normal water surface elevation.

The power intake is an independent structure located within the reservoir at an elevation about 83 feet below the crest of the dam. The intake is connected to a 570-foot-long power tunnel, 285 feet of which are lined. The intake control gate is located about 190 feet downstream of the intake and consists of a roller gate connected by a shaft which connects with the surface at the control house. The power tunnel is connected to a 320-foot-long, riveted steel penstock and a surge tank. From the surge tank, the penstock drops a final 80 feet to an 8.5-foot-diameter butterfly valve located inside the powerhouse.

The powerhouse, approximately 40 feet wide by 60 feet long, contains a single main 17,500 hp turbine/generator (vertical Francis), a small horizontal station unit, and associated station equipment. The project's installed capacity is 13.1 MW. A substation is located above the powerhouse, where the generator voltage is transformed to 69 kV and conveyed about 7 miles via an overhead three-phase transmission line (Line No. 3) to the Elwha Project. Project data are summarized in Table 2-1.

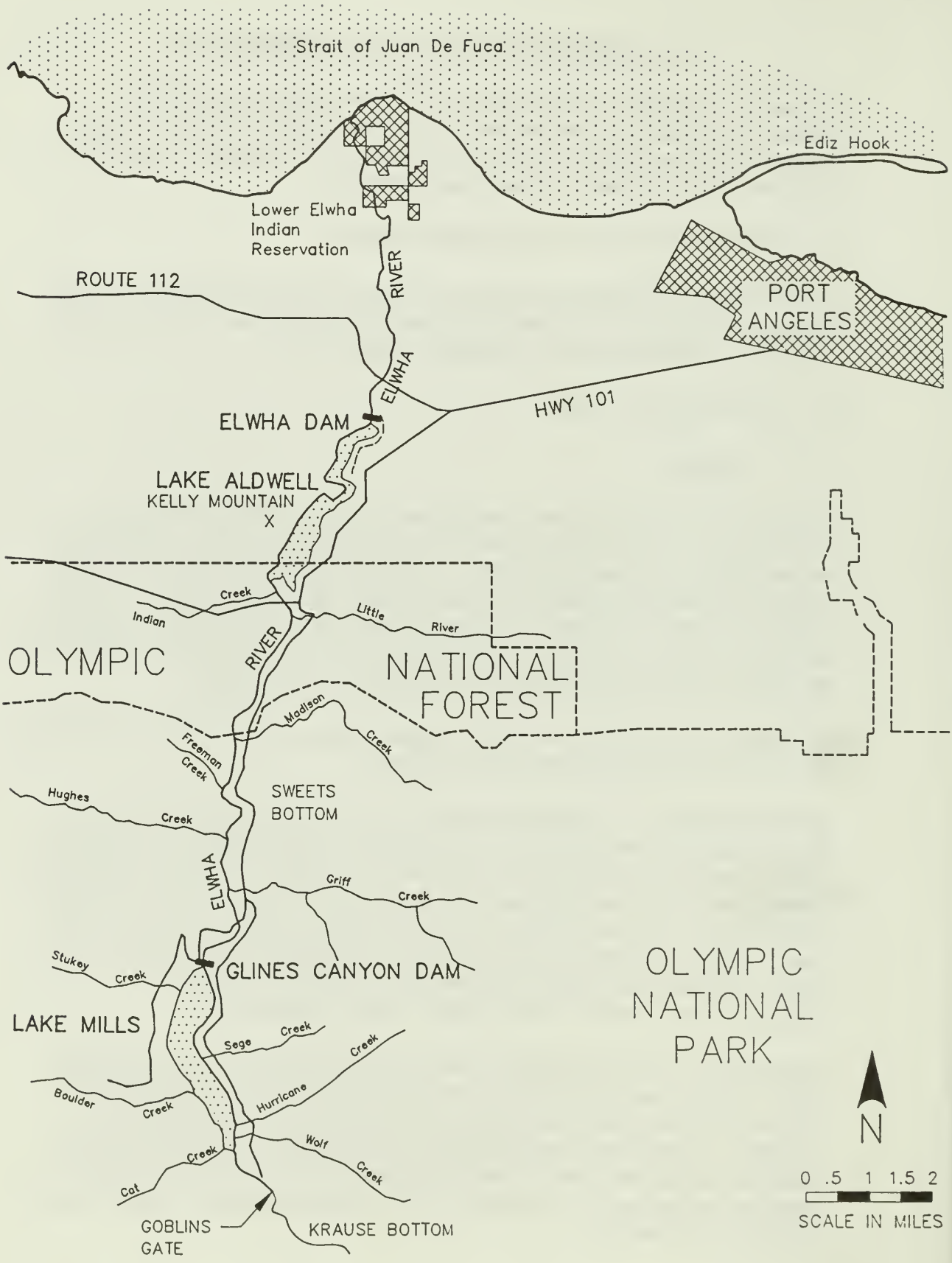


Figure 2-1. Elwha River Project vicinity. (Source: the staff).

FIG2-1

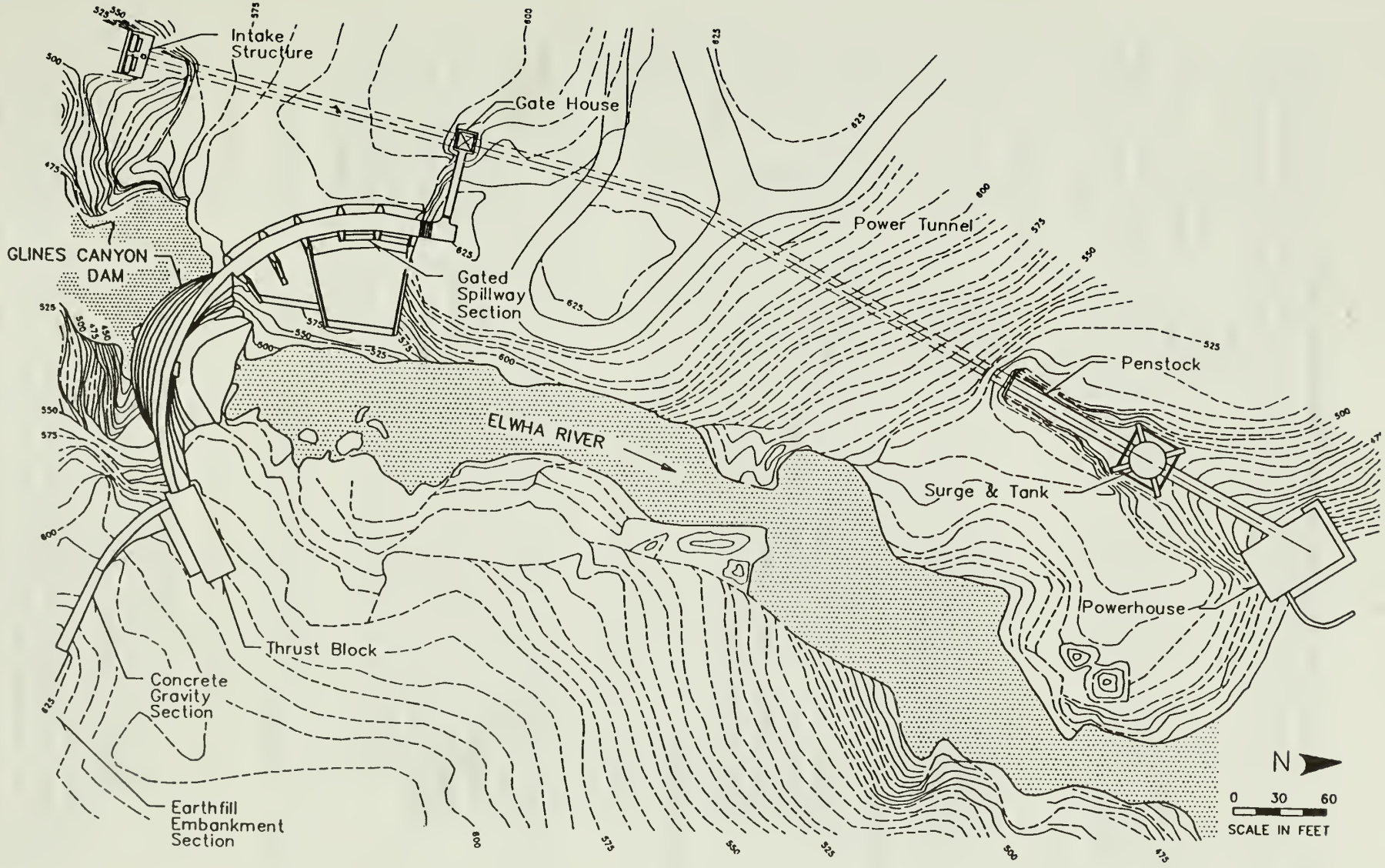


Figure 2-2. Glines Canyon Project. (Source: James River II, 1989).

Table 2-1. Data summary, existing projects (Source: the staff).

Feature	Glines Canyon Project	Elwha Project
DAM		
Length (ft)	270	450
Height (ft)	210	105
Crest Elevation (ft msl)	610	188
IMPOUNDMENT		
Name	Lake Mills	Lake Aldwell
Normal Water Surface Elevation (ft msl)	610	187.8
Water Surface Area (acres)	415	267
Gross Storage (acre-feet)	40,000	8,100
POWERPLANT		
Total Plant Nameplate Capacity (MW)	13.1	14.8
Number of Units	2	5
TRANSMISSION LINE		
Voltage (kV)	69	69
Type	Overhead	Overhead
Length (miles)	Line No. 3: 7 miles	Line No. 1: 6 miles Line No. 2: 8 miles
GROSS AVERAGE ANNUAL ENERGY (GWh)	102	70

2.1.1.2 Project Operation

The Glines Canyon Project is largely operated from the Elwha Project control center. An automated supervisory control and data acquisition (SCADA) system at the Elwha center controls a single radial spillway gate, as well as the load on

the generating unit. Other operational functions, such as starting and synchronizing the unit, must be performed at the Glines Canyon powerhouse. Two operators live adjacent to the project and man the facilities during the day, 7 days per week.

While the Lake Mills reservoir offers approximately 30,000 acre-feet of active storage, recent operation (since 1975) has involved reservoir drawdown of 10 feet or less, corresponding to about 4,000 acre-feet of active storage. Annual energy production averages about 102 GWh.

2.1.1.3 Project Safety

The Glines Canyon dam is classified by the Commission as having high hazard potential. This classification refers to the potential for loss of life and significant property in the event of a dam failure. The classification does not infer an assessment of the structural integrity of the projects. Since the dam has been classified as having high hazard potential, the Commission requires that the dam meet the Probable Maximum Flood (PMF) loading condition, or be able to pass a flood above which failure of the structure would not constitute a hazard to downstream life or property. The Commission uses this conservative criterion (which is a federal and industry standard) to maximize the safety of dams with high hazard potential. In addition, this criterion provides for the safety of the project in the event of unanticipated natural forces or other incidents beyond the control of the project owner. The PMF criterion is in addition to other loading conditions.

The Commission has required in the past, and will continue to require in the future, remedial measures at the Glines Canyon Project to ensure public safety (Table 2-2). As a result of stability investigations done under Part 12, Subpart D, of the Commission's regulations (Inspections by Independent Consultant), the Glines Canyon dam has been stabilized to satisfy the PMF loading condition criterion by the installation of post-tensioned anchors in the dam. The work was completed in November 1989. Consequently, the Glines Canyon dam is considered safe under normal loading, unusual flood loading, and seismic (earthquake) loading conditions.

2.1.2 Elwha Project

2.1.2.1 Facilities

Initially completed in 1912, the Elwha dam is approximately 450 feet long at its crest, and about 105 feet high. It consists of a central concrete gravity-type section and an adjacent concrete buttress-type intake section, the combination of which is flanked by a spillway at each abutment (Figure 2-3). The north spillway has four radial gates, each about 14 feet by 23 feet. The south spillway has five

Table 2-2. Summary of actions taken to ensure the dam's structural integrity, Glines Canyon Project (Source: the staff).

Procedural History	Action Taken
First Part 12 Inspection Report (October 29, 1968) recommended: o PMF study to evaluate adequacy of spillway to pass PMF; and	The then existing piers and bridge in the arch section were removed to increase spillway discharge capacity.
o Stabilize dam by installing post-tensioned anchors into bedrock.	Work was completed in 1969.
The licensee submitted revised Exhibit L drawings entailing certain remedial structural modifications in 1973 to accommodate PMF discharge.	
A Commission order approving the Exhibit L drawings and making them a part of the license was issued on July 7, 1976. Order required the licensee to complete remedial work on the dam to enable it to withstand the PMF.	Remedial work was performed, including the installation of post-tensioned anchors in portions of the dam, and construction of a low earthfill dike, a concrete end wall, and additional riprapping. Work was completed in October 1977.
Consultant's report (April 28, 1978) made recommendations for raising and protecting the earthfill portions of the dam and post-tensioning its gravity section.	The licensee completed the recommended modifications in November 1978.
Consultant's report (August 2, 1982) stated that no new deficiencies were revealed by its field inspection that would adversely affect public safety.	
The 1987 Consultant's report proposed that additional post-tensioned anchors be installed.	
The licensee submitted anchoring plans and schedules on June 1, 1987, July 13, 1987, and November 3, 1987.	FERC staff sent a deficiency letter requesting more information regarding the Consultant's reports.
The licensee submitted reports between March and May 1989 (drilling and testing of the concrete and dam foundation, seismicity of the dam site to determine anchor design and stability).	
The licensee submitted a design report and plans and specifications for installing additional post-tensioned anchors (June 9, 1989) to meet the current PMF loading condition.	Work was completed in November 1989.

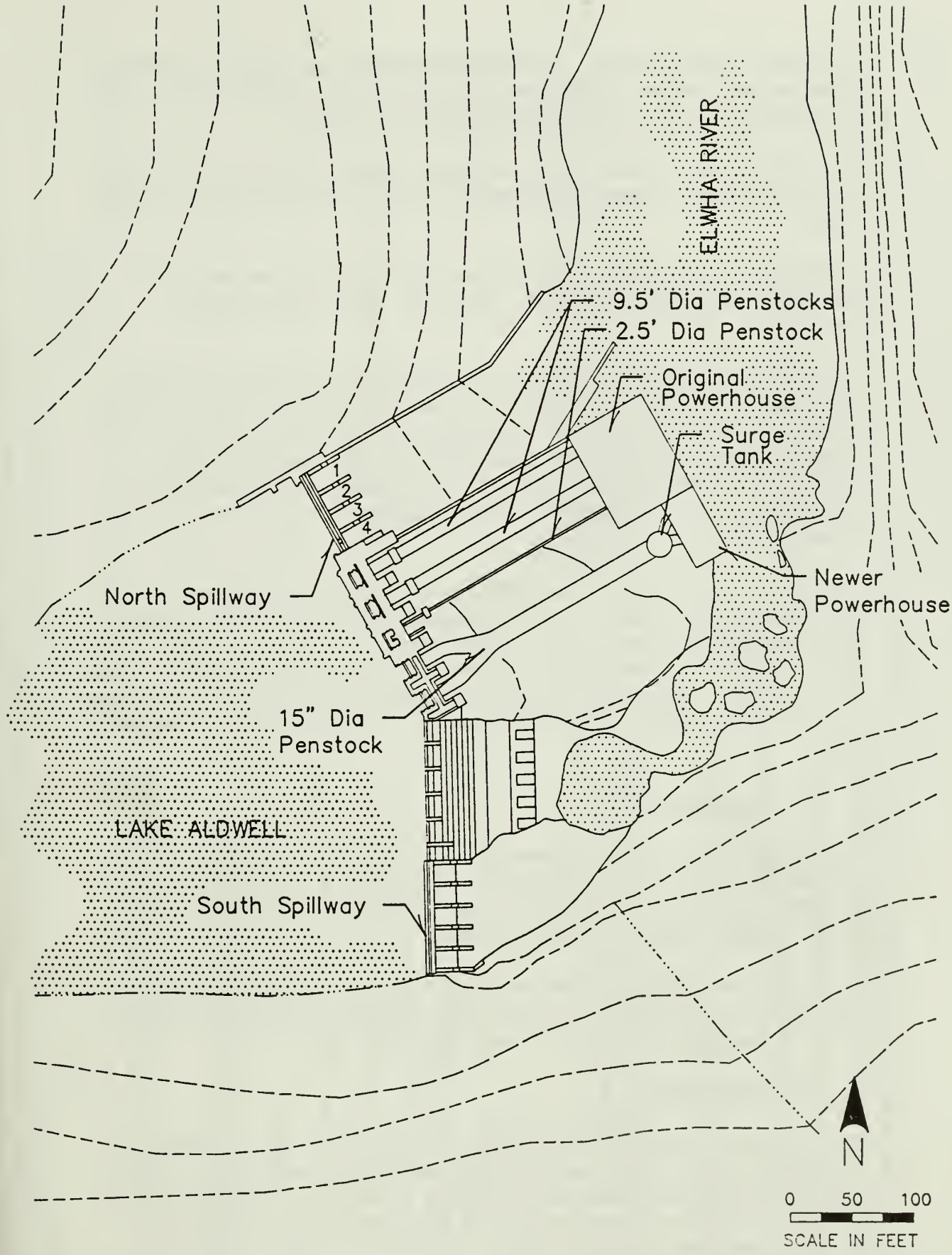


Figure 2-3. Site plan, Elwha Project. (Source: the staff, modified from James River II, 1989).

radial gates of the same size. The north bank spillway was recently modified by adding an ogee transition section from the lip of Spillway Gate No. 3 to the floor of the spillway chute and by smoothing the spillway surface.

The reservoir, Lake Aldwell, has a total storage capacity of about 8,100 acre-feet at El. 188 feet msl. Maximum drawdown is about 7 feet, limited by the surface intakes.

Occupying the buttress dam section are five surface intakes, three leading via penstocks to the original powerhouse, and two to the newer powerhouse constructed in 1921.

In the original powerhouse, there are two 4,800 hp horizontal Francis, double runner turbines (Units 1 and 2) and a third small turbine that provides excitation for the other generators. In the newer powerhouse, there are two vertical 5,000 hp Francis single runner turbines (Units 3 and 4). The total installed capacity at the Elwha Project is 14.8 MW. The control room is located in the original powerhouse and contains the main control panel, communications, and protective relays.

Transformers and circuit breakers are located in a separate room within the original powerhouse. There is one incoming transmission line (Line No. 3) from the Glines Canyon Project, and two outgoing lines, all at 69 kV. Line No. 1 is approximately 6 miles long and transmits energy directly to the Daishowa America Mill. Line No. 2, approximately 8 miles in length, interconnects at the BPA/City of Port Angeles substation with the line carrying BPA (Port Angeles) power to the mill.

2.1.2.2 Project Operation

The Elwha Project is manned 24 hours per day. From the control room, the operators can bring on-line or take off-line any of the five units, load or unload any unit, open or close two radial gates, and perform limited functions via the SCADA system at the Glines Canyon Project.

Since 1983, the reservoir level has been held within a 1-foot range of normal water surface (187.8 feet msl), resulting in essentially a run-of-river operational mode. Annual energy production averages about 70 GWh.

2.1.2.3 Project Safety

Like the Glines Canyon dam (Section 2.1.1.3), the Elwha dam is classified by the Commission as having high hazard potential due to the potential for loss of life and significant property damage in the event of a dam failure. Pursuant to Commission directives, the Elwha dam has been strengthened by the installation of anchors to safely withstand PMF criteria, and the owner has an acceptable Emergency Action Plan in place (Table 2-3).

Table 2-3. Summary of actions taken to ensure the dam's structural integrity, Elwha Project (Source: the staff).

Procedural History	Action Taken
The Elwha Project operated without a FERC license since its completion in 1913. In March 1968, the first Periodic Safety Report was prepared by R. W. Beck for the project owner.	
In 1968 project owner filed license application, but subsequently withdrew its application arguing that FERC did not have jurisdiction.	
Inspection Report prepared by U. S. Army Corps of Engineers in August 1978 concluded: o Elwha dam constitutes a high hazard to downstream life and property in the event of failure. o Dam's spillway capacity was inadequate with potential for failure in extreme floods. o Dam was potentially unsafe for flood peaks above 40,000 cfs. o Measures were recommended: - Provision for action in emergencies - Testing of dam - Analyzing the dam - Repairing the dam - Strengthening the dam - Modifying the dam	
On March 16, 1979, FERC determined that the Elwha Project was required to be licensed. Also required was that the license applicant file a plan and schedule for restoring and strengthening the Elwha dam and an emergency action plan (EAP) of the type required for projects that pose a hazard to life or property.	Certain modifications designed to strengthen the dam under PMF loading were completed in October 1980. However, due to quality control problems during construction, the applicant was unable to fully document that all anchors met specifications.
In a safety and adequacy study dated February 9, 1982, FERC found that the safety of the dam could not be verified.	
On June 1, 1984, FERC issued an order requiring the applicant to retain a board of consultants to evaluate the safety of the project.	
The applicant's consultants recommended that additional anchors be installed.	This work was completed in March 1986.
The applicant concluded that the north spillway section of the dam and the penstock intake needed additional strengthening due to geological conditions.	

Table 2-3. (Continued).

Procedural History	Action Taken
On October 6, 1986, FERC directed the applicant to install anchors in the north spillway and intake sections and to reconvene the Board of Consultants to review all calculations, plans, and specifications.	Construction was completed on January 19, 1987.
FERC conducted site inspections on December 15, 1986, January 13, 1987, and January 14, 1987, and concluded that the Elwha dam was satisfactorily rehabilitated.	
On May 4, 1987, FERC informed the U. S. Army Corps of Engineers that the Elwha dam is able to safely withstand PMF loading.	
FERC staff issued a deficiency letter on the EAP on January 17, 1980.	The applicant submitted an interim EAP on April 4, 1979, updated it on July 26, 1979, and filed its final EAP on December 14, 1979.
FERC regional office notified the applicant of deficiencies in the revised EAP on October 3, 1980.	On June 30, 1980, the applicant filed a revised EAP that included a downstream inundation map.
On September 23, 1983, the FERC regional office notified the applicant that the EAP was accepted under the then existing guidelines.	On June 14, 1983, the applicant submitted a revised EA.
On February 22, 1988, FERC issued a notice of revised emergency action guidelines.	The applicant submitted a revised EAP on March 29, 1988, which was accepted as an interim plan until the new EAP was submitted.
On March 8, 1989, FERC's regional Director, Division of Dam Safety and Inspections, wrote the applicant that the latest EAP is workable, but requested certain revisions.	The new EAP was submitted by the applicant to FERC on January 25, 1989. The applicant filed revisions on June 26, 1989, July 14, 1989, and July 20, 1989. These revisions are being reviewed by FERC staff.

2.2 APPLICANT'S DAM RETENTION PROPOSAL

The applicant proposes to retain both projects and continue generating electric power, but to make facility modifications and operational changes to allow restoration of fish production in the Elwha River based upon natural self-sustaining anadromous populations. Additionally, the applicant proposes project automation improvements and measures related to terrestrial, recreational, and cultural resources.

2.2.1 Elwha Project

2.2.1.1 Facilities

To pass naturally migrating adult anadromous fish upstream of the Elwha dam, the applicant would construct a fish ladder on the south shore of the existing right bank spillway. These upstream passage facilities would include: (1) an inclined bar rack at the powerhouse tailrace exit portals to decrease fish attraction; (2) a ladder entrance, barrier weir and fishway; (3) a fish ladder consisting of a concrete pool-and-weir and orifice section, a Denil section, and a rectangular open channel section; and (4) holding and sorting pools for sorting and counting of migrating fish.

For passing outmigrating anadromous juveniles downstream, the applicant proposes to pass all water used for power production through fish diversion screens and to spill all other water through spillways modified for fish protection. The fish screen system would be comprised of: (1) four 9-foot-diameter Eicher screens installed in the project penstocks; (2) a bypass pipe and vertical travelling screen facility; (3) an open channel flume; and (4) a concrete pool-and-weir structure to convey fish to the powerhouse tailrace.

For protecting the outmigrating juveniles that pass over the spillway, gate bays Nos. 2 and 3 of the Elwha left bank spillway would be modified. The modification would include: (1) an ogee transition section in gate bay No. 2; (2) concrete-lined chutes and training walls the full length of bays No. 2 and No. 3; (3) reconstruction of the spillway gate bottom seals to minimize turbulence; and (4) installation of an additional spillway gate hoist to facilitate spillway operation. Refer to Appendix A, Part 1 for details of the fish ladder, the Eicher screens, and the spillway improvements.

To ensure stable control of the reservoir water level, to prevent flow over the top of the spillway gates and to control ramping rates, the applicant would add a direct current (dc) power system and automate the spillway gate operation for bays No. 2 and No. 3.

2.2.1.2 Operation

To establish operating criteria for the passage facilities, the applicant would conduct intensive evaluations of all facilities during the first several years, followed by a long-term annual monitoring program to ensure that established operating criteria were being met. The applicant would continue to be responsible for the operation of the upstream and downstream passage facilities for the period of the license.

The Elwha Project would continue to be operated in a run-of-river mode.

To implement the fish restoration program, the applicant would fund, for a 10-year period, a broodstock collection and hatchery program for production of juveniles for outplanting into the upper watershed.

In keeping with the 1975 Settlement Agreement with the Washington Department of Fisheries (WDF), the applicant would continue partial funding of the Elwha Chinook Rearing Channel facility. The level of artificial production would be based on dam passage losses of wild fish, while the artificial production would be directed at those stocks which currently support the hatchery-based harvest.

To facilitate long-term river flow monitoring, the applicant would fund the operation of a new stream gage to be installed below Elwha dam, while ceasing operation of the existing McDonald gage after 2 years of concurrent operation.

2.2.1.3 Other Measures

The applicant also proposes measures related to terrestrial, recreational, and cultural resources.

The applicant proposes to dedicate 898 acres for terrestrial mitigation, including Elwha Project lands, James River property adjacent to Lake Aldwell, and the McDonald gage tract. Existing forested project lands would not be harvested but would be retained and enhanced for wildlife benefits. Management activities would include: gating access roads; creating snags; thinning, creating and enhancing wetlands; recontouring shorelines; fencing to prevent disturbance; and protecting the area from encroaching development. Shoreline areas would be enhanced by thinning the dense overstory and allowing hydrophytic shrubs and trees to regenerate.

Recreational opportunities would be improved by the installation of: (1) three remote boat-in campsites on the east side of Lake Aldwell; (2) a project overlook with parking, sanitary facilities and interpretive signs; (3) an improved trail to the pool below Elwha dam for recreationists; and (4) additional interpretive signs.

The Elwha Project is listed on the National Register of Historic Places. The applicant would record the site, through appropriate documentation, to the standards of the Historic American Engineering Record.

2.2.2 Glines Canyon Project

2.2.2.1 Facilities

At the Glines Canyon Project, to pass migrating anadromous fish upstream, a trap-and-haul operation is proposed by the applicant for conveying the adult fish past the 190-foot vertical lift of the Glines Canyon dam. The collection and sorting facility would be located near the Glines Canyon powerhouse, and fish would be trucked to the existing boat ramp on Lake Mills for release. The trap-and-haul facilities would include: (1) a velocity barrier and electric weir structure to direct fish to the fishway entrance; (2) a tailrace rack downstream of the powerhouse; (3) a vertical slot fish ladder along the face of the powerhouse; (4) holding, sorting, and transport pools; (5) a hoist system for loading adult fish onto a transport truck; (6) 3,000 feet of roadway stabilization and resurfacing; and (7) boat launch site improvements for the transport vehicle (refer to Appendix A, Part 1 for details of the applicant's plan).

To improve control of the reservoir water level, to prevent spills over the top of the spillway gates and the fixed spillway section, and to control ramping rates, the applicant would install a dc power system and necessary controls for automating: (1) the operation of the turbine and generators; and (2) one spillway gate.

2.2.2.2 Operation

For downstream passage of outmigrating anadromous juveniles, the applicant would release 100 cfs over the spillway between 9 p.m. and 5 a.m. from April 16 to November 15. Power generation would be reduced only when total inflow was insufficient to meet the spill criterion and to satisfy full turbine hydraulic capacity (1,100 cfs).

The applicant would limit reservoir drawdown for power generation purposes to 10 feet (active storage of 4,200 acre-feet), except between Memorial Day and Labor Day when reservoir drafting would be limited to 2 feet. Following drawdown for power purposes, the applicant would refill the reservoir only during periods of increasing river flow. Flows downstream of the project during refilling would not be allowed to fall below those which were occurring in the period immediately prior to the initiation of refilling. During periods when reservoir elevations would be adjusted for power generation purposes, the rate of change in downstream flows would be controlled within established ramping rates (Table 2-4).

Table 2-4. Elwha and Glines Canyon projects downramping and upramping rates (Source: the staff).

Period	Day ramp rate (inches per hour)	Night ramp rate (inches per hour)
Downramping:		
February 15 - June 15 [1/]	0	2
June 16 - October 31 [2/]	2	1
November 1 - February 14 [1/]	2	4
Upramping:		
Not to exceed six inches per hour during all periods (except natural storm events during which the river rises significantly faster than six inches per hour naturally).		

[1/] For this period, night is defined as one hour after official sunset to one hour before official sunrise.
[2/] For this period, day and night are determined by official sunrise and sunset.

The critical flow below which the ramping rates would take effect would be developed in consultation with the WDF and the Joint Fish and Wildlife Agencies (JFWA).

For the protection of fisheries in the lower river, the applicant would use reservoir storage to augment low river flows on an as-needed basis, in accordance with drawdown protocols to be established by the fisheries agencies.

Fish restoration funding and the applicant's passage facility monitoring and operational responsibilities would be similar to those described for the Elwha Project (Section 2.2.1.2).

2.2.2.3 Other Measures

In addition to fish passage and operational changes, the applicant proposes measures related to recreational and cultural resources. Specifically, the existing Lake Mills boat launch area would be improved, and modifications to the project would be documented in keeping with the project's listing on the National Register of Historic Places and the Historic American Engineering Record.

2.2.3 Construction Plan and Schedule

The proposed facility modifications would be initiated during the first year of the license term and take an estimated 4 years to complete. Construction work force requirements would average 8 man-years each year of the 4-year period. Plant outages during construction of the proposed modifications are estimated to result in a one-time loss of about 49 GWh.

In addition to the proposed project modifications, continued operation of the Elwha and Glines Canyon projects would involve occasional repair and replacement activities during a new license term. Reasonably foreseeable actions would include turbine repairs, generator rewinds, electrical equipment replacement, and overhaul of mechanical and civil features such as gates and penstocks (Appendix A, Part 5 contains further details).

2.2.4 Estimated Energy Output and Costs

The combined average annual energy output of the two projects would be 168 GWh, 2 percent less than the present combined average output of the two projects. The decrease would be associated with the nonpower releases required for fish passage. To operate and maintain the proposed fish passage facilities, the project operation and maintenance (O&M) workforce would be expanded by about four full-time equivalents.

The cost of the applicant's dam retention alternative includes ongoing baseline O&M costs, the capital and O&M costs for proposed project modifications, the cost of foregone power generation from plant outages during project modifications and from fish facility flows, and the occasional expenses associated with future repair and replacement actions (Table 2-5). The initial capital cost, exclusive of interest and plant outages during construction, would be approximately $14.7 million (1990 dollars).

The value of foregone energy generation for plant outages during construction is based on the forecasted cost of the Daishowa America mill purchasing additional power at the assumed mid-point of the construction period (28.4 mills/kWh in 1994). The baseline O&M cost is based on actual 1989 costs, escalated at the assumed long-term rate of inflation.

2.2.5 Measures Considered for Improving the Applicant's Proposal

The applicant's proposal was reviewed by the staff to determine whether it could be modified to more fully achieve the principal resource objectives (Section 1.4). The staff's review was conducted by evaluating the rationale presented by the applicant in his proposal (James River II, 1990a) and considering the JFWA

Table 2-5. Cost summary for the applicant's proposal (Source: Appendix A, Part 7, Table A-23).

Cost Category	Estimated Cost[1/]	
	One-Time	Recurring (Annual)
Baseline operation and maintenance		$1,525,000
Project modifications		
Elwha	$8,771,000	175,000
Glines Canyon	2,829,000	103,000
Fish restoration	3,070,000	240,000[4/]
Subtotal, initial capital cost	$14,670,000	
Foregone power generation		
Outage during construction[2/]	1,238,000	
Fish facility releases[3/]		376,000
Long-term repair and replacement	9,013,000	

[1/] 1990 dollars unless otherwise noted.
[2/] Based on forecasted cost of purchased power in 1994 (1994$).
[3/] Fifty-year levelized cost in 1996 dollars.
[4/] First 10 years only; after 10 years cost would decrease to $150,000 for rearing channel.

review comments on the applicant's proposal (letter from William C. Frymire, Susan K. Driver, F. Lorraine Bodi, Russell W. Bush, Joint Fish and Wildlife Agencies, June 12, 1990). The measures were formulated to emphasize several factors: (1) maximum fish passage success with a minimum of uncertainty; (2) operational experience of various passage facility designs; and (3) flexibility for subsequent alterations of the plan as the effectiveness of less costly or less restrictive measures is demonstrated by the applicant. As a result, the staff-developed measures tend to be more conservative than those proposed by the applicant in terms of fishery restoration, but also more costly in terms of construction costs.

These staff-developed measures are described and evaluated in Section 4.1.3.3, and further descriptive details can be found in Appendix A, Part 2.

2.3 REMOVAL OF BOTH DAMS ALTERNATIVE

This alternative would involve decommissioning the Elwha and Glines Canyon projects, removing the existing structures and returning the river to a free flowing condition. The electrical energy presently produced by the projects would be foregone, and other power generating or conservation resources would be required to replace the lost power.

The removal plan described in the following subsections represents one of several approaches to dam removal. In the staff's view, it is the preferred approach to removing the dams, based on a balancing of safety, environmental impact and cost considerations, and in light of presently available knowledge of geologic and sediment conditions within the reservoirs (Appendix A, Part 4). Further site investigations and analyses may necessitate modifications of the dam removal plan.

2.3.1 Elwha Project

Removal of the Elwha Project would involve: (1) the use of a gated tunnel diversion to drain the reservoir and divert river flows during sediment control and dam removal activities; (2) the stabilization of reservoir sediments to the extent possible within the confines of the reservoir; (3) the complete removal of the dam and other project structures once sediment stabilization was complete; and (4) reclamation and revegetation of disturbed areas. The principal elements of the removal plan for the Elwha Project are summarized in the following paragraphs. Refer to Appendix A, Part 3 for a more complete description.

Successful diversion is required for work to be conducted in dewatered conditions, thereby resulting in safe conditions for efficient work performance. The diversion would consist of a 13.5-foot-diameter concrete-lined tunnel 980 feet long located in the rock abutment on the left bank adjacent to the dam. An 8-foot by 14-foot concrete-lined gate shaft about 90 feet deep would be constructed 300 feet from the upstream end of the tunnel. A 14-foot-high by 10-foot-wide wheeled gate would be installed at the bottom of this gate shaft to control the flow in the diversion tunnel.

The diversion tunnel excavation would proceed from the downstream portal towards Lake Aldwell following completion of an access road. Use of a lake tap procedure would require a section of rock shell in Lake Aldwell at the upstream end of the diversion tunnel to stay in place as a plug until the work on the diversion tunnel, the gate shaft, and the wheeled gate was completed. The rock shell at the diversion tunnel entrance would then be blasted to tap the lake, thereby opening the diversion passage. Because of the complexity of the overall procedure, extensive geotechnical assessments would be required prior to final design. The assessment would include borings along the proposed alignment to determine the suitability of the rock for both the tunnel and lake tap area. Underwater exploratory investigations would also be required in the area of the

tap to ensure that overburden would not prevent lake tap construction or subsequent blockage. Final tunnel alignment and lake tap positioning would be determined based upon these investigations.

The spoils resulting from construction of the diversion tunnel, approximately 7,370 cubic yards, would consist of various sizes of rock fragments. The material would be hauled to an upland disposal area located to the west of the upper reaches of Lake Aldwell. The upland disposal site would require approximately 1,000 feet of temporary road construction, and transport of the material would require approximately 720 truckloads.

Delta sediment materials consisting of mostly sands and gravels would be placed in terraces located within the existing upper reservoir area, away from the future river channel. Dredging of sands and gravels would be carried out using a conventional dragline, while excavators and loaders would be used for drained and dried finer materials. Trucks would be used for hauling materials to the terrace surfaces. Terraces would be developed with modest slopes (1 foot vertical for each 4.5 feet horizontal) to ensure stability. Erosion control blankets and revegetation of completed terraces would further stabilize the sand and gravel sediments.

Silt present on the reservoir bottom in the downstream portion of the reservoir would not be moved by mechanical means. Instead, silt not transported downstream by the scour channel would be allowed to remain in place. After drawdown, it would be protected by erosion control blankets and would be revegetated.

Following the completion of river diversion and stabilization of reservoir sediments to the extent possible, demolition of the main gravity dam and other structures would begin. The gravity dam would be lowered to El. 80, and the steel piling downstream of the gravity section would also be removed to this elevation. Demolition of the dam would employ conventional drill and blast techniques commonly used for rock excavation. Blasting would be controlled so that most of the concrete rubble would be directed to the dewatered upstream side of the dam where it would then be loaded into trucks and removed to the disposal site.

The right spillway structure, the powerhouse, and penstocks would then be removed. To the extent possible, steel parts within the powerhouse and the penstocks would be disposed of as scrap. Parts which cannot be disposed of as scrap would be hauled away for disposal.

When removal of the dam and all structures are complete, the small cofferdam used to direct flows into the tunnel intake and the remainder of the approximately 60-foot-deep sediment accumulation upstream from the dam would be removed in a controlled manner by standard earth-moving and hauling equipment.

The final phase would involve reclamation of the site, including filling and grading the north spillway. Reclamation of the project area would also include hydroseeding soil slopes with native plant species to restore the site to as close to its preconstruction condition as possible.

2.3.2 Glines Canyon Project

Removal of the Glines Canyon Project would involve: (1) the use of a gated diversion tunnel to drain Lake Mills and divert river flows during sediment control and dam removal activities; (2) construction of an approximately 1,000-cfs capacity bypass channel for dilution of sediment-laden discharges; (3) the stabilization of reservoir sediments to the extent possible within the confines of the reservoir; (4) the complete removal of the dam and other project structures once sediment stabilization is complete; and (5) the reclamation and revegetation of disturbed areas. The principal aspects of the removal plan are summarized in the following paragraphs, while a more complete description is presented in Appendix A, Part 3.

To drain Lake Mills, a diversion tunnel would be constructed in the left abutment adjacent to the existing Glines Canyon dam. It would consist of a 12-foot-diameter diversion tunnel, a 12- by 8-foot vertical gate shaft and a 12-foot-high by 9-foot-wide control gate. The tunnel would be concrete lined and approximately 925 feet long.

Construction of the diversion tunnel would extend from the downstream outlet and advance toward the reservoir. A lake tapping procedure would require that a rock plug remain near the entrance of the diversion tunnel until construction of all tunnel components was completed. The plug would then be removed by blasting. Because of the complexity of a lake tapping procedure, extensive geotechnical investigations and assessments would be required prior to and during final design. These investigations would include borings to determine the suitability of underground formations for both the tunnel and lake tap location. Material obtained from tunnel construction would consist of rock and rock fragments. The total volume of material would be approximately 6,300 cubic yards, and would be disposed of by transporting to an off-site land disposal area. No new access roads would be required to construct the diversion tunnel. A staging area of approximately two acres would be needed and would be located north of the existing dam adjacent to the existing access road.

To provide the capability to dilute sediment-laden diversion tunnel discharges, thereby reducing suspended sediment concentrations downstream, the tunnel's diversion capability would be supplemented by an open channel bypass that would use the existing power intake and conduit system, in conjunction with a diversion channel extending to the upper end of the reservoir. Flows would be diverted from the upstream delta area, through the channel, and into the existing power intake. The diversion channel would be constructed by excavating and filling as necessary to develop a trapezoidal section. At the upstream end of the reservoir,

the channel's interior wall would be extended across the stream, thereby forming a diversion dam. Stream flows in excess of the diversion channel capacity would overtop the diversion dam and enter the reservoir. The powerhouse would be modified to allow for free discharge from the tunnel and penstock system.

Stabilization of the sand and gravel delta deposits would be initiated concurrently with the reservoir drawdown. Dragline excavation would be used to control channel development while the drawdown is underway. Exposed delta surfaces would also be excavated using conventional excavation methods. Excavated sands and gravels would be placed on the upper surface of the delta. Silt present on the reservoir bottom in the downstream portion of the reservoir would not be excavated or otherwise moved by mechanical means. Silts in and adjacent to the scour channel developed during reservoir drawdown would be allowed to sluff into the scour channel and to be carried downstream out of the reservoir. Silts not transported downstream would be allowed to remain in place. After drawdown, it would be protected by erosion control blankets and would be revegetated.

Essentially, all sediment stabilization activities would be completed to the extent possible prior to beginning demolition of the dam. The dam and other concrete structures would be demolished by drilling and blasting, and would be disposed of in the same manner as described for the Elwha Project (Section 2.3.1).

2.3.3 Construction Plan and Schedule

While work at the two projects would occur independently, decommissioning of the two projects would occur concurrently over a 5-year period in order to advance the realization of the fish restoration program (Figure 2-4).

For the Elwha Project, the first season would consist of constructing the diversion tunnel and associated control works. The following two seasons would involve lowering the reservoir and stabilizing sediment to the extent possible within the existing bounds of the reservoir. The final construction season would involve physically removing the dam and spillway structures, decommissioning the diversion works, and regrading the site. Much of the activity would be performed during lower flow periods, represented by the midsummer to early fall period.

At Glines Canyon, the first season would consist of constructing the diversion tunnel and associated control works. The following three seasons would involve lowering the reservoir, constructing the open channel diversion bypass, and transporting and stabilizing the sediment material to the extent possible within the existing bounds of the reservoir. The final construction season would involve physically removing the dam and other structures, decommissioning the diversion works, and regrading the site.

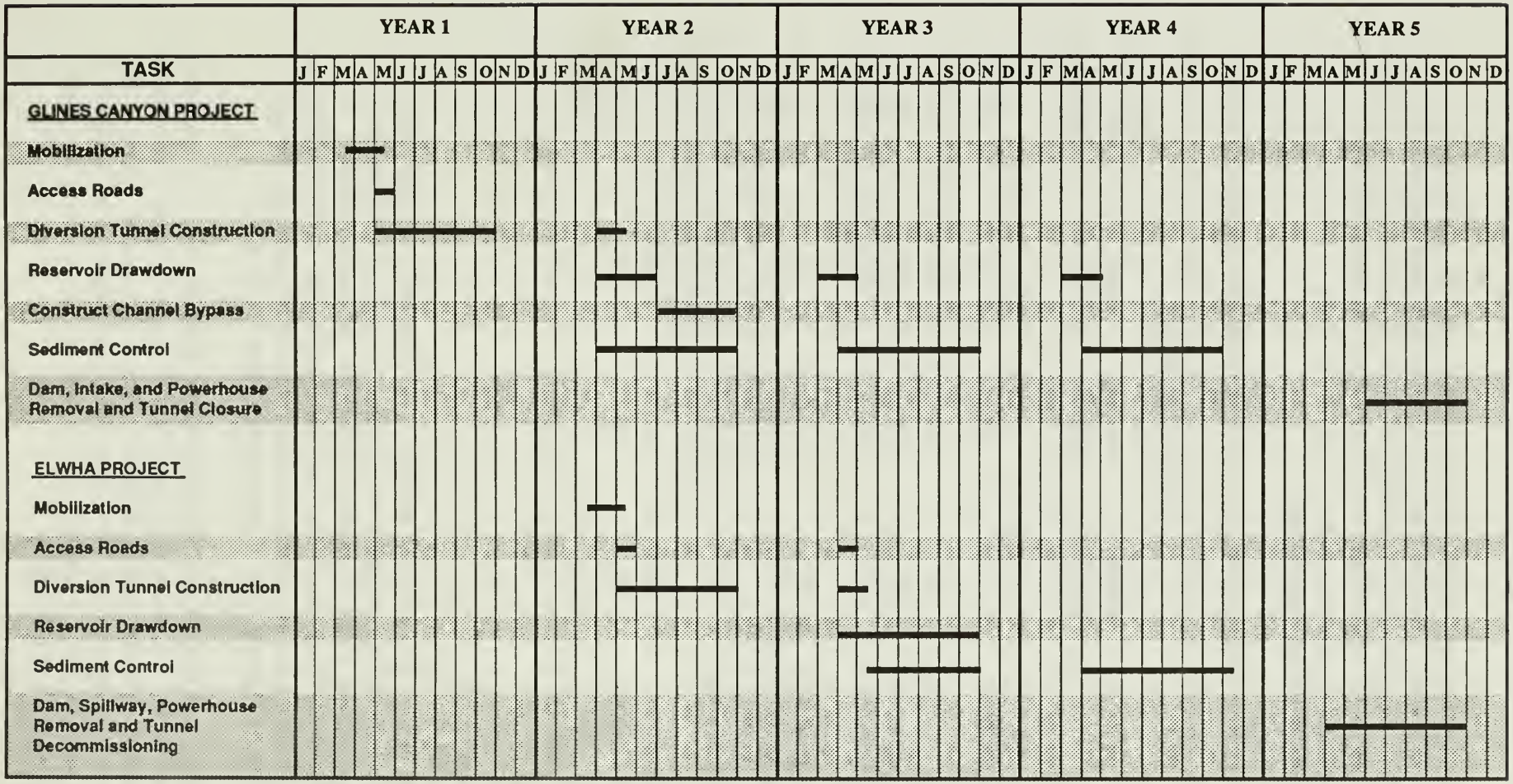


Figure 2-4. Construction schedule, removal of both dams. (Source: the staff).

The work force requirements would range between 20 and 78 workers, not including supervisory and administrative personnel (Table 2-6). In total, the construction effort would involve an average of about 22 man-years over a 5-year period. The current 10-person O&M workforce would no longer be needed, but it is assumed that one full-time equivalent would be necessary to monitor and maintain the revegetated reservoir areas.

Table 2-6. Workforce requirements, dam removal alternative (Source: the staff).

Period	Man-Months/Month: Elwha Project	Glines Canyon Project	Both Projects	Total Man-Months
Year 1				
May through October	--	20	20	120
Year 2				
April through mid-May	30	48	78	117
Mid-May through June	30	18	48	72
July through October	30	35	65	260
Year 3				
April through mid-May	30	18	48	72
Mid-May through October	18	18	36	198
Year 4				
April through October	18	18	36	252
Year 5				
April through May	15	--	15	30
June through October	15	20	35	175
TOTAL				1,296

2.3.4 Estimated Costs

The initial cost of dam removal ($64 million in 1990 dollars) includes the expenses of river diversion, sediment stabilization, demolition and removal of the structures, revegetation, and fish production facilities for supporting the restoration program. There would also be plant outage costs during removal and ongoing maintenance costs associated with the revegetation program, the fish restoration program, and the loss of power production (Table 2-7).

Part of the initial cost of dam removal is associated with the need to maintain an adequate power factor after the loss of generation from the projects. To maintain the mill's presently favorable power factor at or above 95 percent, which is the threshold for penalty payments to BPA, capacitors would need to be installed. With removal of both dams, 15,000 kVAR of capacitor banks would be required, with a cost estimated at $180,000.

Table 2-7. Cost summary for removal of both dams (Source: Appendix A, Part 7, Table A-24).

Cost Category	Estimated Cost[1/]	
	One-Time	Recurring (Annual)
Elwha Project removal	$23,927,000	$30,000
Glines Canyon removal	37,248,000	45,000
Fish restoration	3,070,000	240,000[4/]
Subtotal, initial capital cost	$64,245,000	
Foregone power generation		
Outage during removal[2/]	11,061,000	
Loss of the projects[3/]		16,512,000

1/ 1990 dollars unless otherwise noted.
2/ Based on forecasted cost of purchased power in 1994 (1994 dollars).
3/ Fifty-year levelized cost in 1996 dollars.
4/ First 10 years only.

2.4 GLINES CANYON PROJECT REMOVAL WITH RETENTION OF ELWHA

This alternative involves the installation of upstream and downstream fish passage facilities at the Elwha Project and the removal of the Glines Canyon Project. The fish passage measures at the Elwha Project would be those described in the applicant's proposal (Section 2.2). The removal of the Glines Canyon Project would be conducted as described for the removal of both dams alternative (Section 2.3). As in the case of removal of both dams, capacitors (9,900 kVAR) would need to be installed to maintain an acceptable power factor.

The physical modifications associated with this alternative would occur over a 5-year period. Construction work force requirements would average about 19 man-years over the construction period. Approximately 320 GWh of energy would be foregone on a one-time basis due to plant outages during the construction period. The estimated costs of adding fish passage facilities to the Elwha Project and removing the Glines Canyon Project are summarized in Table 2-8. The initial capital costs of this alternative would be about $49 million (1990 dollars) exclusive of interest and plant outage during construction.

Average annual generation would be approximately 68 GWh. The O&M workforce would involve seven full-time equivalents, three less than the current 10-person O&M staff.

Table 2-8. Cost summary for the Glines Canyon removal alternative (Source: Appendix A, Part 7, Table A-25).

Cost Category	Estimated Cost[1/] One-Time	Recurring (Annual)
Baseline operation and maintenance		959,000
Elwha project modifications	8,771,000	175,000
Glines Canyon removal	37,297,000	45,000
Fish restoration	3,070,000	240,000[4/]
Subtotal, initial capital cost	49,138,000	
Foregone power generation		
Outage during construction[2/]	7,947,000	
Fish facility releases[3/]		209,000
Loss of Glines Canyon[3/]		9,792,000
Long-term repair and replacement	6,195,000	

[1/] 1990 dollars unless otherwise noted.
[2/] Based on forecasted cost of purchased power in 1994 (1994$).
[3/] Fifty-year levelized cost in 1996 dollars.
[4/] First 10 years only; after 10 years cost decreases to $150,000 for rearing channel.

2.5 ELWHA PROJECT REMOVAL WITH RETENTION OF GLINES CANYON

This alternative involves the incorporation of fish passage measures at the Glines Canyon Project and the removal of the Elwha Project. The fish passage measures for the Glines Canyon Project would be those described in the applicant's proposal (Section 2.2). Elwha Project removal would be accomplished in the manner described in Section 2.3 (Removal of Both Dams). To maintain an acceptable power factor, 7,600 kVAR of capacitors would be installed to compensate for the loss of Elwha Project generation.

Construction activities associated with this alternative would be completed within 4 years of license issuance. During the construction period, the work effort would average about 13 man-years. Plant outages during construction would result in a one-time loss of about 175 GWh. Table 2-9 summarizes the costs of this alternative. The initial capital cost, exclusive of interest and plant outage during construction, is estimated at approximately $30 million (1990 dollars).

Annual generation would average 100 GWh under this alternative. Operation and maintenance requirements would dictate a 7-person staff.

Table 2-9. Cost summary for the Elwha Project removal alternative (Source: Appendix A, Part 7, Table A-26).

Cost Category	Estimated Cost[1/] One-Time	Recurring(Annual)
Baseline operation and maintenance		566,000
Elwha Project removal	24,473,000	40,000
Glines Canyon modifications	2,829,000	103,000
Fish restoration	3,070,000	240,000
Subtotal, initial capital cost	30,372,000	
Foregone power generation		
Outage during construction[2/]	4,352,000	
Fish facility releases[3/]		167,000
Loss of Elwha[3/]		6,720,000
Long-term repair and replacement	2,818,000	

[1/] 1990 dollars unless otherwise noted.
[2/] Based on forecasted cost of purchased power in 1994 (1994$).
[3/] Fifty-year levelized cost in 1996 dollars.
[4/] First 10 years only; after 10 years cost decreases to $150,000 for rearing channel.

2.6 REPLACEMENT POWER

Reduced output from the Elwha and Glines Canyon projects, or their entire loss, would require the Daishowa America Mill to replace the lost electrical energy from other sources. Potential sources of replacement power would be: (1) utilizing in-mill conservation potential, (2) new power production facilities at the mill (probably cogeneration), and (3) acquiring additional supplies from the regional system through the BPA and the City of Port Angeles. In any of the three cases, the loss of generation from the Elwha and Glines Canyon projects would represent an increased load which would have to be met by conservation or generating resources. To the extent that the replacement resource is then no longer available to meet the region's future projected electrical energy deficits, resources additional to those that would otherwise have been required would need to be called upon to meet the region's load.

In planning to meet the region's future power needs, the Northwest Power Planning Council has developed a portfolio of cost-effective conservation and generating resources. The resource portfolio is used by the Council to assess resource scheduling requirements and the cost-effectiveness of specified resource acquisition and development proposals. Cost-effective resources are those that meet criteria of relative cost, availability, reliability, and environmental acceptability. The specific resources required from the portfolio are a function of future load growth.

Any or all of the portfolio's resources are considered nonexclusionary alternatives to the Elwha and Glines Canyon projects; that is, while the timing and extent of development of the portfolio's resources could be influenced by the loss of Elwha and Glines Canyon generation, the existence or nonexistence of Elwha or Glines Canyon would neither preclude nor necessitate development of any particular resource from the portfolio. For example, to the extent that there is cost-effective conservation available at the Daishowa America Mill, that conservation resource is available to the region irrespective of what happens to the Elwha and Glines Canyon projects. On one hand, the existence of the projects does not preclude the conservation resource from being tapped; any Elwha/Glines Canyon power not needed because of conservation savings at the mill could be transmitted to other power users in the region. Conversely, the termination of the Elwha and Glines Canyon projects do not necessitate the utilization of any conservation opportunity at the mill; the power could be replaced by other conservation or generating resources in the region.

Each of the resources identified by the Council as cost-effective is described in Appendix A, Part 8. Table 2-10 summarizes the council's assessment of energy available from each of the resources considered for the resource portfolio.

Table 2-10. Resource availability for the resource portfolio[1/].

Resource	Available energy (MWA)	Comment
Conservation	2,375	Reassessment underway
Transmission and distribution loss reduction	200	
Conservation voltage regulation	100	Assessment underway
Hydropower efficiency improvements	110	
Natural gas (for backing up nonfirm hydropower)	712	Cost-effective limit with 1986 gas price forecast using simple cycle turbines; reassessment underway
New hydropower	410	
Cogeneration (biomass and natural gas)	190 - 320	Reassessment underway
Coal	4,800	Environmental uncertainties, tentative estimate
Thermal plant efficiency improvements	219	Insufficient data for assessment of coal plant opportunity
Geothermal	350	
Wind	400	
Biomass	120	Includes municipal solid waste; tentative
Nuclear (WNP-1 and WNP-3)	1,686	Uncertain ability to finance preservation and completion
Solar	--	Not cost competitive
New imports	--	Not estimated

[1/] Source: NPPC, 1989a; 1990.

2.7 ECONOMIC EVALUATION OF THE APPLICANT'S PROPOSAL AND ALTERNATIVES

The economic impact of the alternatives can be viewed properly from two distinct perspectives, regional and local. Both perspectives are important, and the Draft Environmental Impact Statement (DEIS) addresses both. The regional perspective provides the basis for evaluating the overall dollar costs from a broad public interest perspective. In this analysis, the value of energy foregone is the estimated cost of generating an equivalent amount of energy by means of the region's long-term marginal resource (Section 2.7.2).

The local perspective serves as a basis for assessing the cost impact to the Daishowa America Mill and the associated socioeconomic effects on the local economy of Port Angeles (Section 2.7.3). For this analysis, alternative energy sources are valued at the estimated price for purchasing replacement power.

Prior to undertaking these two economic analyses, the present use of project power is described, along with the terms of that use (Section 2.7.1).

2.7.1 Use of Project Power

The current disposition of the power output from the Elwha and Glines Canyon projects provides a backdrop for assessing the economic costs and benefits of the alternatives. Prior to the fall of 1987, James River Corporation owned the paper mill at Port Angeles and the two projects. All power generated by the projects was used to serve the needs of the mill. In the latter part of 1987, James River sold its paper mill to Daishowa America. Under the terms of a formal power supply agreement associated with the sale of the mill, James River and Daishowa agreed to the following:

1. James River continues to own and control the hydroelectric projects;

2. Subject to James River's oversight, Daishowa operates the projects for James River;

3. Daishowa is responsible for paying the operating costs of the projects;

4. The entire electrical output of both projects is provided to Daishowa for its use in the mill;

5. James River is responsible for all aspects of the licensing process;

6. James River will provide a partial refund of the sales price for the mill to Daishowa in the event that the power supply agreement terminates during its first 5 years due to project termination or related events;

7. In the event that the projects receive licenses with terms and conditions that allow economically feasible operation, and upon the request of either party, James River and Daishowa will jointly apply to the Commission for authorization to transfer both projects to Daishowa;

8. In the event that the projects become uneconomical for Daishowa, James River may continue to own the projects, operate them, and sell their output to another party; and

9. In the event that a request for a transfer of license was denied by the Commission, the arrangement for providing power to the mill would expire unless either party exercises an option to extend the agreement for an additional period of 10 years. In this case, after expiration of the agreement, including any extensions, James River would be free to sell the projects' electrical output to another party (James River II, 1990b).

Over the past 8 years, the Elwha and Glines Canyon projects have contributed between 34 and 42 percent of the mill's energy requirements (Table 2-11). The remainder of the power required by the mill is purchased from Port Angeles City Light, which receives its power from BPA. Daishowa America has proposed an expansion of the mill, which would be associated with an increased annual energy requirement of approximately 195 average MW, or about 1,708 GWh in annual energy requirements. With the expansion, the hydroelectric projects' contribution would fall to about 8 percent of total mill requirements. Currently, mill expansion is not being vigorously pursued.

2.7.2 Long-Term Marginal Resource Comparison

The applicant's proposal for dam retention would be the least cost alternative at $39 million (Table 2-12). The highest cost alternative would be removal of both dams ($245 million). The majority of the cost associated with removal of both dams (67 percent) is associated with the loss of power generation.

The costs of the remaining two alternatives fall at intermediate cost levels, $184 million for Glines Canyon removal with retention of Elwha and $103 million for Elwha removal with retention of Glines Canyon.

To assess project economics, net present value analysis was applied to each of the four principal alternatives. The three elements included in the economic analysis were: (1) the dollar cost of constructing (or removing) project facilities (including plant outage costs during construction); (2) incremental increases or decreases in the base operation and maintenance costs attributable to the alternatives; and (3) the value of power generation foregone as a result of implementing the alternatives. Because of the absence of generally accepted methodologies, no attempt was made to assign dollar estimates to nondevelopmental values such as fish production, recreational use, terrestrial resources, or aesthetics.

Table 2-11. Daishowa America Mill power requirements and project utilization (Source: letter from Yutaka Mochizciki and Stan Hicks, Daishowa American, March 29, 1990; James River II, 1988a).

Year	Gigawatthours			
	Elwha Project [1/]	Glines Canyon Project [1/]	Total hydroelectric	Mill require-ments
1982	73	103	176	455
1983	76	105	181	455
1984	75	106	181	440
1985	53	85	138	411
1986	59	90	149	387
1987			153	399
1988			171	411
1989			140	396
8-Year Average			161	419

[1/] Includes 4 percent adjustment for transmission loss.

The Pacific Northwest is characterized by an intertied electrical system and a coordinated planning approach defined by the Pacific Northwest Electric Power Planning and Conservation Act. From a regional perspective, the addition or elimination of a generating resource in the region results in an adjustment in the region's load/resource balance. The regional dimension of the potential loss of power generation at the Elwha and Glines Canyon projects is reinforced by the practical considerations in responding to that loss.

BPA is obligated by the existing power sales contract with the City of Port Angeles (and the Northwest Power Act) to serve load growth, including industrial loads, to the extent that Port Angeles requests such service. Similarly, BPA would be required to serve the additional load if the generation from the Elwha and Glines Canyon projects ceased to be available to Daishowa, if Daishowa were to request additional service from Port Angeles to substitute for the lost

Table 2-12. Economic analysis summary, net present value cost of the alternatives (Source: the staff).

Alternative	Incremental Costs (thousands of 1996 dollars)[1/] Capital and O&M costs	Value of Lost Generation [2/]	Total Cost
Applicant's dam retention proposal	$35,583	$3,530	$39,113
Removal of both dams	80,855	164,221	245,076
Glines Canyon removal with retention of Elwha	84,383	99,960	184,343
Elwha removal with retention of Glines Canyon	35,088	67,881	102,969

[1/] Present value of costs occurring over the 50-year period of analysis.

[2/] Lost generation valued at the 50-year levelized cost of the region's long-term marginal generating resource.

generation, and if Port Angeles sought service from BPA to meet the increased Daishowa load (Washington Department of Ecology, 1989).

The economic benefits (or costs) of the proposed and alternative actions associated with the Elwha and Glines Canyon projects were estimated through comparative evaluation with the cost of providing a comparable amount of power by means of the region's long-term marginal generating resource (coal-fired powerplant) as defined by the Council. Because of the abundance of coal reserves available to the Northwest and because of the proven nature of coal-fired powerplant technology, the Council uses the cost and performance characteristics of coal-fired powerplants as the basis for estimating long-term marginal resource costs. The cost of the Council's benchmark coal plant is used by the Council as a threshold value against which to compare other resources. Resources with costs that are less than the coal-fired alternative are included in the Council's resource portfolio, as long as they satisfy certain other criteria of availability, predictability, and acceptability. The resource portfolio then serves, in the Council's planning process, as a pool of cost-effective resources from which to plan in response to an uncertain energy future.

The least cost resource mix for any particular energy future is determined by the load forecast. In its 1989 Supplement to the 1986 Power Plan, the Council's least-cost planning analysis calls for new coal-fired resources as early as 1995 in the case of the high load forecast (e.g., as quickly as they can be brought on-line), in 1998 for the medium-high forecast, and approximately 2007 for the medium-low forecast. For the low load forecast, new coal-fired plants are not called for during the Council's 20-year planning period. For analytical purposes and in light of trends in the regional load/resource balance, the staff has assumed that the region will require a new coal-fired powerplant to meet firm energy deficits in 1998, the date indicated by the Council's medium-high forecast.

To assess economic benefits of the proposed project, the staff compared the levelized unit cost of the hydroelectric project to the levelized cost of providing an equivalent amount of power from the region's long-term marginal resource, the Council's benchmark coal-fired powerplant. The "levelized" cost is the constant annual amount equivalent to the discounted value of costs over the period of analysis.

Equivalence between the hydroelectric and coal-fired alternatives was achieved by modifying the fixed costs of the coal-fired powerplant to reflect the nonfirm portion of the hydroelectric project's output. The coal-fired powerplant capacity cost was reduced by an amount representing the cost of the combustion turbine capacity needed to firm the hydroelectric project's nonfirm generation under critical water conditions. The 50-year levelized cost of equivalent coal-fired generation is about 96 mills/kWh in 1996 dollars.

The applicant proposes to complete the installation of fish passage facilities in 1996 (assuming issuance of licenses by mid-1992). This time frame closely matches regional needs under the Council's high and medium-high load growth forecasts, but is in advance of projected firm energy need under the Council's medium-low and low forecasts. Therefore, prior to the time when the staff has assumed new coal-fired resources to be needed to meet firm energy deficits (e.g., 1998), the economic power benefits attributable to the hydroelectric project are limited to those associated with displacing the variable cost of energy generation from existing regional coal-fired plants.

The cost of any energy generation foregone due to construction outages was treated as an expense to the applicant and was valued at the forecasted cost to the mill for purchasing replacement power at the time the outage is anticipated to occur.

In keeping with the staff's standard practice, the economic analysis was conducted using nominal (i.e., current) dollars, with a long-term inflation rate assumption of 5.0 percent. The cost data for the coal-fired powerplant and combustion turbine alternatives, including fuel cost escalation, were based on Council estimates (NPPC, 1989a).

The estimated construction costs, including any necessary cost for power factor correction, were inflated to the midpoint of construction at 5.0 percent. Interest was added for funds used during construction, based on a rate equal to the assumed long-term private financing rate. Capital improvements to the projects were assumed to be financed at 11.0 percent interest over 30 years. The period of analysis was 50 years. Operation and maintenance costs were assumed to inflate at 5.0 percent over the period of analysis. Comparable treatment was afforded the coal-fired plant alternative and the associated combustion turbine.

The cost categories considered for each alternative are summarized in Table 2-13, while the cost and energy estimates used to characterize the alternatives are presented in Table 2-14.

Table 2-13. Cost categories included in the economic analyses (Source: the staff).

Cost Category[1/]	Applicability
Capital cost of project modifications	All alternatives
Power factor correction costs	Dam removal alternatives
Interest during construction	All alternatives
Plant outage during construction	All alternatives
Baseline operation and maintenance of the hydroelectric plant	Credit to alternatives involving dam removal
Operation and maintenance associated with project modifications	All alternatives
Long-term repair and replacement costs	Credit to alternatives involving dam removal

[1/] Project removal would advance the need for transmission upgrades presently planned by BPA. Loss of both projects could advance the construction as much as 5 years, but the actual timing would be principally determined by load growth in the Port Angeles area. The cost of advanced construction of the transmission upgrade has been excluded from the analysis due to the uncertainty of construction timing.

Table 2-14. Energy output and cost summary, by alternative (thousands of dollars) (Source: the staff).

Alternative	Average Annual Energy (GWh)	Initial Capital Costs (1990$)	Outage During Construction (1994$)	Long-Term Repair & Replacement (1990$)	Recurring Annual Expenses (1990$)	
					Base O&M	Incremental O&M
Applicant's Dam Retention Alternative	168	14,670	1,238	9,013	1,525	518 2/
Removal of Both Dams	-0-	64,245 1/	11,061	-0-	-0-	315 3/
Glines Canyon Removal with Retention of Elwha	68	49,138 1/	7,947	6,195	959	460 2/
Elwha Removal with Retention of Glines Canyon	100	30,372 1/	4,352	2,818	566	383 2/

1/ Includes cost of power factor correction.

2/ After first 10 years, decreases by $90,000.

3/ After first 10 years, decreases by $240,000.

2.7.3 Assessment of Daishowa America Mill Power Cost Impacts

Each of the alternatives under consideration would directly affect the cost of power to the Daishowa America Mill. The effect would result from a combination of decreased hydroelectric generation provided to the mill and a higher cost for any remaining hydropower generated.

All alternatives would result in a substantial increase in the cost of power for the hydroelectric portion of the mill's total electrical energy supply. The increase in total mill energy costs resulting from the increased cost of the hydroelectric component is proportionately less at higher mill energy demand levels.

The Elwha and Glines Canyon hydroelectric projects currently provide about 38 percent of the mill's electrical energy requirements (Section 2.7.1). The remainder of the mill's electrical energy needs are met by Port Angeles City Light, which in turn is served by BPA. Thus, the mill's total electrical energy costs is a composite of hydroelectric generation costs and purchased power costs (Table 2-15).

The cost of power to the mill from the hydroelectric projects is substantially less than the cost of power purchased from the city [e.g., 10.4 $/megawatthour (MWh) hydroelectric versus 24.1 $/MWh for purchased power in 1989]. As a result in 1989, the Elwha and Glines Canyon projects accounted for 19 percent of the mill's total energy cost and provided a substantial 35 percent of total energy requirements.

The future amount of power provided to the mill from the Elwha and Glines Canyon projects, and the cost of that power, were estimated by the staff for a 10-year period beginning in 1996, the year when all fish passage facility costs would have been incurred (Table 2-16). A reference case is also provided which reflects what the cost of Elwha and Glines Canyon power would be in the absence of any modifications.

The applicant's dam retention plan results in power costs for the hydroelectric projects that are substantially higher (10-year average of 39.0 mills/kWh) than would occur in the absence of project modifications (17.9 mills/kWh). The power costs associated with the applicant's dam retention plan would be comparable, over the first 10 years, to the cost of purchasing BPA power from the City of Port Angeles.

It should be noted that for alternatives that involve removal of one or more dams, the cost of dam removal has been excluded from the power cost calculations presented in Table 2-16. For example, the estimated 10-year average power cost for Glines Canyon removal and retention of Elwha (71.1 mills/kWh) reflects the costs of modifying the Elwha Project, but does not include the cost of removing Glines Canyon. To cover the cost of Glines Canyon removal in the power cost of

Table 2-15. Daishowa America Mill power costs (Source: the staff, modified from letter from Priscilla Derick, Attorney for James River II, March 29, 1990).

Item	1988	1989
Purchased Power		
Usage:		
Peak 60-minute demand (MW)	56.2	54.0
Energy (GWh)	239.9	255.8
Rates:		
Capacity ($/kW)	2.99	2.99
Energy ($/MWh)		
Sept - March	20.3	20.3
April - August	15.9	15.9
Actual Unit Costs:		
Capacity ($/kW)[1/]	2.69	2.48
Energy ($/MWh)[2/]	18.8	18.8
Composite ($/MWh)[3/]	24.0	24.1
Annual Cost:		
Purchased Power	$5,764,479	$6,173,387
Hydroelectric Generation		
Usage:		
Peak Monthly Average Output (MW)	27.8	26.6
Energy (GWh)	171.0	140.0
Unit Costs:		
Routine O&M ($/MWh)	6.2	10.4
Annual Cost:		
Hydroelectric Generation	$1,058,799	$1,452,001
TOTAL POWER COST	$6,823,278	$7,625,388

[1/] Includes adjustment for off-peak demand credits.
[2/] Winter/summer melded cost.
[3/] Total annual cost divided by total energy purchased.

Table 2-16. Forecasted availability and cost of hydroelectric generation. (Source: the staff).

Year	Unit Power Costs (nominal mills/kWh)				
	Reference case (no modifications, 172 GWh)	Applicant's dam retention proposal (168 GWh)	Removal of both dams (0 GWh)	Glines Canyon removal and retention of Elwha (68 GWh) [1]	Elwha removal and retention of Glines Canyon (100 GWh) [1]
1996	15.0	35.0	N/A	64.3	23.8
1997	15.6	35.7	N/A	65.6	24.4
1998	16.2	36.6	N/A	67.0	25.0
1999	16.8	37.4	N/A	68.4	25.6
2000	17.4	38.3	N/A	70.0	26.3
2001	18.1	39.3	N/A	71.5	27.0
2002	18.8	40.3	N/A	73.2	27.8
2003	19.6	41.3	N/A	75.0	28.6
2004	20.4	42.4	N/A	76.8	29.4
2005	21.2	43.5	N/A	78.7	30.3
Average	17.9	39.0	N/A	71.1	26.8

[1] Dam removal costs excluded from the cost calculation. If the cost of removal was included, the average cost of power for the Glines Canyon removal and the Elwha removal alternatives would be 179 mills/kWh and 72 mills/kWh, respectively.

the remaining Elwha Project would result in a value of 179 mills/kWh, rather than the 71.1 mills/kWh shown.

The quantity and source of the mill's remaining requirement cannot be predicted with certainty. Currently, all power requirements not met by generation from the hydroelectric projects are satisfied by power purchases from Port Angeles City Light. In the future, the mill will likely continue to purchase power from Port Angeles City Light, but the quantity purchased would be dependent on mill expansion and realization of in-mill conservation potential.

The mill's untapped conservation potential is unknown, as is the cost to the mill of implementing such conservation. According to Daishowa America, "further cost effective conservation opportunities are relatively limited" (letter from Priscilla Derick, Attorney for James River II, March 29, 1990). No confirming site-specific audit of conservation potential has been reported. In the pulp and paper industry, electricity use can vary widely among plants because each plant has unique process and equipment (NPPC, 1989b). According to the Council, the conservation measures that can typically be applied are: motor replacements, process cooling, heating and drying measures, pumping measures, and lighting improvements. Daishowa America over the past 2 years has achieved conservation savings from paper machine and refiner screen rebuilds and upgrades (Appendix A, Part 8, Section 8.1).

To reflect the uncertainty associated with the forecast of the mill's future power requirements, the staff developed three alternative scenarios: (1) continuation of current use (400 GWh); (2) current use plus Phase I mill expansion estimates (1,320 GWh); and (3) current use less 25 GWh per year. The latter alternative is a hypothetical case provided for illustrative purposes. It is based on an arbitrary assumption that cost-effective conservation measures can be found in the mill that represent approximately the conservation savings reported by Daishowa America since the beginning of 1989. This hypothetical case further assumes that the mill does not have to bear the cost of tapping those conservation resources; rather, it is assumed that the costs are borne by the public sector through such programs as BPA's Energy Saving Program for industrial conservation.

The power not provided by either conservation savings or hydroelectric generation is assumed by the staff to be met by continued purchase of BPA power through Port Angeles City Light (Section 2.7.2). The forecasted price of purchased power is based on estimates provided by BPA and adjusted for Port Angeles City Light overhead costs and state and local taxes (Table 2-17).

Two different rate categories could potentially apply to all or a portion of the replacement power purchased from the city, Priority Firm (PF) and New Resource (NR). In the absence of major mill expansion, the PF rate is applicable. Currently, all Port Angeles City Light power is provided by BPA at the PF rate. The NR rate would only become relevant if there was a "new large single load" (an establishment that increases its load by 10 average MW over the 1987 contract

Table 2-17. Projected price of purchased power to Daishowa America Mill (Source: the staff).

Year	Rate ($/MWh)			
	BPA Rate to Port Angeles City Light[1/]		City Light Rate to Daishowa America[2/]	
	Priority Firm	New Resource	Priority Firm	New Resource
1996	27.7	42.5	30.7	47.2
1997	29.2	46.5	32.4	51.6
1998	30.6	49.0	34.0	54.4
1999	32.5	51.8	36.1	57.5
2000	33.9	55.1	37.6	61.2
2001	35.4	57.8	39.3	64.2
2002	37.0	60.8	41.1	67.5
2003	39.3	65.7	43.6	72.9
2004	41.0	68.7	45.5	76.3
2005	43.6	74.1	48.4	82.3
Average			38.9	63.5

[1/] Wholesale Power Rate Projections 1989-2010, Bonneville Power Administration, October 1989.

[2/] Adjustment of 11 percent based on personal communication, Robert Titus, Director Port Angeles City Light, July 27, 1990.

determination level within a 12-month period). The determination level for the Daishowa America Mill is 40.3 average MW, so the mill's load could increase from the present 25 to 28 average MW to 50.2 average MW (and 9.9 MW more in each subsequent year) without triggering the NR rate. Thus, even the loss of the generation from both Elwha and Glines Canyon projects (19.6 average MW) would not cause the threshold to be exceeded. Accordingly, the PF rate has been used in the cost analysis for the current use and the current use less conservation savings scenarios, while a combination PF and NR rate has been assumed for the mill expansion scenario.

A comparison of Tables 2-16 and 2-17 indicates that the power costs associated with the applicant's dam retention plan would be comparable to the price of BPA power (priority firm rate) purchased through Port Angeles City Light. The cost of power for the Glines Canyon removal alternative (71.1 mills/kWh) would be substantially in excess of purchased power costs over the first 10 years, while the Elwha removal alternative would result in costs (26.8 mills/kWh) significantly less than the other alternatives, but more than the reference case.

With respect to overall power costs to the mill, all alternatives would result in higher overall costs than under the no-modification reference case (Table 2-18). As long as the cost of dam removal was not passed along to the mill, the applicant's dam retention plan and the removal of both dams alternative would result in essentially the same overall power costs to the mill (approximately 39 mills/kWh for the 400 GWH demand scenario).

Table 2-18. Forecasted cost of power to Daishowa America Mill. (Source: the staff).

Year	Total Cost of Power (thousands of dollars, nominal)				
	Reference case	Applicant's dam retention proposal	Removal of both dams[1]	Glines Canyon removal with retention of Elwha[1]	Elwha removal with retention of Glines Canyon[1]
Continuation of Current Use Scenario (400 GWh)					
1996	9,607	12,988	12,280	14,544	11,595
1997	10,093	13,514	12,960	15,197	12,165
1998	10,561	14,024	13,600	15,822	12,707
1999	11,149	14,657	14,440	16,617	13,403
2000	11,604	15,158	15,040	17,218	13,922
2001	12,111	15,712	15,720	17,890	14,504
2002	12,647	16,298	16,440	18,601	15,120
2003	13,349	17,056	17,440	19,550	15,951
2004	13,920	17,682	18,200	20,306	16,604
2005	14,728	18,550	19,360	21,401	17,563
Sum	119,769	155,639	155,480	177,146	143,534
Average Weighted Cost of Power (mills/kWh)					
	29.9	38.9	38.9	45.3	35.9

[1] Dam removal costs not included.

Table 2-18. (Continued).

Year	Total Cost of Power (thousands of dollars, nominal)				
	Reference case	Applicant's dam retention proposal	Removal of both dams[1]	Glines Canyon removal with retention of Elwha[1]	Elwha removal with retention of Glines Canyon[1]
Current Use Plus Mill Expansion Scenario(1,320 GWh)					
1996	50,997	54,441	56,480	57,633	54,161
1997	55,198	58,694	61,334	62,279	58,638
1998	58,094	61,636	64,607	65,455	61,695
1999	61,411	65,002	68,346	69,082	65,191
2000	64,999	68,643	72,453	73,042	68,999
2001	68,105	71,803	75,954	76,448	72,274
2002	71,492	75,245	79,781	80,165	75,848
2003	76,805	80,625	85,885	86,023	81,495
2004	80,319	84,199	89,844	89,876	85,199
2005	86,265	90,218	96,669	96,428	91,516
Sum	673,686	710,506	751,353	756,432	715,014
Average Weighted Cost of Power (mills/kWh)					
	51.0	53.8	56.9	57.3	54.2

[1] Dam removal costs not included.

Table 2-18. (Continued).

Year	Total Cost of Power (thousands of dollars, nominal)				
	Reference case	Applicant's dam retention proposal	Removal of both dams[1]	Glines Canyon removal with retention of Elwha[1]	Elwha removal with retention of Glines Canyon[1]
Current Use Less Conservation Savings Scenario (375 GWh)					
1996	8,287	11,457	10,793	12,915	10,151
1997	8,703	11,910	11,391	13,488	10,645
1998	9,104	12,351	11,953	14,036	11,116
1999	9,606	12,895	12,691	14,733	11,720
2000	9,998	13,329	13,219	15,261	12,171
2001	10,433	13,809	13,817	15,851	12,677
2002	10,893	14,316	14,449	16,475	13,212
2003	11,493	14,968	15,328	17,307	13,932
2004	11,984	15,510	15,997	17,971	14,500
2005	12,673	16,257	17,016	18,929	15,331
Sum	103,174	136,802	136,653	156,965	125,454
Average Weighted Cost of Power (mills/kWh)					
	27.5	36.5	36.5	41.9	33.5

[1] Dam removal costs not included.

3.0 AFFECTED ENVIRONMENT

3.1 GENERAL DESCRIPTION OF THE ELWHA RIVER

The Elwha and Glines Canyon projects are located on the Olympic Peninsula near Port Angeles in northwest Washington. Both projects are within Clallam County and occupy portions of the lower mainstem Elwha River (Figure 3-1).

The Elwha River is a major Pacific Northwest waterway that is unique due to its location in a pristine watershed. The majority of the Elwha River watershed is located in Olympic National Park, and is protected from timber harvest, agriculture, and other land-use disturbances. Within the park boundaries, flow regimes of the river tributaries are natural and water quality is excellent. The Elwha flow regime below Lakes Mills and Aldwell is essentially natural due to dam operations that approximate run-of-river conditions. Sediment discharge and water quality in the middle and lower reaches, however, has been altered by the dams.

The Elwha River has a drainage area of 321 square miles, of which 267 square miles (83 percent) are located in Olympic National Park. The basin is approximately 10 miles wide in an east-west direction and 35 miles long (U.S. Army Corps of Engineers, 1987). The river flows in a northerly direction into the Strait of Juan de Fuca, entering the Strait 5 miles west of Port Angeles, a timber, tourism, and shipping community of about 17,000 and the largest town on the Olympic Peninsula. The Elwha River is the fourth largest river by drainage area among the major north Washington coastal and Strait of Juan de Fuca streams. Its watershed area is smaller than the Quillayute (629 square miles), Queets (449 square miles), and Quinault (434 square miles) rivers, and slightly larger than the Hoh River (298 square miles).

The Elwha Project (located at RM 4.9) and the Glines Canyon Project (located at RM 13.5) divide the Elwha River into lower, middle, and upper reaches (Figure 3-2).

3.2 GEOLOGY, SOILS, AND RIVER MORPHOLOGY

The elements of geology, soils, and river morphology are highly important in this impact analysis primarily because of the ways in which sediments stored in Lake Mills and Lake Aldwell might affect fish habitat and floodplain characteristics under the dam removal alternatives. Geophysical factors involving subsoil and bedrock formations are less important because of their relative stability with respect to the dams or other project features, with or without dam removal.

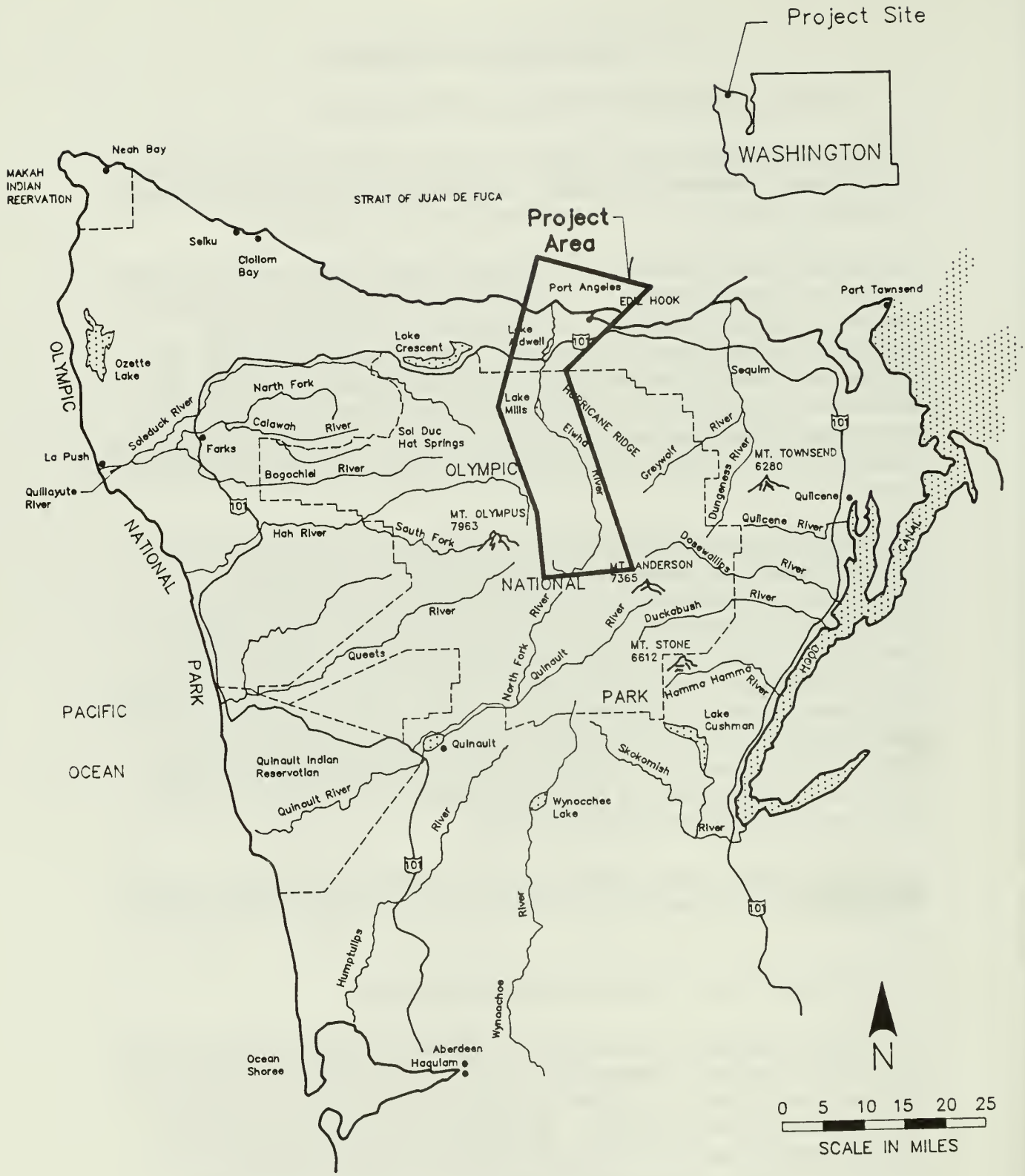


Figure 3-1. The Elwha and Glines Canyon projects area. (Source: the staff).

FIG31-1B.C

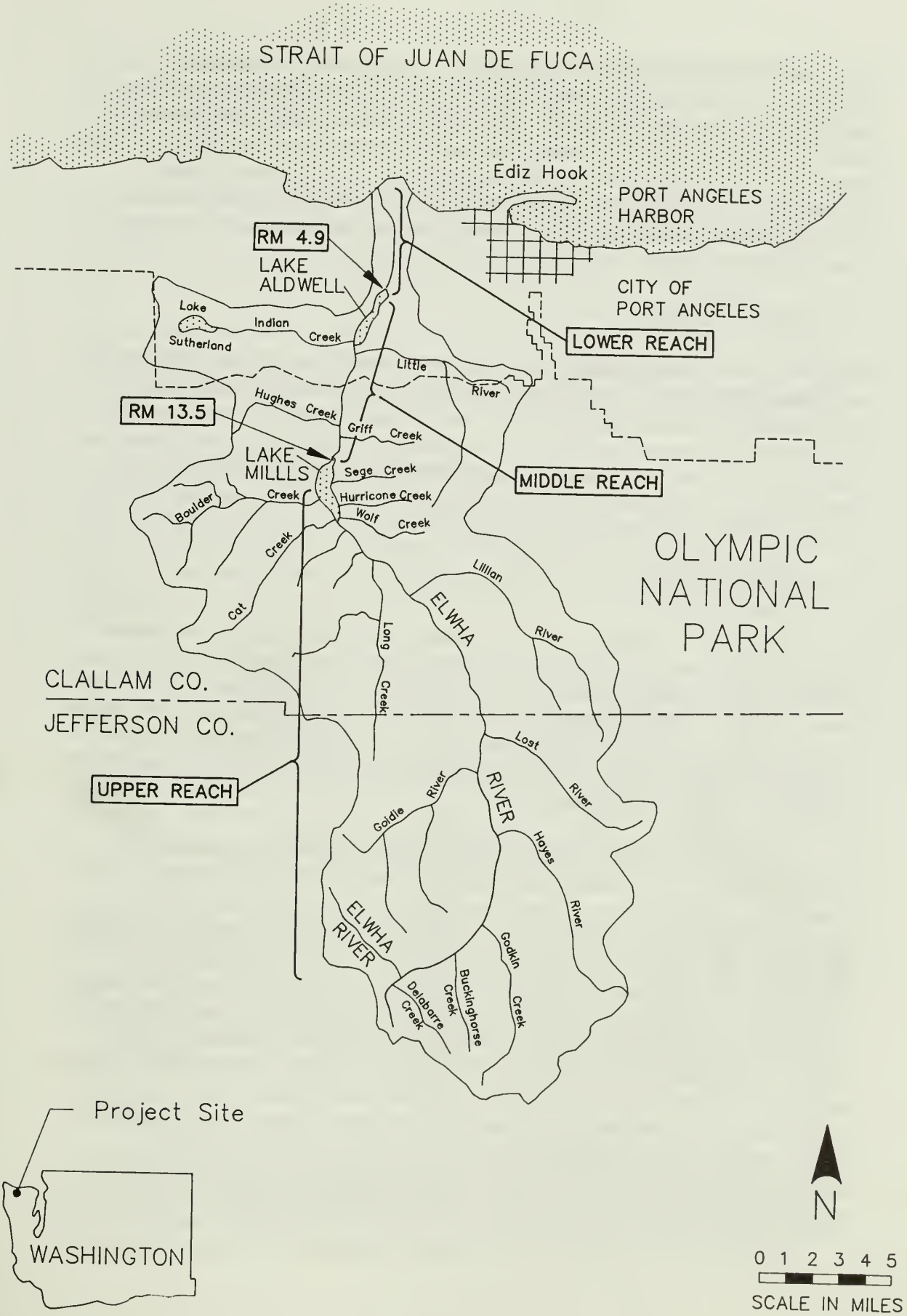


Figure 3-2. Three reaches of the Elwha River. (Source: the staff).

FIG312.DWG

The characteristics of both alluvial and colluvial sediments are important throughout the Elwha's three main reaches, its delta, and along the shorelines eastward and westward of its delta. The characteristics and dynamics of Ediz Hook are also related to the Elwha River and its eastern shoreline sediment dynamics, and are discussed in detail in this chapter. As in other Affected Environment chapters, there is some discussion of the historical perspective to illustrate pre-dam conditions, and to provide insight into processes which might ensue under any dam removal or dam retention action.

3.2.1 Bedrock Geology

The Elwha River Basin generally overlies heavily folded and faulted sedimentary and metamorphic rocks. The upper Elwha Basin overlies fine-grained rocks metamorphosed into slate and phyllite. The middle and lower Elwha reaches overlie mostly deformed sandstones. The Hurricane Ridge fault zone crosses the study area, but there is no evidence for recent fault activity (Crawford, 1976; Tabor, 1975). A detailed review of Olympic Peninsula bedrock geology is found in Tabor (1975) and Tabor and Cady (1978).

3.2.2 Surficial Geology

Surface deposits in the study area are dominated by glacial deposits and recent alluvium. The lower 3.5 miles of the Elwha River is cut into at least 150 feet of erodible, unconsolidated glacial outwash and till that was deposited by an ice sheet about 17,000 to 14,000 years ago. In the vicinity of Lake Mills, the river is cut into at least 600 feet of delta sediments that were deposited in a glacial lake impounded by the ice sheet. These glacial deposits provide much of the sediment transported by the Elwha River.

During the Fraser glaciation, about 13,000 to 20,000 years ago, the northern Olympic Peninsula was affected by continental ice extending out of British Columbia (the Cordilleran Ice Sheet) and alpine glaciers expanding from source regions within the Olympic mountains. During the maximum extent of the Fraser glaciation, one branch of the Cordilleran Ice Sheet blocked drainage from the Elwha River Valley creating a large glacial-age lake (referred to in this document as Glacial Lake Elwha) that may have extended 10 to 15 miles upstream from Lake Mills (Crandell, 1965; Tabor, 1975; Crawford, 1976; Thorson, 1980). Rivers draining into Glacial Lake Elwha deposited large amounts of sediment as deltas, the remnants of which can be seen in the eroding cliffs on the west side of Lake Mills. These deposits are at least 600 feet thick in places, and consist of coarse, stratified material interbedded with fine silts and clays from lake deposition. The remnants of these glacial lake deposits are relatively erodible, and currently supply sediment to Lake Mills and the Elwha River.

Extensive alpine glacial deposits in the upper basin are an important sediment source for the Elwha River (James River II, 1989), and during previous glaciations alpine ice extended at least as far as the southern end of Lake Aldwell (Crandell, 1965).

Retreat of the Cordilleran Ice Sheet led to the drainage of Glacial Lake Elwha and re-establishment of river drainage in the lower half of the Elwha River Valley. The Elwha River cut rapidly through the glacial deposits, leaving steep-sided slopes in the vicinity of Lake Mills, and bluffs cut into ice sheet deposits in the lower valley. Since deglaciation, the landscape of the Elwha River Valley has been modified primarily by mass wasting on slopes combined with river erosion and deposition. The major deposits associated with these processes are occasional landslide blocks and the extensive deposits of river alluvium in the lower reaches of the Elwha River (Figure 3-3).

3.2.3 Seismicity, Faulting, and Volcanism

The Puget Lowland is one of the more seismically active areas of the United States, but historically the earthquakes in this region have typically been of relatively small magnitude. No earthquake in the past 150 to 200 years west of the Puget Sound has exceeded magnitude 7.5 on the Richter scale (Hopper et al., 1975).

The Olympic Peninsula is heavily faulted, and at least two major fault zones cross through the study area (Figure 3-3). These fault zones developed at least 5 million years ago, and there is no evidence of major recent fault motion in the area (Tabor, 1975). These fault zones developed 12 to 30 million years ago and was probably also active 12 to 5 million years ago. Although there is no surface evidence of more recent major fault motion in the Olympic Peninsula, Wilson et al. (1979) have suggested limited fault motion in the southeastern part of the Olympic Peninsula as recently as 1,235 years ago.

Volcanism related to cascade volcanoes which include Mount Rainier, Mount Adams, Mount Baker and recently erupted Mount St. Helens pose little hazard to the project area. The primary hazard from these volcanoes, should they erupt, is volcanic ash which would drift downwind and cause minor maintenance problems. The prevailing westerly winds would transport the major portion of the ash into eastern Washington as occurred with the eruption of Mount St. Helens.

3.2.4 Soils

The Elwha study area is characterized by a relatively limited range of major soil types, described in detail by Halloin (1987). Soils throughout the area are post-Pleistocene (less than 8,000 years old) and are developed either directly from glacial sediments, or on alluvium or colluvium derived primarily from glacial

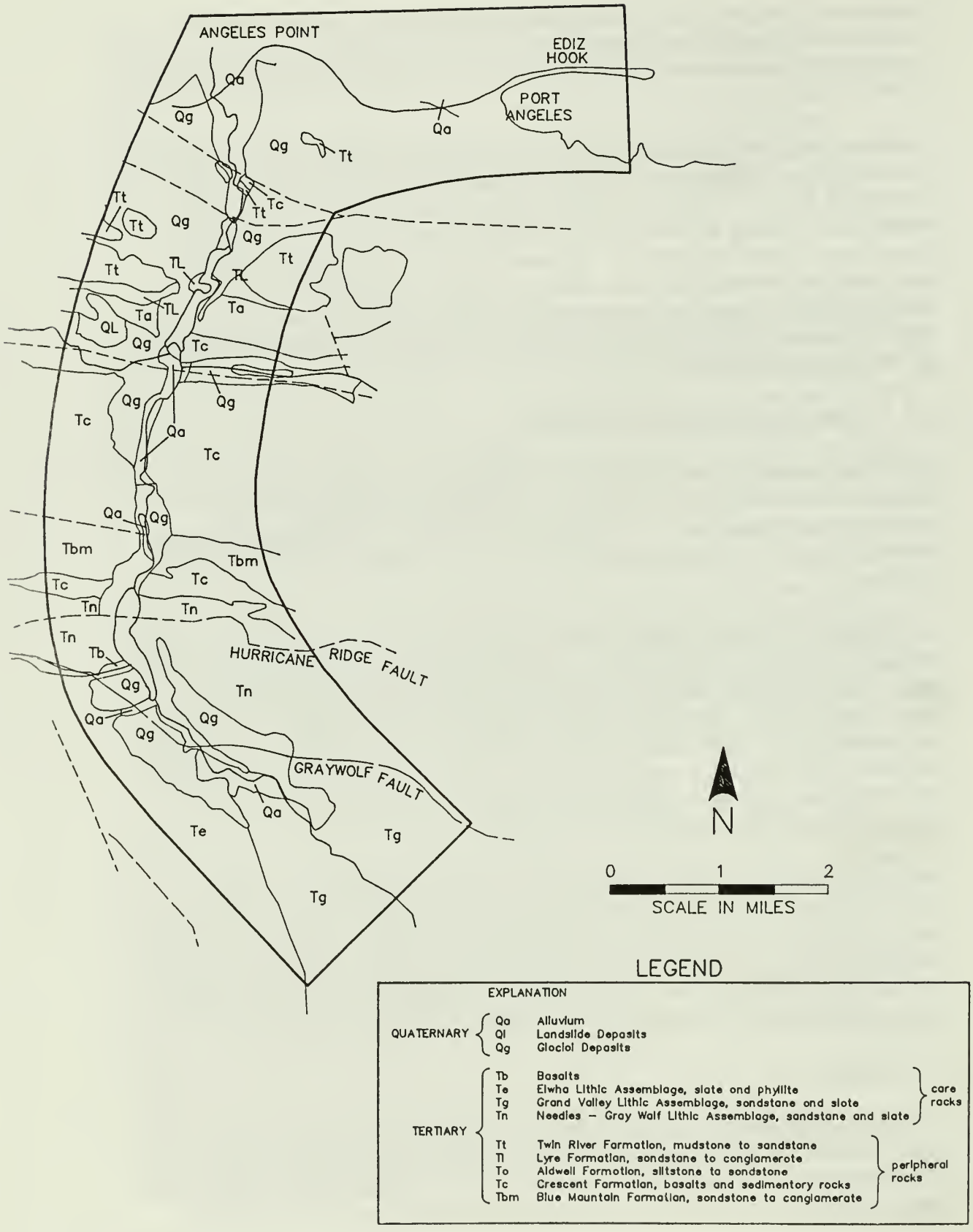


Figure 3-3. Middle and lower Elwha geologic map. (Source: the staff, modified from Tabor, 1975).

fig3–3a

sediments. In the upper part of the study area, the river's floodplain is quite narrow, or completely absent in some places. On steep side slopes the soils are well-drained colluvial units, and on floodplain areas the soils are well-drained gravelly loams or gravelly sandy loams which become increasingly gravelly and cobbly with increasing depth (Halloin, 1987). Most of the lower Elwha River has an extensive floodplain that includes soils of the Carlsborg-Puget-Dungeness soil unit, a series of well-drained soils on terraces, floodplains, and alluvial fans.

3.2.5 River Morphology and Sedimentology

The mainstem Elwha River is about 45 miles in length (Figure 3-4). Above RM 43 the river is very steep with an average gradient of 16 percent with boulder cascades. The river channel between RM 42 and Delabarre Creek (RM 40) has an average channel gradient of 6 percent. Below Delabarre Creek the river channel slope decreases to 1 percent and the channel meanders across alluvial deposits in the valley bottom. From RM 40 to Lake Mills, the river flows in alternating wide alluvial channels with slopes of 1 to 3 percent and narrow canyons. The middle Elwha channel (Figure 3-5) from Lake Mills to Lake Aldwell has alternating pools and riffles with an average slope of 0.8 percent. From the Elwha dam at RM 4.8 to RM 3, the Elwha channel is constrained in Elwha Canyon. The channel has steep bedrock walls with a bedrock and boulder bed. Below RM 3 the river opens up into a wide alluvial valley cut into gravelly glacial outwash sediments. The lower Elwha channel has an average slope of 0.4 percent with active point bars and side channels.

The Elwha River channel and coastal areas are affected to a significant degree by the Elwha dam (RM 4.8) and Glines Canyon dam (RM 13.4) which trap sediment and woody debris and alter river flow conditions. There are no detailed pre-project surveys of the morphology and sedimentology of the Elwha River system although limited direct and indirect information is available for certain areas from historic photos, old maps, notes from early river expeditions, and analysis of old river deposits.

3.2.6 Upper Reach

Above RM 40, the Elwha is a steep mountain river (average gradient 6 to 16 percent), dominated by boulder cascades and log jams. The log jams create backwater effects, trapping coarse sediments. As sediment builds up, the local bed slope is decreased, causing the deposition of a wedge of sediment grading from gravel near the log jam to large cobbles and boulders several hundred yards upstream. This decrease in channel gradient also causes the riverbed to widen and migrate laterally, often resulting in bank undercutting and log jam failure. The river periodically breaches one side of the obstruction, and cuts down through the stored alluvium to the level of the riverbed downstream of the jam, rapidly

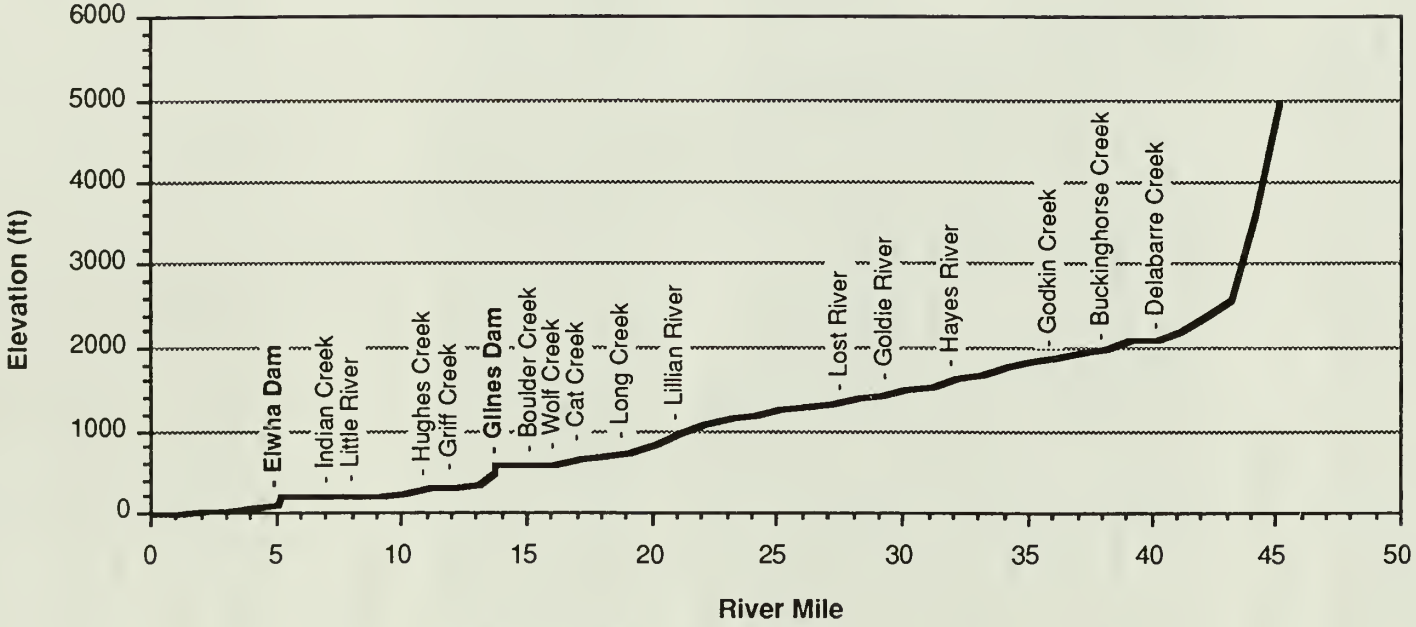


Figure 3-4. Longitudinal profile of Elwha River: river mile 45 to delta. (Source: the staff).

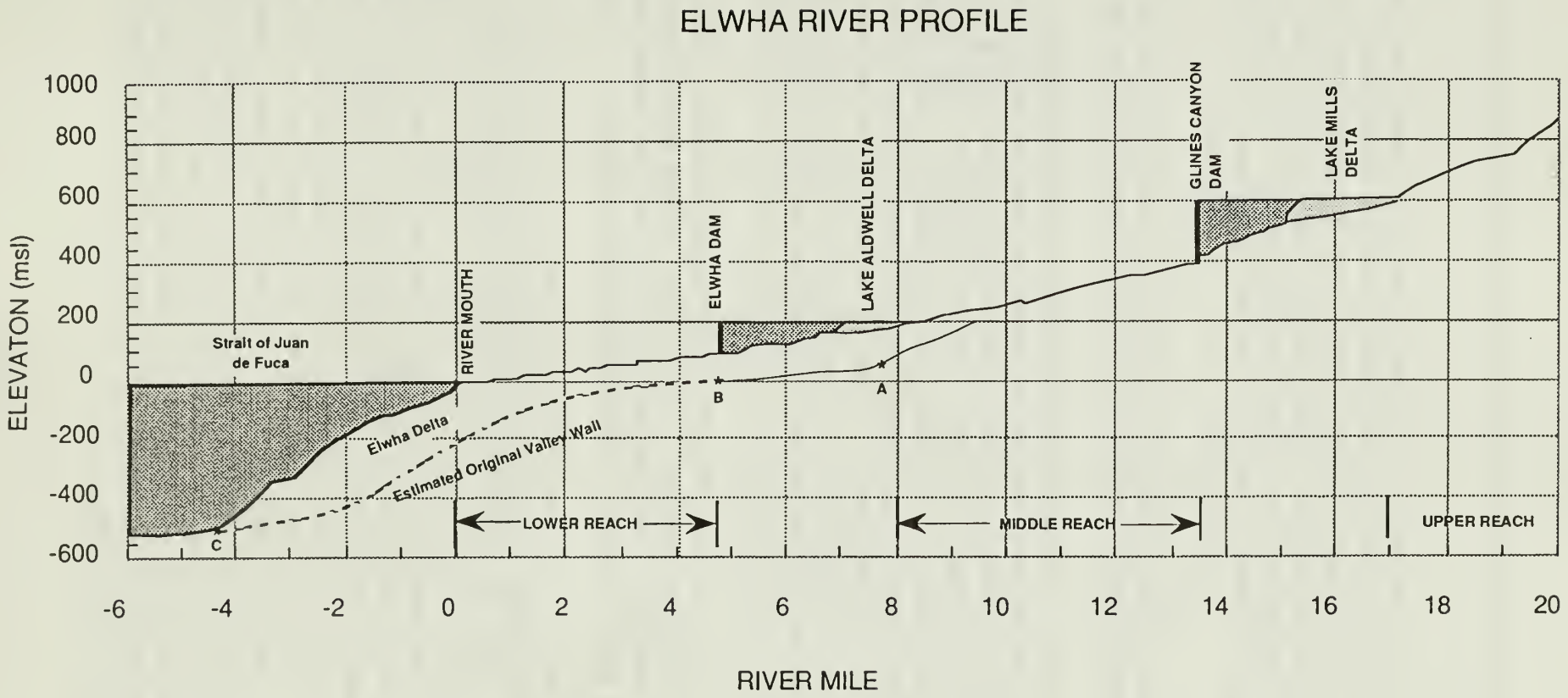


Figure 3-5. Elwha River longitudinal profile: river mile 20 to delta. (Source: the staff).

releasing the trapped sediment which is then transported downstream, often to the next log jam.

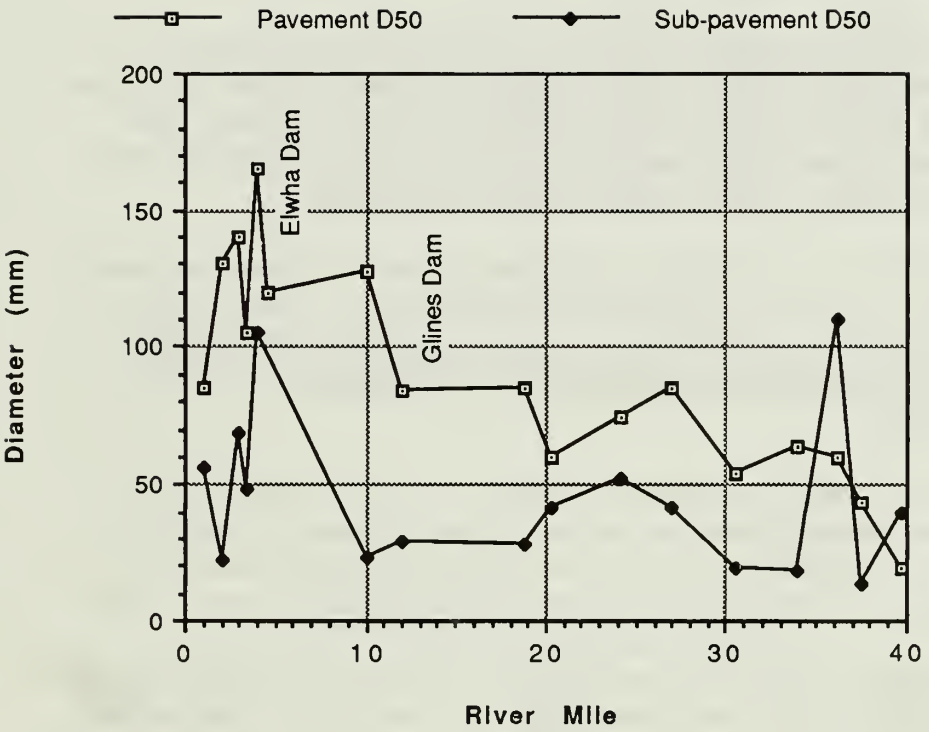
Below RM 40 (the confluence with Delabarre Creek), the Elwha River changes from a steep mountain river to a river flowing through alternating wide, low-gradient alluvial reaches (known locally as "bottoms" as in bottom lands), and narrow, high gradient canyons. This alternating bottom-and-canyon form is also typical from Lake Mills to Lake Aldwell, and thus conditions in this upper reach provide a good indication of pre-project conditions along much of the middle reach.

River substrate sampling (James River II, 1988b) indicates the sub-pavement and pavement channel substrate coarsens downstream of the dams (Figure 3-6).

The higher-gradient canyons are typically bedrock walled, with channels consisting of bedrock, large boulders and occasional gravel patches. Typically, large boulders are clustered together as riffles or rapids, while most of the gravel and cobble-sized sediment accumulates in the intervening pools. During high flows, channel sediment in the pools is scoured with coarse channel sediment being deposited in the riffles and gravels and sand being deposited on the river bars. Sands and silt, transported as suspended sediment, deposit on the tops of flood bars (overbank deposits) and are transported downstream with the silt and clay-sized material. The silt and clay-sized sediment washes through the system except for less than 1 percent that mixes with channel and overbank deposits.

At the outlet of the canyons, the channel widens and sand, gravel, cobbles and large woody debris are deposited. In the bottoms, the river channel typically meanders, reworking previously deposited river alluvium, and in some cases undercutting higher side-slope terrace deposits possibly associated with Glacial Lake Elwha.

Geyser Valley (also known as Krause Bottom and Press Valley) is the first bottom above Lake Mills, and consists of a wide, braided channel between Grand Canyon (RM 19.8) and Rica Canyon (RM 17.5). The overall channel slope is about 2 percent and bar material below the outlet of the Grand Canyon grades from boulders (3 to 6 feet in diameter) near the outlet to large cobbles several hundred yards downstream. Most sediment in the braided reach is composed of cobbles and large gravel. In several locations the river is eroding glacial terraces along its bank. Rica Canyon has steep bedrock walls with alternating boulder riffles and deep pools. Lake Mills backs up water at the end of Rica Canyon; therefore, most of the cobbles and boulders transported by the river are deposited within the canyon as large, aggrading bars. Before the creation of Lake Mills, this coarse material was presumably transported through Rica Canyon and deposited in the upper end of Smoky Bottom (the bottom between Rica Canyon and Glines Canyon now occupied by Lake Mills).



Note: Pavement D50 curve represents the median grain size in the pavement, or surface, layer. Sub-pavement D50 represents the corresponding curve for the median grain size in the sub-pavement layer.

Figure 3-6. Downstream changes in the Elwha River channel substrate. (Source: James River II, 1988b).

3.2.7 Lake Mills/Smoky Bottom

At least 10.9 million cubic yards of sediment are trapped in Lake Mills, with an estimated additional amount of 0.87 million cubic yards of mainly coarse material trapped in Rica Canyon and the lower reaches of Cat Creek. The average sediment transport rate into Lake Mills from 1926 to 1989 for sediment that is trapped in the lake is estimated at 180,000 cubic yards per year. With this estimate of the sediment transport rate, it will take about 300 years to fill Lake Mills with sediment.

The Lake Mills delta, with a total volume of 7.44 million cubic yards and maximum sediment thickness of 70 feet, is composed primarily of sand and gravel (Figure 3-7), with smaller amounts of clays, silts, cobbles and boulders. The volume of sediment in the Rica Canyon portion of the delta was estimated based on the river profile (Figure 3-5) and typical canyon cross-section.

Beyond the delta there are 4.31 million cubic yards of fine lake bottom sediments composed primarily of silt with some clay and minor amounts of sand (Figure 3-8). This fine material is spread fairly evenly to a thickness of 12 feet along the length of the lake. It is concentrated in the center of the reservoir and thins towards the margins.

The natural upstream sediment supply from above RM 13.52 of 260,000 cubic yards per year was estimated based on the total trapped sediment in Lake Mills plus an estimate of the amount of sediment that washes through the reservoir based on an average trap efficiency of 70 percent (HEC-6 model; Brune, 1953).

Several sources provide information concerning the characteristics of the area now occupied by Lake Mills before the Glines Canyon dam was built. A map of the reservoir area made prior to dam construction in 1921, and several photographs of the reservoir area taken before inundation (James River II, 1987) show a broad, slightly meandering and locally braided channel with gravel and cobble bars. The average slope of this reach was 1 percent (James River II, 1987) and the channel sinuosity was 1.1. The channel was not as braided as the present Elwha River in the Press Valley, but was bordered by extensive, gently sloping terraces up to 800 feet wide that show up on Mausolf's (1975) bathymetric chart of Lake Mills and in seismic profiles [James River II, 1987 (unpublished); James River II, 1990j].

3.2.8 Middle Reach

Recent aerial photographs (Walker & Associates, 1989) show that the middle reach meanders and braided forms are not highly active. Comparison with areas above Lake Mills suggests that these features were probably active before Glines Canyon Project construction, when sediment transport during high flows prevented vegetation establishment.

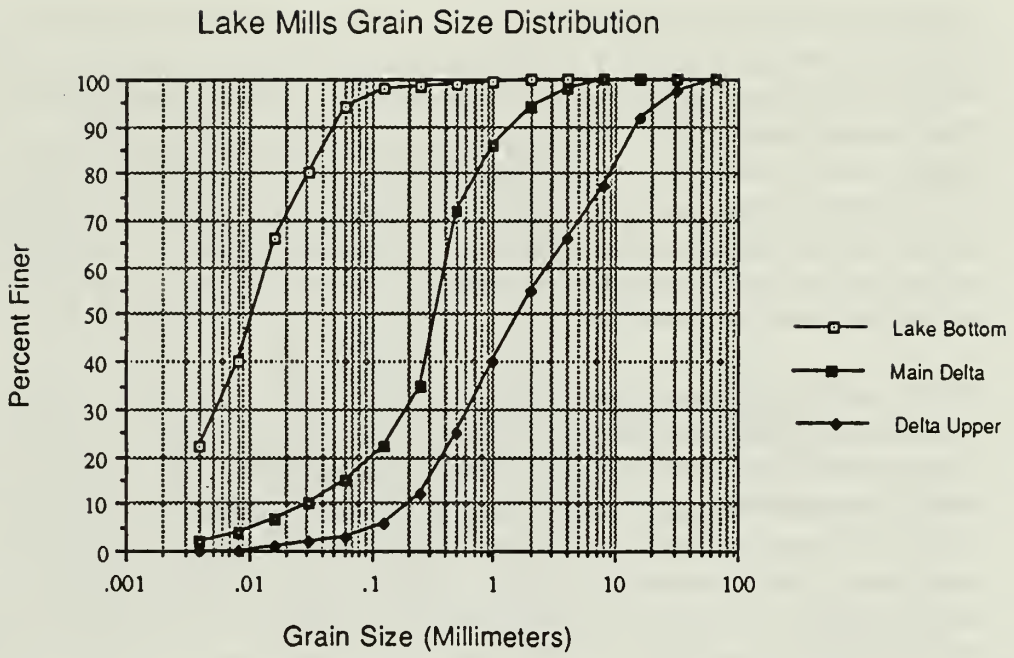


Figure 3-7. Lake Mills grain size distribution of sediment deposited between 1926 and 1989. (Source: James River II, 1988b).

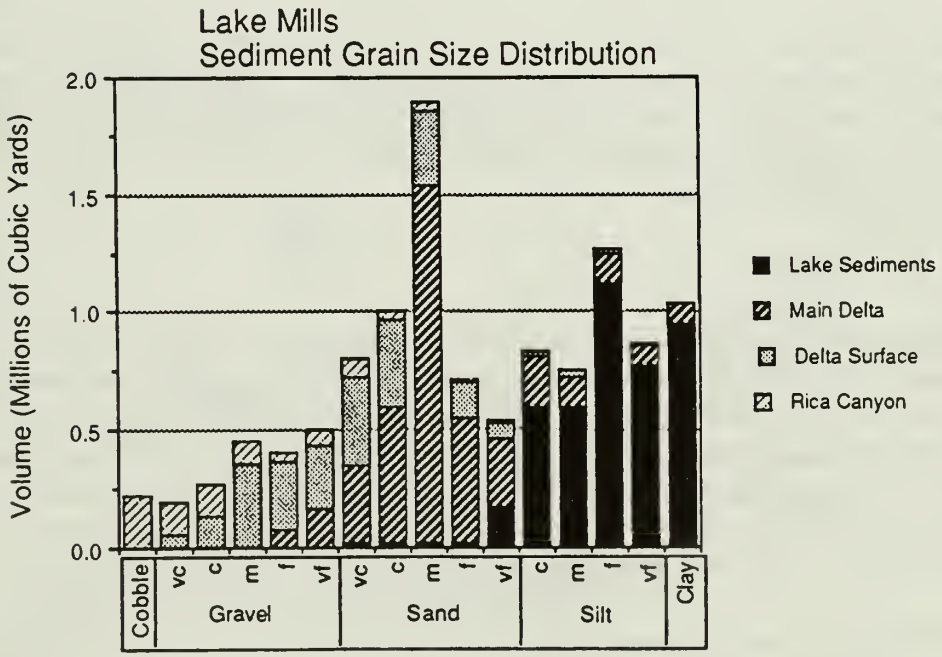


Figure 3-8. Lake Mills volume of sediment deposited between 1926 and 1989. (Source: James River II, 1988b).

Immediately below the Glines Canyon dam between RM 13.4 and 12.5, the Elwha River is constrained within a valley to a channel width between 80 to 250 feet. From the Olympic Hot Springs Road Bridge to the rock canyon section at the MacDonald stream gage, channel widths are between 200 and 400 feet. The greatly reduced sediment supply in the middle and lower Elwha River has resulted in a coarser surface pavement with reduced sand and gravel in the sub-pavement and on the bar surfaces when compared to natural conditions. The lack of sand on the bar surfaces is particularly noticeable when compared to the upper Elwha and other rivers in the region.

In the middle reach reworking of the valley alluvium by lateral channel migration is reduced because the channel has become stabilized as evidenced by the very coarse armor layer, well vegetated medial and point bars, low lateral migration rates, and stable vegetated banks along much of the length. Comparison of the 1950 USGS topographic map with the 1989 aerial photographs (Walker & Associates, 1990) indicates low lateral migration rates of 100 to 200 feet over the 40-year period has occurred along much of the channel but primarily at meander bends. Sediment supply from tributaries (watershed area of 73 square miles) into the middle and lower Elwha River is small relative to supply from the upper Elwha (watershed area of 247 square miles). The suspended sediment transport rate recorded at the MacDonald stream gage comes from the tributaries when they are in active flood stage, from the channel alluvium when floods break up the armor layer (estimated at about 9,000 cfs), and the material flushed through Lake Mills.

About 25 percent of the middle reach channel length is riffle, 25 percent run, and 50 percent pool as estimated from aerial photographs. Overall channel slope of the middle reach is 0.7 percent (0.4 degrees), with local riffle and pool water surface slopes of 0.03 percent to 8 percent at low flow and 0.04 percent to 1.6 percent at flood flows.

3.2.9 Lake Aldwell

At least 4.18 million cubic yards of sediment are trapped in Lake Aldwell. Between 1914 and 1989 an average of about 55,000 cubic yards of sediment per year has been trapped in the lake. An estimated 2.2 million cubic yards of sediment were deposited in Lake Aldwell prior to construction of Glines Canyon dam. The current average rate of sediment accumulation in Lake Aldwell is estimated at 31,000 cubic yards per year. With this estimate of sediment accumulation, it will take about 400 years to fill Lake Aldwell with sediment.

The delta with a total estimated volume of 3.2 million cubic yards and maximum sediment thickness of 40 feet and typical thickness of 20 feet, is composed primarily of sand and gravel (Figure 3-9), with smaller amounts of clays, silts,

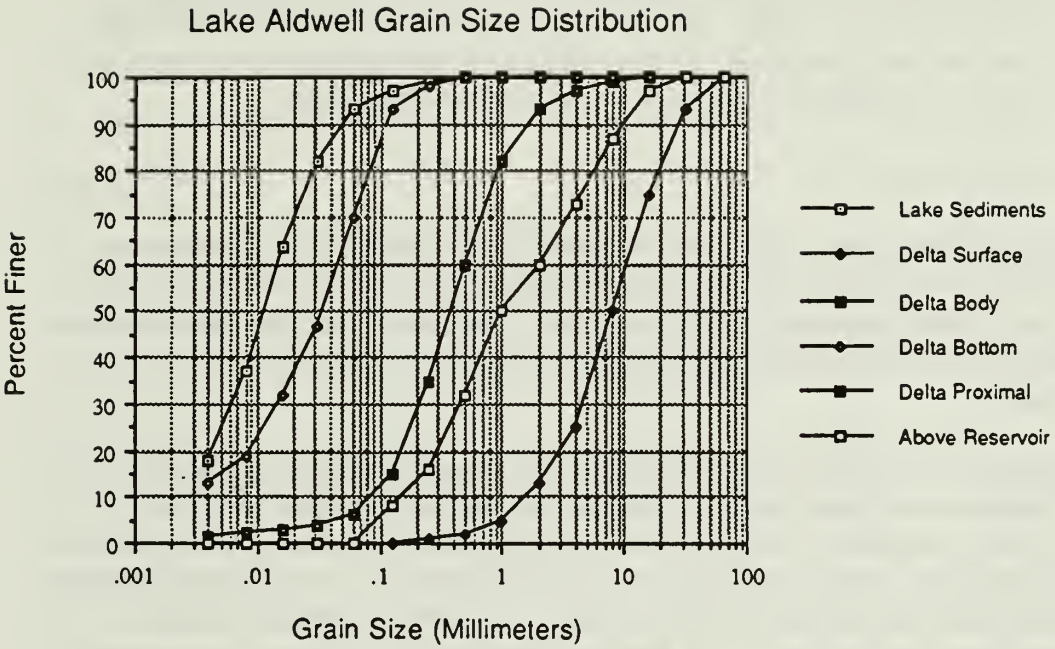


Figure 3-9. Lake Aldwell grain size distribution of sediment deposited between 1914 and 1989. (Source: James River II, 1988b).

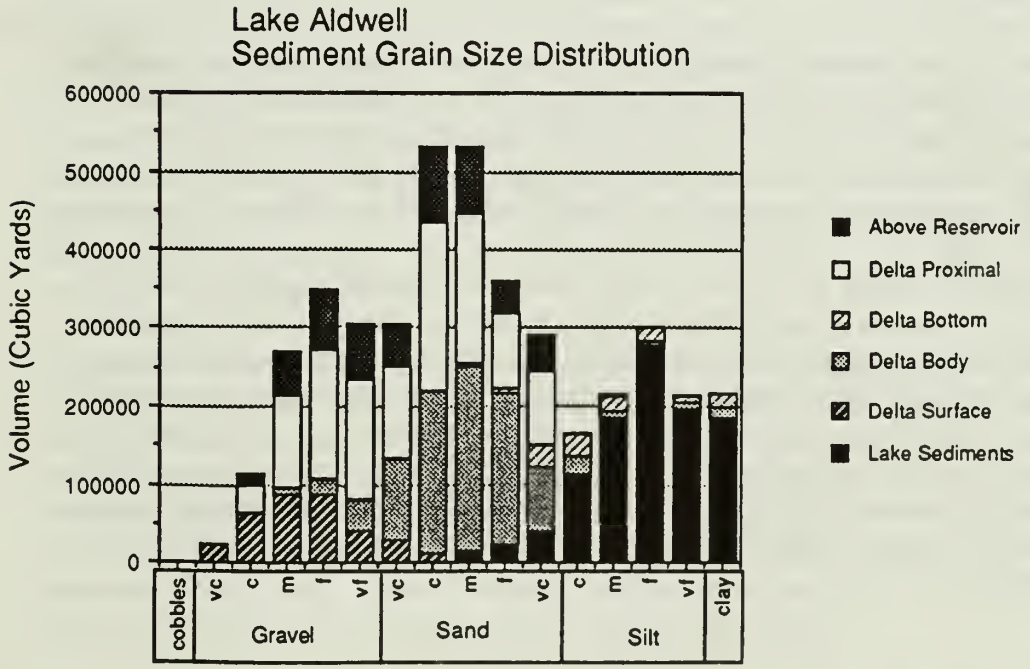


Figure 3-10. Lake Aldwell volume of sediment deposited between 1914 and 1989. (Source: James River II, 1988b).

cobbles and boulders. Beyond the delta there are 1 million cubic yards of fine lake bottom sediments, composed primarily of silt with some clay and minor amounts of fine sand (Figure 3-10). This fine material is between 5 and 6 feet thick in the southern lake basin, thins to less than a foot in the narrow former canyon section and is 3 to 5 feet thick in the northern lake basin.

3.2.10 Lower Reach

Available photographs indicate that the lower river included active unvegetated cobble and gravel bars as part of a meandering and braided channel system. These bars were maintained by high sediment inputs both from the river upstream of this area, and from erosion of floodplain and glacio-fluvial valley wall sediments.

The Elwha dam was built in Elwha Canyon that extends downstream to RM 4.0. Large tree-covered, stable bars are between Elwha dam and about RM 3.0. Below Elwha Canyon the river has cut a wide alluvial plane into gravelly glacial outwash deposits. The alluvial plane is wedge-shaped, bordered by steep cliffs of glacial outwash approximately 150 feet high. In the river channel there are numerous active point bars, which become increasingly prominent downstream. The channel shifts frequently, leaving abandoned channel segments that are clearly visible on aerial photos (James River II, 1987). With limited sediment transport from the Elwha River Basin, the channel is primarily reworking older river deposits and locally eroding the high banks of glacial outwash.

3.2.11 Tributaries

Elwha tributaries generally have extremely steep gradients due to the glacially influenced cross-sectional profile of the Elwha Valley. Most tributaries have significant waterfalls near their confluences with the mainstem river. The mainstem Elwha River has 15 tributaries greater than 4 miles in length (Table 3-1). No major tributaries enter the Elwha River in the reach below Elwha dam.

Four major tributaries are located along the middle reach of the Elwha River (Figure 3-2). Indian Creek flows through lowlands of second growth timberland and intermittent farmland, and drains Lake Sutherland. Little River is a larger tributary with a moderate gradient, which drains a watershed highly disturbed by logging. This stream currently drains second growth forest. Hughes Creek is extremely steep in gradient throughout its entire length, and originates at about 4,000-foot elevation. Griff Creek is located about 2 miles below Glines Canyon dam, has an extremely steep gradient, and also originates at about 4,000-foot elevation.

Table 3-1. Major Elwha River tributaries (Source: Williams et al., 1975).

Name	Location of Mouth (River Mile)	Tributary Length (miles)
Indian Creek	7.5	5.7
Little River	7.8	7.5
Hughes Creek	11.3	4.6
Griff Creek	11.4	4.1
Boulder Creek	15.1	7.6
Wolf Creek	15.8	4.0
Cat Creek	15.9	6.7
Long Creek	18.5	8.0
Lillian River	20.9	11.1
Lost River	27.7	7.7
Goldie River	29.4	8.6
Hayes River	31.9	9.0
Godkin Creek	36.1	7.2
Buckinghorse Creek	37.5	4.1
Delabarre Creek	40.4	4.3

Eleven tributaries enter the mainstem river above Glines Canyon dam. Boulder Creek is extremely steep in gradient, originates at about 4,000-foot elevation, and drains into Lake Mills. Cat Creek is a moderate gradient stream which enters the Elwha River at the upper end of Lake Mills. Major tributaries to the Elwha River above Lake Mills include Long Creek and Lillian River. Long Creek drains extremely steep terrain along the north side of Mount Ferry, and has its confluence with the Elwha River in Geyser Valley. Lillian River has its headwaters at Lillian Glacier above 6,000 feet in elevation, and also has a very steep gradient throughout its length. This tributary flows into the Grand Canyon section of the Elwha River.

Important tributaries located in the upper Elwha River drainage include Lost River, Goldie River, Hayes River, and Godkin Creek. These tributaries have steep gradients, though they shift to moderate gradients near their confluences with the Elwha River. The lower elevation valleys through which the mainstem river and tributaries flow have especially dense vegetative cover. Buckinghorse Creek and Delabarre Creek are located in the most upstream reaches of the mainstem Elwha River. These headwater tributaries of the Elwha River are located in glacial and alpine areas of the Olympic Mountains.

3.2.12 Elwha River Mouth and Coastal Area

Over the past 9,000 years the Elwha River has deposited an extensive elongated delta into the Strait of Juan de Fuca. The delta is roughly 5 miles wide, 6 miles long and estimated to be 200 feet thick (Figure 3-11). The delta is composed of sand, gravel and cobbles with delta samples indicating a sand gravel surface to about 2,000 feet offshore (U.S. Army Corps of Engineers, 1971).

Historical evidence indicates that the channel has in the past migrated within the full extent of the 1.2 mile width between the high bluffs. At present, the main Elwha channel is constrained on the western side of the delta by a setback levy constructed in 1989. A jetty was constructed on the west side of the river mouth that prevents the river from migrating to the west until beyond the shore zone.

The formation of Ediz Hook is closely linked with the Elwha River (Galster, 1989). Ediz Hook is composed of sand, gravel, and cobbles driven by the dominant eastward transport of: (1) sediment from west of the Elwha River (Ql); (2) sediment discharged from the Elwha River (Qe); (3) material eroded from sea cliffs between the Elwha mouth and the hook (Qb); and (4) sediment discharged from Dry Creek (Qd) (Galster, 1989; U.S. Army Corps of Engineers, 1971; Galster and Ekman, 1977).

From 1937 to 1951, the western portion of Ediz Hook was noticeably eroding while the eastern end was still growing but at a slower rate (Galster and Ekman, 1977). The annual volume of longshore sediment was reduced due to construction of the Elwha dam and construction and armoring of the water supply pipeline along the coastal bluffs (Galster, 1989). Several measures were taken to protect parts of the Hook from further erosion (U.S. Army Corps of Engineers, 1971; Galster, 1989). During the 1960's, further measures were taken to ensure increased protection for the water supply pipeline and Ediz Hook. The U.S. Army Corps of Engineers (1971) conducted a study of the erosion problem and recommended a protective construction program (U.S. Army Corps of Engineers, 1976) which is now in place. It is estimated that the distal bulb of the Hook is still growing at 7,000 cubic yards per year (Galster, 1989).

In the area of the delta east of Angeles Point, between 75 and 150 feet of shore recession has occurred since 1908 (James River II, 1987). West of Angeles Point there has been considerable oscillation about the mean shore but little noticeable recession, which is typical of sediment migration along the shore. This indicates the present longshore sediment supply (Ql+Qe) is able to maintain the delta form in the immediate area of the mouth but further east the reduced sediment load is inadequate to maintain the shoreline.

Elwha River sediment load has been a significant factor in the erosion of Ediz Hook. There has been at least a 10-year delay from the time the industrial

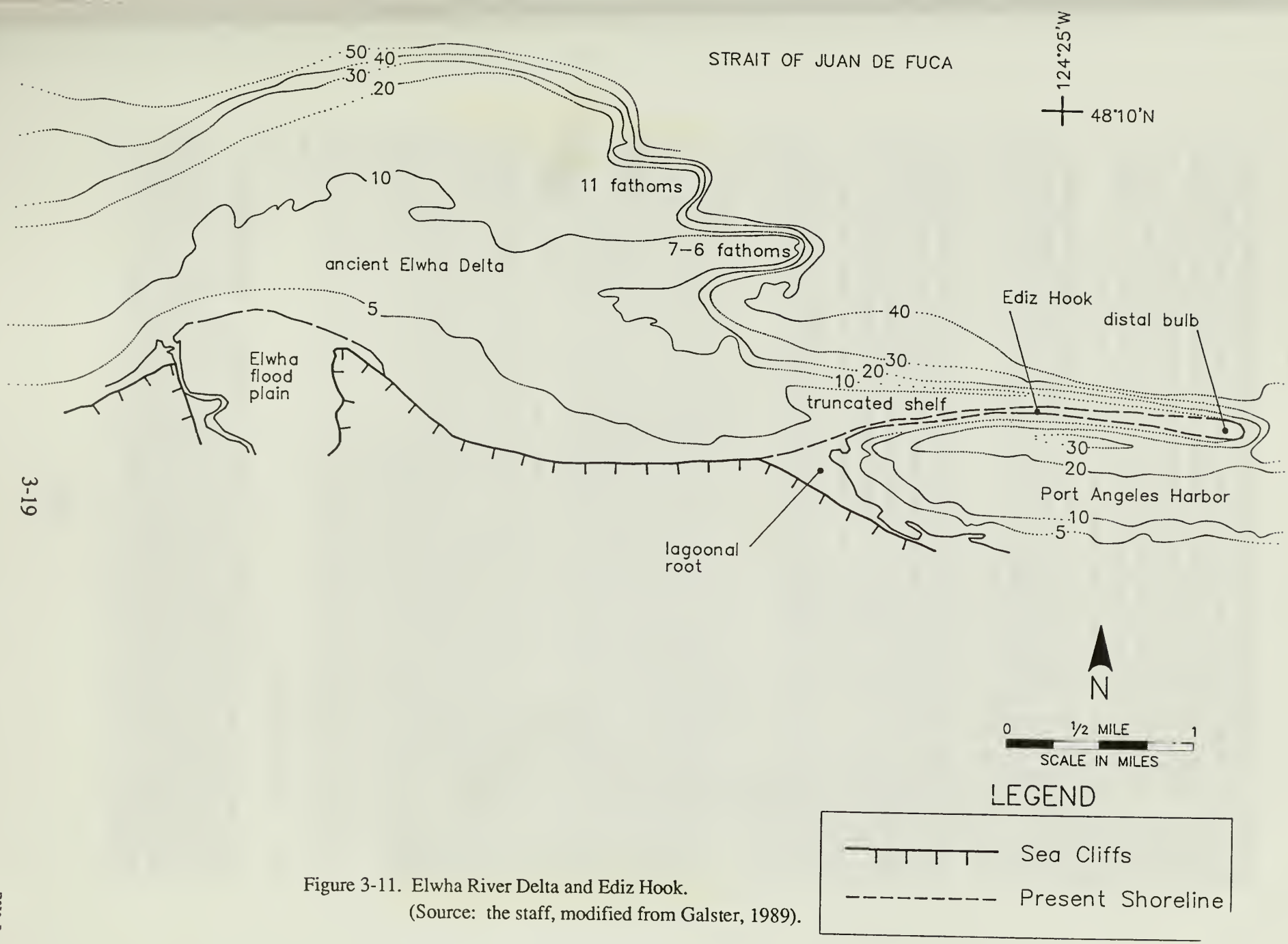


Figure 3-11. Elwha River Delta and Ediz Hook.
(Source: the staff, modified from Galster, 1989).

FIG32-7

waterline was installed along the coastal bluff to the start of rapid Hook erosion (U.S. Army Corps of Engineers, 1971). This type of delay is to be expected because longshore transport of sediment is a slow process taking many years for sediment introduced to the coastal zone to move along the coast. Beach nourishment studies on Ediz Hook indicate it takes up to 3 years for introduced sediment to be fully removed longshore (Galster, 1989). Reduction of the Elwha sediment supply in 1914 would take some time to be felt at Ediz Hook. Indications are that erosion of the delta mouth east of Angeles Point began in the 1926-to-1940 interval and accelerated in the 1940-to-1949 period (James River II, 1987). Further delay would be expected for the reduced sediment loads to be felt 4 miles down the coast at Ediz Hook.

Sand in the nearshore zone indicates it is not all washed away from the coastal area. Typical of coastal areas, dunes of sand are probably shifting around in this zone with the net transport direction dependent on the dominant current directions. Re-analysis of the Corps' longshore sediment budget (U.S. Army Corps of Engineers, 1971) to incorporate the new estimates of Elwha bed load sediment supply to the river mouth indicates the Elwha sediments available to the longshore zone are 50 percent of the bluff-derived sediments rather than the original estimate of 17 percent.

The total estimated volume of bed load sediment supplied to the coastal littoral zone of 400,000 cubic yards per year, which has been corrected for the new Elwha sediment quantity and distribution data, indicates the sediment supply was greatly in excess of the estimated longshore wave transport capacity (U.S. Army Corps of Engineers, 1971). This indicates the coastal zone was transport limited and the Elwha delta and coastal area shorelines could be maintained. With removal of 36 percent of the longshore sediment load from closure of the Elwha River and 55 percent of the total sediment load from the armoring of the bluffs, the sediment supply was reduced well below the estimated wave transport capacity making the coastal zone sediment supply limited. The coastal zone east of the Elwha mouth including Ediz Hook could no longer be maintained by the sediment supply. As a result the offshore area of sand and gravel deposits has been reduced in volume leading to over-steepened beach slopes, landslides and exposure of Ediz Hook to greater erosion (Galster, 1989).

3.3 WATER QUANTITY AND QUALITY

3.3.1 Water Quantity

The average annual discharge of the Elwha River is 1,506 cfs. Precipitation in the Elwha River drainage is influenced by a strong rainshadow effect by the Olympic mountains in a northerly direction. Precipitation is greatest in the upper river drainage, and occurs as rain during the fall and early winter, and as heavy snow during the winter. Average annual precipitation in the upper Elwha

drainage exceeds 220 inches per year (U.S. Army Corps of Engineers, 1987). Precipitation is substantially less in the lower Elwha drainage at the Elwha Ranger Station (El. 360 feet) near the northern park boundary, averaging 56 inches per year. The rainshadow effect is most apparent near Port Angeles, which has an average precipitation of only 26 inches per year (U.S. Army Corps of Engineers, 1987).

The annual discharge pattern of the Elwha River is influenced by heavy Pacific tract storms in the early winter, snowmelt during spring months, and baseflow conditions during the summer. Baseflow conditions reflect groundwater discharge, and melting of glaciers and residual snowpacks at the higher elevations. Lowest discharges occur from August to October, with daily average discharges ranging from 618 to 952 cfs. Two separate high-runoff periods are observed on the Elwha River, with greatest discharge occurring during December due to heavy winter rain, and June due to peak snowmelt (Table 3-2). Daily discharge during these months averages 2,000 to 2,300 cfs.

Maximum daily discharges (Table 3-2) have occurred in November (24,400 cfs) and March (22,400 cfs); these months have the greatest potential for extreme precipitation events. Instantaneous flood discharges have ranged from 4,680 cfs in 1936, to 41,600 cfs in 1898 (Figure 3-12). The greatest recorded discharge in recent years was 27,700 cfs, which occurred in 1981. Frequency analysis of yearly peak discharges indicates that a 5,000-cfs discharge corresponds to a flood event having a 1-year return interval (Figure 3-13). A 2-year flood event, which represents bankfull flooding conditions on many rivers (Dunne and Leopold, 1978), corresponds to a discharge of approximately 13,000 cfs. The 41,600 cfs flood of 1898 has a 71-year return period, as calculated by peak discharge records existing as of 1984.

Minimum daily discharges from 1898 to 1988 have ranged from 10 cfs in October, to 746 cfs in June (Table 3-2). These minimum flows have been largely influenced by storage in Lake Mills during drought periods. Average monthly data (Table 3-2) provide a more realistic description of minimum flow conditions existing under present run-of-the-river operation of Lake Mills and Lake Aldwell. Minimum values for monthly average discharges are lowest during September (330 cfs), October (252 cfs), and November (219 cfs), which represent extreme seasonal drought conditions occurring between spring snowmelt runoff and winter storms.

3.3.2 Water Use

Water from the Elwha River is currently diverted for industrial, domestic, and agricultural use, and by tribal fish hatcheries and state fish rearing ponds. Water is obtained from a diversion dam located at RM 3.4 and flows into a canal for industrial use. Water is also diverted to the Washington Department of Fisheries

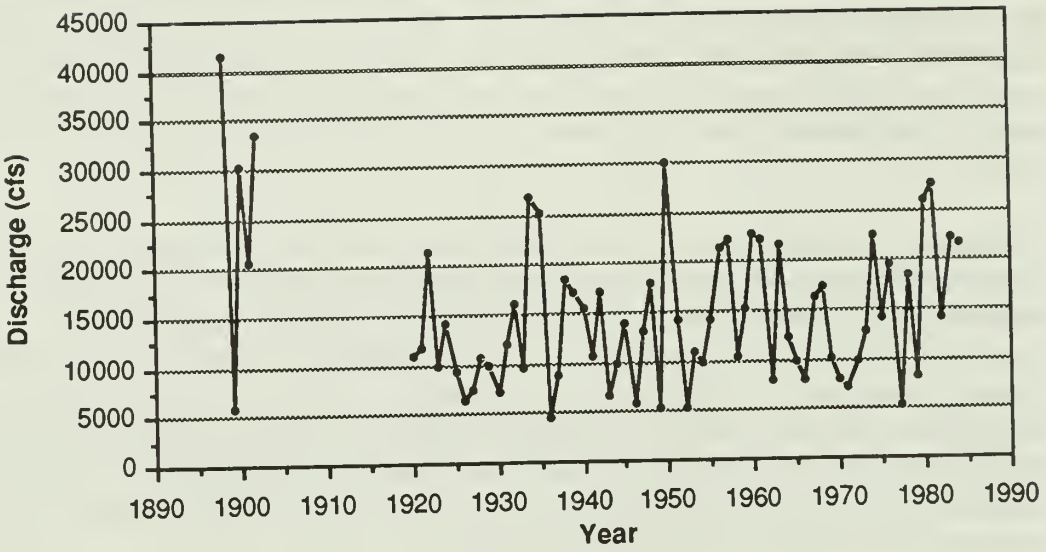


Figure 3-12. Elwha River peak discharges by year, 1898 to 1984. (Source: USGS gaging station at McDonald Bridge).

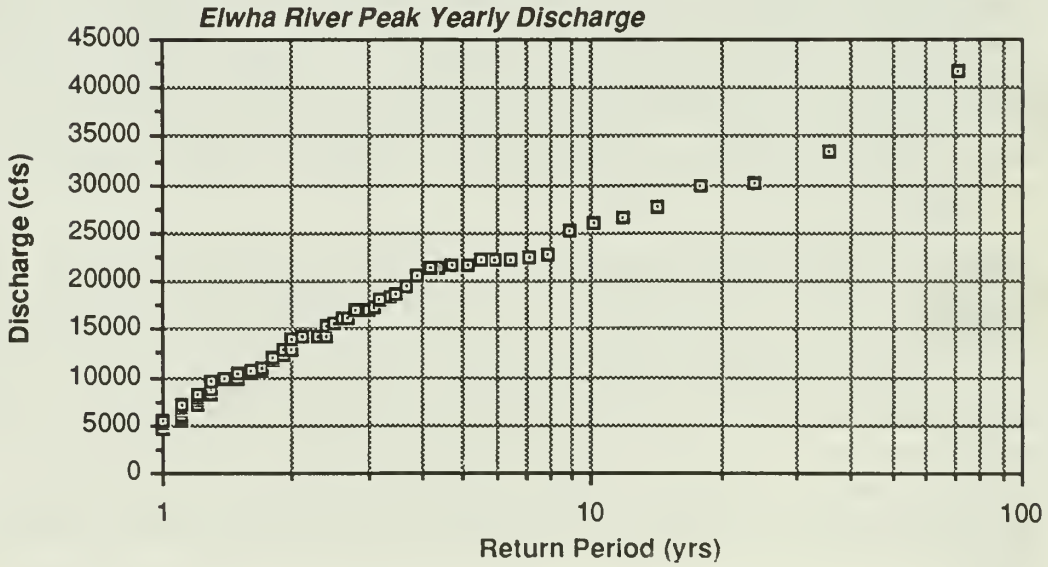


Figure 3-13. Frequency of yearly peak flow events for the Elwha River. (Source: USGS gaging station at McDonald Bridge).

Table 3-2. Monthly and annual discharge statistics for the Elwha River (1898-1902, 1920-1988) [Source: USGS gaging station located at McDonald Bridge below Lake Mills (269-square-mile drainage area)].

Month	Discharge (cfs) Daily Mean	Daily Maximum	Daily Minimum	Monthly Maximum	Monthly Minimum
October	952	11,100	10	2,800	252
November	1,655	24,400	40	4,667	219
December	2,092	19,700	31	5,111	642
January	1,863	18,600	218	4,033	424
February	1,708	12,300	90	3,826	476
March	1,300	22,400	133	3,307	511
April	1,265	10,100	54	2,210	689
May	1,935	6,720	499	3,333	962
June	2,293	8,738	746	4,096	922
July	1,559	4,540	76	2,917	595
August	846	3,320	30	1,642	434
September	618	3,680	11	1,331	330
ANNUAL	1,506	24,400	10	2,085	859

(WDF) fish rearing channel located immediately below the diversion dam. Ranney wells (water collectors consisting of porous pipes placed in a streambed) are located under gravels at the intake of the state fish rearing channel, and provide water for domestic use to the City of Port Angeles.

Existing water rights on the Elwha River total 206 cfs. Of this, 200 cfs is held by the City of Port Angeles, with the remainder used by property owners on the river. Of the city's water rights, 150 cfs are obtained from the city water intakes, while the remaining 50 cfs are obtained from Ranney collectors. Fifty cfs are diverted at the city's water intakes and returned to the Elwha River after passing through the WDF rearing channel. During extreme drought conditions, this 50 cfs represents the minimum flow in the lower reach below diversion facilities. The remaining 100 cfs is diverted at city water intakes for industrial users, including the Daishowa America Mill, which presently utilizes 31 cfs from the river. Proposed expansion of the paper mill would require an additional 10-cfs diversion.

3.3.3 Water Quality

The Elwha River, its tributaries, Lake Mills, and Lake Aldwell are classified by the State of Washington Department of Ecology (DOE) as having Class AA waters, a classification given to surface waters having "extraordinary" water quality. Water quality degradation is limited to nonpoint sources of pollution--primarily sediment input, bank erosion, and elevated water temperatures--resulting from logging and agriculture which occur in the lower portion of the watershed outside Olympic National Park. Increased water temperatures also occur in the middle and lower reaches of the Elwha River in late summer and early fall due to storage of heat in Lake Mills and Lake Aldwell.

From an ecological perspective, the lower and middle reaches of the Elwha River are significantly affected by loss of particulate organic matter (POM) transported from the upper river to Lake Mills and Lake Aldwell. Because of the heavily forested nature of the upper Elwha River drainage, relatively large amounts of organic detritus (i.e., leaf material from riparian hardwoods, needle material from conifers and woody debris) are conveyed in the upper river channel, and ultimately settle in Lake Mills and Lake Aldwell. Reservoirs trap POM and generally lower the production of the river channel downstream (Ward and Stanford, 1983; Petts, 1984). Low POM levels generally limit aquatic invertebrate diversity and production in rivers below reservoirs (Ward and Stanford, 1979).

Lake Mills, and to a lesser extent Lake Aldwell, tend to increase temperatures during summer due to their relatively large surface area and their long hydraulic residence time. Lake Mills has a flushing time of 32 days with a 500-cfs inflow. Thermal mixing of water in these reservoirs provides reduced daily and seasonal fluctuations in outflow water temperatures. Warming of the lower river is most pronounced in late summer and early fall caused by storage of heat in Lake Mills and Lake Aldwell during early and mid-summer. As a consequence of the combined warming of the river by Lake Mills and Lake Aldwell, water temperatures in the lower reach of the Elwha River are elevated approximately 2°C in July and August, and 3 to 4°C in September and October (James River II, 1989). Lake Mills is responsible for most of this warming due to its relatively high volume. Effects of reservoir warming on the lower reach during the remainder of the year are insignificant. This river warming coincides with the annual low-flow period in the Elwha River, and is greatest during early October. Warming has recently been cited as a contributor to the occurrence of Dermocystidium, a disease which has caused mortality in lower Elwha anadromous fish.

Water temperatures in the Elwha River are lowest during January and February and highest during August and September (Table 3-3). Seasonal patterns in water temperature are highly influenced by yearly discharge and climatic conditions.

Table 3-3. Monthly statistics for maximum daily water temperature (°C) in the lower reach of the Elwha River at RM 3.3 (Source: WDF fish hatchery records).

Month	1987			1988			1989		
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
January	5.0	7.2	4.4	2.8	3.3	2.2	3.3	4.4	2.8
February	5.9	6.7	5.0	4.2	5.0	2.8	1.3	2.2	0.0
March	6.6	7.8	5.6	5.9	6.7	5.6	3.2	5.0	1.1
April	8.5	8.9	7.8	7.1	8.3	5.6	6.5	7.8	5.0
May	10.4	11.1	10.0	8.8	9.4	8.3	8.8	9.4	8.3
June	12.1	14.4	10.6	10.9	12.2	9.4	10.9	12.2	9.4
July	14.7	16.1	13.3	11.3	13.9	9.4	11.7	12.8	10.6
August	17.5	18.9	15.6	14.5	16.1	13.3	12.3	13.3	11.1
September	17.0	19.4	15.6	14.3	16.1	11.7	12.6	13.9	11.7
October	15.5	17.8	13.3	11.3	13.3	8.3	10.0	12.2	6.1
November	10.8	13.3	8.9	7.3	8.9	5.6	4.5	6.1	2.8
December	5.2	8.9	2.8	4.4	6.1	2.2	3.2	5.0	2.2

This is exemplified by the years 1987 through 1989. River discharges during 1987 were extremely low, were moderate during 1988, and were relatively high in 1989. During 1987, water temperatures were substantially higher for all months when compared to those observed during the higher flow years of 1988 and 1989. During the 1987 drought year, maximum daily water temperatures in the lower reach had mean monthly values of 17.5°C in August, and 17.0°C in September (Table 3-3). Maximum water temperatures during the same year were 18.9°C in August and 19.4°C in September.

Values for pH, turbidity, dissolved oxygen, hardness, and alkalinity indicate high quality water (Table 3-4). Values for pH and alkalinity indicate neutral-to-slightly-alkaline conditions typical of oligotrophic (low biological productivity) waters (Wetzel, 1975). Dissolved oxygen values are very close to saturation at all times of the year, indicating high quality water quality conditions for cold-water fish (U.S. Environmental Protection Agency, 1976). Most water quality parameters vary little with time except for turbidity and suspended sediments, which increase during high discharge periods. Increased turbidity is also observed during glacial melt periods in the spring.

Nutrient concentrations in the Elwha River are relatively low, again reflecting the Elwha's undegraded water quality. Nitrate, ammonia, total phosphorous, and orthophosphorous concentrations, as shown in Table 3-4, are below those known to limit algal production (Wetzel, 1975; Vollenweider, 1968). Total phosphorous

Table 3-4. Water quality statistics for the Elwha River, October 1985 to September 1986[1/] (Source: USGS gaging station at McDonald Bridge, RM 8.6).

Parameter (Units)	Mean	Minimum	Maximum	Std. Dev.
Discharge (cfs)	1171	631	1900	473
Conductance (umhos/cm)	93	80	108	11
pH	7.7	7.2	7.9	.3
Temperature (°C)	7.8	3.0	13.5	4.7
Turbidity (NTU)	2.3	1.5	3.8	1.0
Oxygen, Dissolved (mg/l)	11.8	9.8	13.3	1.5
Percent D.O. Saturation	98	97	100	2
Hardness (mg/l as CaCO3)	41	37	46	4
Alkalinity (mg/l as CaCO3)	37	32	40	3
Dissolved Solids (mg/l)	57	49	68	3
Suspended Sediments (mg/l)	4	1	7	2
Nitrate Nitrogen (mg/l as N)	.1	<.1	.1	-
Ammonia Nitrogen (mg/l as N)	.02	.01	.04	.01
Phosphorous, Total (mg/l as P)	.01	<.01	.04	-
Orthophosphorous (mg/l as P)	.01	.01	.02	.0

[1/] Samples obtained on a bimonthly basis.

concentrations for most uncontaminated lakes range from 0.01 to 0.03 mg/l as P (Hutchinson, 1957). The Elwha River has an average total phosphorous concentration (as P) of 0.01 mg/l. As a result of these nutrient concentrations, Lake Mills has very low phytoplankton production, and can be considered oligotrophic (Mausolf and Sundvick, 1976). Because of low algae production, Lake Mills and Lake Aldwell exert a minimal influence on water quality downstream.

3.4 FISHERIES RESOURCES

Elwha River fisheries resources are of exceptional importance in this impact analysis, not only in terms of their current values but also in terms of the fish production potential which exists in the river basin. Largely because of Elwha and Glines Canyon dams, Elwha River anadromous fish production, depending on species, is currently only a small percentage of historical numbers. Description of the existing Elwha River fishery conditions in this chapter, then, is incomplete without reference to the potential for both anadromous and resident fish production which exists within the watershed and which would become available under the proposed project alternatives. This production potential may be evaluated in two ways: (1) relative to numbers within various fish species which utilized the river in pre-impoundment or early post-impoundment periods, and (2) relative to the quality and extent of fish habitat currently observable in the basin.

In this section, we first present a historical perspective which offers insights into the kinds and numbers of fish formerly present in the Elwha River Basin. Second, we present accounts of existing fishery conditions including abundance of the anadromous and resident species, and the habitats which now occur in the various river reaches and tributaries, both below and above the dams. Of the fish species present, the anadromous fish (those which migrate from freshwater to saltwater and return) are considered most important in this analysis. These include salmon and steelhead and two species of migratory trout. Of the anadromous species, chinook (Oncorhynchus tshawytscha) and coho (Oncorhynchus kisutch) salmon and steelhead trout (Oncorhynchus mykiss) are given the greatest measure of treatment because of their potential for recovery and the extent to which they might utilize the basin's habitat potential.

The level of treatment given a particular anadromous fish species in this and following sections should not be construed to imply relative importance. Under the resource objectives established for this analysis, restoration of anadromy for all anadromous species is used categorically, without reference to one species or group of species being more important than another.

3.4.1 Historical Perspective

3.4.1.1 Estimated Historical Fish Numbers

To place the Elwha's production potential in perspective, Table 3-5 presents estimates of anadromous species production by the JFWA. The numerical estimates are for either run size (the total mature fish produced) or spawning escapement (number of fish actually ascending the river to spawn). The estimates in Table 3-5 were calculated using two types of methods (juvenile rearing habitat potential and adult spawning habitat potential), and the terms "upper" and "lower" in Table 3-5 reflect the results of multiple JFWA estimates. Because of the imprecise nature of estimating potential production, these values are not considered by the JFWA as the absolute boundary of what may have been present in the Elwha River in the past. The staff has reviewed these estimates and generally approved of the techniques used to calculate them. However, since there is no reliable validation criterion for such historical estimates, they are presented only as indicators of scale and not standards for comparison.

Of particular interest are the relatively high estimates for pink (Oncorhynchus gorbuscha) and chum (Oncorhynchus keta) salmon. These numbers indicate high production potential for the amount of available habitat. Elwha chinook numbers, in comparison to the Lewis River (Washington's most productive, naturally spawning fall chinook river) represent high production. Steelhead are also produced in relatively high numbers.

Table 3-5. Estimates of potential production for nine Elwha River anadromous fish species, expressed as run size or spawning escapement.[1/]

Species	Lower Estimate	Upper Estimate	Comments
Steelhead	8,651	[2/]	Run size
Coho	7,742	19,143	Spawning escapement
Chinook	[2/]	17,493	Spawning escapement
Pink	56,512	137,600	Spawning escapement
Chum	[2/]	25,600	Spawning escapement
Sockeye	[2/]	23,436	Run size
Cutthroat	929	9,990	Run size
Dolly Varden	3,709	[2/]	Run size

1/ Source: JFWA Comments to FERC Request for Additional Information, May 28, 1987.
2/ No estimate provided.

As discussed later in this section, it is questionable whether sockeye salmon (Oncorhynchus nerka) used the Elwha within the period of human accounts.

Additionally, based on surveys conducted in similar rivers in Washington, the Elwha River probably harbored, and continues to harbor, more than the nine fish species listed in Table 3-5. These include minnows (Cyprinidae) including dace, peamouth and squawfish; suckers most likely the largescale sucker (Catostomus macrocheilus); threespine sticklebacks (Gasterosteus aculeatus); sculpins (Cottus spp.); whitefish (Prosopium williamsoni); and marine species such as flounders.

Verbal records indicated that spring and summer chinook, chum, pink, coho, and steelhead were historically present in the Elwha. Fall chinook were not discussed in these verbal records, but the current presence of fall chinook suggest that these may have been present. The current presence of both summer and winter steelhead in the Elwha and in other streams on the Strait of Juan de Fuca suggest that both races may have historically existed in the Elwha. Sockeye salmon were not mentioned by two native Lower Elwha Klallam Tribe members who fished the rivers prior to the construction of Elwha dam, nor are sockeye currently present in any Strait of Juan de Fuca stream system, suggesting that this species may not have been present (testimony of Elsie Joseph and Ed Sampson, Lower Elwha Klallam Tribe, Washington, 1977). The Elwha was predominantly an anadromous fish producer because of its relatively harsh environment (characterized by high

velocity water with extreme turbulence during runoff) and because its anadromous fish populations probably outcompeted resident fish for space and food.

Elwha River anadromous fish also had to endure the river's harsh environment, particularly those which utilized the river's middle and upper reaches. This probably resulted in fish specifically adapted to those conditions which would affect the restoration potential for species which have no current Elwha River genetic background.

Of all Elwha River anadromous fish species, perhaps the chinook salmon was most affected by adaptation to the river's stern environment. Chinook in excess of 100 pounds were recorded as late as 1930, 18 years after the closure of Elwha dam (Brannon, 1930). Chinook of this size would be among the largest known anywhere within that species' range from California through the Yukon River drainage in Alaska. Chinook in the 60-90 pound range are known to be highly sought after as trophy fish in British Columbia's Rivers Inlet area and Alaska's Kenai River, which are considered the two of the greatest salmon fishing destinations in North America.

Though similarly unique sizes have not been reported for other Elwha salmon species, the river was formerly known for its large production of pink salmon, suggesting that even after dam closure the Elwha was one of the Puget Sound region's largest pink salmon producer (personal communication, Richard Goin, Port Angeles resident and Elwha River observer, Port Angeles Scoping Meeting, December 1989).

Steelhead and possibly other species could have traveled as far as 43 miles upstream (James River II, 1988d). A major waterfall at RM 34 could have blocked some species depending on timing and condition of the fish. Pink and chum salmon would probably have been restricted to the region below Rica Canyon (RM 16) (James River II, 1988c) or further downstream (WDF, 1971) because of their relative inability to ascend passage barriers or steep stream segments.

3.4.2 Current Elwha Fisheries Status

3.4.2.1 Anadromous Species

Elwha River anadromous fish species currently include fall chinook, coho, pink, and chum salmon, winter and summer steelhead, and anadromous cutthroat trout Oncorhynchus clarki) and Dolly Varden (Salvelinus malma). Hatchery-produced fish currently dominate the runs of chinook, coho, and steelhead. A chum salmon stocking program was terminated in 1987.

The Elwha River is currently the largest producer of steelhead and chinook salmon on the Strait of Juan de Fuca, and has averaged second to the Dungeness River for coho and pink salmon production. Its chum salmon production is small compared to other Strait streams (personal communication, Jim Ames, WDF, April 5, 1990). The current salmon run sizes, which are mostly hatchery fish, are a small portion of total numbers within the state, but are significant regionally.

The Elwha River is also a major producer of hatchery steelhead ranking 10th in the state winter steelhead sport catch in 1987-88 (WDW, 1988). It is the largest steelhead producer of Strait streams, again based mostly on hatchery plants (Point No Point Treaty Council and Washington Department of Wildlife, 1989).

3.4.2.2 Resident Fish Species

Resident sport fish in the river system are dominated by rainbow trout and, to a lesser degree, Dolly Varden. A very small number of cutthroat trout and brook trout are also present (upper river creel survey 1974 and 1976 from J. Meyers, Biologist, Olympic National Park, January 1990; Mausolf and Sundvick, 1976; Collins, 1983). The Elwha drainage is a major wild trout producer on the Olympic Peninsula. Its ranking compared to other regional streams is not known but a creel survey conducted on Lake Aldwell, Lake Mills, and the middle reach indicated a high fishing effort (about 22,000 hours seasonally, Collins, 1983).

3.4.2.3 Marine Shellfish

The shellfish resources of the Elwha River delta are limited because of the large substrate, steep slope of the beach, and small area. The quantity of shellfish resources relative to Puget Sound and regional areas is insignificant because shellfish can be found in abundance in many areas and habitats are not restricted to river deltas.

The composition and abundance of shellfish prior to the dam construction is not known. Hardshell clams, typically a major intertidal shellfish resource, may have been more abundant than at present because of the change in sediment composition from sand-gravel-cobble to a more coarse gravel-cobble mix, and possibly because of a larger intertidal area that may have existed in the past.

3.4.3 Species Accounts

3.4.3.1 Chinook Salmon

Chinook salmon are described by the season during which they enter their natal streams to spawn. For example, spring chinook typically enter fresh water earlier than fall chinook. The only existing Elwha chinook is characterized as a "summer/fall" stock, which will be referred to simply as "fall" chinook in this

document. A few spring chinook may be present, but they may not be the original Elwha stock. Soleduck and Dungeness spring chinook were planted in 1973 and 1977 and may have been the origin of any spring chinook present in the river. It is unlikely that spring chinook have maintained genetic integrity because of co-temporal spawning with other chinook in the lower Elwha for as long as 78 years.

Fall chinook enter the Elwha River primarily from July through October (Williams et al., 1975; James River II, 1988a). Peak spawning occurs from September through mid-October. Juvenile outmigration generally occurs from January through early July and consists mostly of underyearling fish (less than 1 year old) (Williams et al., 1975). Native Elwha underyearlings often become smolts in late July and early August (Schroder and Fresh, 1985). Native yearling (fish 1 year old or greater) migration occurs in May and June (James River II, 1988b).

Fall chinook in the Northwest typically use the main channels of large rivers to spawn and rear, but with some rearing occurring in estuaries if they are large enough. The Elwha River has a small estuary, perhaps resulting in longer rearing periods in the river before downstream migration to the ocean (Levy and Northcote, 1982; Nicholas and Hankin, 1989; Healey, 1980; Levings et al., 1988; Reimers, 1971).

Latest records indicate stocking of chinook has been regular since 1960. The major stock has been Elwha River fall chinook; spring chinook planted in 1973 and 1977 were from Dungeness and Soleduck hatchery stocks. Since 1976 about 500,000 chinook yearlings have been released annually with fry and fingerlings to total 3 million fish per year (James River II, 1988a).

Recent data indicate that since 1982, chinook escapement to the hatchery has been between 1,000 to 2,000 fish, peaking in 1988 but with no definable trend (Table 3-6). Although data in Table 3-6 suggest that most fish in the system are wild, it is believed that many of these are fish of hatchery origin which did not enter the rearing channel (personal communication, Tim Flint, WDF, April 5, 1990).

In-river chinook harvest, formerly restricted, has increased recently. Harvest by the Lower Elwha Klallam Tribe is usually less than 100 fish per year (Table 3-6).

Many of the fish reported as wild escapement were gaffed to supply needed hatchery spawners. From 1986 to 1989 the number of gaffed fish ranged from 505 to 1,138 with gaffed brood stock averaging 44 percent of the fish spawning in the channel (letter from Bill Graeber, WDF, March 20, 1990). Fish returning to the Lower Elwha Tribal Hatchery is a small portion of the total ranging from 11 to 57 fish from 1978-89.

Table 3-6. Run and harvest information for the Elwha River chinook salmon.[1/]

Year	Total Run[2/]				Run to Strait[2/]				Run to River[3/]				Terminal Escapement[3/]				Hatchery[4/]	Calculated[5/]	Reported[6/]
	Hatchery	Off-Station	Wild	Total	Hatchery	Off-Station	Wild	Total	Hatchery	Off-Station	Wild	Total	Hatchery	Off-Station	Wild	Total	Rack Count	In-River Harvest	Tribal Harvest
1968	0	0	3,742	3,742	0	0	1,583	1,583	0	0	1,550	1550	0	0	1,550	1,550		0	
1969	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	
1970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	
1971	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	
1972	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	
1974	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	0	5
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	275	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	503	0	23
1978	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	379	0	36
1979	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	469	0	73
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	947	0	17
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	570	0	11
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,709	0	84
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	711	0	30
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,771	0	8
1985	1,513	0	3,823	5,336	640	0	1,617	2,257	616	0	1,558	2,174	513	0	1,550	2,163	1,150	11	30
1986	3,213	0	4,608	7,820	1,359	0	1,949	3,308	1,298	0	1,860	3,158	1,285	0	1,842	3,127	1,285	31	32
1987	3,336	0	11,986	15,322	1,411	0	5,070	6,481	1,353	0	4,860	6,213	1,283	0	4,610	5,893	1,283	320	327
1988	5,669	0	15,697	21,666	2,398	0	6,640	9,038	2,299	0	6,367	8,666	2,089	0	5,784	7,873	2,089	793	787
1989 7/	2,922	0	11,208	14,130	1,236	0	4,741	5,977	1,180	0	4,523	5,703	1,135	0	4,352	5,487	1,135	216	

1/ Table modified from that presented in James River II, 1988a.

2/ Based on WDF (1984), which indicated average 1976-81 catch distribution of 57.7% of total run were captured prior to entering the Strait. Value calculated by dividing total run to the Strait by 0.423.

3/ Based on WDF catch-escapement run size calculation summary through 1985 and data for 1986-89 (personal communication, Bill Graeber, WDF, April 5, 1990).

4/ WDF data (James River II, 1988a) and 1986-89 data (personal communication, Bill Graeber, WDF, April 5, 1990).

5/ Run to the river minus escapement.

6/ From WDF tribal catch records (James River II, 1988a, and Ward and Hoines, 1988).

7/ Preliminary data.

One of the major limiting factors for chinook production in the lower river is mortality from Dermocystidium. Hatchery mortality from this disease has averaged about 20 percent in recent years (letter from Bill Graeber, WDF, March 20, 1990). The source of the disease is not known but it appears not to be Lake Mills water (James River II, 1990e). While low flows and higher temperature appear to have correlated with high mortality rates in the past (James River II, 1988d), the latest test results indicate that although temperature was a factor, the disease was active from 46-60°F (James River II, 1990e). In the Priest Rapids (Washington) chinook spawning channel, Allen et al. (1968) noted that temperatures greater than 60°F were not the major cause of mortality from the disease, and that Priest Rapids temperatures below 60°F resulted in higher chinook spawner mortality than temperatures above 60°F.

Chinook salmon production in the lower Elwha River is probably not limited by availability of spawning gravels. While more or improved gravel may allow for more spawning, current spawning density, as measured by number of redds (spawning nests) per mile, is already much higher than other northwest streams. Average redd density during 1988 (the highest recorded density year) averaged 248 redds per mile for the whole 4.9-mile accessible reach of the river and 310 redds per mile in one 1.2-mile reach (Table 3-7). This average is much higher than the average 15-redds-per-mile density of other north-coast, Washington streams (WDF, 1981).

Only in the reach immediately downstream of the dam (RM 4.4 to 4.9) and at the river mouth (RM 0.0 to 0.2) was significant chinook spawning not observed. A spawning habitat survey completed on October 11, 1988 noted that the first good quality spawning area below the dam occurred at about RM 4.0. James River II (1988e) presented a summary of spawning substrate quality which indicated that poor spawning substrate was in the first 0.8 mile below the Elwha dam.

Survival of early spawning chinook eggs may be adversely affected by temperatures in excess of 14-16°C that can occur in late summer, early fall during low-water, high-temperature years (Table 3-3). Temperatures in excess of 14-16°C can cause mortality of chinook eggs (Reiser and Bjornn, 1979; Seymour, 1956; Olsen and Foster, 1955).

A total of 15.5 miles of stream (5.8 miles of mainstem) would be accessible to chinook salmon in the middle reach of the Elwha River if fish passage were provided at Elwha dam (James River II, 1988b). This reach has limited spawning area for chinook salmon because of unsuitably large substrate, mainly large cobble and boulders. The region was estimated to have the potential to support 500 chinook spawners (WDF, 1971). Indian Creek and Little River provide some additional spawning area (WDF, 1971). Other tributaries, although accessible, may be less suitable for chinook spawning because of their small size. The

Table 3-7. Counts of fall chinook redds in the lower Elwha River, 1986-1989 (Source: letter from Bill Graeber, WDF, March 20, 1990).

	Peak Number of Redds/Mile By Year[1/]			
River Mile	1986	1987	1988	1989
0.0-0.2	--	0	--	--
0.2-3.2	62	108	289	199
3.2-4.4	69	96	310	212
4.4-4.8	10	25	80	50
4.8-4.9	--	0	0	0
Total Redds	273	447	1,217	863

1/ Values are highest single count of redds for any date during the given year.

middle reach area probably has more available rearing area than would be utilized by juvenile chinook spawned within the reach.

The upper reach (RM 16 to 42.9) is probably passable for most chinook above Glines Canyon dam. A falls at RM 33.7 could block some chinook if they were not in prime condition and if flows were low at their arrival time (James River II, 1988a). Assuming the falls are passable, approximately 49 stream miles (including 27 miles of mainstem) would be accessible to chinook in this reach (James River II, 1988a). Much of the upper reach provides excellent spawning habitat for chinook salmon (WDF, 1971). Some of the major tributaries would also be suitable for chinook spawning such as Cat Creek, Godkin Creek, and Delabarre Creek (WDF, 1971). In the upper reach, given the apparently large area of suitable spawning habitat, chinook rearing area could be limited.

3.4.4 Coho Salmon

Coho salmon are another highly prized sport and commercial salmon species in Washington. The Elwha River, because of its hatchery program, is currently the largest producer of coho salmon on the Strait of Juan de Fuca. Run size is a small portion (less than 1 percent) of Puget Sound coho runs, but equal to about 16 percent of runs arriving at four major North Coast rivers.

Adults enter the river from mid-August through November with some arriving as late as January (Williams et al., 1975). Spawning takes place from November through January. Most juveniles emerge from the gravel from late winter through mid-spring (Williams et al., 1975; Scott and Crossman, 1973). Juveniles live for over a year in the system before migrating to the ocean typically from late March through June, with peak outmigration measured in May (Wunderlich, 1983).

Coho salmon typically spawn in tributary habitats, but can spawn in main side channel habitats with suitable conditions (Williams et al., 1975). Coho juveniles prefer pools and backwater areas (House and Boehne, 1986; Lisle, 1986) and are often associated with log cover (Bustard and Narver, 1975). Overwintering habitat, which is critical for survival, is often associated with off-channel areas such as ponds (Peterson, 1980) and side channels (Peterson and Reid, 1984; Swales and Levings, 1985) although main channel pools are also used for overwintering (Swales and Levings, 1985). In general, the Elwha's lower reach does not provide substantial amounts of preferred coho salmon spawning or rearing area. Coho stocking has included planting from the Dungeness River stocks from 1967 to 1976. Stocks used after 1977 were collected from the Elwha River, but are probably not Elwha River native stock. Some coho rearing and release occurred from the WDF rearing channel from 1974 to 1982. The Elwha Tribal Facility has been used for coho rearing since 1977 and has been the only source of coho to the river since 1983.

Coho are typically stocked as yearling fish in April and May. Recent releases ranged from 0.6 to 1.0 million per year. Since 1977, coho returns to the Elwha have ranged from 5,000 to 18,000 per year with the majority being hatchery fish (Table 3-8). Reported in-river harvest by the Lower Elwha Klallam Tribe has been as high as 15,000 fish but is usually 6 to 10 thousand. Estimated escapement of wild fish is small, ranging from 100 to 400 fish.

The same length of stream available for chinook would be available for coho in the middle reach (James River II, 1988b). Available coho spawning habitat in the mainstem middle reach appears to be limited (WDF, 1971). There are 9.7 miles of tributaries accessible to coho spawning, which is favorable, because coho often utilize tributary streams more than chinook. Because coho spend at least 1 year in fresh water before migrating, rearing habitat is important to overall production. Coho rearing habitat in the middle reach may be restricted because of the dependence of coho on the quantity of low flow summer habitat (Zillges, 1977; Baranski, 1989).

The same areas accessible to chinook are considered accessible for coho in the upper reach (RM 16 to 42.9). The falls at RM 33.7 may be more difficult for coho to pass because of their expected run timing in fall and early winter. For the coho that pass the falls, 48.8 miles of stream would be available; for those not successful, 32.0 miles would be available (James River II, 1988b). About half of

Table 3-8. Run and harvest information for the Elwha River coho salmon.[1/]

Year	Total Run[2/]				Run to Strait[3/]				Run to River[3/]				Terminal Escapement[3/]				Hatchery Rack Count[4/]	Calculated In-River Harvest[5/]	Reported Tribal Harvest[6/]
	Hatchery	Off-Station	Wild	Total	Hatchery	Off-Station	Wild	Total	Hatchery	Off-Station	Wild	Total	Hatchery	Off-Station	Wild	Total			
1965	0	0	951	951	0	0	425	425	0	0	400	400	0	0	400	400		0	
1966	0	237	949	1,186	0	106	424	530	0	100	400	500	0	100	400	500		0	
1967	0	0	989	989	0	0	442	442	0	0	400	400	0	0	400	400		0	
1968	0	0	1,013	1,013	0	0	453	453	0	0	400	400	0	0	400	400		0	
1969	0	0	262	262	0	0	117	117	0	0	100	100	0	0	100	100		0	
1970	0	5,029	957	5,987	0	2,248	428	2,676	0	2,100	400	2,500	0	2,100	400	2,500		0	0
1971	0	3,416	978	4,394	0	1,527	437	1,964	0	1,400	400	1,800	0	1,400	400	1,800		0	0
1972	0	235	235	470	0	105	105	210	0	100	100	200	0	100	100	200		0	0
1973	0	0	955	955	0	0	427	427	0	0	400	400	0	0	400	400		0	0
1974	0	0	966	966	0	0	432	432	0	0	400	400	0	0	400	400		0	0
1975	0	0	588	588	0	0	263	263	0	0	427	427	0	0	100	100	0	327	147
1976	699	0	1,340	2,009	299	0	599	898	271	0	542	813	200	0	400	600	177	213	213
1977	8,519	0	3,098	11,617	3,808	0	1,385	5,193	3,504	0	1,274	4,778	1,100	0	400	1,500	1,050	3,278	3,278
1978	9,257	0	3,085	12,342	4,138	0	1,379	5,517	3,884	0	1,295	5,179	900	0	300	1,200	894	3,979	3,978
1979	39,702	0	787	40,490	17,747	0	352	18,099	16,398	0	325	16,723	10,100	0	200	10,300	10,092	6,423	6,423
1980	24,685	0	4,295	28,980	11,034	0	1,920	12,954	10,399	0	1,809	12,208	2,300	0	400	2,700	1,983	9,508	9,507
1981	11,441	0	383	11,823	5,114	0	171	5,285	4,731	0	158	4,889	3,000	0	100	3,100	1,179	1,789	1,745
1982	36,063	0	1,503	37,566	16,120	0	672	16,792	14,873	0	620	15,493	4,800	0	200	5,000	3,557	10,493	10,538
1983	37,530	0	2,085	39,615	16,776	0	932	17,708	16,293	0	905	17,198	1,800	0	100	1,900	1,331	15,298	15,298
1984	19,367	0	1,490	20,857	8,657	0	666	9,323	8,412	0	647	9,059	2,600	0	200	2,800	278	6,259	6,259
1985	36,161	0	1,779	37,940	16,164	0	795	16,959	15,207	0	748	15,955	6,100	0	300	6,400	836	9,555	9,554
1986	15,805	0	971	16,776	7,065	0	434	7,499	6,820	0	419	7,239	3,259	0	200	3,459	375	3,780	3,781
1987	21,346	0	2,248	23,595	9,542	0	1,005	10,547	9,307	0	980	10,287	1,899	0	200	2,099	--	8,188	8,155
1988	2,633	0	1,271	3,904	1,177	0	568	1,745	1,157	0	559	1,716	414	0	200	614	--	1,102	963

1/ Table modified from that presented in James River II, 1988a.
2/ Based on the WDF (1984) which estimates 55.3 percent of total run stock were captured prior to entering the Strait. Value calculated by dividing total run to Strait by 0.447.
3/ Based on WDF catch-escapement run size calculation summary.
4/ WDF data (James River II, 1988a).
5/ Run to the river minus escapement.
6/ From WDF tribal catch records (James River II, 1988a, and Ward and Hoines, 1988).

the available stream miles are tributary streams suitable for coho spawning. The tributaries would not be preferred coho rearing areas because of their high slopes, which generally exceed 3 percent along most of their accessible length. Baranski (1989), studying streams in Puget Sound, found that the highest number of coho smolts were produced from streams with slopes between 1 and 2 percent. Although the mainstem river slope is generally between 1 and 2 percent, it is also wider than streams that are considered to have the highest production per unit surface area (Zillges, 1977).

3.4.5 Pink Salmon

Pink salmon are a major commercial salmon species in odd years in Puget Sound. Elwha River pink salmon production (about 200 fish) is small compared to the total run to Strait of Juan de Fuca streams (Table 3-9). No hatchery program has existed for pink salmon in recent history. The major pink salmon stream on the Strait is the Dungeness River which in recent years has had a run of 4,000 to 11,000 fish, although historically the run was much higher (personal communication, Jim Ames, WDF, January 16, 1990).

Elwha River pink salmon runs have declined dramatically since 1979 (Table 3-9). Peak runs to the river since 1959 were nearly 40,000 in 1963. Since 1979, estimated runs have been in the hundreds. In-river harvest has been negligible (two fish maximum) in the last 10 years (Table 3-9).

Estimated ocean and Canadian harvest of Elwha pink salmon prior to entering the Strait has ranged from 15 to 49 percent (average 28 percent) from 1959 to 1987. Additional significant unaccounted harvest may also occur in Canadian waters (personal communication, Jim Ames, WDF, April 5, 1990). Other factors potentially affecting pink salmon runs are increased hatchery outplants of juvenile coho, steelhead, and chinook. Significant stocking of hatchery fish (particularly coho) has often resulted in decreased numbers of chum or pink because of predation by the hatchery fish on newly emerged pink and chum salmon (Cardwell and Fresh, 1979; Fresh and Cardwell, 1982; Fresh (ed.), undated; Johnson, 1973). Also, ocean conditions that affect the survival of juveniles have been found to correlate significantly with pink salmon runs in Puget Sound (Gallagher, 1979). High temperatures in late summer spawning during low-flow, high-temperature years could also adversely affect egg survival.

Spawners enter the river typically from mid-July through September with spawning occurring from mid-August through late October. Juveniles emerge from mid-January through late April and migrate directly to the ocean or estuary (Scott and Crossman, 1973) arriving from April to early May (Gerke and Kaczynski, 1972). Once the fry reach the coast they typically spend about two months in the nearshore area before moving to deeper water (Gallagher, 1979).

Table 3-9. Run and harvest information for the Elwha River pink salmon.[1/]

Year	Total Run[2/]				Run to Strait[3/]				Run to River[3/]				Terminal Escapement[3/]				Calculated In-River Harvest[4/]	Reported Tribal Harvest[5/]
	Hatchery	Off-Station	Wild	Total	Hatchery	Off-Station	Wild	Total	Hatchery	Off-Station	Wild	Total	Hatchery	Off-Station	Wild	Total		
1959	0	0	17,005	17,005	0	0	12,176	12,176	0	0	10,000	10,000	0	0	10,000	10,000	0	
1961	0	0	9,451	9,451	0	0	8,062	8,062	0	0	8,000	8,000	0	0	8,000	8,000	0	
1963	0	0	69,961	69,961	0	0	48,833	48,833	0	0	40,000	40,000	0	0	40,000	40,000	0	
1965	0	0	19,953	19,953	0	0	15,324	15,324	0	0	15,000	15,000	0	0	15,000	15,000	0	
1967	0	0	18,731	18,731	0	0	11,838	11,838	0	0	10,000	10,000	0	0	10,000	10,000	0	
1969	0	0	2,248	2,248	0	0	1,641	1,641	0	0	1,500	1,500	0	0	1,500	1,500	0	
1971	0	0	5,806	5,806	0	0	4,448	4,448	0	0	4,000	4,000	0	0	4,000	4,000	0	0
1973	0	0	15,618	15,618	0	0	10,964	10,964	0	0	9,600	9,600	0	0	9,600	9,600	0	0
1975	0	0	2,327	2,327	0	0	1,664	1,664	0	0	1,500	1,500	0	0	1,500	1,500	0	2
1977	0	0	10,109	10,109	0	0	6,106	6,106	0	0	5,000	5,000	0	0	5,000	5,000	0	0
1979	0	0	18,481	18,481	0	0	9,444	9,444	0	0	7,100	7,100	0	0	7,100	7,100	0	2
1981	0	0	540	540	0	0	306	306	0	0	200	200	0	0	200	200	0	0
1983	0	0	272	272	0	0	242	242	0	0	200	200	0	0	200	200	0	0
1985	0	0	233	233	0	0	176	176	0	0	102	102	0	0	100	100	2	2
1987	0	0	132	132	0	0	111	111	0	0	50	50	0	0	48	48	2	2

1/ Table modified from that presented in James River II, 1988a.

2/ Total run calculated by dividing run to Strait by proportion escaping ocean and Canada harvest. The values varied by year ranging from 0.511 to 0.853 (personal communication, Jim Ames, WDF, April 5, 1990).

3/ Based on WDF catch-escapement run size calculation summary. After 1975, all escapement estimated based on a historical relationship between Dungeness and Elwha, escapement not actual Elwha surveys (personal communication, Jim Ames, WDF, April 5, 1990).

4/ Run to the river minus escapement.

5/ From WDF tribal catch records (James River II, 1988a, and Ward and Hoines, 1988).

Substrate composition in the lower river is not optimum for pink salmon spawning but this is probably not the cause of the current low run sizes. Ray Johnson (letter, former Fish Biologist, WDF, October 28, 1988) indicated that the river's current pink salmon spawning potential is similar to what it had been between 1959 and 1967 when most escapement ranged from 8,000 to 15,000 (letter from Fred Winchell, Aquatic Biologist, Hosey and Associates, Bellevue, Washington, November 2, 1988).

Middle reach substrate is not suitable for pink salmon because of its large size. Additional spawning areas would be available in the 9.7 miles of tributary streams in this reach.

Pink salmon will probably not use the upper reach for spawning. They may have historically ascended to RM 16 (James River II, 1988d). The WDF (1971) suggested that the region above Glines Canyon dam (RM 13.4) "was probably too steep to provide significant spawning area" for pink or chum.

3.4.6 Chum Salmon

Chum salmon are a major commercial species in Puget Sound but are infrequently captured by sport fisherman. Runs of Elwha River chum salmon, including hatchery fish, is a small portion of the total run to Strait streams and a very small portion of the total Puget Sound runs. Run to the Strait has typically been less than 1,000 fish, peaking in 1980 at 1,500 (Table 3-10). Reported tribal in-river harvest since 1978 has ranged from less than 50 to 1,100, averaging about 400 since 1981. Ocean and British Columbia harvest of Elwha River chum salmon is considered minor at less than 5 percent (WDF, 1984).

Chum salmon migrate to the Elwha from September through early December (Williams et al., 1975) with the majority entering in November and December (James River II, 1988a). Actual spawning occurs from early October through early January (Williams et al., 1975). Rearing and outmigration is very similar to pink salmon. Fry emerge from the gravel from late January through early June (mostly beginning in April) and migrate directly to the estuary or ocean (Williams et al., 1975; Scott and Crossman, 1973). Puget Sound chum spend their first few weeks in the marine environment in shallow water (less than 1 meter) before moving gradually offshore (Gerke and Kaczynski, 1972). Factors found to correlate with chum run size have included salinity and temperature in the marine environment during early marine rearing for odd brood runs, presumably as a result of competition with young pink salmon. In even years, low flow during spawning periods has affected production (Gallagher, 1979).

Spawning habitat in the lower reach would be largely unsuitable for chum salmon. The lack of success of the chum planting program suggests that factors other than spawning may currently be affecting chum survival. As discussed for pink

Table 3-10. Run and harvest information for the Elwha River chum salmon.[1/]

Year	Total Run[2/]				Run to Strait[3/]				Run to River[3/]				Terminal Escapement[3/]				Calculated In-River Harvest[4/]	Reported Tribal Harvest[5/]
	Hatchery	Off-Station	Wild	Total	Hatchery	Off-Station	Wild	Total	Hatchery	Off-Station	Wild	Total	Hatchery	Off-Station	Wild	Total		
1965	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	
1966	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	
1967	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0	
1968	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	
1969	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	
1970	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	5
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	188
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	53
1978	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	375
1979	0	88	0	88	0	85	0	85	0	85	0	85	0	40	--	40	45	45
1980	0	1,584	0	1,584	0	1,524	0	1,524	0	1,401	0	1,401	0	1,008	--	1,008	393	390
1981	0	386	0	387	0	372	0	372	0	372	0	372	0	309	--	309	63	65
1982	0	1,423	0	1,402	0	1,349	0	1,349	0	1,331	0	1,331	0	219	--	219	1,112	1,113
1983	0	260	0	260	0	250	0	250	0	246	0	246	0	93	--	93	153	153
1984	0	1,210	0	1,210	0	1,164	0	1,164	0	1,154	0	1,154	0	710	--	710	444	444
1985	0	666	0	670	0	645	0	645	0	620	0	620	0	250	--	250	370	370
1986	0	293	0	287	0	276	0	276	0	267	0	267	0	7	--	7	260	266
1987	0	925	0	925	0	890	0	890	0	872	0	872	0	4	--	4	868	824
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--	0	0	271

1/ Table modified from that presented in James River II, 1988a.
2/ Based on the WDF (1984), which indicates that 3.8 percent of total run was harvested prior to entering the Strait. Values calculated by dividing run to Strait by 0.962.
3/ Based on WDF catch-escapement run size calculation summary. No actual spawning surveys conducted in Elwha, but wild escapement (not shown) assumed to be 5 percent of the total Strait escapement. Under this assumption, wild Elwha escapement would range from 7 to 550 for 1968 to 1988 and averaged about 270 from 1981 to 1988 (personal communication, Jim Ames, WDF, April 5, 1990).
4/ Run to the river minus escapement.
5/ From WDF tribal catch records (James River II, 1988a, and Ward and Hoines, 1988).

salmon, high numbers of hatchery fish (coho, steelhead, and chinook) have often reduced wild chum populations in Washington State, in many cases more so than pink salmon populations (Johnson, 1973). The small Elwha River estuary may also reduce chum survival as estuaries are utilized for juvenile chum rearing (personal communication, Jim Ames, WDF, January 16, 1990).

Large substrate in the middle reach mainstem would restrict chum salmon spawning greatly. Some spawning would be available in the tributaries, particularly Indian Creek and Little River. As with pink salmon, ocean conditions may play an important role in production of chum in the system independent of adequate spawning because all rearing occurs in the marine environment.

Historical upstream distribution of chum salmon is not known. For the same reasons discussed for pink salmon, it is unlikely that chum salmon would successfully ascend to the upper reach.

3.4.7 Sockeye Salmon

Sockeye salmon are one of the most prized commercial salmon species in Washington although state-originated runs are small. Elwha River sockeye salmon stocks do not currently exist. From 1978 to 1987 sockeye harvest in the river occurred in two years with a catch of 7 and 4 fish (Ward and Hoines, 1988). These fish may have been strays from coastal (Ozette or Quinault), Puget Sound (Baker or Cedar), or Fraser River runs.

All major stocks of sockeye in Washington require a river system with an accessible lake. The Elwha River does not have an accessible lake in the lower 4.9 miles, although Lake Sutherland would become accessible with passage over Elwha dam.

3.4.8 Steelhead Trout

Steelhead trout are one of the most sought after sport fish in the state and also support substantial tribal commercial harvest. Because of its large hatchery release program, the Elwha River is the largest producer of steelhead of the Strait streams. It is one of Washington State's major steelhead systems ranking tenth in total winter steelhead sport catch in 1987 to 1988 (WDW, 1989b). Some of the major North Washington Coast streams produce more steelhead such as the Quillayute and Hoh rivers.

The Elwha River produces winter and summer steelhead. As is typical for other streams in the area, the winter run is larger accounting for more than 80 percent of the total steelhead harvest (Table 3-11). Both winter and summer steelhead have been stocked in the lower Elwha with consistent stocking of winter steelhead since 1965 and summer steelhead since 1968. Beginning about 1979 the Lower

Table 3-11. Elwha River steelhead run and harvest summary.[1/]

Winter Run

Year	Smolts Released (N-2)	Return Rate to Fishery	Total Hat.[2/] Return Rate	Run Size			Escapement			Harvest			
				Total	Wild	Hatch.	Total	Wild[3/]	Hatch.[4/]	Total	Non-Treaty	Treaty Commer.	Treaty C&S
81-82	51,000	--	5.19	2,907	643	2,264	563	260	303	2,344	1,001	1,258	85
82-83	66,400	--	2.60	2,243	647	1,596	465	198	267	1,778	674	1,088	16
83-84	63,600	--	4.54	3,590	554	3,036	603	332	271	2,987	1,379	1,582	26
84-85	86,300	--	6.10	6,085	835	5,250	761	592	169	5,324	3,456	1,857	11
85-86	95,600	--	3.95	4,655	834	3,821	648	435	213	4,007	1,232	2,767	8
86-87	89,950	--	3.12	3,542	493	3,049	473	341	132	3,069	518	2,546	5
87-88	118,800	--	3.66	4,690	499	4,191	621	454	167	4,069	2,299	1,760	10
88-89	73,630	--	2.25	2,923	416	2,507	321	289	32	2,602	1,091	1,486	25
Average	80,660	--	3.75	3,829	611	3,214	557	363	194	2,947	1,456	1,793	23

Summer Run

Year	Smolts Released (N-2)	Return[5/] Rate to Fishery	Total Hat.[6/] Return Rate	Run Size[6/]			Escapement[6/]			Harvest			
				Total	Wild	Hatch.	Total	Wild	Hatch.	Total	Non-Treaty	Treaty Commer.	Treaty C&S
81	20,020	4.11	5.88	--	--	1,257	--	--	377	880	858	22	0
82	26,115	3.73	5.33	--	--	1,109	--	--	333	776	534	242	0
83	17,820	2.73	3.90	--	--	984	--	--	295	689	651	8	30
84	15,175	2.28	3.26	--	--	623	--	--	187	436	435	1	0
85	20,285	2.12	3.03	--	--	490	--	--	147	343	258	5	80
86	20,700	0.66	0.94	--	--	189	--	--	57	132	108	24	0
87	18,900	0.64	0.91	--	--	191	--	--	57	134	127	7	0
88	19,800	--		--	--	373	--	--	112	261	157	103	0
Average	19,852	2.40	3.42	--	--	652	--	--	196	456	391	52	14

1/ From Point No Point and WDW 1989-90, winter and summer steelhead report (1989).

2/ Survival of 2 plus 3 salt fish.

3/ Wild escapement = Total escapement minus hatchery escapement; includes hatchery fish not entering hatchery.

4/ Hatchery rack count = Total run minus (total harvest divided by 0.9).

5/ Based on return of age 1,2 and 3 salt fish assuming all harvest is hatchery.

6/ Based on assumed harvest rate of 70 percent (30 percent escapement) and all fish harvested are hatchery fish. No wild run information available.

Elwha Tribal Facility began to rear winter steelhead and has continued to collect stocks returning to the Elwha River for rearing and release. In recent years, this facility has become the primary winter steelhead rearing facility for the Elwha River.

Run size of winter and summer steelhead has averaged about 3,800 and 700 per year, respectively (Table 3-11). Wild run winter steelhead are estimated to be a small portion of the total (about 16 percent). Although wild summer steelhead abundance has not been assessed, it is probably also a small portion of the total.

Unlike salmon stocks all harvest of steelhead occurs in the river. Total harvest is generally proportional to run size with winter and summer harvest averaging 2,947 and 456, respectively. Most of the tribal harvest occurs on the winter stock (60 percent of total winter harvest), while sport harvest rate is highest on summer stocks (85 percent of total summer harvest) (Table 3-11).

Calculated return rate from smolt plants from 1981 to 1988 averaged about 3.8 percent and 3.4 percent for winter and summer stocks, respectively (Table 3-11). These rates were estimated based on the return of age 2 and 3 ocean fish for winter and age 1, 2 and 3 summer fish (Point No Point Treaty Council and Washington Department of Wildlife, 1989; data from Bob Gibbons, Fish Biologist, Washington Department of Wildlife, April 16, 1990).

Winter steelhead enter the Elwha from mid-November through May with most hatchery fish entering from early December through mid-April. Summer steelhead enter from mid-March through September with the major portion from April through August. Both races spawn from late January to early June depending on time of arrival. Hatchery winter steelhead usually spawn earlier than wild fish (Johnson and Cooper, 1986). Summer steelhead reside in the river for up to 6 months before spawning (Wydoski and Whitney, 1979). Steelhead juveniles live in fresh water from one to three years before migrating to the sea although the majority in Washington spend two years before leaving. Most Elwha River outmigration occurs in May and June (James River II, 1988b).

Steelhead spawn in mainstem and tributary streams and use a wide range of substrate sizes from fine gravel to medium cobble. Steelhead juveniles live in tributaries and large mainstem rivers (Gibbons et al., 1985).

The lower Elwha reach probably has little suitable steelhead spawning habitat. Available rearing habitat may be the main factor limiting Elwha wild steelhead production. A model developed by Gibbons et al. (1985) based on river size and gradient can be used to estimate optimal wild steelhead escapement in the lower Elwha. On the basis of this model, optimal escapement should be about 200 fish (James River II, 1988b). Estimated average number of returning fish has been about 600 over the last 8 years (Table 3-11), indicating that to obtain the optimum

escapement, harvest rate would have to be 66 percent. Optimal harvest rates on wild stocks are usually lower than this so it seems reasonable that, if the run is maintaining itself, harvest rates are not too high. These results suggest that production in this system is controlled by rearing habitat.

An estimated 15.7 miles of accessible habitat would become available for steelhead in the middle reach with fish passage. The large substrate in the mainstem restricts spawning potential in this area. The 9.9 miles of tributaries would supply steelhead spawning. Because steelhead typically spend 2 years in fresh water before migrating to the ocean, rearing habitat is often the limiting factor in their production. Moderate to high gradient habitat (0.5 to 5.0 percent slope mainstem regions, Gibbons et al., 1985) are generally the most productive for rearing steelhead based on abundance of parr (i.e., age 1+ fish). Much of the mainstem and major tributaries in this reach are in this slope range and should provide good rearing habitat for steelhead.

The upper reach has a potential accessible stream length of 60.0 miles for fish which pass the falls at RM 33.7. Steelhead have the least trouble of all anadromous species in ascending these falls (James River II, 1988d). There should be no shortage of steelhead spawning habitat in this upper reach. The Elwha mainstem should supply excellent rearing for steelhead which typically utilized slopes in the range of 1 to 3 percent which are prevalent in the upper Elwha. The tributary area is limited in the upper reach area because of the steep valley walls (26.3 miles of accessible tributary stream miles).

3.4.9 Resident Rainbow Trout

Nonanadromous rainbow trout are the most sought-after freshwater game fish in Washington. Recent creel surveys of sport catch in the two Elwha River reservoirs and intervening river indicated extensive use by fishermen (22,000 hours of fishing effort per summer season, Collins, 1983). Rainbow trout are the most abundant game fish in the river and reservoirs above Elwha dam based on historic (Table 3-12; Mausolf and Sundvick, 1976) and recent surveys (Collins, 1983).

The life history of rainbow trout is similar to the steelhead. They spawn from April to June with fry emerging in early to mid-summer depending on temperature (Scott and Crossman, 1973). Reservoir populations may reside in the reservoir all their life or spend 1 to 3 years in the streams before migrating to the reservoirs. Rainbow trout are well adapted to Northwest streams, commonly residing in most regions of a watershed including lakes, mainstem rivers, and tributary streams.

The creel survey conducted by Collins (1983) found slight differences between rainbow stocks in Lake Mills and those in the middle reach and Lake Aldwell. He concluded that the rainbow populations in all areas sampled were probably

Table 3-12. Reported catch in the Elwha River above Lake Mills.[1/]

Species	1974 Reported Catch	1974 Percent Catch	1976 Reported Catch	1976 Percent Catch	Total Reported Catch	Total Percent Catch
Rainbow	29	20.7	350	61.3	379	53.3
Dolly Varden	105	75.0	212	37.1	317	44.6
Cutthroat	0	0	2	0.4	2	0.3
Brook trout	6	4.3	7	1.2	13	1.8
Total	140	100.0	571	100.0	711	100.0

1/ Data from J. Meyers, NPS, 1990.

controlled by fisherman harvest. Since this study, fishing restrictions have been imposed, but some fishermen still believe the fishing has not improved and that other factors may be affecting populations.

Factors which may presently control rainbow populations below Glines Canyon dam include poor spawning gravel quality (which would affect abundance) and low food supply (which would affect fish growth and possibly survival).

3.4.10 Cutthroat Trout

Sea-run cutthroat trout are a major sport species in the state (Johnston and Mercer, 1976) although they are less abundant in most areas than steelhead (DeShazo, 1980). A region-wide decline in sea-run cutthroat populations has occurred in the past 15 to 20 years reducing their overall abundance (Trotter, 1989).

Resident cutthroat trout are not abundant in the Elwha upper reach based on sport fish harvest records (Table 3-12). Only 2 of 711 fish reported caught in 1974 and 1976 above Lake Mills were cutthroat. A 1981-82 creel survey of Lake Aldwell and Lake Mills did not list cutthroat as a species captured (Collins, 1983). It is possible that more isolated populations may be present further up tributary streams in this system because cutthroat in Washington are often present in these areas (Trotter, 1989).

Sea-run cutthroat typically spawn in tributaries of small- or moderate-sized streams with watershed areas up to 120 km^2 and low stream gradients in their lower reaches draining sloughs or meadowlands (Trotter, 1989). The lower Elwha has neither small tributaries nor low gradient areas adjacent to meadowlands; its habitat characteristics therefore are generally less conducive to cutthroat trout production than more characteristic streams.

Adult anadromous cutthroat trout migrate upstream from July to January (Trotter, 1989). This migration may occur at least once before they are ready to spawn. Spawning occurs from December to March (typically in February) and most often in small tributaries. Repeat spawners are common (with up to 40 percent of the spawners returning). Fry emerge from March to June and smolt migration occurs between ages 2 and 6. Generally, fish from coastal stocks leave later (age 5) than do fish from inner Puget Sound (most at age 2). Outmigration is from March to May, most often in mid-May. Rearing also usually occurs in small tributaries, often associated with pool habitat similar to that favored by coho. Adults in the marine environment stay within 50 km of their stream of origin. They remain nearshore with most not passing into deep water. Resident fish have a similar time for spawning and emergence but often have very limited movement within the stream and may spend their life within a few hundred meters of their original spawning area.

In the lower and middle reaches of the Elwha, spawning substrate quality is generally poor, but other factors also determine Elwha cutthroat abundance. Anadromous cutthroat in the lower reach may be limited by lack of preferred spawning or rearing habitat (small tributaries). Resident fish in the middle and upper reaches may be more limited by competition with resident rainbow trout. Hanson (1977) found that, when cutthroat and steelhead juvenile (anadromous rainbow) were placed in the same habitat, rainbow had the advantage in competing for selected habitat. He also noted that they were unable to find sympatric (occupying the same area) populations of cutthroat and steelhead trout in Idaho. Phillips et al. (1980) found in the Skagit River system that, when cutthroat, coho, and steelhead juveniles were present together, cutthroat were the least abundant (13 percent).

3.4.11 Dolly Varden

Dolly Varden are not an important sport species in Washington because of their limited abundance. Johnson (personal communication, WDW, April 6, 1990) characterized the species in Washington State as widely distributed but not locally abundant. Generally, little is known about the species in Washington State.

A fisherman survey in 1974 and 1976 indicated 45 percent of all fish captured in the Elwha upper reach were Dolly Varden (Table 3-12). A 1975 survey of Lake Mills fish populations indicated that about 15 percent of the lake sport fish were

Dolly Varden with an estimated population of 7,500 (Mausolf and Sundvick, 1976). The authors concluded that their survey probably over-estimated lake fish populations. A creel survey conducted on Lake Mills, Lake Aldwell, and in the middle reach noted Dolly Varden as a minor catch, although it did not state numbers of fish caught by species.

Anadromous Dolly Varden have not been identified with certainty in the lower reach but they could be present. Wydoski and Whitney (1979) noted that, although they are found in all major coastal drainages in Washington, only a few streams and lakes have sizable numbers.

Anadromous populations migrate from the sea upriver from May to December (usually August to September) with spawning occurring in the fall, usually October (Scott and Crossman, 1973). Fry emerge in April to mid-May. Anadromous stocks migrate to sea at age 3 or 4 in the spring and return to the same river in the fall, spending only late spring to fall in the marine environment each year of their life. When in the ocean the fish only migrate a short distance from the river staying in the tidal water (Scott and Crossman, 1973). In systems with lakes such as the Elwha, resident fish may undergo similar migrations, spending summer in the lake and other times in the river (Wydoski and Whitney, 1979). The Elwha River reservoirs are not accessible to anadromous Dolly Varden.

This species is most often found in abundance only in systems with high gradient and very clean, cold water, which is characteristic of much of the Elwha River (personal communication, Thom Johnson, WDW, April 6, 1990).

Major factors that limit Dolly Varden are not readily apparent for the Elwha system for anadromous or resident populations.

3.4.12 Sturgeon

Sturgeon are a major commercial and recreational species in Washington with the most important stocks utilizing the Columbia and Chehalis rivers. They are occasionally taken in Indian commercial nets in the Elwha River (James River II, 1988c). Sturgeon are most typically associated with large rivers or protected bays in Washington. On the basis of commercial harvest data, only 13 percent of all sturgeon in Washington are captured north of Grays Harbor including all other ocean areas and Puget Sound (Ward and Hoines, 1988). The only known spawning populations of white sturgeon in the region are the Columbia and Fraser rivers, British Columbia, although others cannot be ruled out (personal communication, John Devure, WDF, April 30, 1990). Sturgeon stocks that originate in one river system may be captured in another system some distance from their river of origin (Stockley, 1981; Scott and Crossman, 1973). Although the factors controlling Elwha sturgeon population is not known, compared to

major spawning streams, the Elwha River is small, with a small estuary which may limit sturgeon production.

3.4.13 Marine Shellfish

Shellfish are commonly pursued as a recreational resource in Washington in the intertidal areas and are also commercially harvested from selected areas by Indian Tribes and nontribal commercial interests. The most commonly pursued shellfish in the intertidal areas are hardshell clams, specifically littleneck clams, butter clams, and horseclams. Around the mouth of the Elwha River, harvesting of these species is probably small because of the persistence of PSP (Paralytic Shellfish Poison or Red Tide). This disease is caused by clams ingesting certain species of algae and the subsequent concentration of algal toxins. Because of persistence of this disease in the area, all beaches west of Dungeness Spit are closed to the taking of shellfish by the Washington Department of Fisheries from April 1 to October 31 every year.

The Elwha River intertidal area should support populations of hardshell clams although the beaches are depleted of gravel and have steep slopes that reduce the intertidal area. Goodwin (1973) surveyed subtidal hardshell clam populations in Puget Sound along the Strait of Juan de Fuca. He concluded that the highest populations were found in water less than 30 feet deep and away from heads of bays with poor water circulation and mud and silt bottoms. Al Sholtz (personal communication, WDF, April 14, 1990) noted that river mouths were often good areas to find hardshell clam populations possibly because of the suitable substrate. He stated that good populations of hardshell clams were often found in regions with coarse gravel, although sand and cobble environments would also have hardshell clams present. A survey of the characteristics of the beach area at the Elwha mouth noted that the beach faces were "gravelly with occasional patches of sand" and that steep beach face changed to the more gently dipping shoreface which was composed of "cobbles and boulders" (James River II, 1988b). This indicated that some of the region is probably optimal while the cobble boulder area is not. Also, the steep beach face results in a small intertidal beach area exposed at tide changes, limiting the shoreline area available for clam production and harvest during tide changes.

3.5 TERRESTRIAL RESOURCES

The vegetation and wildlife habitats in the Glines Canyon Project vicinity are essentially pristine because they are protected and managed as part of the Olympic National Park (ONP). Most of the land in the vicinity of the Elwha Project have been logged and support stands of second growth timber, 20 to 80 years in age.

Old-growth conifer forests, wetlands, and riparian areas are diminishing resources nationally and representatives of these communities occur within the Elwha and

Glines Canyon project areas. The vegetation in the Elwha drainage is a unique mix of plant communities found on both sides of the crest of the Olympic Mountains and is of regional importance. Habitat adjacent to both projects is regionally important to wildlife, particularly wintering deer and elk.

3.5.1 Vegetation

The Elwha and Glines Canyon projects are located within the western hemlock (Tsuga heterophylla) zone, the most extensive vegetation type in western Washington and Oregon (Franklin and Dyrness, 1973). This zone is characterized by a wet, mild, maritime climate with relatively dry summers. Plant communities in this zone have been shaped by different moisture regimes due to elevation, soil type, slope, aspect and location, but are generally dominated by western hemlock and Douglas-fir (Pseudotsuga menziesii).

The Elwha River is located in the middle of the Olympic Peninsula, has a north-south orientation, and is one of the longest drainages on the peninsula. Because of its length and depth, the Elwha Valley is quite cold and has a climate that is transitional between the drier conditions to the east and the wetter climate to the west. Consequently, the Elwha Valley supports a mix of unique plant communities that are transitional between the vegetation occurring to the east and west (personal communication, E. Schreiner, Botanist, ONP, Port Angeles, Washington, January 25, 1990). Madrona (Arbutus menziesii)/Douglas-fir/ mazanita (Arctostaphylos spp.) and Douglas-fir/grand fir (Abies grandies) communities occur on dry, well-drained sites and represent eastern peninsula vegetation types found in the valley. Forests dominated by western hemlock with an understory of ferns occur on wet sites throughout the valley and are more characteristic of western peninsula vegetation.

The applicant has conducted terrestrial studies for the Elwha and Glines Canyon Projects on a 3,197-acre terrestrial study area that includes lands in the following locations: (1) adjacent to Lake Aldwell owned by James River; (2) surrounding Lake Mills between Whiskey Bend and Olympic Hot Springs roads; (3) Sweets Bottom, the area adjacent to the Elwha River between Lake Aldwell and Lake Mills; (4) Krause Bottom, the area immediately upstream of Lake Mills; and (5) owned by James River in the vicinity of the McDonald Gage and South Highway 101 (James River II, 1988a, 1988d, 1988e, 1990g). The lands owned by James River are available for mitigation; the other areas are in ONP, Olympic National Forest, or private ownership. Eight vegetated and four nonvegetated cover types have been identified (Table 3-13).

3.5.1.1 Upland and Riparian Communities

Most of the study area consists of upland and riparian forest communities (78 percent), including conifer (43 percent), mixed coniferous/hardwood

Table 3-13. Vegetation cover types in the Elwha/Glines Canyon terrestrial study area (Source: the staff, compiled from James River II, 1988a, 1988d, 1988e, 1990g).

Cover Type	Elwha Project (acres)[1/]	Glines Project (acres)[2/]	Sweets Bottom (acres)[3/]	Krause Bottom (acres)[2/]	Gage Sta. & S. Hwy 101 (acres)[1/]	Total (acres)	% of Total Study Area	% of Total Without Reservoir
Conifer Forest	337	501	304	191	46	1,379	35.5	43.1
Sapling	0	0	0	0	0	0	0.0	0.0
Pole	0	39	44	0	10	93	2.4	2.9
Mature	337	206	151	137	36	867	22.3	27.1
Old Growth	0	256	109	54	0	419	10.8	13.1
Mixed Forest	189	141	224	14	21	589	15.2	18.4
Sapling	0	0	0	0	0	0	0.0	0.0
Pole	0	6	10	0	2	18	0.5	0.6
Mature	189	116	72	14	19	410	10.6	12.8
Old Growth	0	19	142	0	0	161	4.1	5.0
Hardwood Forest	130	55	298	37	15	535	13.8	16.7
Sapling	2	0	0	6	0	8	0.2	0.3
Pole	32	6	28	31	2	99	2.6	3.1
Mature	96	49	205	0	3	353	9.1	11.0
Old Growth	0	0	65	0	10	75	1.9	2.3
Deciduous Shrub	28	0	10	0	9	47	1.2	1.5
Grassland	0	0	47	17	0	64	1.6	2.0
Palustrine Forest	44	14	106	17	25	206	5.3	6.4
Palustrine Scrub/Shrub	1	11	22	18	2	54	1.4	1.7
Palustrine Emergent	1	0	0	0	0	1	0.0	0.0
Riverine	17	7	111	40	7	182	4.7	5.7

Table 3-13. Vegetation cover types in the Elwha/Glines Canyon terrestrial study area. (Continued)

Cover Type	Elwha Project (acres)[1/]	Glines Project (acres)[2/]	Sweets Bottom (acres)[3/]	Krause Bottom (acres)[2/]	Gage Sta. & S. Hwy 101 (acres)[1/]	Total (acres)	% of Total Study Area	% of Total Without Reservoir
Reservoir	268	416	0	0	0	684	17.6	
Cobble/Gravel	0	3	4	47	0	54	1.4	1.7
Barren	0	14	0	0	0	14	0.4	0.4
Developed, Vegetated	12	8	23	0	3	46	1.2	1.4
Developed, Paved	10	1	15	0	0	26	0.7	0.8
TOTAL	1,037	1,171	1,164	381	128	3,881	100.0	100.0
Total Reservoir Area	769	755	1,164	381	128	3,197		

[1/] Owned by James River Corp.
[2/] Olympic National Park.
[3/] Includes 32 acres owned by James River Corp.; the remainder is owned by private individuals, the state, county or is in ONP.

(18 percent) and hardwood (17 percent). Upland grassland (2 percent) and deciduous shrub (1 percent) communities are sparsely distributed, as are vegetated developed areas (1 percent).

Conifers, primarily Douglas-fir, represent more than 75 percent of the trees in conifer forests and between 25 and 75 percent of mixed forests. About 71 percent of the conifer and mixed forest in the study area is second growth, occurring on land that was logged or burned between 40 and 120 years ago. Around Lake Aldwell, second growth stands occur primarily on areas that have been logged and represent nearly 70 percent of the land owned by James River. Second growth conifer and mixed stands represent between 24 and 48 percent of land in Krause Bottom, Sweets Bottom and the vicinity of Lake Mills. Because relatively little

logging has occurred in these areas, most of these second growth stands are probably the result of numerous fires that have occurred in the Elwha drainage since 1891 (Pickford et al., 1980).

No old growth forest remains adjacent to Lake Aldwell. However, old growth forests comprise between 14 and 36 percent of the project lands in Sweets Bottom, Krause Bottom, and the vicinity of Lake Mills. These stands are dominated primarily by Douglas-fir and grand fir interspersed with smaller, subdominant western hemlock and a few big-leaf maple (Acer macrophyllum). The trees in these old growth stands are between 270 and 300 years old but tend to be smaller and more densely stocked than those in drainages to the west because of the drier climate in the Elwha Valley (Fonda and Bliss, 1969). In bottomlands, such as Krause Bottom, the understory of old-growth and mature stands to be open, park-like, and dominated by grasses and forbs, indicating heavy use by elk (Cervis elaphus roosevelti). Similar stands on side slopes, such as those adjacent to Lake Mills, have a dense understory consisting of salal (Gaultheria shallon) on drier sites and ferns on wetter sites.

Conifers comprise less than 25 percent of the trees in hardwood forests. Hardwood forests are usually dominated by red alder (Alnus rubra), interspersed with big-leaf maple, black cottonwood (Populus trichocarpa), and willow (Salix spp.). Mature hardwood stands occur mainly in the riparian corridor along the river, representing 25 percent of the area within Sweet Bottom. About 17 percent of the lands adjacent to Lake Aldwell support hardwood stands. Hardwood forests occur on relatively little land in the vicinity of Lake Mills (7 percent) or Krause Bottom (10 percent).

3.5.1.2 Wetland Communities

Wetlands represent only a small portion of the study area (8 percent) and include forest (6 percent), scrub/shrub (2 percent) and emergent (< .01 percent) types. About 50 percent of the wetlands in the study area occur in Sweets Bottom but the largest stand of palustrine forest (27 acres) is located at the tail of Lake Aldwell. Many of the other wetlands in the project area are relatively small and are found in Krause Bottom, and along creeks draining into the reservoirs. Willow and red alder are the dominant tree species in wetlands; common understory species include salmonberry (Rhus spectabilis), Indian plum (Oemleria cerasiformis), and skunk cabbage (Lysichitum americanum).

Wetland functions in the study area probably include: (1) flood desynchronization; (2) bank stabilization and erosion control; (3) sediment trapping; (4) nutrient retention; (5) wildlife habitat; and (6) exchange of energy and materials (Brinson et al., 1981; Adamus and Stockwell, 1983).

3.5.1.3 Nonvegetated Communities

About 10 percent of the study area is nonvegetated, including the river (6 percent), gravel bars (2 percent), barren areas (0.4 percent), and pavement or buildings (1 percent). Developed areas are primarily associated with project operations at Elwha and Glines Canyon dams. Over 12 percent of the area in Krause Bottom consists of gravel bars.

3.5.2 Wildlife

The variety of plant community types in the terrestrial study area support a diverse mix of wildlife species, including big game, furbearers, raptors, passerine birds, and waterfowl.

In cooperation with the resource agencies, the applicant used the U.S. Fish and Wildlife Service's (FWS) Habitat Evaluation Procedure (HEP) to document existing wildlife habitat in the terrestrial study area and design a program for mitigation (James River II, 1988a, 1988d, 1990i). The HEP was also used to estimate the original impacts of the Elwha and Glines Canyon Projects on wildlife as well as the effects of dam removal.

HEP combines measures of habitat quality and quantity into a single value called a Habitat Unit (HU). Habitat quality is expressed as a Habitat Suitability Index (HSI) that ranges in value from 0 (no value) to 1.0 (optimum). HSI's are calculated from species habitat models that define the structural components or habitat characteristics most strongly correlated with wildlife distribution and abundance. HU's are determined from the product of the HSI for a site and its associated area for a single point in time (e.g., current conditions). To establish a baseline for comparison against project alternatives, HU's are then averaged over 50 years (the life of a new license) and results expressed as average annual habitat units (AAHU's). This averaging process accounts for succession that could affect the quantity or quality of habitat over the license period. It is the change in AAHU's that is used to measure impacts or benefits to wildlife from the alternatives under consideration and associated mitigative measures.

The HEP study area (terrestrial study area) is 3,197 acres. Assuming that the average HSI for a given species is 1.0 over the entire study area and remains constant for the next 50 years, 3,197 AAHU's would be available for that species each year for the duration of the next license period.

The HEP team, a group composed of staff from the FWS, WDW, National Park Service (NPS) and applicant, selected nine evaluation species to represent the wildlife in the terrestrial study area. A description of the wildlife in the study area is presented by major species groups in the following subsections.

3.5.2.1 Big Game

Roosevelt Elk

The Roosevelt elk is the primary big game species in the study area, although little is known about its distribution, density, and movements in the Elwha drainage (personal communication, B. Moorehead, Biologist, Olympic National Park, Port Angeles, Washington, January 25, 1990). Elk on the west side of the peninsula are primarily resident (60 percent) and mean densities range from 30/sq mi for the Hoh to 44/sq mi for the Queets (Houston et al., 1987). The entire west side population is estimated between 3,000 and 4,000 elk (Houston et al., 1988). Valley floors are preferred habitats in all seasons but winter; old growth forests are preferred habitats in all seasons except spring, when grasses in several forests are emerging (Schroer, 1988; Leslie et al., 1984). The elk populations on the west side of the peninsula appear to be stable and at equilibrium with their food resource (Leslie et al., 1984).

Elk on the east side of the peninsula are migratory and use low-elevation valley bottoms outside ONP during the winter and calving season (April-May). Riparian habitats provide migration corridors and subalpine parklands in ONP are preferred summer habitat (Schroer, 1986). Elk on the east side of the peninsula are much less abundant than on the west side. The east side population is estimated to total 400 elk with subpopulations between 40 and 100 animals (Houston et al., 1988). These subpopulations are considered vulnerable because of low numbers and increasing development on winter range adjoining ONP (Houston et al., 1988).

Since the Elwha is intermediate between east and west side drainages on the Olympic Peninsula, it probably supports both resident and migratory elk (personal communication, B. Moorehead, Biologist, ONP, Port Angeles, Washington, January 25, 1990). Elk herds of about 60 animals have been reported in the vicinity of Glines Canyon dam (Switzer, 1976). The understory throughout much of Sweets Bottom is open and "park-like", indicating intense browsing by elk.

Optimal winter habitat for elk includes a mixture of forage and cover areas close to each other. In the study area, old growth conifer stands represent optimal habitat because they provide thermal and hiding cover during severe cold as well as forage. Mature second growth conifer stands primarily provide thermal cover. Primary forage cover types include mature second growth hardwood and mixed forests, shrublands, grasslands, and palustrine areas. Based on the HEP results, winter forage for elk in the study area is limiting; consequently, habitat quality is low (HSI = 0.19). The study area provides 513 AAHU's for elk out of a maximum of 2,757 AAHU's if all habitats were optimum.

Black-tailed Deer

The black-tailed deer (Odocoileus hemionus) is also a common big game species in the Elwha drainage. Although there is little information on deer density or distribution along the Elwha, most are thought to be year-round residents of the lower elevation bottomlands. The east side of the Olympic Peninsula is considered to be high-quality deer habitat because the drier climate slows the rate of forest succession, resulting in longer seral stages which usually have higher amounts of browse (Taber and Raedeke, 1980). On the west side of the peninsula, deer and elk use the same habitats and have similar diets. However, elk in the Hoh Valley are about three times more numerous than deer, suggesting a competitive advantage during the winter when food resources are least available (Leslie et al., 1984).

Based on the HEP results, winter forage for deer in the study area is limiting; consequently, habitat quality is low (HSI = 0.24). The study area provides 648 AAHU's for deer out of a maximum of 2,757 AAHU's if all habitats were optimum. The same cover types that provide forage and cover for elk in the study area are used by deer.

Other Big Game

Other big game in the Elwha drainage include the black bear (Ursus americanus) and mountain lion (Felis concolor). Black bear density in ONP is about 4.7/sq mi, as high as the density in Yellowstone National Park (personal communication, B. Moorehead, Biologist, ONP, Port Angeles, Washington, January 25, 1990). However, it is likely that black bear density along the Elwha is lower than the ONP average because of the lack of salmon carcasses, which are known to provide food for this species in other drainages (Cederholm et al., 1989). No mountain lions were observed during the applicant's field studies but this species has been observed along the Elwha in the past (Woods, 1976).

3.5.2.2 Furbearers

A large number of furbearers, particularly mustelids, are known to occur throughout ONP but little is known of their habitats and densities (personal communication, B. Moorehead, Biologist, ONP, Port Angeles, Washington, January 25, 1990). Raccoon (Procyon lotor), muskrat (Ondatra zibethicus), mink (Mustela vison), river otter (Lutra canadensis), and beaver (Castor canadensis) use the riparian, aquatic, and wetland habitats along the Elwha. The pine marten (Martes americana) inhabits late successional coniferous forests (Allen, 1982), is fairly common throughout ONP, and probably occurs in the study area. The fisher (Martes pennanti) is rarely seen and may be threatened within ONP (personal communication, B. Moorehead, Biologist, ONP, Port Angeles, Washington, January 25, 1990).

Based on the HEP results, the study area provides 99 AAHU's for the beaver. Palustrine scrub/shrub wetlands in the study area provide optimal winter forage (HSI = 1.0) for beaver, while the other palustrine and aquatic cover types are of low-to-moderate value for this parameter (HSI = 0.3-0.6).

The study area also provides about 330 AAHU's for the mink, including 49 AAHU's from palustrine wetlands, 95 AAHU's from riverine habitats, and 186 AAHU's from Lake Aldwell. The Elwha River and Lake Aldwell have long shorelines with dense cover and provide nearly optimal (HSI = 0.9) habitat for mink. Wetlands in the study area are moderate quality (HSI = 0.5) mink habitat. The staff concluded Lake Mills was not suitable mink habitat because of reservoir fluctuations of up to 10 feet.

3.5.2.3 Small- and Medium-Sized Mammals

Fifteen species of small- and medium-sized mammals, including shrews, bats, squirrels, mice, rabbits, and skunks, potentially occur in the Elwha drainage. This species group provides the major prey base for most terrestrial furbearers and many raptors in the study area.

HEP results indicate that the study area provides 1,345 AAHU's for the Douglas' squirrel (Tamiasciurus douglasii). This species prefers large Douglas-fir trees and mature conifer stands provide higher quality habitat (HSI = 0.8) for the Douglas' squirrel than mixed conifer stands (HSI = 0.5).

3.5.2.4 Raptors

Up to 11 species of raptors have been observed in the Elwha drainage, including the red-tailed hawk (Buteo jamaicensis), northern pygmy owl (Glaucidium gnoma), and sharp-shinned hawk (Accipiter striatus) (Sharpe, 1990). The bald eagle (Haliaeetus leucocephalus), northern spotted owl (Strix occidentalis), barred owl (S. varia, northern goshawk (Accipiter gentilis), turkey vulture (Cathartes aura), and osprey (Pandion haliaetus) have also been observed in the study area and are addressed in Section 3.5.3 because they have federal and/or state status.

HEP results indicate that the study area provides 747 AAHU's for the Cooper's hawk (Accipiter cooperii). Hardwood and palustrine forest stands provide higher quality habitat (HSI = 0.6-0.7) for the Cooper's hawk than coniferous or mixed forest stands (HSI = 0.1-0.3).

3.5.2.5 Waterfowl

Lake Aldwell, Lake Mills, and the Elwha River provide habitat for a wide variety of waterfowl. The common goldeneye (Bucephala clangula), bufflehead (B. albeola), and lesser scaup (Aythya affinis) are common winter residents on both

reservoirs. Common mergansers (Mergus merganser), mallards (Anas platyrhynchos), and harlequin ducks (Histrionicus histrionicus) have been observed year-round on the lower and middle reaches of the Elwha River and may breed in the area (Sharpe, 1990).

HEP results indicate that the study area, primarily the shallow delta portions of Lake Aldwell, provides 40 AAHU's of wintering habitat for the lesser scaup. The remainder of the study area is unsuitable as habitat for this species because of lack of food. Freshwater mollusks, primarily clams and snails found in water less than 10 feet deep, are primary prey for the lesser scaup (Mulholland, 1985).

3.5.2.6 Marine Birds

Because of its proximity to the Strait of Juan de Fuca, the lower Elwha River, particularly the delta, provides forage habitat for a variety of marine birds. The glaucous-winged gull (Larus glaucescens) is a common year-round resident in the delta and is occasionally observed on Lake Aldwell (Sharpe, 1990). Thayer's and mew gulls (L. thayeri and L. canus are common in the delta during the fall and winter. California gulls are found from the delta to Lake Mills in the late summer and fall. The double-crested cormorant (Phalacrocorax auritus) and common loon (Gavia immer) are occasionally observed on the reservoirs as well as the near-shore marine environment. The marbled murrelet (Brachyramphus marmoratus), a federal candidate species and proposed state sensitive species, is addressed in Section 3.5.3.

3.5.2.7 Upland Game Birds

Relatively few upland game bird species occur in the Elwha drainage. However, the blue grouse (Dendragapus obscurus), ruffed grouse (Bonasa umbellus), and band-tailed pigeon (Columba fasciata) are common breeding residents in forest habitats (Sharpe, 1990).

3.5.2.8 Nongame Birds

Many species of nongame birds occur in the Elwha drainage. The American dipper (Cinclus mexicanus) breeds along the river and its tributaries. Violet-green swallows (Tachycineta thalussina) are common in open areas near the dams, bridges, and other man-made structures. The robin (Turdus migratorius), Townsend's warbler (Dendroica townsendi), dark-eyed junco (Junco hyemalis), and winter wren (Troglodytes troglodytes) are common breeding residents of the conifer and mixed forests in the study area (Sharpe, 1990). The hairy woodpecker (Picoides villosus), warbling vireo (Vireo gilvus), and evening grosbeak (Coccothraustes vespertinus) have been observed in the deciduous forests in the riparian corridor along the river (Sharpe, 1990). Old growth and mature conifer forests provide habitat for a variety of nongame birds, including the pileated

woodpecker (Dryocopus pileatus), red-breasted nuthatch (Sitta canadensis), golden-crowned kinglet (Regulus satrapa), varied thrush, and chestnut-backed chickadee (Sharpe, 1990). Open habitat types support the MacGillivray's warbler (Oporornis tolmiei), white-crowned sparrow (Zonotrichia leucophrys), and rufous hummingbird (Selasphorus rufus) (Sharpe, 1990).

HEP results indicate that the study area provides 635 AAHU's for the pileated woodpecker, a proposed state sensitive species. Since this species requires large trees (diameter-at-breast height [dbh] >20 inches) and snags for reproduction and feeding, optimal habitat is generally provided by mature and old growth conifer stands (Schroeder, 1983). The old growth and mature mixed and conifer stands in the study area provide moderate quality (HSI = 0.5-0.7) habitat for the pileated woodpecker. Habitat quality appears to be limited by less than optimal numbers of large trees and snag size.

The study area also provides 12 AAHU's for the yellow warbler (Dendroica petechia). Optimal habitats for this species are wet areas with dense, moderately tall stands of hydrophytic shrubs (Schroeder, 1982). Consequently, the yellow warbler generally occurs in palustrine scrub/shrub wetlands and shrublands. These habitats in the study area provide low quality (HSI = 0.1-0.2) habitat for the yellow warbler, primarily because of a low shrub cover and height. However, the palustrine forested wetlands and riparian hardwood stands in the study area may provide some habitat for this species as well.

3.5.2.9 Reptiles

Most reptiles prefer relatively dry areas and few species use the moist habitats provided by the forests in the study area. The northwestern garter snake (Thamnophis ordinoides) has been observed in the study area and the common and western terrestrial garter snakes (T. sirtalis and T. elegans) probably occur as well. The rubber boa (Charina bottae) and northern alligator lizard (Elgaria coerulea) are the only other reptiles likely to occur in the study area.

3.5.3 Threatened and Endangered Species

The FWS has documented the occurrence of two federally protected species in the Elwha/Glines Canyon study area, the bald eagle and northern spotted owl (letter from L. Childers, Acting Field Supervisor, FWS, Olympia, Washington, February 28, 1990). In addition, two Category 2 candidate species for federal status, the marbled murrelet and Cotton's milk-vetch (Astragalus cottonii) may occur in the vicinity of the projects. Category 2 candidate species include taxa with information indicating that proposed listing as threatened or endangered is possibly appropriate but substantial data on biological vulnerability and threats are lacking (50 CFR Part 17). Although candidate species are not currently federally

protected, they could be proposed or listed as threatened or endangered during the licensing process.

A number of other plants and wildlife potentially occurring in the study area are proposed or listed by the WDW or Washington Natural Heritage Program (WNHP) as endangered, threatened, sensitive, or monitor species. In addition, the NPS maintains a list of plants, including several WNHP-listed species, that are considered unique within ONP. All species listed by the WNHP, WDW, or NPS are protected within the park. Species listed by the WNHP or WDW also receive some protection on land managed by the state (i.e., Department of Natural Resources) or U.S. Forest Service.

3.5.3.1 Federally Listed Species

Bald Eagle

The bald eagle, a federally listed threatened species, has been observed year-round in the study area. No nests have been documented along the reservoirs or the river, but two pairs of eagles below RM 7 exhibited territorial behavior during the breeding season in 1990. The absence of nesting in the study area may be due to several factors including low prey availability and intensive logging on private lands that have eliminated perch and nest trees. The Strait of Juan de Fuca from Port Angeles to Neah Bay, however, is used by as many as 50 nesting pairs; two of these sites occur just east of the Elwha delta (Angeles Point Quad. T. 31N. R.07W. S.26) (letter from T. Cyra, Biologist, WDW Nongame Program, Olympia, Washington, February 12, 1990; personal communication, D. Taylor, WDW Nongame Program, Olympia, Washington, April 14, 1990).

The applicant conducted surveys of the study area from November 25 to April 14, 1990 that encompassed both the wintering and early nesting period of bald eagles (James River II, 1990h). The purpose of these surveys was to document eagle use of the mainstem of the Elwha River, associated tributaries, and coastal areas. Eagle abundance was determined in four survey sections including: (1) Coastal Survey Section, from the dike access road to the high bluff along the eastern portion of the delta; (2) Lower Elwha Survey Section, from the delta to Elwha dam (RM 0.1 to 4.8); (3) Middle Elwha Survey Section, from the southern half of Lake Aldwell to, but not including, Glines Canyon dam (RM 5 to 13.5); and (4) Upper Elwha Survey Section, from Glines Canyon dam and Lake Mills, south to Krause Bottom (RM 13.6 to 18). A total of 86 site visits were made to 19 stations positioned strategically within each survey section.

Fourteen eagles were detected during the survey period. The survey results and discussions with regional biologists and local landowners indicate that eagle densities upriver decreased with distance from the delta and that very low numbers occurred above Lake Mills. Significantly greater numbers of eagles were detected

along the Coastal Surveys Sections (8 detections), followed by Midriver (3), Lower River (2), and Upper River (1).

The applicant also performed an additional survey of the study area from April 30 to May 15 that encompassed a greater portion of the breeding season. Most eagles, three immatures and six adults, were observed in marine habitats in the vicinity of the Elwha delta and western Freshwater Bay. An additional seven sightings were made collectively in the Lower and Middle Survey Sections, although there was no evidence of breeding.

Bald eagles in the study area feed primarily on high concentrations of glaucous-winged gulls and other marine birds along the coast, chinook salmon carcasses in the lower river section, nonanadromous fish stocks in the reservoirs, and carrion, especially elk and heron carcasses. High prey availability along the coast in comparison to the middle and upper river sections may explain the observed patterns in eagle use within the study area. Loss of anadromy, especially in the middle and upper sections, appears to be a significant factor limiting eagle use of the Elwha. However, low use on the Lower Elwha where food availability is relatively high is probably related to the loss of potential roosts, perch sites, and nesting habitat due to logging.

Northern Spotted Owl

The northern spotted owl, a species listed as federally threatened in the Northwest in June 1990, is typically found in unlogged old-growth forests or mixed forests of mature and old-growth timber (Forsman et al., 1984). Forests with old-growth characteristics occur throughout the Elwha drainage in ONP, and the NPS conducted surveys to determine spotted owl use of this area from March through August 1990. Surveys involved calling for owls at survey stations along 16 transects, 3 different times during the breeding season; habitat data were also collected. Surveys will be conducted for 2 additional years in the valley (personal communication, B. Moorehead, Biologist, Olympic National Park, Port Angeles, Washington, September 25, 1990).

Results of the surveys documented seven pairs of spotted owls, five breeding, between the headwaters of the Elwha and the ONP boundary. Two nests were located and eight juveniles observed and banded. In addition, two single owls were observed and five adults banded. Although no spotted owls were observed in the immediate vicinity of the Glines Canyon Project, most of the forests adjacent to Lake Mills and project facilities are a mix of mature and old growth time and are considered by the NPS to be spotted owl habitat (personal communication, B. Moorehead, Biologist, Olympic National Park, Port Angeles, Washington, September 25, 1990).

Most of the forests adjacent to Lake Aldwell and the Elwha Project facilities being less than 100 years old are not suitable spotted owl habitat because they lack the characteristics of old growth required by this species (Forsman et al., 1984).

3.5.3.2 Federal Candidate Species

Marbled Murrelet

The marbled murrelet has been observed flying in the Elwha Valley and probably nests in the drainage (personal communication, B. Moorehead, Biologist, NPS, Port Angeles, Washington, January 25, 1990). In the Pacific Northwest, this species nests in trees in old-growth stands usually near coastal feeding areas, although nests up to 45 miles from the coast have been documented (Marshall, 1988).

The applicant conducted surveys to determine marbled murrelet use of the study area and the Elwha Valley from 3 March through 1 September, 1990 (James River II, 1990f). Eighty-eight surveys were conducted during this time, including 55 at dawn and 33 at dusk. Observations were made from 13 stations along the river, 6 north of the ONP boundary to the Elwha delta and 7 south of the boundary to Krause Bottom. The selected survey station were: (1) in stands that most closely met the nesting requirements of marbled murrelets; (2) well distributed throughout the Elwha Valley below Krause Bottom; (3) on sidehills or other locations that offered a wide view of the sky; and (4) in areas with minimal noise from the river so that vocalizations could be clearly heard. A minimum of 4 dawn surveys were conducted at each station. Stations where marbled murrelets were observed received additional visits. The protocol for the surveys was based on the Pacific Seabird Group's Handbook for Marbled Murrelet Surveys at Inland Sites (Paton et al., 1989).

In addition to the surveys along the river, 9 stations were also established along the marine shoreline adjacent to the study area, between Ediz Hook and Crescent Bay. Each site was visited twice each month during the survey period and observations were made for a minimum of 10 minutes per visit. Lake Aldwell and Lake Mills were also routinely visited during the survey period to check for marbled murrelets that may have been resting or feeding on the surface. Lake surveys lasted a minimum of 10 minutes.

A total of 85 detections of marbled murrelets, 1 visual and 84 acoustical, were made during the surveys along the river. All detections were from stations south of the ONP boundary and were made during the dawn surveys. Fifty-four of the observations were of birds flying in a linear fashion along the axis of the Elwha Valley and 12 were of birds circling above the canopy. Flight patterns of the other 19 observations could not be determined. Murrelets in flight ranged from canopy level to about 1,200 feet above the canopy, with the majority between 300

to 600 feet. Most detections were of single murrelets but groups of 2 and 3 were not uncommon. Consequently, 142 murrelets were observed along the river over the entire survey period.

Results of the surveys along the river indicate that most of the marbled murrelets do not breed in the Elwha Valley between Krause Bottom and the delta. This area appears to be used primarily as a flight corridor between the marine environment and nesting stands located along the upper reaches of the Elwha Valley or tributaries. It is estimated that about 15 pairs of marbled murrelets used the upper Elwha Valley or tributaries during the 1990 breeding season. Based on observations of murrelets calling and circling the canopy, nests may be located in stands along Boulder, Cat, Idaho, and Stukey creeks and above Altaire Campground.

A total of 1,018 marbled murrelets were observed from the marine stations. Distribution at sea appeared to be correlated with habitat complexity, such as the bays and/or mixed rock-sand substrates near Ediz Hook and Crescent Bay. Lower numbers of murrelets were observed in relatively featureless habitats, such as the Elwha delta. No murrelets were observed feeding or resting on either Lake Mills or Lake Aldwell.

Cotton's Milk-vetch

Cotton's milk-vetch, a Category 2 federal candidate species, is endemic to the Olympic Mountains in Clallam County (Hitchcock and Cronquist, 1981). This species, a member of the pea family, is also listed by the WNHP as threatened (WNHP, 1987). The WNHP has no records of the occurrence of Cotton's milk-vetch in the Elwha/Glines Canyon study area. The known habitat of Cotton's milk-vetch is limited to talus slopes (Hitchcock and Cronquist, 1981), which may occur at higher elevations in the Elwha watershed but are lacking in the study area. Surveys conducted in July to August 1990 of all areas potentially affected by any of the five alternatives did not locate this species.

3.5.3.3 Wildlife Species with State Status

The bald eagle and northern spotted owl are listed as state threatened and endangered, respectively. There are no other listed or proposed state threatened or endangered wildlife known to occur in the Elwha/Glines Canyon study area.

Wildlife species classified by the WDW as sensitive are those that could become threatened or endangered if current water, land, and environmental practices continue (WDW, 1988). The WDW database has no records documenting the occurrence of state sensitive wildlife species in the study area. However, the northern goshawk, Vaux's swift (Chaetura vauxi), marbled murrelet, and pileated woodpecker, all proposed state sensitive species, have been observed during

various surveys conducted in the study area. Because the pileated woodpecker was included in the HEP conducted by the applicant, its use of the study area and habitat requirements was addressed in Section 3.5.2.9. The marbled murrelet, also a state proposed sensitive species, was addressed in Section 3.5.3.2.

Proposed state monitor species are those that: (1) have significant popular appeal; (2) require limited habitat during some portion of its life cycle; (3) are indicators of environmental quality; (4) require further field investigation to determine population status classification; (5) have unresolved taxonomic problems that may bear upon classification; or (6) were justifiably removed from endangered, threatened, or sensitive classification (WDW, 1988). Two state proposed monitor species, the osprey and long-eared myotis (Myotis evotis), have been documented by the WDW in the Elwha/Glines Canyon study area. Four other state proposed monitor species, the great blue heron (Ardea herodias), barred owl, turkey vulture, and trumpeter swan (Cygnus buccinator), have also been observed in the study area (Sharpe, 1990).

Northern Goshawk

The northern goshawk is a breeding resident in the study area and is occasionally observed year-round. One pair is known to traditionally nest along the Whiskey Bend trail (Sharpe, 1990). The goshawk breeds in the dense canopy of mature conifer forests or mixed stands of conifers and deciduous trees. This accipiter preys on medium-sized mammals and birds and hunts from a concealed perch or while flying. Foraging often occurs at the edges of forests and grouse are an important prey item (Verner and Boss, 1980).

Vaux's Swift

The Vaux's swift is a common summer breeding resident in the Elwha and Glines Canyon study area (Sharpe, 1990). Since this species requires tall (>40 feet), large snags (>25 inches dbh) for nesting, optimal breeding habitat is generally provided by mature and old growth forests in riparian or upland areas (Brown, 1985). The Vaux's swift feeds exclusively on flying insects captured in mid-air over a variety of open habitats, including forest clearings, lakes, and streams (Verner and Boss, 1980).

Osprey

Two breeding paris of osprey occur in the study area; one near the boat launch on Lake Mills (Hurricane Hill Quad. T.29N. R.07W. S.20) and the other along the lower reach of the Elwha River, near the Highway 101 Bridge (Elwha Quad. T.30N. R.07W. S 03) (letter from T. Cyra, Biologist, WDW Nongame Program, Olympia, Washington, February 12, 1990). Each pair has an active and alternative nest site. Preferred nest sites for osprey are large, broken or

flat-topped trees or snags within 240 feet of water (FWS, 1984). Optimal feeding habitats are lakes and rivers with clear water and shorelines with at least six trees per kilometer suitable for perching close to the water. Trees suitable for perching are snags, dead-topped trees, or open crowned trees that allow easy access for take-off and landing (FWS, 1984). The osprey in the study area appear to forage primarily on the resident fish in the reservoirs (Sharpe, 1990).

Long-eared Myotis

The long-eared myotis is a medium-sized bat that is uncommon to rare in western Washington (Larrison, 1970). A communal roost and breeding site has been documented west of the river between Lake Aldwell and Lake Mills (Elwha Quad. T.30N. R.07W. S.32) (letter from T. Cyra, Biologist, WDW Nongame Program, Olympia, Washington, February 12, 1990). Long-eared myotis breed in snags greater than 15 inches dbh and inhabit old growth conifer and mixed forest stands (Brown, 1985).

Great Blue Heron

The great blue heron has been observed feeding regularly along the middle and lower reaches of the Elwha River during the winter (Sharpe, 1990). Great blue herons are opportunistic feeders and will forage wherever they can locate prey. Fish are preferred prey but small mammals, frogs, birds, and insects have been reported in the diet of the great blue heron. Herons are colonial nesters and rookeries are usually located in large trees in forested areas near water (Short and Cooper, 1985). The great blue heron rookery nearest the study area is located just west of the Elwha River delta (personal communication, F. Sharpe, Biologist, Port Angeles, Washington, July 31, 1990).

Barred Owl

Two pairs of barred owls were observed in the Elwha Valley in ONP during the spotted owl surveys conducted by the NPS (personal communication, B. Moorehead, Biologist, ONP, Port Angeles, Washington, September 25, 1990). An additional barred owl sighting occurred in the study area, just off the West Elwha Trail along the middle reach of the river (Sharpe, 1990). This species inhabits conifer, mixed deciduous/conifer, and deciduous forests and requires large trees and snags (>20 inches dbh) for nesting (Allen, 1987). A highly adaptable generalist, the barred owl has recently expanded its range from the eastern United States and Canada to the Pacific Northwest. The key to its range expansion is believed to be the creation of suitable habitat conditions due to clearcutting and the establishment of mixed deciduous/conifer forests.

The habitat and dietary requirements of the barred owl are similar to those of the spotted owl and the range of these two species is now sympatric throughout the

Pacific Northwest (Hamer et al., 1987). However, compared to the spotted owl, the barred owl has a smaller home range that does not vary with season, a higher reproductive rate, lower mortality, and more aggressive behavior. These factors allow the barred owl to rigorously defend its home range throughout the year and may give it a competitive advantage over the spotted owl (Hamer et al., 1987).

Turkey Vulture

The turkey vulture is a regular summer resident in the Elwha and Glines Canyon vicinity and may nest on canyon walls in the study area. Large kettles (aggregations of raptors) of turkey vultures have also been observed over the study area during spring and fall migration. Since the turkey vulture is a weak flier, spring aggregations probably reflect the birds' known tendency to avoid crossing large bodies of open water. In the fall, kettles of turkey vultures over the northern Olympic Peninsula probably represent groups that have crossed the Strait of Juan de Fuca from Vancouver Island during favorable winds (Sharpe, 1990). Turkey vultures feed exclusively on carrion and generally nest on cavities on cliff faces or in rock or brush on steep hillsides (Verner and Boss, 1980).

Trumpeter Swan

Trumpeter swans have been observed wintering on Lake Aldwell every year since surveys began in 1981. In 1989, 16 swans were observed on Lake Aldwell, representing 22 percent of the wintering trumpeter swan population of Jefferson and Clallam counties (letter from M. Jordan, The Trumpeter Swan Society, Snohomish, Washington, January 12, 1990). In the winter of 1990, 12 trumpeter swans wintered on Lake Aldwell and routinely visited Lake Mills (Sharpe, 1990). The trumpeter swans that winter in Washington breed in Alaska (Bellrose, 1980). Winter habitat for trumpeter swans includes open fields of grasses and waste crops; and/or relatively shallow, protected waters that remain ice-free and contains stems, tubers, and seeds of freshwater plants (Angell and Balcomb, 1984).

3.5.3.4 State-listed Sensitive Plant Species

There are no plant species potentially occurring in the study area that are listed by the WNHP as threatened or endangered. However, tall bugbane (Cimicifuga elata), branching montia (Montia diffusa), and pine broomrape (Orobanche pinorum), all plants listed by the WNHP as sensitive, have been documented in the study area (letter from N. Sprague, Assistant Information Manager, WNHP, Olympia, Washington, February 20, 1990). An additional two state-listed sensitive plants, the giant helleborine (Epipactis gigantea) and fringed pinesap (Pleuricospora fimbriolata), have been found in low-elevation areas in the north-central portion of the Olympic Peninsula and potentially occur in the study area (personal communication, E. Schreiner, Botanist, ONP, Port Angeles, Washington, January 25, 1990) (Table 3-14). Sensitive species are those

Table 3-14. State-listed sensitive plant species documented or potentially occurring in the Elwha/Glines Canyon study area.

Species	Common Name	Family	Documented Location	Distribution[3/]	Habitat[4/]
Cimicifuga elata[1/2/]	tall bugbane	Buttercup	T.29N. R.07W. S.20	scattered	moist woods at lower elevations
Epipactis gigantea[2/]	giant helleborine	Orchid	none	scattered	stream banks, lake margins, near springs and seeps
Montia diffusa[1/]	branching montia	Purslane	T.29N. R.07W. S.04	scattered	moist areas
Orobanche pinorum[1/]	pine broomrape	Broomrape	T.29N. R.07W. S.09	scattered	coniferous woods
Pleuricospora fimbriolata[2/]	fringed pinesap	Heath	none	scattered	coniferous woods

1/ Letter from N. Sprague, Assistant Information Specialist, WNHP, Olympia, Washington, February 20, 1990.
2/ Meeting with E. Schreiner, Botanist, ONP, Port Angeles, Washington, January 25, 1990.
3/ Source: WNHP, 1987.
4/ Source: Hitchcock and Cronquist, 1981.

considered by the WNHP to be vulnerable or declining that could become endangered or threatened in the state without active management (WNHP, 1987).

Surveys conducted in July through August 1990 of areas potentially affected by any of the alternatives located one state-listed sensitive species, the giant helleborine. This orchid was discovered growing on the slope between the road to Whiskey Bend and the bypass reach (T. 29N R.07W. S.17). The habitat consisted of closed-canopy, mature mixed conifer/deciduous stand, with few understory shrubs, forbs, or grasses. The population included nine plants in three groups, located in an area with a relatively low slope, about 20 feet from a seep.

3.5.3.5 Plants Unique in Olympic National Park

The NPS lists 28 plants that occur in low-elevation areas of the north-central portion of the Olympic Peninsula that are considered unique in the Elwha drainage and receive special protection within the park (Table 3-15). This list includes two species that are also classified as sensitive by the WNHP.

Surveys conducted in July through August 1990 of areas potentially affected by any of the alternatives located two plant species considered unique in the Elwha drainage, the bicolored linanthus (Linanthus bicolor) and yabea (Yubea microcarpa). A large cluster of bicolored linanthus, consisting of several hundred individual plants, was discovered growing along the Elwha-Glines Canyon transmission line right-of-way, about 1.5 mile south of the ONP boundary T. 29N. R.07W. S.04). This site was a slightly raised rocky area, about 10 feet in diameter with thin soil and relatively few other species. Yabea was located on the rocky outcrop just north of Glines Canyon Dam, on the east side of the river (T. 29N. R.07W. S.17). This site contained about 100 individual plants of yabea, all growing in pockets of soil that have accumulated under the shrubs scattered over the outcrop.

3.6 LAND USE

Like most of the Olympic Peninsula, the Elwha River Valley has traditionally been used for recreation, timber production, fish harvest, and residential uses. The upper reach of the river is dedicated to park uses, while the middle and lower reaches have more mixed uses including native American cultural and subsistence uses.

The Glines Canyon Project is located within the Olympic National Park on lands generally dedicated to preservation and recreational uses. The Elwha Project is situated within a riverine and coastal area consisting of rural residential land uses with some lands being managed for forestry resources. Land use is described in the following subsections in terms of land ownership, existing land use, proposed land use, and relevant river and land management plans.

Table 3-15. Plant species that occur in low elevation areas of the north-central portion of the Olympic Peninsula that are considered unique by the NPS (Source: personal communication, E. Schreiner, Botanist, ONP, Port Angeles, January 25 and February 6, 1990).

Species	Common Name	Family	Habitat
Botrychium virginianum	Virginia grape-fern	Ophioglossaceae	moist woods and thickets; valleys to mid montane
Aspidotis densa	Aspidotis	Polypodiaceac	cliff crevices and moist, rocky slopes; foothills to timberline
Pityrogramma triangularis	Gold-fern	Polypodiaceae	rock crevices; open, rocky slopes; valleys and foothills
Polystichum imbricans	Imbricate sword-fern	Polypodiaceae	rock crevices; dry, coniferous forests
Claytonia exigua	Common montia	Portulacaceae	moist to dry soil
Cimicifuga elata	Tall bugbane	Ranunculaceae	moist woods at low elevation
Stellaria nitens	Shining chickweed	Caryophyllaceae	gravelly meadows to grassy hillsides; often moist areas
Athysanus pusillus	Sandweed	Cruciferae	grassy areas
Thysanocarpus curvipes	Lacepod	Capparidaceae	open hillsides; woodland borders
Lithophragma parviflora	Small-flowered fringecup	Saxifragaceae	grasslands to lower montane forests
Saxifraga integrifolia	Swamp saxifrage	Saxifragaceae	wetbanks; subalpine meadows
Trifolium microden	Thimble clover	Leguminosae	meadows; sandy to rocky soils
Trifolium oliganthum	Few-flowered clover	Leguminosae	meadows to dry, rocky soils

Table 3-15. Plant species that occur in low elevation areas of the north-central portion of the Olympic Peninsula that are considered unique by the NPS. (continued)

Species	Common Name	Family	Habitat
Trifolium tridentatum	Tomcat clover	Leguminosae	grassy hillsides and meadows
Clarkia amoena var. *caurina*	Farewell-to-spring	Onagraceae	dry banks
Daucus pusillus	Rattlesnake weed	Umbelliferae	dry, open places at low elevation
Linanthus bicolor var. *bicolor*	Bicolored linanthus	Polemoniaceae	open places at low elevation
Microsteris gracilis	Microsteris	Polemoniaceae	meadows or along streams
Collinsia parviflora var. *grandiflora*	Small-flowered blue-eyed Mary	Scrophulariaceae	vernally mesic habitats
Orobanche pinorum	Pine broom rape	Orobanchaceae	coniferous forests
Crocidium multicaule	Spring-gold	Compositae	dry, open places at low elevation
Koeleria cristata	Koeler's grass	Gramineae	open forest to subalpine ridges; sandy-rocky soils
Brodiaea coronaria var. *coronaria*	Harvest brodiaea	Liliaceae	grassy slopes and rocky bluffs
Dichelostemma pulchellum var. *pulchellum*	Northern siatas	Liliaceae	grassy meadows to glacier outwash "prairies"

Table 3-15. Plant species that occur in low elevation areas of the north-central portion of the Olympic Peninsula that are considered unique by the NPS. (continued)

Species	Common Name	Family	Habitat
Stipa lemmonii	Needlegrass	Gramineae	forested foothills to mountain areas
Tonella tenella	Small-flowered tonella	Scrophulariacea	open, grassy areas
Triteleia hyacinthina var. *hyacinthina*	Hyacinth triteleia	Liliaceae	grassy, open flats to midmontane meadows
Yabea microcarpa	Yabea	Umbellifera	moist places including rock crevasses and under shrubs

3.6.1 Land Ownership

The upper half of the middle reach and most of the upper reach of the Elwha River are located on National Park Service lands (Figure 3-14). The Olympic National Park contains over 900,000 acres and has three significant special designations that protect the existing natural environment. Most of the Olympic National Park has been designated as Wilderness under the Washington Park Wilderness Act of 1988 (Public Law 100-688). The wilderness area, to be managed so that the presence and effects of humans remain unnoticed, includes those portions of the Elwha River Valley above Lake Mills. The Olympic National Park has also been designated as a Biosphere Reserve and a World Heritage Park. The Biosphere Reserve designation is an international designation made under the Man and Biosphere Program directed by the United Nations Educational Scientific and Cultural Organization (UNESCO) in 1976. The Biosphere Reserve designation is a recognition of the park's vast expanses of unmanipulated natural ecosystem. The World Heritage Park designation, made by UNESCO in 1981, recognizes the natural beauty of the park, its virgin temperate rain forest, wild herd of Roosevelt elk, and the pristine coastal and mountainous features.

The Glines Canyon dam and powerhouse facilities are located on a privately held in-holding within Olympic National Park. The 160-acre in-holding is one of very few parcels of privately owned land within ONP. Public land ownership along the middle reach and lower reaches is shared by the U.S. Forest Service, Washington Department of Natural Resources, and the Washington Department of Wildlife. The U.S. Forest Service owns approximately 1 square mile of land located immediately east and west of the Elwha River in the middle reach. The Washington Department of Natural Resources (WDNR) lands are primarily managed for forestry resources and are located in large tracts on both sides of Lake Aldwell and a few miles east of the lower reach in the coastal area. The Washington Department of Wildlife (WDW) owns approximately 109 acres along the lower reach of the Elwha River. These lands are used by the Washington Department of Fisheries (WDF) for the rearing of salmon, as well as by fishermen for access to the lower river.

There are several private landholders along the middle and lower river reaches. The applicant owns approximately 1,018 acres around all sides of Lake Aldwell including the site of the Elwha dam and powerhouse. Several timber companies and private individuals own other tracts adjacent to and above the river shoreline in the lower reach.

The Lower Elwha Indian Reservation consists of 422 acres situated at the mouth of the Elwha River. These lands were first set aside under the Act of June 18, 1934 (25 U.S.C. 461-465). In 1968, these lands were designated as the Lower Elwha Indian Reservation by presidential proclamation.

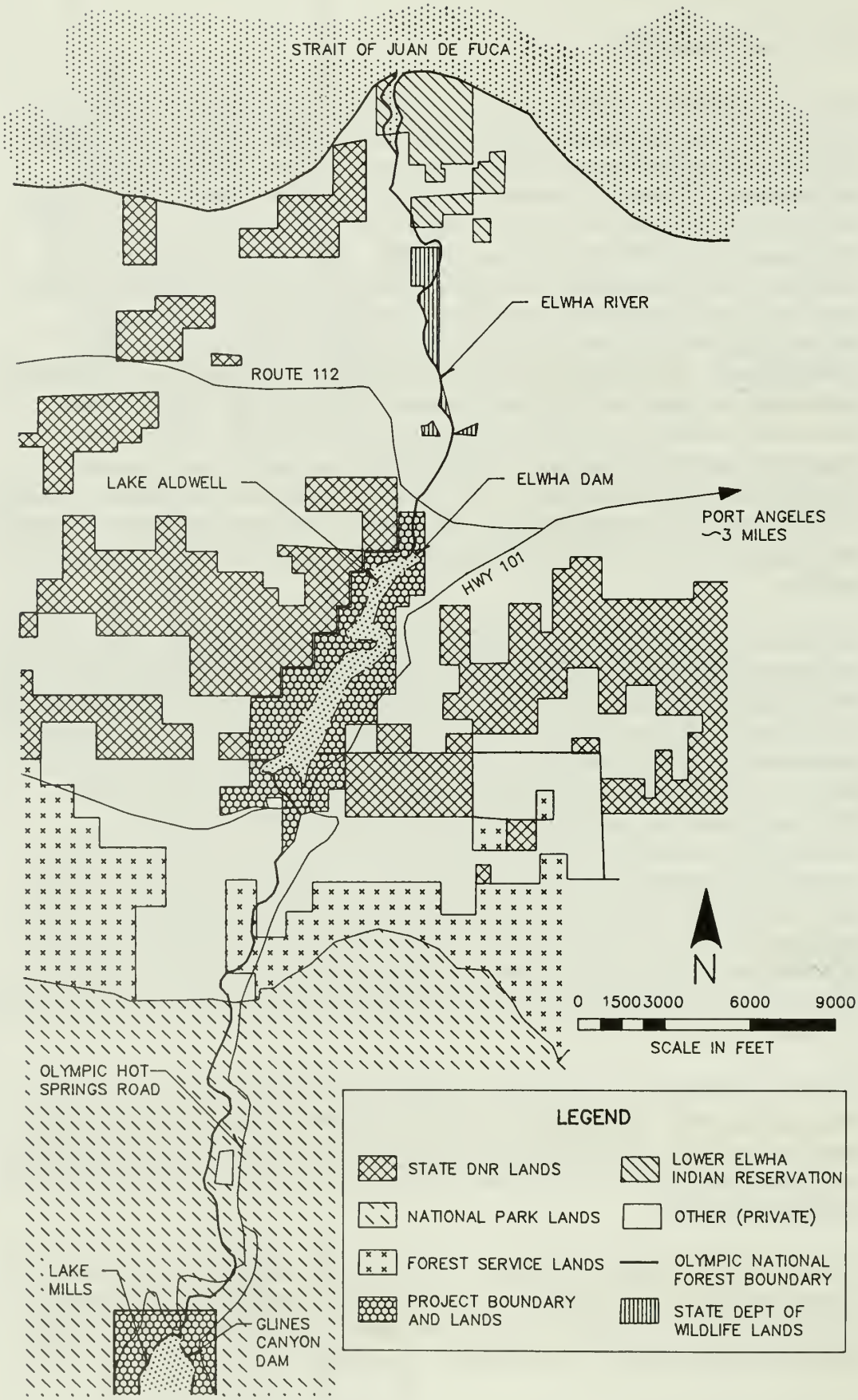


Figure 3-14. Land ownership in the project vicinity. (Source: the staff modified from James River II, 1989).

FIG361.DWG

The project boundary proposed for the Elwha Project includes all lands owned by the applicant around Lake Aldwell. The project boundary for the Glines Canyon Project includes the 160 acres owned by the applicant and the area occupied by Lake Mills with a small shoreline buffer. The 15 miles of transmission lines connecting the projects with Port Angeles are also part of the project boundary.

3.6.2 Existing Land Use

The Elwha River Valley is used for water- and land-based commercial, industrial, and recreational uses. Recreational uses of Elwha area land and waters include fishing, hiking, camping, sightseeing, and whitewater boating (Section 3.7). In addition, some residential uses are adjacent to the river in the middle and lower reaches (Figure 3-15).

The management of the recreational use of land and waters of the upper Elwha River is closely coordinated with the preservation and protection of the flora and fauna of the region including fishery, botanical, and wildlife resources. The use of upper Elwha River lands for preservation and protection of biological and other natural systems is best described in the statement of purpose for the Olympic National Park:

> The purpose of the proposed national park is to preserve for the benefit, use and enjoyment of the people, the finest sample of primeval forests of Sitka spruce, western hemlock, Douglas fir, and western red cedar in the entire United States; to provide suitable winter range and permanent protection for the herds of native Roosevelt elk and other wildlife indigenous to the area; to conserve and render available to the people, for recreational use, this outstanding mountainous country, containing numerous glaciers and perpetual snow fields, and a portion of the surrounding verdant forests together with a narrow strip along the beautiful Washington coast (House Report 224, 52 Stat 1241; 16 U.S.C. 241-246).

The preservation and protection of wildlife and fishery resources outside the park stems from agency management of land and waters under the jurisdiction of the Olympic National Forest, WDNR, WDW, WDF and Clallam County.

Timber production and forestry management occurs on lands managed by the WDNR, Olympic National Forest, and private timber companies in the lower middle and lower river reaches. Most of these lands are on 30- to 50-year harvest cycles; most were last harvested 20 to 30 years ago.

A portion of the middle and lower river lands is dedicated to power generation and transmission. The Glines Canyon Project has approximately 7 miles of transmission line, running to the Elwha Project facilities. This transmission line generally follows the Olympic Hot Springs Road and is on a 100-foot right-of-way located partially on National Park Service land. There are other utility lines serving the Elwha Valley on adjacent right-of-ways. These utility lines are

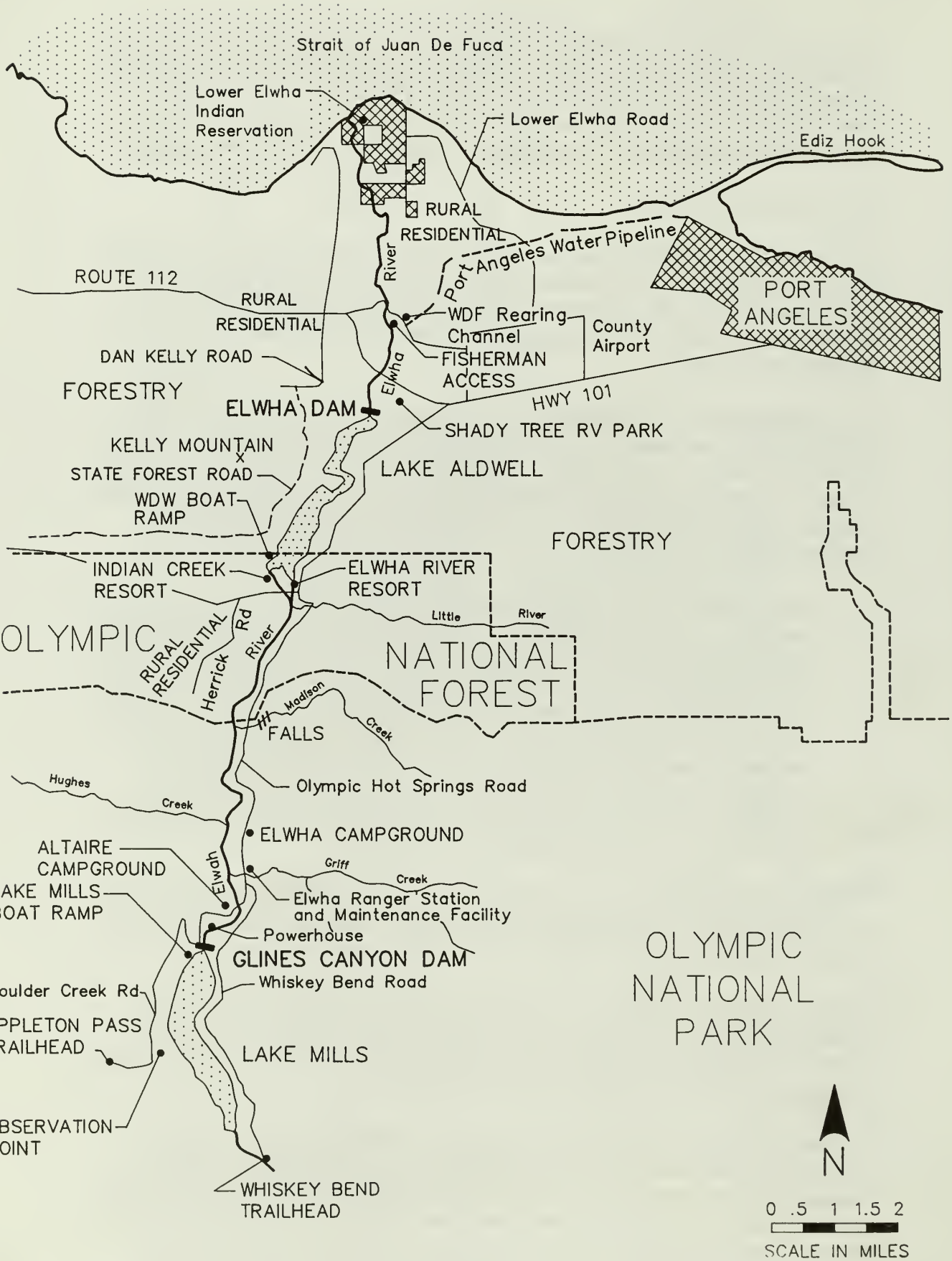


Figure 3-15. Generalized land uses in the project vicinity. (Source: the staff).

FIG36-2

operated under renewable 5-year special use permits from the NPS. The Elwha Project has approximately 8 miles of transmission lines crossing private land and extending into Port Angeles.

Residential, commercial, and industrial uses in the project vicinity are generally guided by Clallam County zoning and shoreline management designations. There are various pockets of residential dwellings and a few, small gravel quarries located primarily along county roads in the lower Elwha Valley. In this area, the Elwha River has a broad floodplain particularly along the eastern shorelines in and around the Lower Elwha Indian Reservation. Clallam County participates in the Federal Emergency Management Agencies flood insurance program, and has therefore adopted flood rate insurance maps depicting the 100-year floodplain for the lower Elwha River. Owners of residences within the 100-year floodplain can choose to buy federal insurance to protect against flood damages. In addition, the Army Corps of Engineers has recently constructed a levee structure on the lower river, near the mouth, to protect private and Indian lands in that area.

Clallam County has implemented county-wide zoning to guide the type and distribution of the various residential, commercial, and industrial developments. A large portion of the land along the lower middle and lower Elwha River reaches are zoned for forestry uses. The forestry use designation allows for housing densities as high as one house per 5 acres in some places, particularly in the lower reach. The forestry use designation is intended to protect large forest tracts from encroachment of uses which threaten effective forest management practices. The other major zoning designation in the lower reach is rural residential. Rural residential zones designated for the lower Elwha River area are intended to provide areas for residential development for those persons seeking to live in a low to moderate density, rural setting, free from encroachment of future commercial and industrial uses. Clallam County shoreline designations are described in Section 3.6.4.

3.6.3 Proposed Land Use

The upper Elwha River is regarded by the Olympic National Park and Olympic National Forest as suitable for designation as a wild and scenic river (NPS, 1990), but a study of its eligibility and suitability has not been undertaken.

The middle reach of the Elwha River is rated as an above-average river for whitewater boating by the Washington Rivers Inventory. The Washington Rivers Inventory, compiled by the Washington State Parks and Recreation Commission and National Park Service, is an attempt to identify rivers in Washington State that might qualify for protective status under the Scenic Rivers Program, Northwest Power Planning Council Protected Areas Amendments, or Wild and Scenic Rivers Program. To date only one river in Washington, the Skykomish, has been designated under the State Scenic Rivers Program.

No other proposed land use changes have been identified at this time.

3.6.4 River and Land Management Plans Applicable to the Project Area

River and land management plans relevant to the Glines Canyon and Elwha projects have been identified at the federal, state, and local levels. Several of these plans are considered "comprehensive plans" under Section 10(a)(2) of the Federal Power Act.

Federal Plans

Fishery Management Plan

The National Marine Fisheries Service and the Pacific Fishery Management Council jointly prepared the Fishery Management Plan for Commercial and Recreational Salmon Fisheries Off the Coasts of Washington, Oregon, and California in 1978. Updated in 1989, the plan addresses recreational and commercial fishery regulations for areas within the Fishery Conservation Zone. This zone lies within the coastal regions of Washington, Oregon and California. Under the plan, objectives are set for habitat preservation, production, and escapement of each salmon species. The Elwha River is considered along with all other Puget Sound rivers and streams. The objectives for the Puget Sound rivers apply primarily to the natural production of Chinook and Coho stocks. The most relevant management objectives for Coho and Chinook stocks in rivers such as the Elwha include the restoration and enhancement of natural production of these species to their optimum levels. The objectives for production of these species state that whenever fish habitat or population losses occur as a result of development, the fishery agencies should actively seek full compensation such as restoration of lost habitat, or additional facilities to boost fish production to previous levels. The plan emphasizes the need to maximize the ocean recreational catch and duration of season in order to reduce the impacts to recreationists and local communities.

Northwest Conservation and Electric Power Plan

The Northwest Power Planning Council (the Council) derives its authority from the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (P.L. 96-501), which required the Council to develop an electric power plan for the Northwest that called for the development of resources that would be cost-effective and environmentally acceptable. The Act authorizes the Council "to give consideration in regional power planning to environmental quality, compatibility with the existing regional power system, protection, mitigation, and enhancement of fish and wildlife and related spawning grounds and habitat, including sufficient quantity and quality of flows for successful migration, survival, and propagation of anadromous fish" (16 U.S.C., 839a 839h). The Council's plan, the Northwest Conservation and Electric Power Plan, provides

measures such as the protected areas' amendments to meet the obligations of the 1980 Act.

The protected areas' amendments designate over 44,000 miles, roughly 20 percent of the Northwest's rivers and streams, as areas that should be protected from future hydroelectric development. The protected areas are where the Council believed hydroelectric development would have an unacceptable risk of loss to fish and wildlife species of concern, based on the areas' value as habitat for anadromous fish, resident fish, and/or wildlife. The designations are listed by stream reaches within a given drainage basin.

Primarily as a result of the existence of dams on the Elwha River, the entire river was assigned the unprotected designation. Most agencies, including the Council, recognize that rivers and streams in the upper Elwha basin are already protected from development by virtue of their location within Olympic National Park.

Olympic National Park Plans

The Olympic National Park has several plans and legislative authorities which guide management of park resources. In addition to the general national park guidance found in federal legislation such as the Organic Act of 1916 (39 Stat. 535 of seg) and Redwoods Act of 1978 (P.L. 95-250), the park is guided by the original establishing legislation of June 28, 1938, the Olympic National Park Master Plan of October 1976, the Olympic National Park Land Protection Plan of 1983, and the draft Resources Management Plan of January 1990.

The Park Master Plan is a general park plan covering all areas of the Olympic National Park. The plan addresses general management, resource management, and visitor use of the park. Under the general management objectives, the plan calls for managing backcountry areas as wilderness, acquiring all private in-holdings, and coordinating management of mutual resources with other jurisdictions. Regarding resource management objectives, the plan calls for the restoration and maintenance of the primary natural resources of the park. The essential stated objective is to restore and perpetuate environmentally regulated ecosystems in the park. Under the visitor use objective, the plan calls for the encouragement of high-density usage in park periphery areas and communication of natural resource values to visitors who use backcountry areas (NPS, 1976).

The Land Protection Plan is intended to identify methods of ensuring the protection of the natural, historic, scenic, cultural, recreational, or other significant resources and to provide for adequate visitor use. The plan identifies three areas of private ownership in the Elwha area, of which two areas have been targeted for acquisition on a seller-willing basis. The area occupied by the Glines Canyon dam was not identified in the plan as a priority for acquisition (NPS, 1984).

The Resources Management Plan is a general implementing plan for the Park Master Plan and other park management objectives as stated in the enabling legislation. The plan is used as a budgeting document that addressed long-range needs of the park in order to adequately protect park resources. The plan does not address any issues specific to the Elwha drainage, although it does recognize that the Elwha River potentially qualifies as a wild and scenic river (NPS, 1990).

State Plans

Statewide Comprehensive Outdoor Recreation Plan

The Washington Outdoors 1990 Assessment and Policy Plan (APP) is one element of the Washington Statewide Comprehensive Outdoor Recreation Planning Program (SCORP). The APP in its seventh edition provides the basis for a 5-year plan of action for the management of Washington recreation resources. The APP contains an inventory of current recreation resources, a demand forecast, and discussion of policies addressing important issues.

The most popular recreational activities in Washington are sightseeing, picnicking, and operating a motorized vehicle on the road for pleasure. The APP breaks the state up into five geographic regions, which helps to determine regional differences in use based on origin of users. The Elwha River projects are located in Region 1, a region characterized as satisfying more recreational demand than it generates. For example, Region 1 creates only 9 percent of the state's fishing demand, yet 30 percent of the State's fishing activity takes place within the region. In all five regions, activities such as visiting interpretive centers, outdoor photography, and walking in a neighborhood park are the activities with the greatest anticipated growth by the year 2000.

The APP has a policy section which addresses issue areas such as trails, open space, water resources, and recreation on federal lands. Trails and water resources are important to the Elwha River projects. The issue of trails addresses the need for new trails recognized as a priority statewide and the major policy stated focuses on the need for a coordinated trail planning effort on a comprehensive statewide basis. The issue of water resources is one of seeking to better balance the preservation of rivers with power generation, withdrawals, and other economic uses. The major issue of importance to hydroelectric power projects identified in the APP is the increasing statewide loss of free-flowing river opportunities. This loss is addressed in the APP by a policy adopted which is to encourage the addition of new rivers into the protective systems such as State and Federal Wild and Scenic Rivers.

Strategies for Washington's Wildlife

The WDW has implemented a plan to protect the state's wildlife resources. The plan, Strategies for Washington's Wildlife, addresses wildlife-related issues for 1987 to 1993. The plan, which addresses the occurrence and protection of many

wildlife species, does not specifically address resources of any one geographic area. Among the plan's objectives are (1) a requirement for provision of adequate fish passage facilities at dams; (2) to maintain and increase, where possible, sustainable wild trout populations; and (3) to establish instream flows to protect wildlife. The plan's first priority is to establish and perpetuate the highest quality wildlife habitat (WDW, 1987).

Hydroelectric Project Assessment Guidelines

The Washington Department of Fisheries developed a draft plan in 1987 known as Hydroelectric Project Assessment Guidelines. The plan was developed to give direction to hydropower project proponents in developing or siting a new hydroelectric project. While the plan does not specifically address licensing of existing projects, certain parts of the plan relate to measures and mitigation considered appropriate by the Washington Department of Fisheries. The plan addresses the anadromous fishery resources of the state (WDW, 1987). The goal of the plan is no net loss of existing or potential habitat or production. The WDF utilizes criteria to determine the significance of project-specific impacts and the potential to contribute to cumulative impacts to anadromous species. For the Elwha and Glines Canyon projects, the most significant criteria are for fish passage. The threshold for significance for fish passage is no alteration, disruption, hindrance, or blockage of upstream or downstream migration of fish. It is a policy of the WDF to avoid or mitigate adverse environmental impacts to the fishery. The WDF will require reasonable alternatives to the proposed action and/or proven measures which will mitigate or eliminate the identified potential adverse impacts.

Local Plans

Clallam County Comprehensive Plan

The Clallam County Comprehensive Plan was prepared by the Clallam County Planning Department in 1986. The plan is intended to provide a general guide for the orderly growth and development of the county. The plan, implemented through county-wide zone designations, pertains to unincorporated areas of Clallam County exclusive of federal and state lands. The plan addresses commercial, industrial, residential, and transportation land uses. The plan also addresses the siting of energy facilities; however, this only pertains to oil terminals and oil pipelines (Clallam County, 1986). The plan states that it is critical that the county growth policies protect and enhance identified recreational resources so that the county continues to attract significant numbers of visitors who are vitally important to Clallam County's economy.

Shoreline Master Program

Since Clallam County is one of 15 of Washington's coastal counties, the County's Shoreline Master Program is also part of the Washington State Coastal Zone

Management Program. As such, federal agencies are required under Section 307 of the Coastal Zone Management Act of 1972 to be consistent to the maximum extent feasible with the State's Coastal Zone Management Program. Washington's Coastal Zone Management Program centers on the controls provided in the State's Shoreline Management Act, which is implemented through the County and City Shoreline Master Programs. The Elwha projects are not directly within the coastal zone resource boundary; however, they are considered as being within the planning and administrative boundary of the coastal zone. Projects within the planning and administrative boundary are not as likely to require stringent control measures to prevent direct impacts to the coastal zone. Generally, projects which are consistent with the Shoreline Master Program will also be consistent with the Coastal Zone Management Program.

The Clallam County Shoreline Master Program was prepared by the Clallam County Shoreline Advisory Committee in 1989. The plan addresses land use within 200 feet of rivers, streams, lakefronts, and coastal shorelines. The goal of the plan is to preserve, to the fullest extent possible, the scenic, aesthetic, and ecological qualities of the shorelines of Clallam County. The plan is implemented through county-wide shoreline designations. The Elwha River has three shoreline designations for areas outside the Olympic National Park. The middle reach of the Elwha and coastal zone at the mouth is designated as rural. Rural shoreline zones are those that are marked by intensive agricultural or recreational use. The shorelines of Lake Aldwell are designated natural. The natural shoreline zone pertains to areas that are largely undeveloped and are relatively intolerant of intensive human use. The lower reach of the Elwha is designated as conservancy. The conservancy shoreline is one for which protection from development is warranted because of steep slopes, flood protection, or areas which cannot be provided with adequate water supply or sewage disposal (Clallam County, 1989). The Shoreline Master Program also addresses hydroelectric development and impoundment structures. The policies for hydroelectric development primarily address the development and siting of new facilities; however, the policies do indicate that the expansion of existing hydroelectric facilities is preferred over the development of new facilities.

In addition to the three specific zones, the entire Elwha River is considered a shoreline of statewide significance. The shoreline of state-wide significance designation requires local governments to recognize statewide interest over local interest, to preserve the natural character of the shoreline, and to enhance public access and recreational opportunities when implementing shoreline regulations and permitting shoreline uses (Clallam County, 1989).

3.7 RECREATIONAL RESOURCES

While not a well-known recreational area, the Elwha River is one of several important recreational rivers within the Olympic Peninsula. The long and wide Elwha Valley serves as an important corridor to back country use within the Olympic National Park. The lower Elwha River has an important winter steelhead

fishery, and trout fishing is generally rated as very good in the back country areas of the upper river.

The intensity of recreational use of the Elwha River drainage is moderate in comparison to the many recreational resources available on the Olympic Peninsula. Numerous regionally significant recreational resources on the peninsula are very well known and highly used. Areas within the Olympic National Park such as the Hoh River rain forest, Lake Crescent, Hurricane Ridge, and Lake Quinault receive considerably greater use than the Elwha River drainage.

3.7.1 Regional Recreational Resources

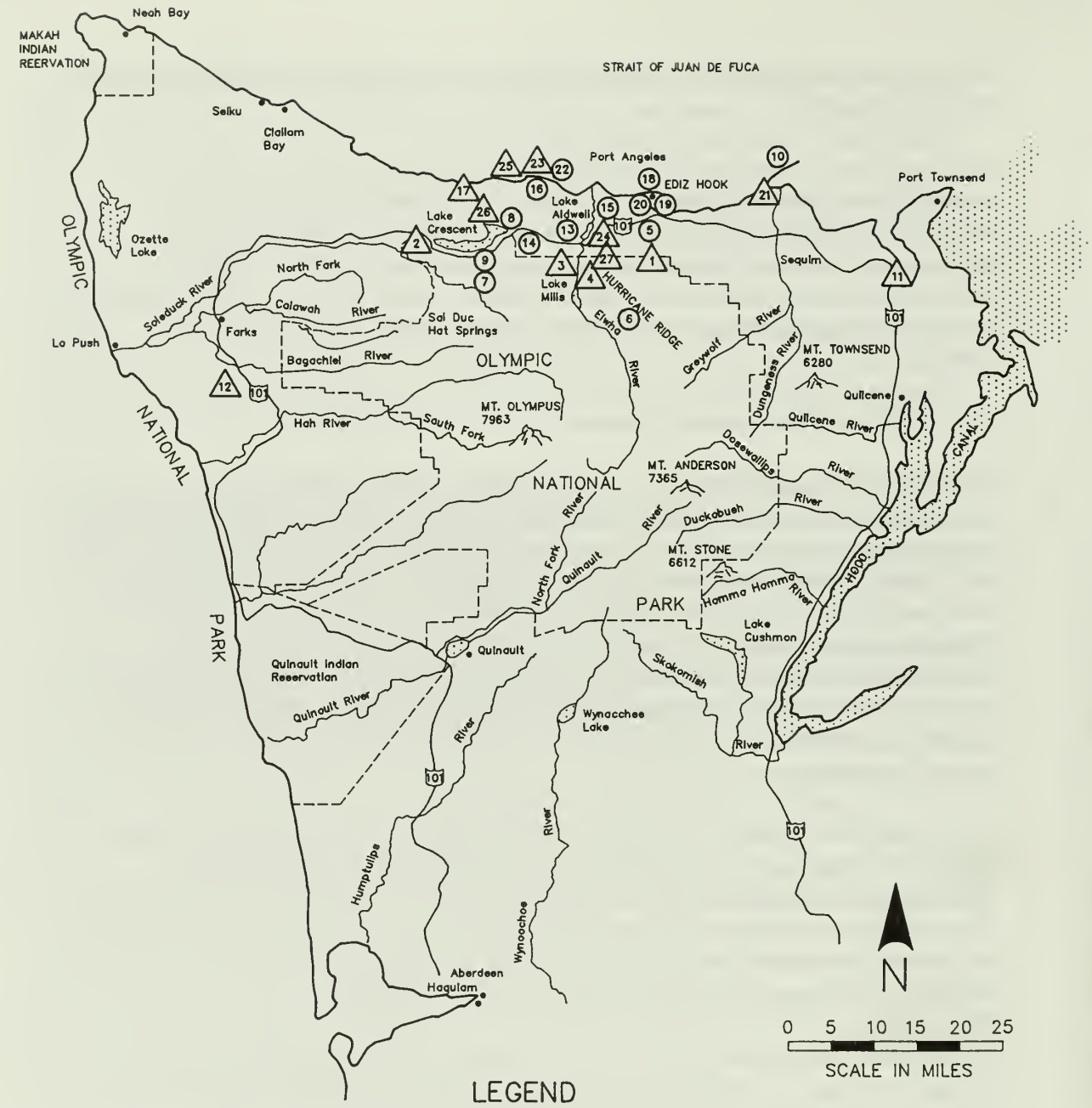
The Olympic Peninsula contains numerous federal, state, and county- administered recreational areas (Figure 3-16). The Olympic National Park, Washington State's most visited national park, has several attractions and well-known features such as the Olympic rain forest and rugged Pacific coastline. Other important visitor areas within the park include Hurricane Ridge, Lake Crescent, and Lake Ozette. Outside the park, other important tourist destinations and recreational areas include Port Townsend, a historic waterfront city; Neah Bay, a Makah Indian town with an excellent saltwater sport fishery and cultural heritage museum; Lake Quinault, a resort area; and Hood Canal, a popular waterfront area for second homes and retirees.

The Olympic National Park comprises 922,065 acres and receives approximately 3,500,000 visitors a year, primarily from the Puget Sound area. There are approximately 1,000 developed campsites within the park. The Olympic National Forest generally surrounds the park and encompasses 649,975 acres. The Forest has several developed campgrounds with 379 campsites and an extensive trail network, which generally provides access to the park areas.

The most popular forms of dispersed recreational activity include back country hiking, sightseeing, wildlife observation, and angling. Some hunting and whitewater boating occur in the region; however, hunting is not allowed within the park. Recreational activities at developed sites include camping, sightseeing, and picnicking.

The most popular back country hiking areas are within Olympic National Park. These include the cross-park corridors such as the Elwha River, Quinault River, and Dosewallips River.

Sightseeing involves roadside or trailside wildlife observation, visits to museums and interpretive facilities, and roadside viewpoint pull-offs. Many areas on the Olympic Peninsula contain developed day-use areas suitable for sightseeing and picnicking. The Olympic Peninsula contains a variety of saltwater and freshwater fishing opportunities. Saltwater fishing for salmon, ling cod, and halibut is excellent along the north coast from Neah Bay to Port Townsend. Salmon,



LEGEND

1 Heart O' the Hills–NPS	15 Elwha River Access–WDW	20 – Day Use
2 Fairholm–NPS	16 Striped Peak Vista–WDNR	21 – Campground
3 Altaire–NPS	17 Lyre River–WDNR	NPS – National Park Service
4 Elwha–NPS	18 Ediz Hook Boat Launch–PORT	USFWS – U.S. Fish & Wildlife Service
5 Pioneer Memorial Museum–NPS	19 East Haven Boat Launch–PORT	STATE – Washington
6 Hurricane Ridge–NPS	20 West Haven Boat Launch–PORT	WDW – Washington Dept of Wildlife
7 Marymere Falls–NPS	21 Dungeness Recreation Area–CO	WDNR – Washington Dept of Natural Resources
8 East Beach Picnic Area–NPS	22 Freshwater Bay–CO	PORT – Port of Port Angeles
9 Barnes Point–NPS	23 Salt Creek Recreation Area–CO	CO – Clallam County
10 Dungeness–USFWS	24 Elwha River Resort–PR	PR – Private
11 Sequim Bay–STATE	25 Carol's Crescent Beach Resort–PR	
12 Bogachiel–STATE	26 Log Cabin Resort–PR	
13 Lake Aldwell Boat Ramp–WDW	27 Indian Creek Resort–PR	
14 Sutherland Lake Access–WDW		

Figure 3-16. Map of recreational resources in the project vicinity. (Source: the staff).

FIG37-1

steelhead, and other trout fishing occurs on the Bogachiel, Soleduck, Calawah, Elwha, Hoh, Queets, and Dungeness rivers. The nearby Pysht and Lyre rivers also have popular steelhead fishing opportunities.

Whitewater boating opportunities are found on the Humptulips River, Queets River, Quinault River, Wynoochee River, and Elwha River.

3.7.2 Recreational Setting of the Elwha River Valley

The most prominent existing recreational uses in the Elwha River area are hiking, fishing, camping, horseback riding, and whitewater boating. Other less prevalent uses include sightseeing, picnicking, wildlife observation, and hunting.

Access to the Elwha River area is primarily via local roads connecting to U.S. Highway 101 and State Highway 112. Vehicular access to the river is only possible at specific locations along the lower 13 miles. Above Lake Mills, the river is only accessible by trail and the shoreline is inaccessible in several areas due to the steep banks and deep gorges.

The two project reservoirs provide limited recreational opportunities due to their small size, cold water temperatures, and poor accessibility due to steep terrain. Lake Aldwell has steep shorelines with limited access from roads. Lake Mills is situated in more mountainous terrain with very steep side walls and generally has more severe weather. Most of the lower river area remains snow free year round, but recreational use mainly occurs between May and September of each year.

Management of Recreational Use

The management of recreational resources in the Elwha River area is the responsibility of the National Park Service, U.S. Forest Service, Washington Department of Wildlife, and the applicant. The portion of the Elwha River drainage located upstream of RM 9.5 is managed by the Olympic National Park. This area is part of the Elwha Sub-district, and management is guided by the Olympia National Park Master Plan as well as the park enabling legislation and other NPS guidance (Section 3.6.4). Most of the Elwha drainage area, except around Lake Mills and the lower valley, are also designated as wilderness under Public Law 100-668 of November 16, 1988. The recreational management of wilderness areas is to be addressed in a forthcoming Backcountry Management Plan anticipated to be implemented in late 1990.

Several developed facilities exist within the nonwilderness areas of the Elwha Sub-district. These facilities consist of nine trailheads, five of which are associated with other developed facilities, the Altaire and Elwha campgrounds, Madison Creek Falls, and an unnamed picnic area. The Elwha Campground, open year-round, is located along the east bank of the Elwha River at approximately RM 11. The Elwha Campground serves as a trailhead for the Cascade Rock Trail. The Altaire Campground is generally operated from May to

October each year and is located on the west bank of the Elwha River at approximately RM 12.5. The Altaire Campground has a hand boat launch for whitewater boaters, and also serves as a trailhead for the West Elwha Trail. There are several popular undeveloped recreational sites within the backcountry areas of the park and along roadside corridors. Observation Point above the northwest end of Lake Mills, and several informal fishing pullouts located along the road in the middle reach are popular day-use areas and have little or no development. Fishing in the Elwha River and Lake Mills are subject to the National Park Service regulations. Currently, the fishing regulations are similar to WDW state regulations for Lake Aldwell and the lower Elwha River, except that no fishing license is required within the park.

The Olympic National Forest administers a 2-mile-wide strip of land bordering the park as part of the Soleduck Ranger District. The Forest Service land in this area, which borders the Elwha River, is managed to provide a variety of recreational opportunities in a pleasing scenic environment while maintaining or enhancing wildlife and fish habitat (USFS, 1990). There are no developed facilities within the National Forest in this area.

The Washington Department of Wildlife (WDW) administers 109 acres located along the lower Elwha River below Lake Aldwell. There is a spawning channel and a fisherman access site along the east side of the river, accessible from the Elwha River Road. The WDW also administers a boat ramp on the south end from Lake Aldwell. This property was donated by the applicant and is accessible directly off U.S. 101. The WDW also manages all game fishing in the project area, except those areas within the Olympic National Park. Under current regulations, the lower Elwha River from the mouth to 200 feet below Elwha dam is open for game fishing from June to mid-April each year with a trout catch limit of two fish of at least 12 inches. Lake Aldwell is open to game fishing mid-April through October each year with the same size regulations and limits as in the mainstem river. The Elwha River above Lake Aldwell is also under the same regulations as the lower mainstem river although the open season is from June to October each year, and fishing is not allowed within 400 feet of Glines Canyon dam.

The applicant administers a boat ramp facility on the north end of Lake Mills and allows recreational use on all project lands and waters except near the dam intake structures and tailrace areas. The boat ramp consists of a gravel-surfaced parking area, launch lane, floating finger-dock, toilet, four picnic tables, and also serves as a trailhead for the West Lake Mills Trail. An informal, steep hiking trail near Elwha dam provides anglers access to pools beneath the dam. In addition, an informal equestrian trail runs from the Elwha dam westward toward the rural residential areas along Dan Kelly Road.

Angling

The recreational fishery of Elwha River focuses on resident trout and winter steelhead. The upper Elwha River from the Elkhorn Ranger Cabin to the Hayes River is considered one of the best fishing rivers in the park (Kirk, 1980). Lake Aldwell and Lake Mills also receive some use during the summer trout fishing season. The eastern shorelines and the north end of Lake Aldwell provide good fly fishing either by trolling or casting from boats. The lower Elwha River also provides an excellent winter steelhead fishery. Trolling from boats on the river is not allowed. The winter steelhead fishery is most popular during December and January. The summer steelhead fishery is most popular during July. The salmon sport fishery, administered by the Washington Department of Fisheries, is generally open October through December. Up to six coho salmon over 10 inches in length can be taken, with only two fish over 20 inches allowed, and any chinook or pink salmon must be returned to the river. The saltwater fishery in the Strait of Juan de Fuca, near the mouth of the Elwha River, is also considered excellent. The Strait of Juan de Fuca sports fishery is generally open year-round with varying daily closures and varying catch limits on salmon. Large feeding Chinook Salmon are taken along the inside of Ediz Hook during the winter months. The Ediz Hook area is especially popular for chinook salmon fishing during the late summer months. Coho and pink salmon are taken just offshore during late August and September. Several charter fishing boats operate out of Port Angeles.

Hiking

Both day and overnight hiking is popular in the Elwha River Valley. Overnight hiking in the back country is most popular during the summer months. There are 9 trailheads located within the Elwha drainage basin which provide access to 20 designated trails in the back country areas of the basin. Of the 9 trailheads, 5 provide access to trails of 3 miles or less which are most popular with day users. Trails such as Cascade Rock, Griff Creek, West Elwha, and the two Lake Mills trails generally provide views of the Elwha River Valley and can be done as day hikes. Overnight backcountry use, by hiking or horseback riding, is most prevalent in either the Boulder Creek drainage or upper Elwha Valley.

Other Uses

Camping in the Elwha River area occurs at either the two National Park Campgrounds (Elwha and Altaire) or at one of two private resorts (Elwha River and Indian Creek). Most camping use occurs during the summer months and is associated with tent and trailer use; however, the resorts do offer some cabin and cottage-type accommodations. There is also a small private RV park off the Lower Dam Road and Highway 112.

Between Glines Canyon dam and upper Lake Aldwell, the Elwha River is used for whitewater boating. Both kayaks and rafts utilize the intermediate-rated stretch

between the Altaire Campground and the Elwha Resort. Above Altaire Campground, an area known as Gorge Rapids provides more advanced water conditions for whitewater enthusiasts. One commercial outfitter operates out of the Elwha River Resort during summer and another operates out of Port Angeles and offers guide service for kayaking. The primary put-in site for most whitewater trips is at the Elwha Campground and the primary take-out point is at the Elwha River Resort.

In addition to camping and whitewater boating, there is limited access for day use activities on the beach areas at the mouth of the river. A scenic view pull-out is located at the Elwha River Bridge off Highway 112 and Lower Dam Road.

3.7.3 User Characteristics

While comprehensive visitation records of recreational use in the Elwha River Valley are not available, the National Park Service keeps track of visitors to the park and campground use information is available based on Park fee collection schedules. Additionally, the Washington Department of Game has collected information from seasonal creel surveys on both project reservoirs and in the upper Elwha River areas. The Elwha subdistrict generally receives less recreational use than most other subdistricts within ONP. The Elwha subdistrict generally receives one-fourth as many annual visitors as the neighboring Hurricane subdistrict, and only one-twentieth as the Lake Crescent subdistrict. The Elwha subdistrict receives about the same visitation as Bogachiel State Park, but only about one-sixth as Sequim Bay State Park. Olympic Raft and Guide Service, the main commercial rafting concessionaire on the Elwha River, reports 747 people rafted the middle reach of the Elwha in 1988 and 854 in 1989.

The applicant has estimated that annual recreational usage at the Elwha Project is between 3,000 and 4,000 persons, with peak weekend usage estimated to be between 75 and 100 persons (James River II, 1988e). The WDW implemented creel surveys for Lake Aldwell and Lake Mills in 1981 and 1982 (Collins, 1983).

From approximately July through September of each year, anglers spent between 8,500 and 9,500 hours fishing both lakes. The creel surveys indicate that total angler days for Lake Mills during the 3-month period in 1981 and 1982 was 1,265 and 1,082, respectively. While the angler visits to Lake Mills would most likely also be counted in the National Park Service Elwha subdistrict entrance figures, the usage at Lake Aldwell would not be. On the basis of steelhead sports catch summary data, WDW reported that the summer steelhead fishery yielded 127 fish to anglers in 1987-88, and 157 fish in 1988-89 seasons. The catch for winter steelhead is much higher with anglers reporting catches of 2,299 fish and 1,091 for 1987-88 and 1988-89, respectively. No figures are available for angling days or hours expended (WDW, 1989b).

The NPS visitation figures indicate total annual back country overnight use for the Elwha Sub-district ranged from 8,000 to 14,000 persons during 1985 through

1989. The two Elwha River campgrounds (Elwha and Altaire) receive significantly fewer overnight camping visits than the other national park campgrounds (Heart O' the Hills and Fairholm) and two county parks (Salt Creek and Dungeness). The use at each facility, however, is directly proportional to the size of the facility and its season of operation. It should be noted that during peak use periods, such as summer weekends, all campgrounds listed are frequently full and thus reach capacity. Most of the unused capacity is not available during the summer but rather during the winter, early spring, and late fall.

3.8 AESTHETIC RESOURCES

The following sections describe the regional landscape, the project components, the landscape immediately surrounding the project areas, and the aesthetic experiences currently available within the project area. Additionally, the existing visual management of the project areas is described.

3.8.1 Regional Landscape Setting

The lower Elwha River Valley is a modified, mosaic landscape composed of mixed land uses--active logging, forest, pasture, rural residential, including the Lower Elwha Klallam Reservation, quarries, small commercial enterprises, recreational developments, a fish hatchery, and others. The immediate region surrounding the lower river appears as a mix of forest and rural uses. Visually distinctive is the forested, upper Elwha valley, a designated wilderness inside the boundaries of Olympic National Park. It is only accessible by foot on National Park trails. Although nearly pristine, the upper Elwha has several visible remnants of turn-of-the-century cabins and settlements.

Olympic National Park, the core of the peninsula, is famous for its snowcapped peaks, wet and remote old growth forest valleys, and water-carved rock and sand beaches. More nationally famous and popular are the Hoh, Sol Duc, and Quinault rivers. The much photographed and unique Hoh rain forest and interpretive center attract more national and international visitors than the Elwha River. The Sol Duc Hot Springs Resort and Quinault Lodge also attract and serve many visitors. The highest elevation vehicle access in the park is Hurricane Ridge. On a clear day, visitors can look northwest to the upper Elwha Valley.

Because of the amount of active logging on private and public timberlands outside the park boundary, Olympic National Park is a highly visible forest oasis. As seen from roads, trails, and viewpoints, the boundaries are frequently obvious due to adjacent logging.

The protected wilderness attracts many backpackers seeking remote and pristine experiences. The vehicle-accessible front country includes campgrounds, viewpoints, and short trails.

3.8.2 Aesthetic Resource Management

The extremely different landownerships and management policies within the viewsheds of the two project areas result in distinctly different aesthetic resource management settings.

Elwha Project

The Elwha Project is not managed for scenic values by public or private programs or regulations. The Elwha dam and its reservoir, Lake Aldwell, are on private property. The project has not been designed or managed to protect or enhance aesthetic qualities. Within the viewshed of Lake Aldwell are public lands managed by WDNR and WDW. These agencies do not manage their lands to protect aesthetic resources and do not have any agency policies or programs regarding scenic protection. The Clallam County Comprehensive Plan does not specify design regulations to protect scenic values along the Elwha River; however, land use and shoreline zoning ordinances such as shoreline setbacks, open space and landscape screening do indirectly protect scenic resources to varying degrees.

Glines Canyon Project

Although the 160-acre core of the Glines Canyon Project area is privately owned by the James River Corporation, the surrounding lands and waters are publicly owned and managed by the National Park Service (NPS) (Section 3.6.1). In 1988, most of Olympic National Park including the Elwha River Valley above Lake Mills became federally designated wilderness. Unlike Lake Aldwell that is surrounded primarily by private timberlands, Lake Mills is part of a National Park and the portal to federally designated wilderness and UNESCO-designated world biosphere reserve. Fitting to such an internationally significant landscape, the NPS established visual themes for management of the park and the Elwha Valley in 1989 (USDI, 1989a).

Unlike the USFS and BLM, the NPS has not developed a visual resource management system. The NPS' primary management purpose is preservation of all significant resources and therefore does not view the need for a visual resource management system to guide timber harvest, mining, and other activities which do not occur on national park lands. Rather, the NPS develops visual themes as architectural and siting guidelines for visitor and management facilities--the built environment. These NPS visual themes excerpted below are relevant for evaluating aesthetic impacts of the Glines Canyon Project.

> "The natural wilderness, untrammelled qualities of the natural ecosystems is the overall park theme. It is stated in the park's enabling legislation, is reflective of the outstanding visual qualities and characteristics of the park, and emphasizes the reasons visitors come to the park . . . .

. . . The natural elements must always be primary and be complemented by any introduction of man-made objects or improvements. Materials and colors of the objects must be reflective of those adjacent in the natural ecosystems. All shapes and forms must respond to the natural elements and forces of the site.

These natural landscape elements set the overall palette for the visual themes for the developed areas. The wide variety of greens and dark browns in the rain forest combined and complemented by the gray geological rock elements of the high mountain areas, and browns, grays, and blues of the coast establish overall color themes.

In many areas of the park the views are confined. One becomes aware of the intimacy of the lush surrounding forest and of the smallest details. Fragile flowers and plants are hidden in the shadows of a rotting log, as are the lichen and coloring in a rock crevasse, and the footprint of a gull on the ocean beach. The eye becomes aware of these details.

The man-made objects of the park must not compromise this relationship between the visitor and the natural park elements. Objects are placed in the park to provide information, to enable use, and for services, but should not upset the natural balance of the landscapes.

Natural wood and stone will repeat throughout the park in the buildings and facilities. Pitched shake roofs with overhangs, wood siding and finishes, multi-paned windows, subdued finishes are the architectural elements that will continue to be used in the park buildings. Horizontal proportions will reflect the natural elements of wind and water. Other site objects from exhibits, bulletin boards, support structures will use the similar architectural elements.... Individual detailing will occur to emphasize the historical past of the facilities in the park.

Native vegetation shall be used throughout all the landscapes of the park. Mowing and manicuring of park lands shall be confined to urban/high use areas or around visitor centers and resorts. In all other areas, native plants and materials will be used with mowing and brushing confined to insure sight distances and safety. Mowing of road shoulders as lawns is discouraged. Vegetation will also be maintained away from buildings by periodic pruning to allow for circulation" (NPS, 1988b).

The NPS visual themes also address the protection and restoration of historic park facilities. Glines Canyon dam and Elwha dam are on the National Register of Historic Places. The State Office of Historic Preservation is responsible for

administering federal guidelines for protecting the historic structures and their contextual landscape settings. Because Elwha and Glines Canyon are National Historic Register-listed projects, the appropriate visual management objectives may include restoration and protection of their historic character rather than vegetative screening or other mitigation to mute their visual contrast with the surroundings.

3.8.3 Key Viewing Areas

Elwha Dam and Lake Aldwell

Although Highway 101, the major transportation route on the peninsula, parallels Lake Aldwell on the east, there are no direct views of the lake due to vegetation and topography (Table 3-16). There is, however, one informal, undesignated pullout with a broad view of the south one-half of the lake. Other than this pullout, motorists are visually unaware of its presence. Forests, logging operations, and residences are visible along this section of Highway 101.

Highway 101 crosses the Elwha River immediately above Lake Aldwell (Figures 3-17 and 3-18). There are no developed viewpoints; however, the river can be seen from the Elwha Fishing Resort which includes a small grocery, bar, gas station, and cabins. A gravel road leads to a primitive boating and fishing access on the southwest lakeshore. This is the only signed public access viewpoint on the lake. The dam complex on the north end of the lake is accessed by an unsigned county road off Highway 112. There are no developed trails or campgrounds, but anglers do fish below the dam and sightseers occasionally walk across the dam. Besides the occasional fisherman and sightseer, an unimproved trail heading west from the damsite allows occasional horseback riders views of the lake.

Glines Canyon Dam and Lake Mills

Visitors to the dam and lake must turn off Highway 101 and travel the Olympic Hot Springs Road adjacent to the middle reach and past the park entrance, ranger station, and campground (Figure 3-19). The Griff Creek and Cascade Rock trails leave the valley bottom in this area and have occasional views of Lake Mills and the Elwha River. Near the dam, a small gravel parking area provides access to the dam facilities. The public is fenced back away from the dam and canyon. A steep gravel road leads down to a primitive boat launch, dock, picnic area, and trail along the west shore. Above the dam Olympic Hot Springs Road continues on as a popular route to the hot springs and backcountry and provides views down to the lake as it climbs to higher ground. Observation Point is a pull-out with a panoramic view of Lake Mills.

Table 3-16. Key viewing areas (Source: the staff).

Elwha Dam and Lake Aldwell
Limited view from Highway 101 pull-out areas
No views from Highway 112
WDW fishing access/Boating
Dam complex only seen from dead-end county road
Informal, undesignated equestrian trail ends at west side of dam
Glines Canyon Dam and Lake Mills
Olympic Hot Springs Road
Dam
Boat Launch/Boating
Observation Point
Pullouts
West Lake Mills Trail
Whiskey Bend Road
Dam
Upper Lake Mills Trail
Middle Reach Between Glines Canyon Dam and Lake Aldwell
Highway 101 Bridge Crossing
Olympic Hot Springs Road and Bridge Crossing
Approximately a dozen residences
Altaire Campground
Olympic National Park Gate
Elwha Amphitheater Trail
Griff Creek and Cascade Rock Trail
Elwha Fishing Resort and Indian Springs Resort
Lake Aldwell Boat Launch
Elwha Damsite
Lower Reach Below Elwha Dam
Highway 112 Bridge Crossing
Elwha River Road Bridge Crossing
Elwha Dike Road Trail
Lower Elwha Indian Reservation
Residential areas on bluffs

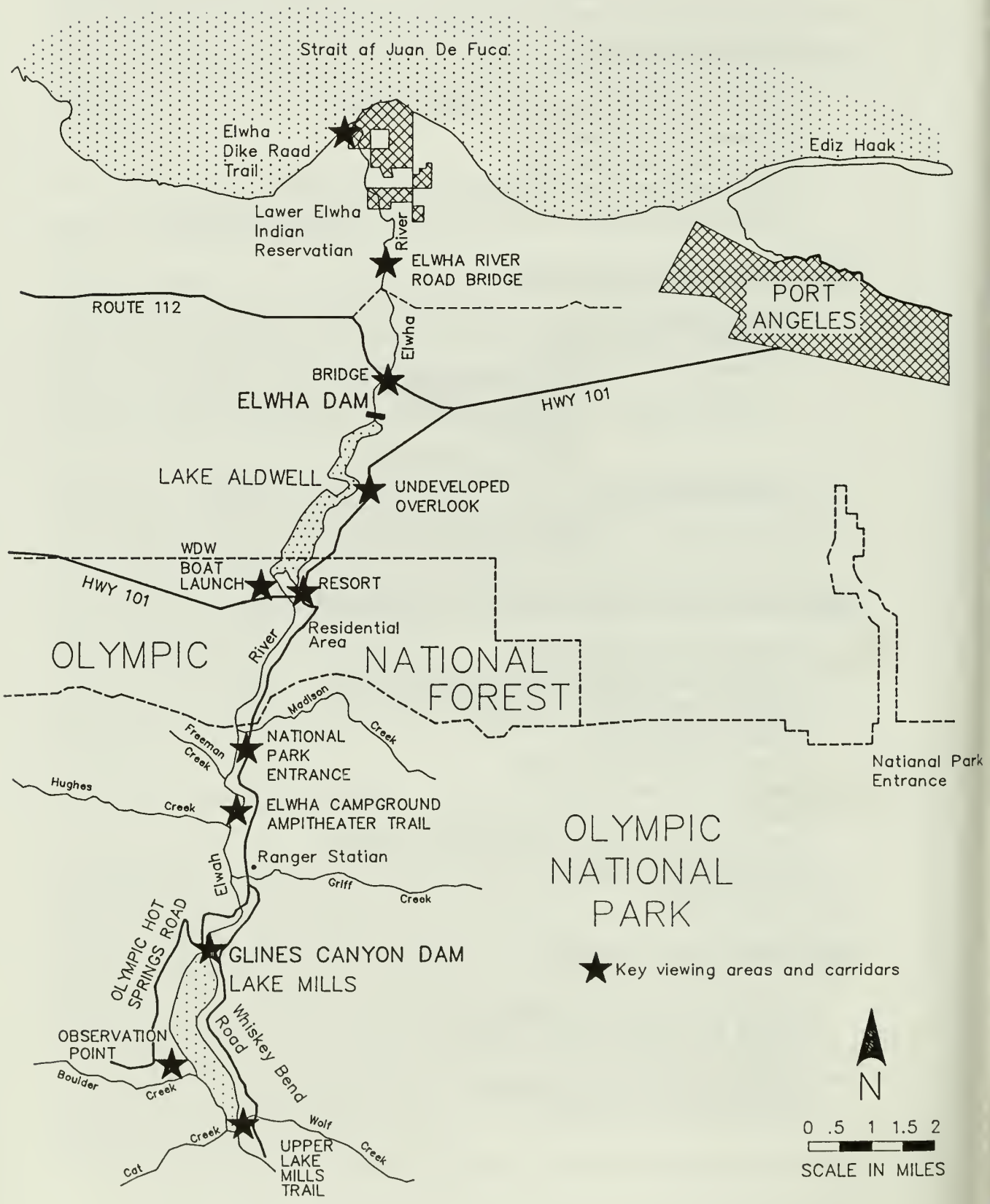


Figure 3-17. Lower and middle reaches Elwha River key view areas. (Source: the staff).

FIG3-2A.DWG

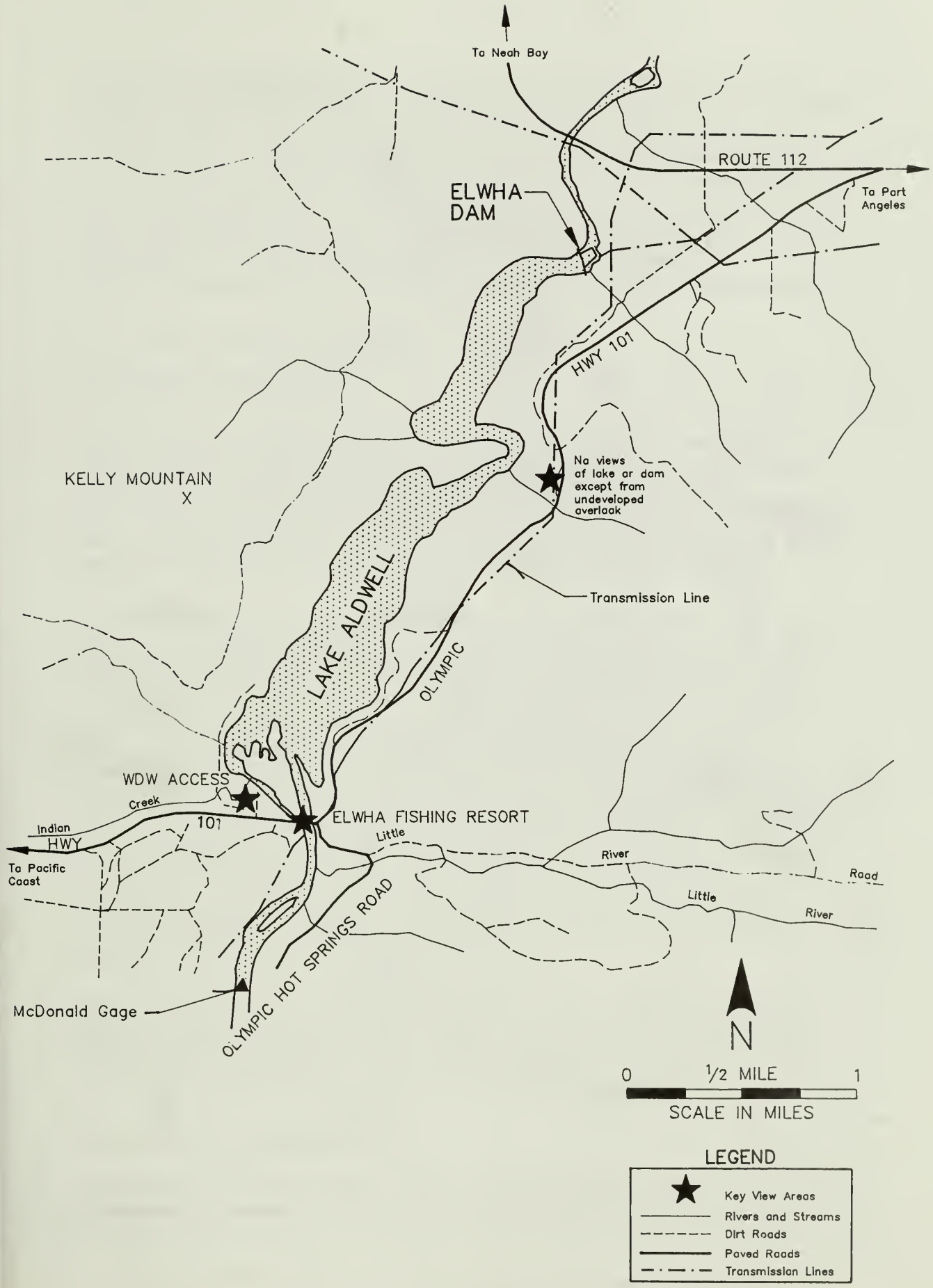


Figure 3-18. Elwha dam/Lake Aldwell key view areas and corridors. (Source: the staff).

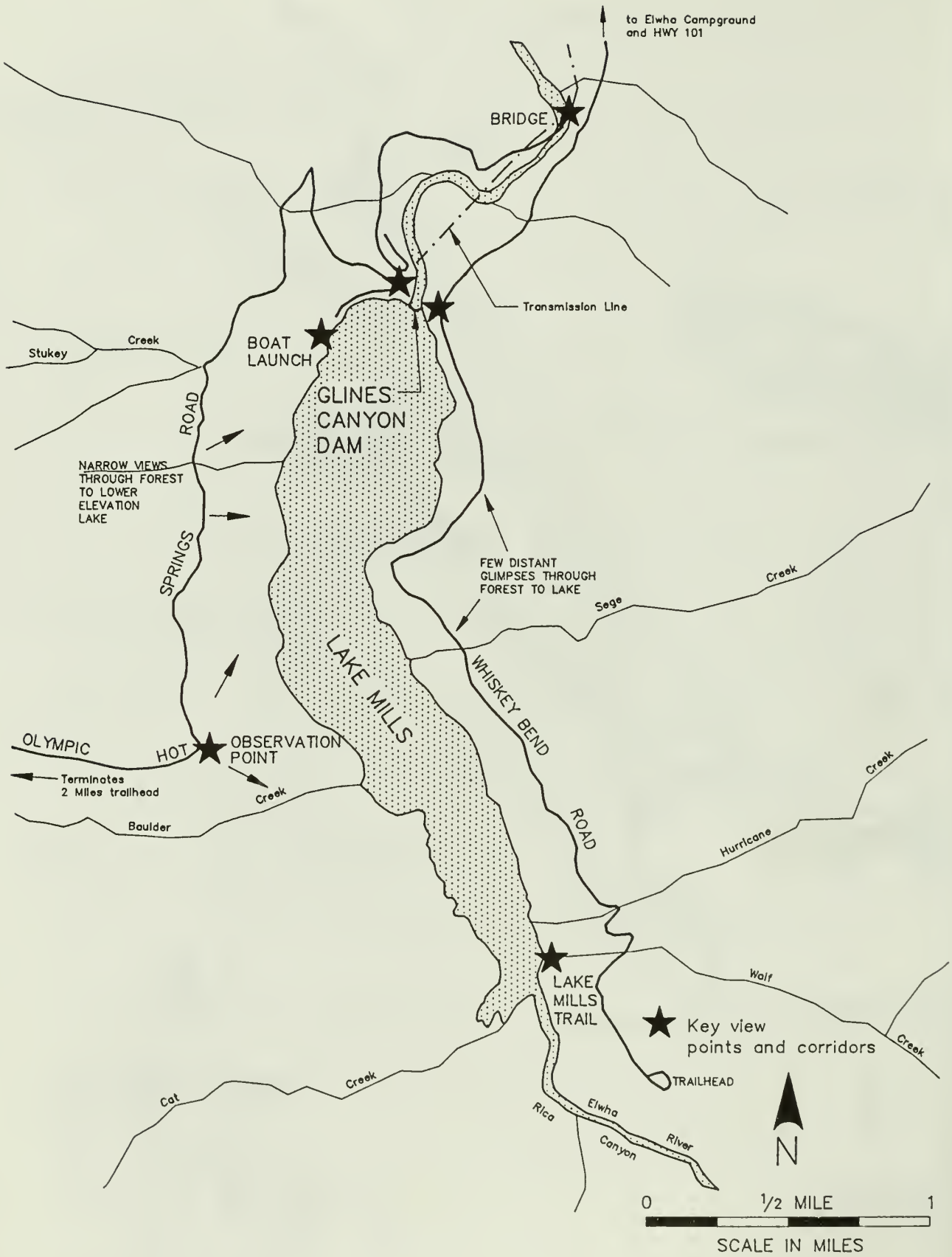


Figure 3-19. Glines Canyon dam/Lake Mills key view areas. (Source: the staff).

LKMILL01.DWG

Whiskey Bend Road is a single gravel lane with occasional pull-outs that leaves Olympic Hot Springs Road below the dam. Forest cover blocks views to the river and lake except in a few places where short and distance glimpses are available. There is a pull-out at Glines Canyon dam. Visitors can walk a short distance to the dam and lake. The terminus of the road is a major trailhead for backcountry trails within Olympic National Park. There are no views to the lake or river from here although, by hiking further, visitors have views of the upper Elwha. At the southern end of the lake, just prior to the Whiskey Bend trailhead, the half-mile-long Lake Mills trail leads steeply to the lake and Wolf Creek waterfall.

3.8.4 Project Features and Settings

Elwha Dam and Lake Aldwell

From the Lower Dam county road, the transmission line right-of-way is first visible with more distant views to the powerhouse, penstock, and dam complex (Figure 3-20). The condition of vegetation within the transmission line right-of-way results in high visual contrast with the surrounding forest. Likewise, native vegetation has been cleared around all utility buildings and structures so they are in open view and high visual contrast to the surrounding landscape.

The weathered concrete of the historic 105-foot-high multiple buttress dam blends with the adjacent rock. It is not a clean concrete wedge in a canyon. Since the original construction, numerous modifications have resulted in a cluttered image. Numerous small peripheral buildings of differing architectural styles, materials, colors, and maintenance upkeep exist on both the east and west banks near the dam. The office/maintenance buildings and the old and new powerhouse are painted white which results in high contrast with dark forest and exposed rock colors. The large, above ground penstocks and surge tank have galvanized metal exteriors which contrast with the adjacent lawn and surrounding forest. Although there are no facilities designed for public access or viewing, visitors are allowed to walk across the dam and spillways which are fenced for public safety. There is minimal access to the downstream canyon and no recreational facilities on the north end of the lake. Viewing is from the road, dam or by boat. Log booms prevent boats from approaching the dam too closely.

Elwha dam flooded a 65-foot-deep canyon, creating Lake Aldwell 3.5 miles long and 0.3 mile wide. The lake elevation varies about 5 feet a year. The shoreline and surrounding hills are forested. The only visible developments are at the dam. The steep topography and forest screen views into and out of the lake.

Glines Canyon Dam and Lake Mills

The historic Glines Canyon dam is a 210-foot-high concrete arch dam wedged in a very narrow canyon. The weathered concrete blends into the adjacent canyon

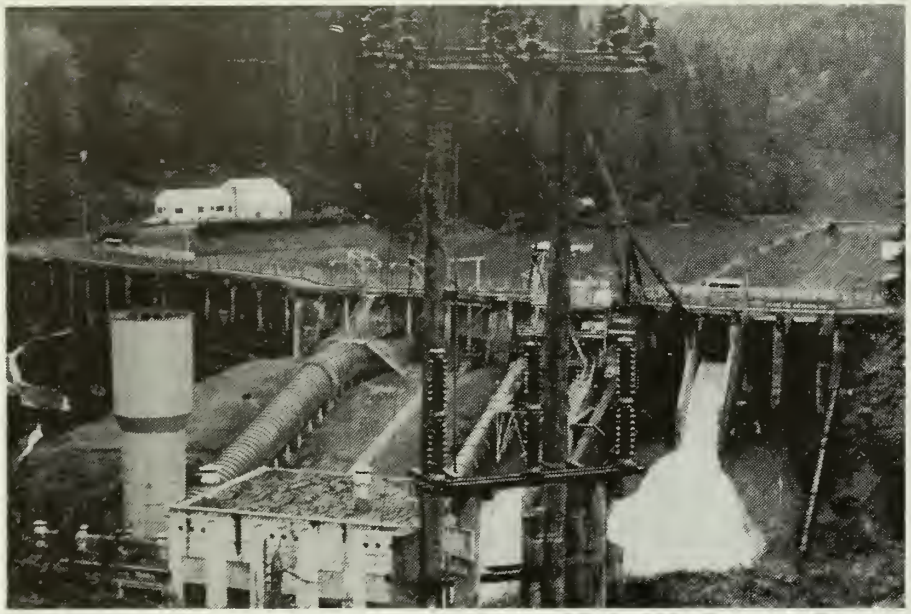






Figure 3-20. Upper left: Elwha dam, view south from private service road.
Upper right: Elwha Project powerhouse, view northwest downstream from private service road.
Lower left: Lake Aldwell above Elwha dam, view southeast. (Source: the staff).

walls. Classic, round globe lamp colonnade lines the top of the dam (Figure 3-21). The tops of the dam and spillway are fenced to block all public access. The globes outside the fence closure are missing, presumably the result of theft or vandalism. Both physical and visual access are very limited from the Whiskey Bend Road and Olympic Hot Springs Road.

Visible from Olympic Hot Springs Road are the surge tank painted grass green, the white facade powerhouse, and residential and maintenance facilities painted cream. The white and light colors are in high visual contrast with the surrounding steep, forest hillsides. Large clearings have been created around the buildings which makes them highly visible and results in a turf grass green patch. The dam and other structures are generally limited to a short glimpse for most visitors who are on their way by vehicle to or from the backcountry trailheads.

Lake Mills is in a narrow, forested canyon. It is approximately 2.5 miles long, 0.5 mile wide, and 140 feet deep. Under current operating modes, the pool elevation varies little. The only vehicular access to the lake is from both shores near the dam, including a primitive boat launch on the west bank with hiking trails along the west shoreline. The upper Lake Mills trail terminates with a single viewpoint at the southeast end of the lake. Visitors can see a short distance upstream with a restricted view of the lake and surrounding mountains. Features include large boulder bars, large sluffing bluffs of glacial deposits, and the Wolf Creek waterfall. A hiking trail popular with day users provides access to the west bank.

Transmission Line

The transmission line from the Glines Canyon powerhouse parallels the Olympic Hot Springs Road to Highway 101. It crosses Highway 101 approximately seven times on H-shaped wood towers. North of Elwha dam, the shared transmission line continues cross-country rather than paralleling a road. Within Olympic National Park, single pole towers are used intentionally to limit visual impacts. The right-of-way vegetation is also under special management prescription, thereby mitigating visual impacts within the park boundaries.

3.8.5 Elwha River Character

Portions of the Elwha River, between Glines Canyon dam and Lake Aldwell and below the Elwha dam, are sinuous, meandering channels with numerous permanently forested islands and large boulder bars (Figure 3-22). The river is framed by steep forest walls or lush riparian habitat except near the mouth where the river valley opens up. Residences, roads, and campgrounds have visual access to the river although views are typically restricted by vegetation and topography. On Highway 112 a viewpoint sign reads "Elwha Canyon Scenic Viewpoint," but there is no view of the canyon, only a highway bridge can be seen.



Figure 3-21. Glines Canyon dam, view west from Whiskey Bend Road to Olympic Hot Springs Road. (Source: the staff).







Figure 3-22. Upper: Elwha River between Glines Canyon dam and Elwha dam, view south from Olympic Hot Springs Road. Lower left: Olympic Hot Springs Bridge crossing Elwha River downstream of Glines Canyon dam. Lower right: Mouth of Elwha River, view south from Lower Elwha Reservation. (Source: the staff).

3.9 SOCIOECONOMIC SETTING

The socioeconomic setting encompasses Clallam County, and particularly the City of Port Angeles and the Lower Elwha Indian Reservation. The area's economy is based largely on the natural resources found in the region. Timber has historically played a significant role in the region and continues to do so, and the forest products industry is the largest industry in the county. The area's numerous scenic attractions, recreational opportunities, and marine resources, coupled with a moderate climate, attract recreationists, tourists, fishermen and retired persons. These groups are significant to the local economies in that they create a market for, and place a heavy demand upon, the service and retail trade sectors in Clallam County. The Lower Elwha hatchery and the depleted anadromous fish run on the Elwha River make a small contribution to the value of the regional fishery and to members of the Lower Elwha Klallam Tribe. Native Americans are for the most part outside of the mainstream economy.

3.9.1 Social Characteristics

Population

Clallam County's population increased from 34,770 to 51,648 between 1970 and 1980, and was estimated at 55,200 in 1989. Members of the Lower Elwha Klallam Tribe constitute about 2 percent of the county population (Section 3.9.2). During the 1970's, the population in the county grew at an average rate of 4.0 percent per year. During the same period, the state population grew at less than half that rate at 1.9 percent per year. Since 1980, population growth in the state and county has slowed significantly. In part due to the 1980-1982 recession, population growth in Clallam County slowed to less than 1 percent per year since 1980 while growth for the state has slowed to just over 1.3 percent per year. Recovery from this recession is evidenced by higher growth rates in the later part of the 1980's (Washington State Office of Financial Management, 1989).

Most of the county's population is concentrated around Port Angeles and Sequim. Port Angeles has traditionally been and continues to be the population center of the county, accounting for over 32 percent of the total county population. Factors that contribute to this concentration include industrial activity on Port Angeles' deep water harbor, the "rain shadow" which makes the east end climate more attractive, and land ownership patterns which put most of the south and west area of the county in large commercial timber holdings and the Olympic National Park. The unincorporated portions of the county account for over 57 percent of the population and have experienced the greatest overall growth in the 1980's (Washington State Office of Financial Management, 1989).

The state of Washington, Office of Financial Management, has estimated that Clallam County's population will exceed 61,000 by the year 2000, with much of this increase in the 65 years and over age group (Washington State Office of Financial Management, 1989). With the rising age in population will come a

change in attitudes and lifestyles. These new inhabitants will be less tied to the timber industry and more tied to the amenities that attracted them, such as the natural beauty of the surrounding environment, the rural nature of the area, and the sport fishery resources.

Employment

Employment in Clallam County grew at an average annual rate of 3.3 percent between 1985 and 1988. During this same timeframe, the overall labor force in the county grew by 2.4 percent per year to 22,845 and unemployment fell from an average annual rate of 10.2 percent in 1985 to 8.8 percent in 1988 (Washington State Employment Security Department, 1989). Unemployment is significantly higher among members of the Lower Elwha Klallam Tribe (Section 3.9.2). The highest growth rates in employment between 1985 and 1988 were in the government, retail/wholesale trade, and pulp/paper manufacturing sectors. Overall, Clallam County has lagged behind the state in employment growth but has far exceeded the state in growth within the retail/wholesale trade and government sectors. This is typical of areas that rely heavily on tourism and that have growing older populations.

The forest products industry has traditionally been the county's primary industry. In 1987, 88 percent of all manufacturing employment (over 2,700 jobs) was attributable to the timber industry. In addition, much of the employment at Port Angeles' harbor is tied to the industry. Waterfront activities related to the loading of logs, pulp, paper, and lumber for export and log storage activities provide numerous employment opportunities (Washington State Department of Ecology, 1989).

Tourism is considered Clallam County's second major industry. Recent figures compiled by the Clallam County Economic Development Council (1989a) suggest that in 1987 alone, travel-related expenditures, payrolls and tax receipts accounted for over $75 million in annual income and 3,850 tourist-related jobs (Washington State Department of Ecology, 1989).

Commercial and sport fishing are also significant employers in Clallam County. A fleet of about 250 commercial fishing boats is based in Clallam County (Clallam County Economic Development Council, 1989b) with the majority tied to the Alaska fishery. Native American fishermen, including members of the Lower Elwha Klallam Tribe, participate in the commercial fishery in the Strait of Juan de Fuca. A fleet of about 25 sport fishing charter boats is also present in the area.

Income

In 1986, per capita personal income in Clallam County was $13,345, approximately 12 percent below the state average of $14,976 for the same period. Between 1980 and 1986, per capita personal income in Clallam County rose an average of 1.2 percent per year. During this same time period, Washington

experienced only a 1 percent real annual increase. While personal income in Clallam County is still below the state average, it is slowly catching up.

Total personal income in Clallam County has also risen steadily over the last decade. Much of this is attributable to the steady increase in investment income and transfer payments (payments from the government, such as Social Security). Clallam County is following the national trend toward greater reliance on investment income (dividends/interest/rent). Over 26 percent of the county's personal income in 1986 was attributable to investment income. An additional 23 percent was attributable to transfer payments. Both of these categories are considered "unearned" income and are usually present in large quantities where the percentage of retired persons is high. Total personal income in Clallam County in 1986 was $716,938,000 (Clallam County Economic Development Council, 1989b).

3.9.2 Tribal Characteristics

Land for the Klallam Tribe was set aside in 1936, a portion lying near the mouth of the Elwha River. By presidential proclamation, this land was established as the Lower Elwha Indian Reservation in 1968. In 1984, the tribe had a service population of 1,194 (USDI, 1985). The service population includes all member and nonmember Native Americans receiving services from the tribe on or near the reservation. In 1986 the service population fell slightly to 1,059, and in 1988 grew slightly to 1,099 (USDI, 1987; 1989b). The tribe experiences a very high unemployment rate, ranging from 80 percent in 1984 to 63 percent in 1988 (USDI, 1985; 1989b). Little information is available concerning the average income of those tribal members who are employed. In 1986 and 1988, however, approximately 23 percent of those employed earned under $7,000 per year (USDI, 1987; 1989b).

The Lower Elwha Klallam Tribe has had limited opportunities for economic development, and the resulting poverty is associated with a corresponding pattern of health problems such as obesity, diabetes, alcoholism, drug abuse, and mental health problems (letter from Ralph Kopansky, Lower Elwha Tribal Council, Port Angeles, Washington, July 27, 1990). Many development opportunities at the reservation have been limited in the past, in part because the flood hazard of the Elwha River rendered the tribe ineligible for federal housing and economic development funds (letter from Ralph Kopansky, Lower Elwha Tribal Council, Port Angeles, Washington, July 27, 1990). This situation was partially corrected when the U.S. Army Corps of Engineers recently completed a levee to protect a portion of the threatened lands.

The tribal council offers several services to its service population, including educational, medical and counseling services. The tribal government has also succeeded in securing federal funds and state grants and contracts worth about $1 million annually (Lower Elwha Tribal Council, undated). The tribe also operates the Lower Elwha Hatchery, which in 1987 produced over 63,000 pounds of

chinook, coho, and steelhead. The hatchery employs 4 persons, and in 1987 had an operating budget of about $140,000 (USDI, 1988c). Although not viewed by the tribe as a for-profit enterprise, the hatchery does provide some employment and can indirectly boost the reservation's economy.

The Elwha River fishery has been historically important to the tribe both economically (Section 3.9.3.1) and culturally (Section 3.10). A recent economic overview of the tribe (memorandum, undated, from Russell Busch, Elwha Klallam Tribe: Economic Overview, transmitted by Kopansky on July 27, 1990) documents key aspects of tribal fishing activity from 1982 through 1988 and forms the basis of the following discussion.

From 1982 to 1988, approximately 80 to 125 tribal members were registered to fish, and between 60 and 100 members actually fished at least once during each year. The vast majority of those who fished took part during the inriver fisheries, primarily in the Elwha River. One factor that may be limiting the number of active tribal fishermen and the degree of their activity is the accessibility of fish. From 1982 to 1988, no more than 36 boats have been registered to tribal owners, and no more than 10 of those have been power boats. The power boats allow fishermen to participate in the marine drift gill net fisheries, while the remaining fleet can participate in the marine set net, troll, and/or river fisheries. In 1988, approximately 10 percent of the active fishermen had gross fishing incomes greater than $15,000. All fishermen in that income range had power boats.

Those fishermen not having boats participate exclusively in the river fisheries, and the majority of the tribal fishermen are dependent on the seasonal Elwha River coho and steelhead fishery for a source of income and subsistence. Approximately 60 percent of the active fishermen in 1988 had gross fishing incomes lower than $1,000.

Both the marine and river fisheries are highly seasonal, with the majority of revenue generated between June and December. Much less than 1 percent of the revenue occurs from January through May. Most of the summer income accrues to the small number able to access nonElwha fisheries, most notably Fraser River sockeye. The most significant revenues attributable to the Elwha River fishery are generated during the coho season between September and November. Overall, the Elwha River fishery contributes about 20 percent of the total Tribal fishing revenue, and that income is primarily from the harvest of returning hatchery produced coho. The highly seasonal nature of the fishery results in long periods when there is no gainful employment in fishing, followed by a brief glut accompanied by lower market prices.

The inriver fishery is sometimes upset by sudden releases of water from the upstream dams, destroying nets and potentially endangering tribal fishermen caught unaware.

In sum, the tribe experiences extreme poverty and unemployment, and the tribe considers the fishery potential of the Elwha River as its only significant asset. Most tribal fishermen rely to some degree on the river's fisheries for income or food, receive a relatively small income from those fisheries, and have varying degrees of success from year to year. The fisheries available are extremely seasonal.

3.9.3 The Relationship of Elwha and Glines Canyon Projects to the Local Economy

The Elwha and Glines Canyon dams affect the local economy in two major ways, the first associated with their effect on fisheries, and the second concerning their role as power producers.

3.9.3.1 Fisheries

Present and past fisheries on Elwha River fish stocks included commercial, sport (recreational), and personal use (subsistence) fisheries. Early Indian fisheries before the arrival of European settlers were based on subsistence needs and trading. With the settlement of Europeans after 1850 came sport and commercial fisheries.

Historical fishing activities were described by Lane & Lane Associates (1990) and are summarized below. Prior to construction of the dams in the early 1900's, the Elwha Klallam Indians fished the Elwha River and adjacent Freshwater Bay and the Strait of Juan de Fuca. The fisheries included traditional subsistence and commercial activities targeted for coho, spring and fall chinook, pink, and chum salmon and steelhead. Fishing extended from at least March to November. River fishing was primarily by dip-netting, gaffing, and spearing, often in combination with weir-traps. Indians also trolled and gill netted for salmon in the Strait. The fisheries expanded toward the end of the 19th century, and Indian and nonIndian commercial fishermen began selling their catch to canneries in Port Angeles. The Elwha Klallam Indians supported themselves entirely from their subsistence fisheries and commercial sale to individuals and fish processors in Port Angeles. Runs were generally described as prolific until the Elwha dam was built on the lower river in 1910. Declines in the anadromous fish runs after 1910 are generally attributed to the blockage of spawning fish by the dam. Early attempts at hatchery production failed and efforts ended in 1922.

Commercial, sport, and subsistence fishing continued after the dam was constructed despite severe reductions in run size. Lane & Lane Associates (1990) document Indian subsistence fishing continuing after the dams were built, although severely restricted by either regulations or poor run size. Commercial fishing also continued in the Strait. Sport fishing for salmon and steelhead in the river also occurred. The fisheries were supported by small natural runs of chinook, coho, pink, and chum salmon and steelhead that were able to spawn and rear in the lower river below Elwha dam, and by limited stocking of salmon and steelhead.

In the 1960's and 1970's, hatchery production began for fall chinook, coho, and chum salmon, and summer and winter steelhead to supplement the depleted runs. The Lower Elwha Klallam Tribe maintains a hatchery on the lower river for winter steelhead and coho and fall chinook salmon. The Washington Department of Fisheries maintains an egg-taking and rearing facility for fall chinook. The Washington Department of Wildlife stocks the river with summer and winter steelhead. The runs of spring chinook, chum, and pink salmon, which were not supported by hatchery programs, had declined to negligible levels by the 1970's. Sporadic stocking of spring chinook and chum salmon from other rivers in the 1970's and 80's failed to restore these runs.

In recent years, the fall chinook have supported the largest fishery. Hatchery and natural spawning of hatchery fish in the lower river produce on average about 20,000 to 25,000 adult fish, of which about 80 percent are harvested by the various fisheries (PSC, 1989). Tag return data from Elwha hatchery fish indicate that on average 39 percent of tags returned are from the British Columbia commercial net fishery, 32 percent are from the Strait and Puget Sound sport fishery, 12 percent are from the Strait and Sound commercial net fishery, and 6 percent are from the Washington ocean and Alaskan commercial and sport fisheries. The contribution of the Elwha fish to the total catch in each of these areas is very small. The greatest contribution, roughly 5 percent, is to the Strait/Sound sport fishery. The contribution to the southern Strait sport fishery, especially near the mouth of the Elwha (Freshwater Bay and Ediz Hook), is probably higher. About 5,000 fish per year escape to the Elwha River, where the tribal harvest ranges from about 200 to 800 fish. Due to the limited escapement, sport fishing is restricted in the river.

Present fishery management goals of the Pacific Salmon Commission for the chinook stocks call for measures to reduce the decline in escapement of naturally spawning chinook stocks of the Pacific Northwest (PSC, 1989). Measures include catch ceilings and harvest rate restrictions in commercial and sport fisheries (e.g., Friday closures of the Strait/Sound sport fishery in 1989 and 1990). These and other measures that are being taken to protect other stocks could lead to an increase in escapement to the Elwha River. The Pacific Fisheries Management Council's ocean management is not directed toward Strait/Sound stocks (PFMC, 1978).

Similar to the fall chinook in fishery harvest are the fall run coho salmon with an adult equivalent run of about 20,000 adult fish over the past decade. The Elwha coho salmon stock, primarily derived from the Elwha tribal hatchery, is harvested by marine commercial and sport fisheries. Much of the escapement to the river (35 to 89 percent) is harvested by Indian nets in late summer and fall, with the remainder taken at the hatchery. Only an estimated 100 to 400 fish escape up the river. Sport fishing is allowed in the river during the fall. Like the chinook stocks, commercial and sport fisheries in marine waters are restricted to protect naturally spawning stocks. Again, such measures may lead to an increase in escapement to the Elwha River.

Pink and chum salmon from the Elwha River contribute little to sport, commercial, or tribal fisheries because of their very small run size (Section 3.4).

Steelhead contribute to sport and tribal fisheries. Of the approximately 2,000 to 6,000 fish in the winter run, about 47 percent are harvested in the tribal fishery and 38 percent in the sport fishery. About 70 percent of the average 650 fish in the summer run is harvested in the sport fishery, while the tribal fishery harvest averages only 8 percent.

The total value of the commercial and tribal harvest of Elwha harvested salmon and steelhead, based on price per pound received by fishermen, ranges from $10,000 to $30,000 for steelhead, $16,000 to $187,000 for coho, and $90,000 to $358,000 for chinook (Table 3-17).

3.9.3.2 Power Production

Currently, the entire electrical energy output of the Elwha and Glines Canyon projects is supplied to the Daishowa paper mill. Located in Port Angeles at the base of Ediz Hook, the mill was built in 1920 as a groundwood newsprint mill. It currently receives approximately 39 percent of its power from the Elwha and Glines Canyon projects. The remainder is purchased from BPA through the City of Port Angeles.

Over the past 8 years, the Elwha and Glines Canyon projects have contributed between 34 and 42 percent of the mill's energy requirements (Table 2-13). In 1989, for example, power from the two projects met approximately 35 percent of the mill's power requirements. At the same time, project power accounted for only 19 percent of the mill's total energy cost. The staff estimates that total energy costs account for about 15 percent of total mill operating costs, and that the cost of Elwha and Glines Canyon power would constitute about 3 percent of the overall operating costs of the mill. The relatively low cost of power from the Elwha and Glines Canyon projects provides a cost savings to the mill, and thus slightly improves its position when competing for markets.

The Daishowa mill is one of the top 10 employers in Clallam County. The mill currently employs about 350 persons. Total direct and indirect employment due to the mill may be as high as about 1,200, including the mill's pulp and wood chip suppliers (Washington State Department of Ecology, 1989).

Table 3-17. Approximate commercial value of anadromous fish harvested from Elwha stocks by commercial and tribal fisheries (Source: memo from Les McConnell, U.S. Department of the Interior, Bureau of Indian Affairs, Branch of Fisheries, January 9, 1990).

Species	Catch (1,000's)	Ave. Wt (lbs)	Total Wt (1,000 lbs)	Value $/lb	Value ($1,000's)
Chinook	4-16	14	56-224	1.60	90-358
Coho	2-24	6	12-144	1.30	16-187
Steelhead	1-3	10	10-30	1.00	10-30

3.10 CULTURAL RESOURCES

Cultural resources in the project area include prehistoric and historic archaeological sites and Native American heritage sites.

3.10.1 Regional Prehistory, History, and Ethnography

Prehistory

The project area may have been occupied as early as 12,000 years ago. In 1977 archaeologists discovered the remains of a mastodon associated with human tools and dating to about 12,000 years ago near Sequim, Washington, a few miles east of the Elwha Basin (Gustafson et al., 1987). This site provides unequivocal evidence that humans followed now extinct megafauna into newly exposed lands previously covered by Ice Age glaciers at the close of the Pleistocene.

The succeeding Early Period of Washington prehistory is poorly understood, but the archaeological evidence generally indicates low population density and a generalist food gathering adaptive pattern. On the Olympic Peninsula, materials dating to this period (7,000 to 4,000 B.C.) are called "Coastal Olcott" or "Old Cordilleran." There is some indication of an adaptive shift from the pursuit of Pleistocene megafauna to a greater concentration on hunting migratory land mammals during this period. Several sites at higher elevations in the Olympic Mountains point to this conclusion (Bergland and Marr, 1988).

The Middle Period (4,000 to 1,000 B.C.) probably was a time of gradually increasing population density and a broadening of the food resource base to include greater dependence upon anadromous fish, shellfish, and birds, concomitant with the development of new technologies to efficiently harvest them.

During the Late Prehistoric Period (1,000 B.C. to A.D. 1775), the historically known pattern involving sedentary habitation of coastal villages and strong dependence on anadromous fish as a staple and stored food resource developed. Though it remains a matter of controversy, there is some evidence that exploitation of maritime resources including sea mammals may have intensified after about 1,000 B.C.

History

The first recorded European landing within aboriginal Klallam territory was made by Manuel Quimpter, a Spaniard, in 1790. One year later, another Spanish explorer, Francisco Eliza, named Port Angeles (El Puerto de Nuestra Senora de Los Angeles). In 1792, George Vancouver explored Puget Sound, naming as he went, many of its outstanding geographic features (Russel, 1971; Ruby and Brown, 1986). Spain and Britain were vying at the time to open the area to trade. This competition ended, however, with the collapse of the Spanish Empire in the early 19th century.

Settlement of the northern Olympic peninsula did not begin until the 1850's. A sea captain named Alexander Sampson built a house on the site of Port Angeles in 1857. Settlement, mostly restricted to the coastal zone, increased slowly during the coming two decades. In 1862, Victor Smith moved the U.S. Customs House from Port Townsend to Port Angeles. The 1860's also saw the beginnings of the logging industry and the construction of the area's first road, which connected Port Angeles by land with Gray's Harbor and Dungeness.

Settlement in the Port Angeles area increased more rapidly during the 1870's and 1880's, and it was during this era that the Elwha Valley was first inhabited by European Americans. The Humes brothers homestead and the Herrick Trading Post were established in the Glines Canyon area during this period (Fish, 1983).

In 1889, Port Angeles experienced a land boom because of speculation that the town would become the terminus of the Union Pacific railroad. The population increased from 500 to 3,000 within a year (Hult, 1954). It was 1911, however, before a railroad actually reached the town. Thomas Aldwell, builder of the Elwha dam, described Port Angeles as a "wild frontier town" with 16 saloons and about 1,300 people in 1890, when he arrived (Aldwell, 1950).

The first historically recorded crossing of the Olympic Mountains ascended the Elwha Valley in the winter of 1889. It was sponsored by the Seattle Press newspaper and led by James H. Christie (Woods, 1969). The Press Expedition, as it became known, took 6 months to reach the lower Quinault.

Hydroelectric development came to the Elwha watershed in 1910, with construction of the Elwha Project by the Olympic Power Company, under the direction of Port Angeles entrepreneur Thomas T. Aldwell. Aldwell purchased land for the project and secured its financing. The original dam was poorly

designed and failed as the reservoir was filled. After reconstruction, it supplied most of the electrical power for the Olympic Peninsula, including forts Worden and Flagler, and the Bremerton Naval Yard (James River II, 1987).

Aldwell joined forces with George A. Glines and others to form the Northwest Power and Manufacturing Company, later the Northwest Power and Light Company, in 1916. This company obtained a license from the Federal Power Commission in 1926 to construct the Glines Canyon Project. Glines Canyon was designed to meet the increasing demand for electrical power on the Olympic Peninsula due largely to a rapidly expanding paper and pulp industry. The Glines Canyon and Elwha projects together generated 25 MW of power, which supplied electricity for residential and commercial uses in the towns of Bremerton, Charleston, Port Angeles, and Port Townsend, as well as the industrial needs of the Bremerton Navy Yard and mills located on Ediz Hook spit.

Native American Resources

The Elwha River watershed is within the aboriginal territory of the Klallam Native American tribe. The Klallams spoke the Straits dialect of Coast Salishan and are closely related to other tribes located on the Strait of Juan de Fuca, including the Lummi, Samish, Sook, Saanich, Songhees, and Semiahmoo. Klallam territory stretched roughly from Port Discovery Bay westward to Clallam Bay (Suttles, 1987; Ruby and Brown, 1986).

The Klallams located mainly in permanent villages along the coast and immediately inland, especially along major streams such as the Elwha. Though the aboriginal Klallam harvested a variety of plant and animal food resources, the anadromous fishery was their most important source of food, both for immediate consumption and for long-term storage. They took the salmon using a variety of technologies, including harpoons, gaffs, and hooks. The Klallam constructed weirs across major salmon streams, and trolled in the Strait of Juan de Fuca. The Klallams also ordered their ritual year in reference to the cycle of anadromous fish runs.

The Klallams may have numbered 2,240 before European American contact, but their numbers were quickly reduced during the historic period by diseases, including smallpox (Ruby and Brown, 1986). Klallam villages were known, ethnohistorically, to be located on Ediz Hook, near the Elwha mouth, and near the mouth of Indian Creek, where the Lake Aldwell delta is now located (James River II, 1987).

The Klallams ceded their territory to the United States Government by the Treaty of Point No Point of 1855. This treaty granted the Klallams and other signatories a right to half of the harvestable catch of anadromous fish within their "usual and accustomed grounds and stations." The court decision in U.S. vs. Washington, known as the Judge Boldt decision, upheld the treaty and its entitlement to fishery

harvest in 1974. The treaty also granted the "privilege of hunting and gathering roots and berries on open and unclaimed lands."

Another provision of the Treaty of Point No Point was that the Klallams were to be removed to the Skykomish reservation at the southern end of Hood Canal. Few Klallams moved to the reservation, however, because of its distance from their traditional territory and proximity to their traditional rivals, the Twanas. Most Klallams instead remained in their aboriginal territory, forming small settlements around Hood Canal, Puget Sound, and the Strait of Juan de Fuca. Many Klallams resettled, or remained in the Elwha Valley, and many supported themselves by fishing, both for subsistence and for sale in Port Angeles (Lane & Lane Associates, 1990). According to a federal fisheries report, 360 out of 387 commercial fishermen in Clallam County were Native Americans in 1892 (Wilcox, 1895, cited in Lane & Lane Associates, 1990).

In 1936, the United States purchased 1,604 acres of land to establish a Klallam reservation near the mouth of the Elwha River, and many Klallams moved to the reservation land at that time. The Lower Elwha Reservation was not officially established, however, until President Nixon issued a proclamation creating it in 1968. The reservation today numbers 1,099, many of whom work in the fishing, timber, and wood pulp industries.

3.10.2 Site Inventory and Evaluation

The applicant surveyed the shorelines of lakes Aldwell and Mills, as well as the Elwha River shorelines between the reservoirs, and did not discover prehistoric archaeological sites (James River II, 1987). This may be due to the fact that the most likely places for prehistoric sites are near the river bottoms, under the sediments of lakes Aldwell and Mills.

Two historic sites are located within the project Area of Potential Effects. These are the Elwha and Glines Canyon powerplants which were listed on the National Register of Historic Places as of December 1988. The Elwha River plant is historically significant as an example of an early twentieth century low-head hydroelectric system and as an early and rare example of a multiple buttress dam. The Glines Canyon powerplant is significant for its association with the evolution of powerplant design, its contribution to the automation of hydroelectric power generation, and because it marks the end of the era of single-purpose, hydroelectric installations. Both plants meet the powerplant registration requirements established in the State Historic Preservation Office's Hydroelectric Power Plants in Washington Multiple Property National Register Nomination program (USDI, 1988a; 1988b).

No Native American heritage sites have conclusively been identified in the project Area of Potential Effects. However, there is some indication (Lower Elwha Klallam Tribe, 1989) that a site associated with the Klallam Center of the

Universe Story might be located within Lake Aldwell. This site may be associated with petroglyphs or artifacts.

3.10.3 Native American Consultation

The applicant has consulted with members of the Lower Elwha Klallam Tribe. While these consultations have not resulted in the identification of Native American heritage sites that the project alternatives might affect, the Klallam have repeatedly stressed the importance of the river and its resources, particularly the anadromous fish resource, as the most significant single aspect of their cultural identity. As the Klallam put it, "the fishery is our culture." Responsible stewardship of natural resources has always been a significant element in a culture whose members have depended since antiquity on those natural resources for sustenance. Aboriginal Klallam culture depended on the multiseasonal runs of salmon for their staple food supply and as the driving force of their ritual cycle.

After the coming of European Americans, the Klallam continued to subsist mostly as fishers, but were faced with competition for fishery resources with European Americans, despite the Treaty of Point No Point assigning them half of the fish harvest within their aboriginal territory. Construction of the Elwha dam disrupted the natural ecology of the anadromous fishery, and the Klallam feel that this event disrupted the fabric of their society and culture, and that it constitutes a violation of the Treaty of Point No Point. The court case U.S. vs. Washington upheld Native American fishing rights granted in the treaty, and the Bureau of Indian Affairs regards these rights as equivalent to property rights (Bureau of Indian Affairs, 1990).

The failure of the Elwha dam in 1912, which flooded tribal lands near the river mouth, introduced additional disruption in the form of the fear of another dam failure, which induced many Klallam to move. The Klallam who live and fish on the lower river also feel that water level fluctuations caused by dam operations have threatened the safety of inriver fishers and caused damage or loss to expensive equipment.

To the Klallam, restoration of the anadromous fishery in the Elwha and shellfish populations at its mouth would represent a partial restoration of Klallam culture and a restoration of their fish harvest rights under the Treaty of Point No Point, in addition to its benefits in terms of their market and subsistence economy.

3.11 AFFECTED ENVIRONMENT ASSOCIATED WITH REPLACEMENT OF ELWHA AND GLINES CANYON ELECTRICAL GENERATION

This section briefly describes the regional setting and environmental conditions that might be affected by the alternative conservation and generation resources whose timing and extent of development could be influenced by the reduction, or complete loss, of power produced by the Elwha and Glines Canyon projects. The wide range of alternative resources is identified and described in Section 2.7. No

specific sites have been identified for these resources. In some cases, alternative resources are distributed throughout the region, such as conservation measures; in other cases, alternative resource development depends on future conditions that cannot be forecast on a site-specific basis, such as cogeneration project development by major industries. The following sections summarize those aspects of the regional environment susceptible to impact from power generation and conservation resources.

3.11.1 Air Quality

Over wide areas of the Pacific Northwest, air quality is quite good compared to other parts of the nation. Generally, this can be attributed to the low population density of nonurban areas and lack of major, older industrial complexes. BPA found that sulfur dioxide and suspended particulate matter concentrations are the air pollutants of principal concern with respect to coal-fired powerplants and that concentrations of these pollutants are quite low in the Pacific Northwest near the existing plants (BPA, 1986). Localized high air pollutant concentrations in the region are associated with urbanized areas where there are concentrations of industrial and transportation sources. Rural areas experience occasional episodes of high suspended particulate matter resulting from wind-blown dust during high wind conditions, and are affected by agricultural operations, slash and field burning, and unpaved roads. Nitrogen oxides are emitted by coal-fired powerplants; however, concentrations are quite low in the Pacific Northwest.

Emerging air quality issues include acid rain and acid deposition, the greenhouse effect, and stratospheric ozone. Since these are not localized or acute environmental problems, specific attention has not been focused on the Pacific Northwest. Surveys of acid rain and acid deposition, while limited in the Pacific Northwest, have not indicated that acute impacts are occurring. Greenhouse effect consequences could be serious to the region in the next few decades if predictions of rising ocean levels and changing climates are realized.

Radon has not been found to be an extensive problem in Pacific Northwest homes, although there is concern that measures to increase home energy efficiency can degrade indoor air quality. BPA, in cooperation with local utilities, has programs to monitor indoor air quality.

3.11.2 Fish and Wildlife Resources

The Pacific Northwest may be divided geographically into several subregions: the Columbia River and Snake River Plateaus, and four regions of valley/plains (including the Puget Sound-Willamette Valley) separated by the Coast Range, the Cascades, and the Rocky Mountains. Half of the region is covered by forest (primarily Douglas fir), most densely west of the Cascade Range. Rangeland occupies substantial areas in the Snake River and Rocky Mountain regions. Agricultural lands are located primarily on the Columbia River Plateau, along the

Snake River, and in the Willamette Valley. About two-thirds of the land in the region is publicly owned and managed (BPA, 1988).

Surface water quality in the Pacific Northwest is generally better than much of the rest of the country (BPA, 1983). Such a generalization necessarily fails to account for many specific instances in the region of lost habitat and altered conditions due to industrial and power generation facilities. The Columbia River and its tributaries are significant natural resources of the region and are linked to much of the hydroelectric power generation. Destruction of natural habitats and alteration of water quality by dams, water diversions, channeling, dredging, logging, and mining since the early 1900's has significantly diminished fish spawning and rearing habitat, and the populations of anadromous and resident fish. In addition, passage through turbines and increased migration times due to impoundments have negatively impacted the migratory fish.

Common large mammals of the region include deer and elk in forest and rangeland habitats. Mountain goats, pronghorn antelope, and bighorn sheep are more local in distribution. The endangered Columbian white-tailed deer occurs locally along the lower Columbia River, in the Willamette Valley and near Roseburg, Oregon. The black bear is common in forested areas, and mountain lions occur in forests and rangelands. The endangered grizzly bear and gray wolf occur rarely in the extreme northern portion. Waterfowl and upland game birds are abundant in many agricultural areas and river valleys, and waterfowl are also common in coastal areas. A variety of raptors are present including the threatened bald eagle and uncommon osprey along relatively undisturbed waterbodies and coastal areas, the spotted owl in mature and old-growth forests west of the Cascades, the uncommon Swainson's and ferruginous hawks and prairie falcon east of the Cascades, and the endangered peregrine falcon in a variety of habitats with nearby cliffs.

3.11.3 Other Environmental Conditions

Land disposal of solid and liquid wastes has received increasing attention as a result of federal and state programs to remediate past indiscriminate disposal sites. On a regional basis, land disposal practices are greatly facilitated by the generally arid conditions of the east side of the Cascade Range. Generally, disposal of coal combustion residues has not been found to be a significant environmental problem in the region (BPA, 1986). Coal ash fugitive emissions can be well-controlled by standard operational procedures.

4.0 ENVIRONMENTAL IMPACTS

This section describes the beneficial and adverse impacts of the applicant's proposal and three principal alternatives (Sections 4.1 through 4.4). Effects of both projects, acting individually and in combination, are assessed on the basis of changes from current conditions, but in the context of past, present, and reasonably foreseeable development in the watershed. Since the evaluation indicates the existence of significant adverse impacts, supplemental mitigative measures are identified for each alternative. The impact evaluation for each resource concludes with a summary of unavoidable adverse effects. Section 4.5 addresses potential impacts associated with replacing all or a portion of the electrical energy produced by the Elwha and Glines Canyon projects.

4.1 APPLICANT'S DAM RETENTION PROPOSAL

The alternative evaluated in this section consists of the applicant's proposed structural and operational modifications, along with the various mitigative and enhancement measures also proposed by the applicant and staff. The applicant's proposal is summarized in Section 2.2, and additional details are provided in Appendix A, Part 1.

4.1.1 Geology, Soils, and River Morphology

The applicant's proposal would result in status quo conditions with regard to sediment transport. The Elwha River would continue to deposit all but the finest sediment in the Lake Mills and Lake Aldwell reservoirs, resulting in gradual filling of the reservoirs over the next 200 to 400 years. The middle and much of the lower reach of the Elwha River would continue to be sediment starved, maintaining the current armored nature of the river bed that results from a lack of gravel and sand-size sediments moving downriver. The river channel would remain highly stable between Lake Mills and river mile (RM) 2.0. Minor construction phase erosion and sedimentation effects would be expected due to the very steep terrain and the closeness of proposed structures to the river.

4.1.1.1 Construction Impacts

Temporary and short-term increases in suspended sediment concentration can be expected during instream and near-stream construction phases. Construction of the fish ladder facilities at the Elwha dam and fish trap-and-haul facilities at Glines Canyon dam would cause short-lived increases in river suspended load due to construction occurring directly in and near to the Elwha River. Instream and near-stream construction activities would occur over a duration of one to several months, during which intermittent sediment releases would occur. Downstream dilution from tributary inflow and settling in Lake Aldwell would reduce sediment and the suspended sediment load created during construction. Standard erosion

control methods are likely to be successful in reducing temporary sediment effects downstream.

Excavation of the cutslope and construction of the fish ladder at the Elwha dam is proposed for very steep slopes with some seeps and one small drainage. Disturbance to shallow soils down slope would occur from sidecast. Rock fragments and soil sidecast from blasting and excavation would damage soil and vegetation downslope and introduce sediment into the river.

4.1.1.2 Long-Term Impacts

The natural upstream Elwha River sediment supply would continue to be retained in the Lake Mills reservoir. The Lake Mills delta would continue to grow, eventually filling the lake in an estimated 260 years. All boulders, cobbles, gravel, sand, about 30 percent of the silt supply, 1 percent of the clay supply and all woody debris supplied from the upper Elwha watershed would continue to be trapped in the Lake Mills reservoir.

Local supply of sediment from the middle reach of the Elwha River, Indian Creek, and Little River would continue to be retained in the Lake Aldwell reservoir. The Lake Aldwell reservoir delta would continue to grow, eventually filling the lake about 50 years after the Lake Mills reservoir has filled. All boulders, cobbles, gravel, sand, about 20 percent of the silt supply, 1 percent of the clay supply and all woody debris supplied from the middle reach of the Elwha and tributary watersheds would continue to be trapped in Lake Aldwell. A large portion (80 percent) of the silt supply and almost all the clay would wash through the reservoir downstream to the coastal zone.

The downstream channel (middle and lower reaches) would continue to be stable and armored without the natural upstream sediment supply. Downstream substrate is probably as coarse as it can get given the grain size of materials that are available. Further channel degradation, beyond the estimated 2 to 5 feet that has already occurred, would probably not occur or would proceed very slowly because of the present degree of channel armoring.

Delivery of reduced quantities of bed load sediment (cobbles, gravel and sand) to the Elwha delta and coastal zone would continue to aggravate the coastal erosion in the Angeles Point and Ediz Hook area. Supply of the bed load sediment from the Elwha River has been reduced from about 150,000 cubic yards per year (prior to dam construction) to 2,400 cubic yards per year currently (Section 3.2). This has affected coastal erosion by reducing the sediment supply to the coastal zone by 35 percent. The balance of the coastal zone sediment supply comes from erosion of the coastal bluffs between Elwha River and Ediz Hook (estimated at 40,000 cubic yards per year). Between 1977 and 1985, 145,400 cubic yards of beach nourishment has been placed along Ediz Hook to protect the armor rock placed for

the protection of Ediz Hook (Galster, 1989). The applicant's proposal would contribute to continued erosion and the need to continue periodic nourishment and protection of Ediz Hook.

4.1.1.3 Staff-Recommended Measures

To limit increased suspended sediment concentrations during construction (and operation) of the fish passage facilities, the applicant should develop and implement an erosion and sediment control plan developed in consultation with the Washington Department of Ecology (WDOE), the Washington Department of Fisheries (WDF), the National Park Service (NPS), and the Washington Department of Wildlife (WDW). Construction on steep slopes should be full bench construction without side casting of excavated material.

4.1.1.4 Unavoidable Adverse Impacts

The coastal zone sediment supply of sand to boulder-size sediment from the Elwha River Basin would continue to be reduced to about 51 percent of natural supply rates. Continued beach nourishment and protective measures of the Ediz Hook area would be required.

4.1.2 Water Quantity and Quality

Water quantity in the Elwha River would be largely unaffected under the applicant's dam retention proposal. Discharge would resemble run-of-river conditions except for flow modifications resulting from periodic 10-foot drafting of Lake Mills for power generation and river-flow augmentation. Departure from run-of-river operation of Lake Mills and Lake Aldwell would also occur due to flow augmentation requested by state agencies and tribes during low-flow conditions. With respect to water quality, water temperature in the middle reach would slightly increase as a result of fish passage spills at Glines Canyon dam. Augmentation flows during low-flow periods would not have a significant effect on downstream water temperatures. Flow augmentation would have a slightly adverse effect on dissolved oxygen concentrations in the middle reach.

4.1.2.1 Construction Impacts

Water Quantity

River discharge would not be significantly altered from existing conditions during the four-year construction and installation period for the Elwha dam fish ladder and Eicher screens, and for the Glines Canyon dam trap-and-haul facility. Short-term minor increases in streamflow would be expected during partial reservoir drawdown prior to periods of construction in both Lake Aldwell and Lake Mills. Increased river discharge would most likely occur during the late fall and early

summer. During the remainder of the year, discharge would be expected to approach run-of-river conditions.

Water Quality

Construction of fish passage facilities would result in short-term degradation of water quality in the river below Elwha and Glines Canyon dams. Instream construction of the barrier weir, fish ladder entrance, and tailrace rack at Elwha and Glines Canyon dams would require construction of temporary cofferdams, excavation of the streambed and banks, and concrete work in and near the river. During construction, turbidity levels would increase to between 100 and 300 nephelometric turbidity units (NTU) for a period of several minutes to several hours downstream from construction sites. Minor adverse impacts would be caused by concrete wastes, and runoff or spilling of fuels and lubricants from heavy machinery used during construction. Spillage of fuels and lubricants, if unmitigated, would cause potential contamination of municipal water supplies obtained from the Elwha River for the City of Port Angeles. Roadway stabilization and resurfacing required for the Glines Canyon Project trap-and-haul operation would introduce small amounts of sediment into the river from rainfall runoff, which would cause short-term impacts on river turbidity. Increased turbidity would not be expected after the first or second major storm of the fall, since most construction-originated sediments would be transported out of the river by that time.

4.1.2.2 Long-Term Impacts

Water Quantity

With the applicant's dam retention proposal, discharge in the Elwha River would resemble natural flow conditions. Departure from run-of-river operation would occur during periods of drawdown and filling of Lake Mills. The applicant proposes to fluctuate the reservoir level within the upper ten feet of Lake Mills to optimize power production. Drafting of Lake Mills would be limited to two feet between Memorial Day and Labor Day. Lake Aldwell would continue to operate in a run-of-river mode under the 1975 Settlement Agreement with WDF.

Drawdown and filling of Lake Mills under the applicant's proposal would moderate storm hydrographs for flows between 1,100 cfs (turbine capacity) and approximately 10,000 cfs. Storms providing discharge exceeding this level would fill the reservoir in less than five hours. Timing of storm runoff would consequently resemble a normal run-of-river hydrograph. Drafting of Lake Mills would result in higher than normal discharges during low-flow periods, and lower than normal discharges during peak flow periods. After drawdown, the reservoir would be operated in a run-of-river mode. The applicant intends to refill the reservoir only during the rising limb of a storm hydrograph, or during periods when inflow exceeds turbine capacity, to prevent unusually low-flow conditions in the middle reach of the river resulting from power generation.

Flow augmentation is proposed under the applicant's proposal to increase minimum river flows during critical low-flow periods and would be provided upon request by state agencies and tribes. Flow augmentation from Lake Mills would measurably increase minimum instream flows in the lower reach of the Elwha River during critical low-flow conditions. The applicant currently intends to limit total drawdown to 10 feet below normal pool elevation. Drawdown of Lake Mills would also occur during extreme summer and fall low flows to supplement discharge in the middle and lower reaches of the river. Yearly extreme low-flow conditions would consequently be higher than normal because of flow augmentation. Flow augmentation normally begins when water temperatures exceeded 15°C in the lower reach (James River II, 1988d; 1988f).

There are currently no minimum instream flow requirements for the Elwha River [Washington Administrative Code, 1989 (WAC Sec. 173-500)]. Flow augmentation would occur during September through November, since these are the months that have the lowest historical 1-day discharges. During these months, potential dewatering of the lower reach of the river may occur during critical low-flow conditions because of water diversion totaling 205 cfs by the City of Port Angeles, WDF, and the Lower Elwha Klallam Tribe (Washington Department of Ecology, 1989). Discharge in the Elwha River was less than 205 cfs during a critical low-flow period lasting two weeks in October 1987 at the McDonald Bridge gaging station (U.S. Geological Survey, 1988). Tributary inflow and groundwater seepage below this gage would be minimal, and would account for an additional 30 cfs of inflow between the gage and diversion sites (staff analysis).

Discharges of less than 200 cfs were recorded for five days during this same time period, with a minimum discharge of 197 cfs observed on October 22. These daily mean flows represented the lowest recorded since implementation of run-of-river operations by the applicant in 1975, and represents a daily flow exceedance value greater than 95 percent (staff analysis). Critical conditions such as experienced in 1987 would result in extremely low flows in the lower reach below RM 3.1 given a diversion of 205 cfs at the city's diversion facilities. Since 50 cfs of water withdrawals is returned to the river from WDF rearing facilities, minimum flows exceeding 50 cfs would be expected in the lower reach below the rearing channel outlet at RM 2.9, even during critical low-flow conditions. Only a 0.2 mile reach of the river would be subject to total dewatering during periods of drought.

Extremely low discharges may occur even with flow augmentation, because of the water storage limitations of Lake Mills. Flow augmentation during critical low flows during the early fall of 1987 illustrate this point. During this time, the applicant provided supplemental flows ranging from 50 to 100 cfs from September 8 to October 8. After October 8, supplemental flows were discontinued because pool elevation had been lowered by 10 feet. Consequently, flows during the latter two weeks of October were critically low.

The proposed summer fish passage spill (100 cfs) would not have a significant effect on flow during the remainder of the year, since the spill volume would contribute relatively little to total river discharge. The proposed spill at Glines Canyon dam would have a beneficial effect on river discharge in the 700 feet bypass reach located between the Glines Canyon dam and powerhouse. Because seepage below Glines Canyon dam supplies this reach with less than 10 cfs discharge, fish passage spills would significantly improve flows in the bypass reach.

Water Quality

Water temperatures in the middle reach would be slightly increased under the applicant's proposal due to fish passage spills. Reservoir drawdown for power purposes and flow augmentation would reduce water temperature and dissolved oxygen slightly in the middle reach. Increased turbidity and organic matter concentrations (particulate and dissolved) would be expected from the applicant's proposed drawdown of Lake Mills, but would have little overall significance. Very little change from existing conditions would be expected with respect to gas saturation in the river. The foregoing effects are described for each of the river reaches in sections that follow.

Approach

Water temperature predictions were developed using a reservoir stratification model and a river temperature model (SNTEMA) (Theurer et al., 1984; Bartholow, 1989). Turbidity predictions were developed using an empirical regression model based upon turbidity and suspended sediment data from Olympic Peninsula rivers.

Middle Reach

Water temperatures in the middle reach would continue to be highly influenced by operation of Lake Mills under the applicant's proposal. Water temperatures in the river throughout most of the year would be the same as existing conditions, except during proposed fish passage spills. Fish passage spills from Lake Mills would increase water temperatures in the middle reach by 1.2°C during July, August, and September. Because Lake Mills is thermally stratified during these months, temperature increases in the middle reach would result from the spill of reservoir surface waters. River temperatures immediately below Glines Canyon powerhouse are a combination of cooler, deeper reservoir waters released from power turbines and warmer surface waters released over the dam spillway for fish passage flows. An increase in spill at the expense of turbine flow would consequently increase water temperature downstream. Increased water temperatures would be most pronounced during low-flow conditions, since surface water for passage flows would contribute proportionately more flow to the river below Glines Canyon dam.

Increases in middle reach temperatures would be sporadic due to the proposed intermittent spill. Increased temperature would only occur at night because fish passage spills would take place between 9 p.m. and 5 a.m. Increased temperatures would occur during periods of peak yearly reservoir stratification (summer months). Increases in water temperature would be most significant when reservoir inflows are relatively low, ranging from 200 cfs to 500 cfs. For the 100-cfs fish-passage spill proposed by the applicant, model predictions based on August 19, 1987 stratification conditions indicate that water temperatures immediately below the Glines Canyon powerhouse reach would increase by 1.2°C at 200 cfs, 0.5°C at 500 cfs, and 0.2°C at 1,000 cfs (Table 4-1). Model predictions based on September 6, 1987 stratification conditions indicate that water temperatures below the Glines Canyon powerhouse would increase by 1.1°C at 200 cfs, 0.4°C at 500 cfs, and 0.2°C at 1,000 cfs (Table 4-2).

Elevated water temperatures from fish passage spills would persist during the late summer and early fall as long as river flow was low, the reservoir remained stratified, and air temperatures remained relatively high. The warmest water temperatures released from Glines Canyon dam spillway would not violate state water quality standards, since measurements in Lake Mills (James River II, 1988f; 1990e) indicate that maximum temperatures in epilimnetic reservoir waters do not exceed the 16°C criteria for water temperature [Washington Administrative Code, 1989 (WAC Sec. 173-201-045)]. Since spills and temperature increases would occur at night, temperatures in the middle reach would probably not exceed 16°C even during extremely warm days in low-flow periods.

Flow augmentation at Lake Mills would maintain or slightly decrease water temperatures in the middle reach, depending upon the amount of inflow discharge and lake elevation. Water used for flow augmentation, as proposed by the applicant, would be obtained from turbine intakes located at cooler water layers 90 feet below the surface of Lake Mills. Decreases in water temperature would be achieved when supplemental flows were sufficient to increase the travel time of water in the middle reach of the river, thus reducing the duration of river water exposure to summer warm air temperatures. Water temperature modelling by the staff indicates that temperature decreases obtained through flow augmentation would be less than 0.5°C in the middle reach.

Flow augmentation from Lake Mills would substantially lower dissolved oxygen concentrations in a short reach below the Glines Canyon powerhouse. These adverse concentrations would occur during periods of peak stratification during late July, August and September. Dissolved oxygen concentrations as low as 4.8 mg/l have been measured in hypolimnetic lake waters (James River II, 1988f). Under August 16, 1987 reservoir conditions, waters released from the Glines Canyon powerhouse would have a predicted dissolved oxygen content of 6.0 mg/l. Dissolved oxygen in released waters would be considerably below the state

Table 4-1. Glines Canyon dam outlet water temperatures under existing conditions and applicant's proposal for reservoir stratification conditions occurring August 19, 1987 (Source: the Staff).

Inflow (cfs)	Release Temperature		Net Temperature Increase (°C)
	No Spill (°C)	100 cfs Spill (°C)	
200	12.9	15.1	2.2
300	12.9	15.1	2.2
400	12.9	15.1	2.1
500	12.9	15.0	2.1
600	12.9	14.6	1.7
700	12.9	14.4	1.5
800	12.9	14.2	1.3
900	12.9	14.0	1.2
1,000	12.9	13.9	1.0
1,100	12.9	13.8	0.9
1,200	12.9	13.8	0.9
1,300	12.9	13.7	0.8
1,400	12.9	13.6	0.7
1,500	12.9	13.6	0.7
1,600	12.9	13.5	0.7
1,700	12.9	13.5	0.6
1,800	12.9	13.5	0.6
1,900	12.9	13.4	0.5
2,000	12.9	13.4	0.5

dissolved oxygen criteria for Class AA waters, which is 9.5 mg/l [Washington Administrative Code, 1989 (WAC Sec. 173-201-045)]. Such low dissolved oxygen levels would be confined to a section of the river approximately 0.5 mile below the Glines Canyon powerhouse. However, water below this point would be expected to be near saturation due to rapid reaeration in this relatively high gradient, turbulent section of the river.

The applicant's proposed fish passage flows at Glines Canyon dam would increase the dissolved oxygen content immediately downstream, and have a beneficial effect on river biota. Increased dissolved oxygen concentrations would result because reservoir surface waters are usually fully saturated.

Table 4-2. Glines Canyon dam outlet water temperatures under existing conditions and applicant's proposal for reservoir stratification conditions occurring September 6, 1987 (Source: the Staff).

Inflow (cfs)	Release Temperature: No Spill (°C)	Release Temperature: 100 cfs Spill (°C)	Net Temperature Increase (°C)
200	13.8	15.7	2.0
300	13.8	15.7	2.0
400	13.8	15.7	2.0
500	13.8	15.7	2.0
600	13.8	15.4	1.6
700	13.8	15.2	1.4
800	13.8	15.0	1.2
900	13.8	14.9	1.1
1,000	13.8	14.8	1.0
1,100	13.8	14.7	0.9
1,200	13.8	14.6	0.8
1,300	13.8	14.5	0.8
1,400	13.8	14.5	0.7
1,500	13.8	14.4	0.7
1,600	13.8	14.4	0.6
1,700	13.8	14.4	0.6
1,800	13.8	14.3	0.5
1,900	13.8	14.3	0.5
2,000	13.8	14.3	0.5

The proposed drawdown of Lake Mills for purposes of power generation and flow augmentation would increase turbidity in both the reservoir and the middle reach. Increases in turbidity would occur during drawdown from bank erosion due to wind generated waves and delta erosion. However, this turbidity would be relatively minor when compared to that resulting from sediment transport during early season floods.

Release of reservoir surface waters via spill would slightly increase organic matter input from the reservoir into the middle reach because plankton are more abundant in warmer surface waters. This source of organic matter would be insignificant since Lake Mills is oligotrophic, and consequently has very low densities of plankton.

Lake Aldwell

Water temperatures in Lake Aldwell would not be affected by the applicant's proposed fish passage spills and flow augmentation. Effects of increased temperatures in the middle reach of Lake Aldwell would be minimal because of thermal mixing of warmer river water with cooler reservoir waters.

Waters entering Lake Aldwell would be expected to be 100 percent saturated with dissolved oxygen. Given water temperatures predicted for inflow water at Lake Aldwell, dissolved oxygen concentrations would be expected to exceed state water quality criteria of 9.5 mg/l.

Turbidity would be expected to increase slightly in Lake Aldwell due to drawdown and resulting bank erosion of Lake Mills. Increased turbidity would not be expected to have a significant impact on the lake's biological productivity.

Increases in organic matter loads to Lake Aldwell from Lake Mills would be insignificant, since most particulate organic matter would be expected to be filtered out by benthic invertebrates in the middle reach.

Lower Reach

Lowering of intake headgates at Elwha dam, as proposed by the applicant, would result in a very slight decrease in water temperatures in the lower reach. Reduced temperatures are expected because lowering of intake headgates would selectively withdraw cooler waters from deeper in Lake Aldwell. Temperature reductions in the lower reach would not be significant, however, and would be less than 0.5°C. Lowering of Elwha dam headgates during low-flow conditions in September 1987 resulted in slight reductions (<0.3°C) in lower reach water temperatures. A 10-cfs bypass flow for proposed downstream fish passage facilities at Elwha dam would not be expected to have a significant effect on downstream water temperatures.

Dissolved oxygen in the lower reach would be 100 percent saturated, under the applicant's proposed operation of Elwha dam.

Turbidity in the lower reach would not be expected to change from existing conditions due to operation of Lake Aldwell. Increased turbidity from drawdown of Lake Mills would be slightly reduced by tributary dilution and settling of suspended sediments in Lake Aldwell.

Inputs of particulate and dissolved organic matter into the lower reach would not change significantly from existing conditions under the applicant's proposal.

4.1.2.3 Staff-Recommended Measures

A hazardous spill control plan should be implemented to minimize impacts of oil, fuel, and other chemicals which may contaminate the City of Port Angeles' water supply. Turbidity impacts due to reservoir drawdown and resulting bank erosion would be minimized by maintaining reservoir pool elevation.

4.1.2.4 Unavoidable Adverse Impacts

Increased water temperatures in the middle reach from fish passage spills would typically occur from late August to the end of September. Dissolved oxygen concentrations would fall below state standards below the Glines Canyon powerhouse during peak stratification periods and flow augmentation in August, but would influence only a short reach of the river.

4.1.3 Aquatic Communities

The applicant's proposal would result in slight reductions in survival of salmon and trout eggs and fry, and slightly reduced aquatic invertebrate abundance from higher turbidity during construction. Over the long term, there would be a fair potential for restoring wild, self-sustaining runs of fall chinook and coho salmon, and winter and summer run steelhead and a good potential for restoring winter run steelhead. There would be a poor potential for restoring spring chinook, pink, chum, and sockeye salmon, and sea-run cutthroat and Dolly Varden trout due to unfavorable passage or habitat conditions. Resident trout would decline from the addition of competition from anadromous salmon and trout to the middle and upper reaches of the river.

4.1.3.1 Construction Impacts

The primary construction impacts of the applicant's proposal on aquatic biological communities would be minor short-term adverse effects from increased sediment input into the lower and middle river. The suspended sediment load from construction would temporarily increase the percentage of fine sediment in gravels below the construction sites, which could reduce salmonid egg and fry survival, and reduce benthic invertebrate abundance.

Levels of suspended sediment are not expected to be high or persistent. The construction zones are small and situated in rocky areas, which will reduce fines input. The river substrate downstream of the two dams is generally very low in fines and thus would buffer sediment input to spawning beds of trout and salmon. Also, most major spawning areas below the dams are at least 1 to 2 miles downstream, so settled sediment would be more concentrated near the construction activity above the major spawning areas.

Sediment levels at most times are expected to be below that which can cause mortality of salmonid eggs and fry within gravel spawning beds. Sediment levels greater than 10 to 15 percent fines in redd substrate cause mortality of salmonid eggs and fry (Canadian Department of Fisheries and Oceans, 1983). The highest levels of sediment expected, about 1,200 mg/l during high river flow (Section 4.1.2), would be detrimental if sustained for long periods. Alabaster and Lloyd (1982) found that a concentration of 200 to 1,000 mg/l suspended sediment concentrations could induce direct mortality of fish, if exposure were for weeks or months. Since high flows in the Elwha River are not expected to occur for such long periods, significant direct mortality is not anticipated. Alabaster and Lloyd (1982) noted streams with suspended sediment levels normally between 80 and 400 mg/l are unlikely to support good freshwater fisheries. Since the levels in the stream would only be in this range sporadically, it is not expected that adverse effects would occur independent of the direct mortality.

Sediment would not persist in the stream bottom and spawning gravels as it would be carried downriver or deposited in stream margins during winter high flows.

Short-term sediment input into the river could also adversely affect stream invertebrate productivity during the construction period. Fine sediment would affect benthic invertebrate habitat by filing interstices in the bottom substrate. High suspended sediment loads could also directly stress invertebrates. Such effects are expected to be localized and confined to the construction period. Post-construction high-flow events should wash accumulated sand and silt sediment from the substrate.

4.1.3.2 Long-Term Impacts

With the applicant's proposal, there would be an expansion in available anadromous fish spawning and rearing habitat (Table 4-3) and at least a fair potential for restoration of wild, self-sustaining populations of fall run chinook salmon, coho salmon, and winter and summer run steelhead in the middle and upper reaches of the Elwha River (Table 4-4). The prognosis for restoring wild, self-sustaining runs of spring chinook salmon, pink salmon, chum salmon, sockeye salmon, and sea-run cutthroat and Dolly Varden trout is poor. Populations of resident rainbow trout in the middle and upper river would experience moderate declines with the increase in competition from salmon and steelhead for spawning and rearing habitat. The following sections describe the approach, methodology, and detailed arguments supporting the above conclusions.

Approach

The basic approach for evaluating and comparing the effects of the applicant's and other four principal alternatives focuses on the restoration potential of anadromous fish runs. Restoration of wild, self-sustaining runs is a potential positive effect of

Table 4-3. Potential spawning and rearing habitat for chinook and coho salmon and steelhead in the Elwha River drainage under the applicant's proposal (Source: the staff).

Region	Chinook and Coho Stream Miles[1/]	Steelhead Stream Miles[1/]
Below Elwha Dam (lower reach)	4.9	4.9
Between Elwha and Glines Canyon Dams (middle reach)	15.6	15.8
Above Glines Canyon Dam (upper reach)	49.0	50.4
Total	69.5	71.1

1/ Stream miles potentially accessible excluding Lake Aldwell and Lake Mills.

the alternatives. Impacts on resident fish from restoration of anadromous fish are also evaluated. Resident fish have likely benefitted from the original projects, and would be expected to decline with restoration of anadromous fish runs above the dams.

The staff's approach to assessing restoration potential focuses on four main elements: (1) passage, (2) fishery harvest, (3) habitat, and (4) availability of a native stock of fish for a restoration program.

Passage success for upstream migrating adults and downstream migrating juveniles represents the primary factor in determining restoration potential. The ability of adult fish to ascend the dams via lifts or ladders is a major determinant.

Likewise, the ability of juvenile fish to safely pass downstream through reservoirs, over spillways, or through turbines is also a major factor.

Harvest levels in commercial, sport, and tribal fisheries are also important elements in restoration. Adequate escapement of adult fish back to the river is a key factor in achieving restoration and allowing runs to sustain themselves. If

Table 4-4. Summary of potential restoration of anadromous salmonid stocks in the Elwha River and Glines Canyon dams, under the applicant's proposal (Source: the staff).

Species	Passage	Allowable Harvest Rate	Habitat	Available Stock	Overall Restoration Outlook
Fall Chinook	marginal	marginal	marginal	favorable	FAIR
Spring Chinook	marginal	unfavorable 1/	marginal	marginal	POOR
Coho	marginal	marginal	favorable	marginal	FAIR
Winter Steelhead	marginal	marginal	favorable	favorable	GOOD
Summer Steelhead	marginal	marginal	favorable	marginal	FAIR
Pink	unfavorable	unfavorable 1/	unfavorable	marginal	POOR
Chum	unfavorable	marginal	marginal	marginal	POOR
Sockeye	marginal	marginal	unfavorable	marginal	POOR
Sea-run Cutthroat	unfavorable	marginal	favorable	marginal	POOR
Sea-run Dolly Varden	unfavorable	marginal	favorable	marginal	POOR

1/ Anticipated harvest rate (in combination with predicted passage mortality) is judged to be too high to allow adequate escapement.

anticipated harvest rates are too high to allow adequate escapement, then the allowable harvest factor is considered unfavorable.

The staff has assumed that very stringent harvest regulations are possible during restoration, but after restoration is achieved, harvest should be within present or expected future limitations. The staff has assumed that hatchery production for the purpose of harvest would be discontinued in the future if restoration of a particular run is accomplished. The agencies have stated that restoration of wild stocks is incompatible with hatchery-based mitigation (letter from the Joint Fish and Wildlife Agencies, National Oceanic and Atmospheric Administration, Seattle, Washington, February 27, 1990). Hatcheries are detrimental to natural runs because hatcheries: (1) subvert the genetic integrity of the wild stock; (2) intensify intraspecific and interspecific competition and predation; and (3) cause over-harvest of wild stocks by contributing to increased efforts in fisheries (Bledsoe et al., 1989).

Habitat for spawning and rearing is another factor in restoration. The production potential of the various fish populations would be primarily a function of available spawning gravels and rearing habitat for young. The various alternatives provide different amounts and quality of habitat, thus different degrees of restoration potential.

Finally, the availability of an adequate genetic stock of fish from which to restore a particular run is also a primary determinant in restoration. The staff has assumed that once a particular native genetic stock is targeted for restoration, other hatchery or nonElwha stocks would not be stocked into the river to preclude dilution of the targeted gene pool. The staff also assumed stocks from other rivers would be used to restore a particular run only if a native or existing non-native wild stock were not available.

Methods

Passage survival was calculated as the sum of 10 factors relating to juvenile downstream passage and adult upstream passage (Table 4-5). Detailed explanations of the passage factors by species are presented in Appendix B, along with the rationale and substantiation for the factor values used in the calculations. Survival estimates are made relative to no passage obstructions, which in this case is represented by the removal of both dams alternative.

Of the 10 possible anadromous species and races that could be or are present in the system, passage survival factors were determined for five: spring and fall chinook salmon, coho salmon, and winter and summer steelhead trout. Passage survival was not used for the other species because little is known about these species relative to dam and reservoir passage.

Table 4-5. Passage survival factors (Source: staff).

Downstream Juvenile Factors
1. Lake Mills passage survival
2. Glines Canyon dam spill survival
3. Glines Canyon dam turbine or screen survival
4. Lake Aldwell passage survival
5. Elwha dam spillway survival
6. Elwha dam screen (Eicher or conventional) survival
7. Cumulative passage survival (fish originating above Glines Canyon dam)
8. Delayed survival (all fish)
Upstream Adult Factors
9. Adult survival at Elwha dam ladder
10. Adult survival at Glines Canyon dam (trap-and-haul or ladder)

Harvest rates that would allow sustained optimal yields from the wild stocks of salmon and steelhead from the Elwha River were determined through analysis of the Ricker stock-recruitment curves available from the fishery management agencies. A summary of this analysis is provided in Appendix B.

The allowable fishery harvest rate was determined by adjusting the optimal sustained yield harvest rate by the passage factors. Essentially, this entails allocating the optimal harvest rate between passage mortality and fishing mortality. If passage mortality occurs, then fishing mortality is reduced to maintain the optimal harvest and a self-sustaining population of wild fish. The reasonableness of fishery harvest rates was determined by comparison with existing harvest rates and present goals of fisheries management agencies.

Habitat factors considered included habitat quantity and quality, water quality, disease, predation, and competition. These were reviewed to determine whether they would inhibit or preclude restoration goals.

Availability of a stock for restoration was determined based on the judgment of the staff as to the probability of native fish being available for the restoration program. If Elwha stocks were deemed not available, then the availability of native stocks from nearby watersheds was considered along with the potential of successfully employing the stock in the restoration program.

The overall potential for restoration was determined through a stepwise process involving the factors described above. First, passage survival was considered on its own merit. Second, given the passage survival, the adjusted fishery harvest allowed for optimum sustained yield was reviewed to determine whether such harvest rates were feasible given present harvest rates and expected future management goals for harvest. Third, habitat factors that would help or hinder the restoration potential were considered. Finally, the availability of a stock for restoration was considered. The combination of criteria led to an overall assessment ranging from poor to excellent (Table 4-6).

Chinook Salmon

The restoration potential for fall chinook under the applicant's proposal is judged by the staff to be fair due to a marginal passage survival factor, a marginally achievable fishery harvest rate, and marginal habitat conditions in the middle and lower river (Table 4-4). The restoration potential for spring chinook is judged to be poor due to an allowable fishery harvest rate (20 percent allowable harvest) that would likely not be achievable.

Passage

For fall chinook salmon the total passage mortality was estimated to be 46 percent, of which 37 percent was attributed to downstream juvenile passage and 14 percent attributed to upstream migration of adults (Table 4-7). For spring chinook salmon, total passage mortality was 49 percent with 37 percent associated with downstream passage and 19 percent with upstream migration of adults. For fall chinook, the primary passage-related mortality factor was in-reservoir mortality caused by either residualism or predation. Residualism is a process whereby downstream migrating anadramous smolts volitionaliy remain in a body of water rather than continuing their outmigration. Even though residualism has not been documented in the Elwha River reservoirs, it is a common concern in other Pacific Northwest systems. Predation by Dolly Varden on chinook salmon smolts has been documented in the Elwha River reservoirs. The remaining 6 percent mortality at Glines Canyon dam was from spill and turbine mortality. The 15 percent total outmigration mortality at Lake Aldwell and Elwha dam was attributed primarily to the Eicher screen mortality (10 percent) under the applicant's proposal with the additional 5 percent caused by reservoir passage, similar to that at Lake Mills, and spillway mortality. Upstream passage factors for fall chinook were estimated to be the same for both dams, and were based on evaluations of deficiencies of the applicants proposed Elwha fish ladder and Glines Canyon trap-and-haul operation. Spring chinook mortality factors were identical to those for fall chinook with the exception of upstream mortality factors, which were estimated to be slightly higher, because effects of injury would be more pronounced due to longer residence time prior to spawning.

Table 4-6. Restoration assessment (Source: the staff).

Restoration Outlook	Definition
Excellent	All four factors (passage, allowable harvest, habitat, and stock availability) are favorable.
Good	Two of four factors favorable; remaining factors at least marginally favorable.
Fair	All factors at least marginally favorable.
Poor	One or more factors unfavorable.

In terms of restoration potential, the staff assumes passage losses for chinook salmon under 20 percent to be favorable, 20 to 50 percent as marginally favorable, and greater than 50 percent as unfavorable. Given passage losses of fall and spring chinook are 46 and 49 percent, respectively, passage potential for both spring and fall chinook is judged marginally favorable.

Allowable Harvest Rate

The allowable total harvest rate for fall and spring chinook salmon, given current estimates of optimal exploitation rates, is estimated at 59 and 20 percent, respectively. The current Optimal Exploitation Rate (OER) is 78 percent for fall chinook (average of Washington coastal and Puget Sound wild stocks), and 59 percent for spring chinook (based on Nooksack stock data, personal communication, Gary Morishima, June 27, 1990). Assuming most of the adult fish would ascend to the upper river to spawn, and passage loss would be 46 percent for fall chinook, a combined fishery harvest rate would necessarily be limited to 59 percent (1-[1-.78]/[1-.46]) to maintain optimal sustained yield from the fall chinook population. The allowable spring chinook harvest rate would be 20 percent.

In the staff's judgement, harvest rates of 60 to 80 percent are reasonably possible under present and planned future management goals, while rates of 40 to 60 percent would be only marginally possible. The allowable harvest rates estimated for fall and spring chinook salmon (59 and 20 percent, respectively) are thus judged to be marginally achievable and unfavorable, respectively.

Table 4-7. Passage mortality of fall and spring chinook for the applicant's proposal (Source: the staff).

Lifestage/Region	Fall Chinook Mortality (%)	Spring Chinook Mortality (%)
Outmigration of Juveniles		
Lake Mills/Glines Canyon Dam	27[1/]	27
Lake Aldwell/Elwha Dam	15[2/]	15
Total Outmigration	37	37
Upstream Migrating Adults		
Lake Aldwell/Elwha Dam	7.5	10
Lake Mills/Glines Canyon Dam	7.5	10
Total Upstream Migration	14	19
Total	46[3/]	49

1/ Approximately 21 percent is due to estimated Lake Mills passage mortality and 6 percent is due to spillway/turbine mortality.
2/ Approximately 10 percent is due to estimated Eicher screen mortality and 5 percent to estimated Lake Aldwell passage mortality.
3/ Note total mortality is not additive, but multiplicative.

Habitat

Key features of habitat in the river include spawning gravels, rearing area, predators, and disease potential. Spawning habitat limitations in the middle reach, predator problems in the upper and middle reach, and potential disease problems for young and adult chinook salmon limit the habitat of the Elwha River under the applicant's proposal to a marginally favorable rating.

Spawning habitat appears adequate in the upper and lower reaches, but not the middle reach. Based on WDF (1971) studies, the total spawning area available above Glines Canyon dam and Lake Mills is adequate to fully seed the potential rearing area within this reach for chinook. Spawning habitat in the middle reach

is not adequate to seed rearing habitat with chinook. With good gravel, the middle reach could support 2,400 chinook spawners (WDF, 1971); however, with limited gravel available under present and applicant-proposed conditions, the middle reach would support only a small number of spawners in tributaries or near the mouths of the tributaries. High late summer water temperatures (greater than 14 to 16°C) in the middle and lower reaches could limit chinook egg survival (based on studies by Reiser and Bjornn, 1979; Seymour, 1956; Olsen and Foster, 1955) of the small portion of the run that spawns prior to mid-September. The lower reach spawning habitat is suitable to seed most of the available rearing area, primarily because of the limited river and estuary rearing habitat. WDF (1971) indicated that the lower reach was adequate for about 500 spawning chinook salmon. Continued high (greater than 14 to 16°C) water temperatures in the lower river in late summer, early fall during low-water and high-temperature years would limit chinook egg survival.

The upper and middle reaches of the river have substantiated amounts of high quality, juvenile chinook rearing habitat. The upper reach of the Elwha River has 49 river miles of potential chinook rearing habitat. The habitat is undisturbed and of good quality. The middle reach provides an additional 15.5 miles of rearing habitat. The quality of rearing habitat in the middle reach is also good, although it is lower in quality than the upper river because of channel degradation, bank stabilization, and reduced nutrient input as a result of the presence of Lake Mills. The lower reach of the Elwha River has only 4.9 miles of rearing habitat. This habitat is also of good quality similar to that of the middle reach. The lower reach has a water diversion at about RM 3.0 that reduces rearing habitat during low-flow periods. High late summer water temperature (up to 20°C) during low-flow periods of late summer also reduce the rearing quality of the lower river.

The applicant's proposed drawdown of Lake Mills for power purposes would potentially reduce marginally high water temperatures in the middle reach.

Predation of chinook fry by resident trout in the upper and middle reaches, particularly by Dolly Varden trout, may affect chinook production in the system under the applicant's proposal. The estimated effect of predation was indirectly included in the survival model (see passage survival and Appendix B for discussion). Dolly Varden are known to be a major predator of migrating juvenile salmonids (Scott and Crossman, 1973). Dolly Varden are abundant above and possibly below Glines Canyon dam. During the 1989 chinook migration study, 428,000 chinook fingerlings were planted in the upper river, and 30 Dolly Varden in the lake were examined for stomach contents. James River II (1990e) noted that 16 percent of Dolly Varden examined during the chinook outmigration study had fed upon chinook juveniles. Although predation is a natural phenomenon on most rivers with large salmon runs, reservoir systems increase predation because juvenile chinook are delayed in their downstream passage by reservoirs. Also, physical structures such as tailraces, spillways, and fish ladders often offer an

ideal situation for predatory fish to prey on smolts, which can be concentrated and disoriented by such structures.

Dermocystidium, a major cause of adult chinook mortality in the lower river, may affect survival of chinook salmon in the upper and middle reaches, although its effects should be less than in the lower river. The most recent studies of its occurrence in the Elwha River suggest that its origin is probably not the reservoirs, although its presence was detected in reservoir water (James River II, 1990e). Under the applicant's proposal, the disease would probably remain a problem; however, reduced crowding of adult fish in the lower river by providing passage upriver could improve adult survival. The disease is not likely to be a major problem for chinook juveniles rearing in the river, as it currently is in the rearing facility, because crowding would be less of a factor for wild juveniles. Most juveniles would out-migrate as underyearlings and would not be present when the disease is at its worst. The few fish that do rear into summer or through the winter in the lower river may suffer excessive mortality depending on the level of disease outbreak that year. High water temperature and low-flow conditions in late summer in the middle and lower river may contribute to the incidence of the disease.

Stock Selection and Availability

The staff has rated the availability of stocks for restoration of fall and spring chinook as favorable and marginally favorable, respectively. The native Elwha River system fall chinook stock is available for the restoration program.

The presence of a viable spring chinook stock native to the Elwha River is doubtful, but cannot be ruled out completely. Several factors suggest that its presence is not likely: restricted spawning area for the past 79 years; lack of obvious separation in spawning timing; and stocking of non-native spring chinook in the past. A native spring chinook stock of several hundred fish is present in the neighboring Dungeness River and may serve as stock for restoration.

The applicant is willing to pay for collection, rearing, and planting of a stock(s) selected by the agencies for 10 years to establish runs in the upper river. This time period may be insufficient if problems arise with passage tests, fish disease, predation or other factors that could influence the successful restoration of a stock. The restoration efforts may be inhibited if all major problems within the river system are not solved in the 10-year stocking period.

Coho Salmon

Restoration potential for coho salmon under the applicant's proposal is judged fair due to passage factor, achievable fishery harvest rate, and available stock for restoration that are all rated as marginally favorable (Table 4-4).

Passage

Total passage related mortality for coho salmon was 27 percent, caused equally by downstream juvenile and upstream adult migration passage factors (Table 4-8). The largest mortality component was passage through Lake Mills and over Glines Canyon dam (12 percent), with 7 percent from dam passage and 5 percent from the reservoir factors (residualism and predation). Downstream passage factors at Lake Aldwell and Elwha dam were significantly less because of Lake Aldwell's smaller size and because of the success of existing Eicher screen tests indicating relatively high passage success. Upstream passage factors were equally distributed between the two reservoirs, again because of expected deficiencies in the applicant's trap-and-haul proposal and the Elwha fish ladder. In terms of restoration potential, the staff assumes coho passage losses under 20 percent to be favorable, 20 to 50 percent as marginally favorable, and greater than 50 percent as unfavorable. Given the estimated 27 percent passage mortality, passage potential is judged marginally favorable.

Allowable Harvest Rate

The allowable total harvest rate for coho salmon in the various fisheries, given current estimates of optimal exploitation rates, is estimated at 52 percent. The current OER for coho maximum sustainable yield is 60 to 65 percent for the Washington coast and Strait of Georgia (personal communication, Gary Morishima, June 27, 1990). Because harvest rates are about 80 percent (personal communication, Tim Flint, WDF, July 17, 1990), wild coho stocks in the Puget Sound regions may be over-harvested. Assuming most of the adult fish would ascend to the upper river to spawn, and passage loss would be limited to 27 percent, a combined fishery harvest rate would be limited to 52 percent (at a 65 percent OER) to maintain an optimal sustained yield from the coho population.

In the staff's view, harvest rates of 60 to 80 percent are reasonably possible under present and planned future management goals, while rates of 40-60 percent would be only marginally possible. The allowable harvest rates estimated for coho salmon (52 percent) is thus judged to be marginally achievable.

Habitat

Other than spawning habitat limitations in the middle reach, habitat factors are generally favorable for coho salmon under the applicant's proposal; thus, the staff has judged habitat for coho salmon as favorable.

Spawning habitat for coho salmon is adequate to seed the upper reaches of the river, but not the middle or lower reaches. WDF (1971) indicated that the upper river was of high quality for spawning and rearing. Although the number of fish that could spawn there was not indicated, WDF did state that coho would be able to utilize gravels along the river's edge at higher flows, as well as in the

Table 4-8. Passage mortality of coho salmon for the applicant's dam retention proposal (Source: the staff).

Lifestage/Region	Mortality (%)
Outmigration of Juveniles	
Lake Mills/Glines Canyon Dam	12[1/]
Lake Aldwell/Elwha Dam	3
Total Outmigration	15
Upstream Migration of Adults	
Lake Aldwell/Elwha Dam	7.5
Lake Mills/Glines Canyon Dam	7.5
Total Upstream Migration	14
Total	27[2/]

1/ Approximately 7 percent is due to estimated spillway/turbine mortality and 5 percent to estimated Lake Mills passage mortality.
2/ Note total mortality is not additive but multiplicative.

tributaries. Spawning habitat in the middle reach is probably not adequate to seed the rearing area habitat with juvenile coho. WDF (1971) indicated that the middle reach was only suitable for "a few" coho. Spawning area for coho would probably be less than chinook because coho need smaller substrate, which is limited in the middle reach. WDF (1971) estimated 390 spawners could use tributaries of the middle reach. The lower reach spawning area may be less than required to fully seed this reach because of the large substrate size. Also, the lower river lacks tributaries that are more typically used by coho in systems with chinook runs (Miller and Brannon, 1981).

The upper and middle reaches of the river have substantial amounts of good juvenile coho salmon rearing habitat. The upper reach has 49 river miles of juvenile coho rearing habitat that would be made available with fish passage above Glines Canyon dam (Table 4-3). The coho rearing habitat above Glines Canyon dam, exclusive of Lake Mills, is undisturbed and of good quality. The WDF (1971) characterized the upper watershed as "similar to or better than many other streams in the state that have good to excellent salmon runs." The middle reach has 15.5 miles of rearing habitat (Table 4-3), but habitat quality is lower than the upper reach because of channel stabilization, high summer water temperatures, and reduced nutrient input resulting from the presence of Lake Mills. The lower reach has only 4.9 miles of coho rearing habitat similar to that of the middle reach

except for a lack of tributaries. The water diversion at about RM 3.0 reduces overall habitat during low-flow periods.

Predation of coho in the upper and middle reaches by resident trout, particularly resident Dolly Varden trout, could reduce the potential productivity of the reaches' habitat. However, one study where coho fry were planted above Lake Mills suggests that, at that time, predation was not a major problem, because survival from fry to smolt was high compared to regional streams (Wunderlich et al., 1989). Smolts of coho salmon are generally larger than chinook salmon smolts at the time of migration, and thus would be less susceptible to predation.

Disease is also not expected to limit the productivity of coho habitat in the middle and upper river. Dermocystidium was not a major cause of coho mortality at the tribal rearing facility in the lower river. This facility has an alternative water source during spawning season, which may have reduced the incidence of the disease. At the Cowlitz River hatchery, 30 percent of the adult coho were affected, but no significant mortality was reported (Allen et al., 1968).

Stock Selection and Availability

The staff has concluded that the availability of stocks for restoration of fall coho salmon is only marginally favorable because of the lack of a native or wild stock for the restoration program. Although the lower river hatchery stock would be more suitable for outplanting to the upper or middle reaches than stocks from other rivers, a native stock would be best (Reisenbichler, 1988). The current hatchery stock was originally from the nearby Dungeness River. Based on similarity of location and climate (the next closest major river system), the present stock could be suitable for the environment of the Elwha River.

Steelhead

Restoration potential for winter steelhead under the applicant's proposal is judged good, due to favorable habitat conditions and availability of a spawning stock, and marginally favorable passage survival and allowable harvest rate (Table 4-4). Restoration potential for summer steelhead is judged fair, due to marginally passage survival, allowable harvest rate, and availability of a stock for restoration that are rated marginally favorable.

Passage

Overall winter steelhead passage mortality was estimated to be 31 percent with the primary mortality sources associated with outmigration factors (Table 4-9). Of the 12 percent downstream mortality through Lake Aldwell and over Elwha dam, 10

Table 4-9. Passage mortality of winter and summer steelhead for the applicant's proposal (Source: the staff).

Lifestage/Region	Winter Steelhead Mortality (%)	Summer Steelhead Mortality (%)
Downstream Migration of Juveniles		
Lake Mills/Glines Canyon Dam	8[1/]	8
Lake Aldwell/Elwha Dam	12[2/]	12
Total downstream	20	20
Upstream Migration of Adults		
Lake Aldwell/Elwha Dam	7.5	10
Lake Mills/Glines Canyon Dam	7.5	10
Total Upstream Migration	14	19
Total	31[3/]	35

1/ Approximately 5 percent is due to estimated Lake Mills passage mortality and 3 percent is due to estimated spillway/turbine mortality.
2/ Approximately 10 percent is due to estimated Eicher screen mortality and 2 percent to estimated Lake Aldwell passage mortality.
3/ Note total mortality is not additive, but multiplicative.

percent was caused by the Eicher screen (the single largest winter steelhead mortality factor). Lake Mills and Glines Canyon dam mortalities (8 percent) were primarily from reservoir passage (5 percent) and turbine/spill mortality (3 percent). Upstream passage factors for adults were the same as for chinook and coho (7.5 percent) again because of deficiencies in the applicant's proposed Elwha dam fish ladder and Glines Canyon dam trap-and-haul facility. Mortality factors for summer steelhead were essentially the same except for an increase in upstream passage mortality with spring chinook salmon. This increased mortality was due primarily to increased residence time and the greater threat of passage related injuries during that period. In the staff's view, steelhead passage losses under 20 percent are considered favorable, 20 to 40 percent as marginally favorable, and greater than 40 percent as unfavorable. Given the estimated passage mortality of

31 percent, the level of passage loss for winter and summer run steelhead is judged only marginally favorable.

Allowable Harvest Rate

Given available estimates of optimal exploitation rates, the allowable total harvest rate for winter and summer steelhead would be 17 and 12 percent, respectively. Based on models generated for wild steelhead in major western Washington streams (Gibbons et al., 1985), the OER is approximately 43 percent. Assuming most of the adult fish would ascend to the upper river, the allowable harvest rate for winter steelhead would be 17 percent (1-[1-.43]/[1-.31]). The allowable summer steelhead harvest rate would be 12 percent (1-[1-.43]/[1-.35]). In the staff's judgement, harvest rates of 20 to 40 percent are reasonably possible under present and planned future management goals, while rates of 10 to 20 percent would be only marginally possible. Since all of the steelhead harvest occurs in the river, management is less complicated and more effective than for salmon, and lower harvest rates are possible. The allowable harvest rates estimated for both winter and summer run steelhead are thus judged to be marginally achievable.

Habitat

Other than spawning habitat limitations in the middle reach, habitat factors are generally favorable for steelhead under the applicant's proposal; thus, the staff has judged habitat for steelhead as favorable.

Upper reach spawning habitat is adequate to fully seed the rearing area with juvenile steelhead (WDF, 1971). Spawning habitat in the middle reach is insufficient to fully seed the rearing area and is restricted because of the large size of mainstem river substrate. The lower reach would be suitable for steelhead spawning, although not to the same level as for chinook. Although much of the lower reach substrate is too large for steelhead spawning, it is sufficient to seed the available rearing habitat.

The upper and middle reaches offer a substantial amount of good juvenile steelhead rearing habitat. The upper reach has 50 river miles of rearing habitat with fish passage above Glines Canyon dam (Table 4-3). The steelhead rearing habitat above Glines Canyon dam, exclusive of Lake Mills, is undisturbed and of good quality. The middle reach has 15.8 miles of good rearing habitat quality, although it is not as good as upper reach habitat because of channel stabilization and reduced nutrients trapped in Lake Mills. The lower reach has only 4.9 miles of potential steelhead rearing habitat. This habitat is similar to that of the middle reach in having reduced input of large woody debris, bank stabilization, and reduced nutrients from Lake Aldwell. This region also has a water diversion at about RM 3.0 that may reduce overall habitat during lower flow periods.

Predators are not expected to be a problem for steelhead juveniles, as they generally migrate at a larger size than chinook or coho salmon.

Like coho salmon, disease is not known or expected to be a problem for steelhead.

Stock Selection and Availability

Runs available for restoration include winter and summer hatchery steelhead and a wild stock of winter steelhead. Since it is doubtful that any of the current stocks are native to the Elwha system, as they did not originate from Elwha stocks, successful restoration of wild runs is less assured. Chilcote et al. (1986) found that hatchery stocks on the Kalama River produced offspring from their natural spawning that had poorer survival than native stock spawning. This suggests that hatchery stocks released into the upper river, if not native, are likely to have reduced production compared to that expected from native stocks. For this reason, the existing wild winter stock, although not native to the river, may be the best choice for restoration as its run timing is most consistent with the original native fish.

The staff has concluded that the availability of stocks for restoration of winter run steelhead is favorable due to the presence of a wild run in addition to a hatchery run. The availability of a stock for summer run steelhead restoration is judged only marginally favorable due to the current lack of either a native run or a wild run in the river. Since other stocks of summer run steelhead are available and have been successfully transplanted to other basins, they can probably be relied upon for restoration efforts.

Pink Salmon

Restoration potential for pink salmon is poor due to poor potential survival of fry through Lake Aldwell and a potentially non-achievable allowable harvest rate. No enhancement proposals have been proposed for this stock by the applicant.

Passage

Total passage survival of pink salmon was not calculated using passage factors, but it is expected to be insufficient to maintain stocks above the dams. Pink salmon typically migrate directly to the ocean very shortly after emergence. Although small portions of several stocks are known to occur above lakes or reservoirs, (PSC, 1990; personal communication, Kevin Brent, Assistant Area Biologist, Alaska Department of Fish and Game, Kodiak Island, July 5, 1990) and ascend fish ladders (Andrew and Geen, 1958; personal communication, Jack Orsborn, July 12, 1990; personal communication, Carl Hoffmeister, Alaska Department of Fish and Game, Pink Salmon Manager for Southeast Alaska, July 12, 1990; Blackett, 1987), there is no evidence of substantial pink salmon fry survival to the ocean from these stocks.

The life history of pink salmon fry suggests that passage through a lake or reservoir would not be successful. After emergence, fry typically leave streams as

quickly as possible, often moving to salt water within the first night (Miller and Brannon, 1981). Lakes or reservoirs restrict pink salmon passage (Andrew and Geen, 1960). Pink salmon typically do not feed while in fresh water, so rapid migration to the marine or estuarine environment is essential. Fresh water predation is high for the young pink salmon when other salmonids are abundant, even when downstream travel distance is short (Johnson, 1973; Fresh and Schroder, 1987). The passage delay through Lake Aldwell would substantially increase mortality by increasing the period of exposure to salmonid predators and by increasing the risk of starvation.

Fish that successfully migrate through Lake Aldwell would also suffer additional mortality at the proposed Eicher screen at Elwha dam. Since this screen was not designed for fish as small as migrant pink salmon, they would suffer additional mortality from damage from the screen or from passage through the turbine.

For the above reasons, passage potential for pink salmon is judged to be poor under the applicant's proposal.

Allowable Harvest Rate

Given that the existing harvest of Puget Sound pink salmon is approximately 60 percent, an unfavorable passage potential for juvenile pink salmon would result in an unfavorable rating for the allowable harvest rate.

Habitat

Upstream passage at Elwha dam would allow access to an additional 15.5 miles of habitat in the middle reach, exclusive of Lake Aldwell. The habitat above Glines Canyon dam is not suitable for pink salmon (WDF, 1971). Most of the middle reach habitat is not suitable for pink salmon spawning because of the large substrate (most of the surface substrate in the main channel is greater than 6 inches). There are small patches of gravel near some of the stream mouths, but these areas are only a few square yards each. Some spawning could occur in some of the major tributaries (e.g., Indian Creek and Little River), but the total spawning area is limited.

The lower reach has 4.9 miles of accessible pink salmon habitat. This habitat supported 8,000 to 15,000 adult fish between 1959 and 1967. All of the usable spawning habitat is below RM 4.0 (letter from Fred Winchell, Aquatic Biologist, Hosey & Associates, Bellevue, Washington, November 2, 1988).

Habitat quality for egg survival is also poor during low-water, high-temperature years when water temperature reaches lethal levels ($>16°C$; Raleigh and Nelson, 1985) during the early incubation period (September to October) in the lower and middle reaches.

Overall, given the limited spawning and rearing habitat in the middle reach of the river, and the presence of Lake Aldwell, habitat for pink salmon under the applicant's proposal is judged unfavorable.

Stock Selection and Availability

A pink salmon stock is present in the lower river but is very low in abundance (less than 50 fish). Its use as a brood stock for developing a middle or lower reach run is not practical because of its low abundance. The Dungeness River has an existing stock that could be suitable for the Elwha River although it also is greatly reduced from previous numbers. Given these considerations, the availability of a stock of pink salmon for restoration is judged marginally favorable.

Chum Salmon

Restoration potential for chum salmon is poor under the applicant's proposal because of unfavorable passage potential.

Passage

The problems associated with pink salmon passage also apply to chum salmon. Small outmigrating chum salmon would have difficulty passing through reservoirs resulting in mortality due to predation or starvation. The lack of effectiveness of the proposed Eicher screen at Elwha dam for chum outmigrants would probably result in additional mortality. Because of these potential problems, the passage potential for chum salmon under the applicant's proposal is judged to be unfavorable.

Allowable Harvest Rate

Current estimates of chum harvest prior to entering the Strait of Juan de Fuca is less than 5 percent and only minor additional harvest occurs before arriving at the Elwha River mouth. Optimum exploitation rate for Washington chum stocks is not known, but British Columbia harvest averages about 50 percent (Beacham, 1984). With most of the harvest of the Elwha stock at the river mouth, harvest control should be straightforward. This stock could sustain some inriver mortality and still be restored because of the existing low exploitation rate.

Despite the anticipated unfavorable passage survival, the allowable harvest would be marginally favorable due to existing low harvest rates.

Habitat

Upstream passage at Elwha dam would allow access to an additional 15.5 miles of habitat in the middle reach, exclusive of Lake Aldwell. It is assumed that habitat above Glines Canyon dam is not suitable for chum salmon (WDF, 1971). Most of the middle reach habitat is not suitable for chum salmon spawning for the same reasons described for pink salmon.

The lower reach has 4.9 miles of accessible chum salmon habitat. Substrate in most of the lower reach is less than optimum for chum salmon. Much of the substrate suitable for pink salmon would be usable by chum salmon (substrate suitable for 8,000 to 15,000 pinks).

Overall, habitat for chum salmon under the applicant's proposal is judged to be marginally favorable.

Stock Selection and Availability

A wild chum salmon stock may be present in the lower river. These fish may be returning fish from prior hatchery plants. Their abundance is low, probably less than 500 fish. Their use as a brood stock may be possible, but since many may already be of hatchery origin, there is no advantage to using this stock for future plants. The staff rates the availability of a stock for restoration as marginally favorable.

Sockeye Salmon

The restoration potential of sockeye salmon in the Elwha River system is judged to be poor because of lack of suitable habitat.

Passage

Sockeye are expected to be present only in Lake Sutherland, which lies above Lake Aldwell and Elwha dam. Passage survival would be slightly higher than that of coho or winter steelhead because sockeye smolts are more susceptible to loss of scales than other salmonid species. This would possibly contribute to higher mortality while passing the Eicher screen proposed by the applicant. For this reason, passage potential is judged marginally favorable under the applicant's proposal.

Allowable Harvest Rate

No harvest currently occurs on sockeye stocks from this system. Maximum sustainable yield for sockeye stocks have been reported to be in the range of 60 to 70 percent (Chapman, 1986). Harvest of sockeye would probably occur with other sockeye in the Strait of Juan de Fuca. The exact level of harvest outside of the river mouth would probably be low, but cannot be predicted as no other sockeye runs exist in the Strait. Sockeye would not be subject to the kind of commercial troll and sport harvest that captures a high proportion of the coho and chinook stocks before they reach the Elwha River. For example, less than 2 percent of Lake Washington sockeye are captured by the British Columbia fishery (WDF, 1984). It may be expected that most of the harvest of any sockeye stock originating from the Elwha would be at the river mouth. Because most of the harvest is expected to occur at the river mouth where it can be locally controlled, and passage survival is expected to be marginally favorable, allowable harvest is judged marginally favorable.

Habitat

Sockeye rearing habitat is restricted to Lake Sutherland. Spawning area may be limited in this system as little is available in the tributaries upstream from Lake Sutherland (James River II, 1988a). Some may be available in the lake, but the amount has not been quantified. The lack of definite reports of sockeye being in the Elwha system prior to dam construction suggest that either spawning or rearing habitat in this system is not suitable for sockeye; therefore, habitat is judged unfavorable.

Stock Selection and Availability

Suitable stocks for restoration have not been identified. Currently, a native stock does not exist, although a few sockeye are captured each year in the tribal inriver fishery. The Quinault, Ozette, Lake Washington, and Baker Lake stocks are possibilities; their suitability and availability are not known. A stock adapted to lake shoreline spawning may be necessary, as this is the only known available natural spawning area available. The Baker Lake and Ozette stocks have some shoreline spawning populations. The availability of a stock for restoration is judged only marginally favorable due to a lack of a native stock in the system.

Sea-Run Cutthroat And Dolly Varden Trout

Sea-run trout native to the Elwha River are the cutthroat and Dolly Varden. Restoration potential for sea-run cutthroat and Dolly Varden trout is judged poor under the applicant's proposal because of unfavorable passage potential.

Passage

Passage survival was not calculated, but is expected to be insufficient to maintain wild stocks of either anadromous cutthroat or Dolly Varden trout. Passage survival is expected to be similar to that of steelhead trout described earlier with the following exceptions. Puget Sound female cutthroat often undertake at least one additional upstream non-spawning migration prior to spawning for the first time (Trotter, 1989). Repeat spawners are also common, unlike salmon. Dolly Varden have a similar life history pattern as cutthroat trout. The additional migrations would subject them to additional passage mortality at project facilities, particularly for fish destined for the upper reach. Additional passage losses would reduce the productive capacity of the populations. Downstream passage would add additional mortality. In some cases, sea-run cutthroat stocked above dams have not migrated to the sea in Washington (Johnston and Mercer, 1976). For these reasons the passage potential for sea-run trout is judged unfavorable.

Allowable Harvest Rate

Considering the present level of sport fishing activity on the Elwha River, harvest of sea-run trout is expected to be moderate to high without restrictions. The maximum sustainable yield harvest levels are not known for sea-run cutthroat or Dolly Varden trout, but are probably similar to those of native steelhead stocks or

about 40 percent. The available harvest rate is judged to be only marginally achievable.

Habitat

The same reaches of the river accessible to salmon would be accessible to anadromous sea-run cutthroat and Dolly Varden trout. Most habitat for these fish would be in the upper reach. The total area may be less than for salmon if fish cannot negotiate the falls at RM 33.7, in which case there would be 31.9 miles instead of 49 miles of river available. These fish, being smaller than salmon or steelhead, may not be able to pass the falls. The upper reach would offer good habitat because of its undisturbed nature.

The middle reach habitat would be the same length as that indicated for salmon (15.6 miles). It is expected most spawning in this region would occur in the tributaries so the large mainstem substrate should not limit spawning.

Lower reach habitat would remain unchanged for a length of 4.9 miles. This reach is less suited for sea-run trout because of the lack of tributaries.

The overall habitat suitability for sea-run cutthroat and Dolly Varden trout is judged favorable.

Stock Selection and Availability

It is presently unknown whether wild sea-run cutthroat or Dolly Varden trout exist in the lower river. However, based on past attempts at obtaining wild stocks, it may be difficult to capture suitable numbers to start a stocking program (Johnston and Mercer, 1976). Using cutthroat stocks from other areas has often not been successful, because of straying and residualism. Hatchery sea-run cutthroat trout could be provided from regional hatcheries in Washington, as the Washington Department of Game does conduct an active sea-run cutthroat stocking program. There are no hatchery stocks available for sea-run Dolly Varden. Dolly Varden are reared in other areas including Alaska (personal communication, Thom Johnson, Fisheries Biologist, WDW, April 4, 1990), but transplantations from so great a distance may not offer timing and other adaptive advantages of locally adopted stocks. Since there are likely limited available native stocks for the restoration program, availability is judged only marginally favorable.

Resident Trout

Resident trout consist of populations of rainbow, cutthroat, and Dolly Varden trout found principally in the middle and upper reaches and their tributaries.

Available rearing and spawning habitat would remain the same in all regions of the Elwha River under the applicant's proposal with no effects on populations.

Spawning habitat, which is of lower quality possibly limiting production in the middle and lower reaches, would remain the same.

The introduction of anadromous species to the middle and upper reaches would reduce the abundance of resident trout populations by competing for spawning and rearing habitat. The level of reduction would vary depending on future anadromous fish populations and current habitat utilization relative to the carrying capacity of the system, and the specific degree of competition between species. Generally, the closer a stream is to its carrying capacity and the higher the density of stocked fish, the greater would be the reduction in resident trout populations. Bjornn (1978) found greater than a 50 percent reduction in age two and older resident rainbow trout after large numbers of steelhead fry were stocked into a stream in Idaho. The Elwha River rainbow trout population consists of at least 95 percent age two and older fish (Collins, 1983). Wade et al. (1985) found that stocking steelhead pre-smolts into an Oregon stream resulted in reducing the number of large resident trout (mostly cutthroat) by 52 percent the first year. In contrast, Petrosky and Bjornn (1984) found no significant reduction in resident rainbow and cutthroat trout populations with low to moderate stocking levels of catchable size rainbow trout.

The lower river resident rainbow trout population would not be affected as it already competes with anadromous fish.

Growth rates of resident adult rainbow and Dolly Varden may increase with the introduction of anadromous fish, because salmon fry would provide an abundant forage. Dolly Varden and rainbow trout are noted for feeding on salmonid eggs and fry (Scott and Crossman, 1973).

Fish Community

The applicant's proposal would bring about an overall positive change in the fish community of the Elwha River. Diversity would improve in all reaches of the river. Overall, abundance and production would increase.

Stream Ecology

Overall, the ecology of the river should not change significantly under the applicant's proposal because the dams and reservoirs would continue to control the middle and lower river. The productivity of the Elwha River would improve with the increase in anadromous fish and the introduction of salmon carcasses to the middle and upper river. Spawning anadromous fish may reduce benthic invertebrate production slightly by disturbing substrate.

The applicant has proposed continuation of flow augmentation, presently prescribed by resource agencies, via release of water from Lake Mills in late

summer to reduce potential adverse effects of low flow and high water temperature in the lower river. Flow augmentation would provide a greater usable area of stream habitat in the middle and lower river, but would have little effect on water temperature (Section 4.1.2).

The applicant has also proposed reservoir drawdown for power purposes. This practice could adversely affect juvenile salmon survival in Lake Mills by causing a substantial drawdown of the reservoir, which would reduce the food supply (benthic invertebrates) of juvenile salmonids rearing or moving through the reservoir.

Shellfish

No change in the existing population of shellfish in the estuary and nearby marine waters is anticipated with the applicant's proposal, since no habitat changes are expected.

4.1.3.3 Staff-Recommended Measures

Through the course of EIS scoping and subsequent staff analyses, various concepts were developed for potentially improving the fish passage performance and restoration outlook expected with the applicant's proposal. The staff's assessment of each of these concepts is presented in this section, beginning with those recommended for incorporation into a dam retention plan, if such a plan were to be pursued.

Elwha Fish Ladder Design

The applicant has proposed a fish ladder at Elwha dam which consists of facilities on the Elwha's right bank spillway. The proposal is a composite design incorporating Denil and weir and pool fishways, holding and sorting pools, and a ladder entrance barrier in the fish way. Staff has evaluated the applicant's proposed design and concluded that it has deficiencies. These deficiencies include: (1) unsecured water supply; (2) insufficient attraction flow; (3) lack of entrance pool; (4) limited number of entrances; and (5) potential clogging problems with Denil design. To address these design deficiencies the staff has proposed a modified design incorporating the following elements: (1) pool and weir; (2) secured 100 cfs flow; (3) dual entrances; and (4) an entrance pool (Appendix A, Part 2). Staff estimates that losses of adult salmon and steelhead at these Elwha dam facilities could be reduced from the 7.5 percent to 10 percent as proposed by the applicant to about 5 percent to 7 percent under the staff proposal. The present value life-cycle cost of the facilities would increase from $8.5 to $9.8 million (1996 dollars). The staff proposed modifications are expected to significantly reduce uncertainties associated with the applicant's design.

Contingency Plan for Elwha Dam Downstream Passage

The applicant has proposed that Eicher screen passage systems be installed at all Elwha dam turbine intakes. Staff has concluded that Eicher Screen effectiveness, even in the face of recent positive tests, remains uncertain. Since current tests have only included coho salmon, staff recommends future testing with other anadramous species, including but not limited to chinook salmon and steelhead trout. In the event tests of the Eicher screens in the Elwha Project penstocks fail to demonstrate acceptable performance, staff recommends provisions be made to install conventional screens across the intakes (Appendix A, Part 2). Conventional screening of salmon and steelhead smolts is a proven technology which the staff estimates would provide 98 percent smolt survival. Eicher screens offer potentially substantial cost savings over conventional screens ($3.7 versus $9.3 capital cost) and thus deserve continued testing and evaluation.

Glines Canyon Project Operating Mode

The applicant has proposed to draw the reservoir down up to 2 feet during the summer and up to 10 feet in all other seasons for power purposes. This reservoir elevation control will result in a departure from true run-of-the-river operation at Glines Canyon dam and would cause in-reservoir effects. Staff recommends establishment of true run of the river operation objectives at the Glines Canyon project to reduce any instream effects associated with drawdown, ramping or stranding, and to reduce the negative effects in the reservoir associated with drawdown (turbidity and dewatering of the productive littoral zones in Lake Mills). Staff estimates that use of the upper 10 feet of the reservoir (2 feet during the summer) would result in about a 4 percent increase in energy generation. Thus, the staff's recommendation for run-of-river operation represents the loss of approximately $4.3 million over the 50-year period of analysis (1996 present value).

Glines Canyon Project Trap-and-Haul Upstream Fish Passage Facilities

The applicant has proposed trap-and-haul upstream fish passage operations and facilities at Glines Canyon dam. This operation would include capture of all anadromous adult fish at the time of their arrival at the facility and transport to the Lake Mills boat launch area. The staff believes that the trap-and-haul operation will be suitable and acceptable if properly designed. To assure adequate design, staff recommends that the applicant consult with the JFWA through final design and construction of the trap-and-haul facilities and also with respect to operations.

Fish Passage Monitoring Programs

The applicant's fish passage proposals, in the staff's view, all contain relative degrees of uncertainty in terms of their contribution to anadromous fish restoration. The staff believes that all applicant-proposed fish passage programs should be monitored to both fine-tune their designed operation and to determine their overall effectiveness. Onsite monitoring should be conducted for the

following facilities and operations: (1) Elwha dam fish ladder; (2) Elwha dam Eicher screen emplacements; (3) Glines Canyon dam trap-and-haul facilities and operation; and (4) release of 100 cfs spill at Glines Canyon dam.

Some detail is necessary in describing the spill evaluations at Glines Canyon. It is known from past studies and observations that steelhead, coho and chinook juvenile mortality was relatively high at 100 cfs spill quantities at Glines Canyon dam (Wunderlich et al., 1989). In four previously conducted tests, three survival percentages were (34, 42, and 64 percent) while one survival percentage was high (97 percent) (Wunderlich et al., 1980). These tests were all conducted in the presence of a large boulder situated at the outflow point of the plunge pool. Subsequent to these tests, the applicant through blasting removed this outlet point boulder and observations of the plunge pool outflow conditions indicated that there was no hydraulic restriction to fish exiting the plunge pool at 100 cfs spill flow. No further tests of spill mortality have been conducted since removal of the boulder. Staff recommends conducting replicate tests to determine spill mortality at 100 cfs, 300 cfs, and 450 cfs (the flow at which applicants consider there to be 100 percent survival irrespective of plunge pool exit conditions). The applicant may conduct survival tests at flows lower than 100 cfs after completion of 100, 300, and 450 cfs tests.

All monitoring studies of fish passage facilities should be developed and conducted in consultation with JFWA. Passage facility plans should include provisions for changes in design and operation which are necessary to assure that fish passage efficiency is as predicted by the Commission. Fish release and mortality studies designed to evaluate juvenile downstream passage mortality in Lake Mills and Lake Aldwell should be designed as to provide meaningful data on in- or through-reservoir mortality related to residualism and predation. Fish in both cases should be released far enough upstream of the reservoir to assure that complete reservoir passage is required for those fish marked at the upstream release point. Timing of egress and relative survival of those released fish should be documented in all such studies.

McDonald Stream Gage Funding

The applicant has proposed to fund operation of the McDonald stream gage for a period of 2 years after installation of the new McDonald gage. Staff recommends continuation of the McDonald gage funding until an adequate correlation with the new gage has been established. This correlation will be required to reflect conditions ranging from approximately 10 year low-flow to 10 year high-flow events associated with both natural runoff and rainstorm events.

Anadromous Fish Restoration Plan

The applicant has proposed funding for 10 years of an outplanting stocking program for steelhead, coho, and chinook to promote restoration for these species throughout the Elwha River drainage. Staff believes that, under the influences of

time delays, construction impacts, testing and monitoring, and stock selection and rehabilitation that 10 years will probably not be sufficient to truly evaluate the restoration measures. Therefore, staff recommends continuation for the outplanting program and for evaluation of fish restoration success for an indefinite period. The active restoration efforts should be terminated only upon determination by the Commission that the restoration program has achieved its objectives. The applicant should prepare an anadromous fish restoration plan in consultation with the JFWA. The plan should outline the schedule for restoration, the detail of the hatchery, rearing, and stocking programs, including sources of fish, location of rearing facilities, numbers, sizes and ages of fish to be stocked and their locations.

Other Measures Considered

The following measures, in view of the staff, would not provide fish passage or restoration benefits sufficient to offset their estimated cost of implementation:

(1) Glines Canyon Fish Ladder

Staff considers the long, high (200 feet) fish ladder design necessary at Glines Canyon dam (Appendix A, Part 2) to not be significantly more effective than the applicant's proposed trap-and-haul operation and facilities. Few successful fish ladders of this length exist in the Pacific Northwest or other areas. Given the uncertainty of operational efficiency with a ladder of this height, staff believes that there are probably no substantial differences in expected mortality between a Glines Canyon ladder and a trap-and-haul. The additional cost of the proposed ladder ($11.7 million vs $6.7 million over 50 years) weighed against the potential differences between the two facilities do not compel the staff to recommend a fish ladder.

(2) Glines Canyon Fish Screens

In lieu of using the spillway to pass downstream migrating juveniles, downstream passage could involve a relocated power intake and bypass screening (Appendix A, Part 2). Staff analysis indicates that installation of a new surface intake with conventional fish bypass screens could reduce estimated turbine entrainment loss for juvenile salmon and steelhead from about 6 percent to 2 percent. The change in intake level, however, would result in a slight increase (up to 1 to 2°C over existing conditions at 200 cfs reservoir inflow) in water temperature in the middle reach during the summer months potentially affecting chinook and pink salmon spawning, egg survival and disease resistance. The cost of the new intake and screens ($10,900,000 capital cost) was considered too high in view of the limited potential passage survival benefit and in light of the potential adverse effects of higher summer water temperatures in the middle reach.

The staff considered penstock and powerhouse expansion (Appendix A, Part 2) as a potential means of covering the cost of the relocated intake through additional power generation. It was determined by the staff that the power benefits of penstock and powerhouse expansion exceeded the cost of that expansion, the net benefits ($2.7 million) were not sufficient to appreciably reduce the significant negative life-cycle cost impact of the relocated intakes and fish bypass screens ($27.6 million).

4.1.3.4 Unavoidable Adverse Impacts

An increase in sediment input into the river during construction would have a minor adverse effect on resident and anadromous fish spawning and rearing habitat.

The introduction of anadromous fish into the middle and upper river would reduce the productivity of the resident trout populations in these reaches of the river.

4.1.4 Terrestrial Resources

4.1.4.1 Vegetation

The applicant's proposal would have minor adverse impacts on vegetation. Construction of fish passage facilities would cause permanent loss of vegetation, primarily near existing project developments. The proposed wildlife enhancement plan would modify the species composition and structure of some plant communities and would result in minors adverse effects on forest types due to small patch and strip cuts.

The sites affected by the applicant's proposed fish passage facilities, road improvements, and recreational proposals would all be on land owned by the applicant. Surveys of these sites did not identify any state-sensitive plants or species considered by the NPS to be unique in the Elwha drainage.

Construction Impacts

Construction of the fish passage facilities for the Elwha and Glines Canyon projects would temporarily disturb small amounts of vegetation in the vicinity of both dams and powerhouses. The applicant expects disturbed sites to revegetate naturally within a year, but the staff believes these areas may be dominated by weedy forbs and grasses.

Implementing the wildlife enhancement plan would require temporary roads and landings involving a total of 26.5 acres. Upon completion of the enhancement

program, the applicant would permanently close these roads and landings, scarify them, and seed with a grass/legume mix.

Long-term Impacts

The primary long-term impacts of the applicant's proposal would be (1) the loss of about 1.23 acres of vegetation from the construction of new facilities at Elwha and Glines Canyon, (2) changes in vegetation composition and structure associated with the wildlife enhancement plan at the Elwha Project, and (3) disturbance from increased recreational activity.

Vegetation Loss

The applicant's proposed upstream fish passage facilities for the Elwha Project, including fish ladders, new road, flume, and capture station, would eliminate 0.14 acre of mixed conifer/deciduous forest just east of the dam. The parking lot for the proposed project overlook north of the dam would affect about 1.0 acre of shrubland.

The applicant's proposed trap-and-haul facilities at the Glines Canyon Project would impact about 0.09 acre of vegetated developed/disturbed land near the powerhouse.

The applicant has not developed a plan to replace the vegetation that would be lost from fish passage facilities at either project or the observation area at the Elwha Project.

Vegetation Modification

The applicant's proposed wildlife enhancement plan would modify vegetation composition and structure on over 189 acres of land around Lake Aldwell, representing approximately 21 percent of the 897 acres owned by the applicant in the project vicinity. The following are the applicant's proposed changes (James River II, 1990g):

(1) developing 4.7 acres of palustrine scrub-shrub and 3.4 acres of palustrine marsh in place of a young hardwood stand on the site of a 8.1-acre landslide on the southwest side of Lake Aldwell;

(2) thinning mature deciduous trees from 4.9 acres of deciduous and mixed conifer/deciduous forest stands along the shoreline of Lake Aldwell to enhance the growth of understory shrubs;

(3) selective thinning in 147.6 acres of conifer and mixed conifer/deciduous forest on moderate slopes along the east side of Lake Aldwell to promote the growth of understory shrubs and overstory trees;

(4) strip cutting (up to 1.8 acres each) of 20.2 acres of conifer and mixed conifer/deciduous forest on the east side of Lake Aldwell to create openings and promote the growth on shrubs;

(5) patch cutting (1.5 acres each) of alder and sub-dominant conifers from 18 sites on the west side of Lake Aldwell, to create openings in the canopy of mixed conifer/deciduous and hardwood stands (27 acres total);

(6) creating snags; and

(7) thinning and revegetating the alluvial/colluvial fans associated with five ephemeral tributary streams along Lake Aldwell to promote the growth of hydrophytic shrubs (1.3 acres total). Brush would be piled in shallow-water areas.

The remaining 79 percent (708 acres) of the lands owned by the applicant would be protected. Fencing and several gates would be installed around wetlands currently subject to human disturbance. Forested lands would be managed for the long-term development of old-growth.

Vegetation Disturbance

The applicant plans to develop several recreational facilities near Lake Aldwell, including a boat-in campground (5 acres), a nature trail on the west side of the river downstream of the powerhouse (1/8 mile), and a trail along the northeast side of the reservoir (1/2 mile). Development of the campground and trails would require minor vegetation clearing, primarily shrubs, grasses, and forbs. Increased access by recreationists would result in long-term, minor disturbance to the vegetation in the vicinity of the campground and trails. The risk of human-caused wildfires may also increase, particularly during the summer and early fall when the fire hazard and recreational use are both at their peak.

Staff-Recommended Measures

The staff recommends that the applicant develop a detailed plan to revegetate all areas temporarily disturbed by construction activities at the Elwha and Glines Canyon projects. The revegetation plan should include plant species, fertilization requirements, and provisions to control exotic species and grazing by deer. In addition, the staff recommends that all areas that would be impacted by construction activities, new facilities, recreational activities, or timber removal be resurveyed for state-listed plants. Any locations of state-listed plants should be avoided, if possible.

Unavoidable Adverse Impacts

No major, unavoidable adverse impacts on plant communities would be expected with the applicant's proposal. Staff recommendations would ensure that construction impacts to vegetation in the vicinity of fish passage facilities are temporary and that state-listed plants are protected.

4.1.4.2 Wildlife

The applicant's proposal would result, overall, in positive effects on wildlife. While the construction of fish passage facilities would cause minor loss of wildlife habitat, primarily near existing project developments, the proposed wildlife enhancement plan would improve habitat in the vicinity of the Elwha Project for most wildlife species. Additionally, since the applicant's proposal has a fair chance of restoring anadromy for two of the five native salmon species, populations of some wildlife species that feed on salmon carcasses would likely increase, primarily along the upper reaches of the Elwha River.

Construction Impacts

Construction of fish passage facilities at the Elwha and Glines Canyon projects would temporarily disturb wildlife in the vicinity of the dams and powerhouses for each project. These areas may be avoided by mobile species during construction, and disturbance during the nesting season may cause nest site abandonment. At Glines Canyon, improvement of the road to the boat ramp may disturb osprey use of the alternate nest site located near the boat launch. This nest site would probably not be used during road construction but would probably be reoccupied in later years. Implementation of the wildlife enhancement plan would disturb wildlife in the vicinity of timber clearing, thinning operations and road construction. In addition, the required roads and landings would temporarily eliminate 26.5 acres of habitat.

Long-term Impacts

The primary long-term affects of the applicant's proposal on wildlife would be (1) the loss of about 1.23 acres of habitat from the construction of new facilities at the Elwha and Glines Canyon projects; (2) positive changes in habitat quality from the implementation of a wildlife enhancement plan on project lands around Lake Aldwell; (3) restoration of anadromy above Elwha dam, if successful; and (4) increased disturbance from traffic associated with hauling fish above Glines Canyon dam and from recreational facilities on Lake Aldwell.

Habitat Loss

The applicant's proposed upstream fish passage facilities for the Elwha Project, would cause the loss of 0.14 acre of mixed conifer/deciduous habitat just east of the dam. The parking lot for the proposed project overlook north of the dam would impact about 1.0 acre of shrub habitat. These areas currently provide habitat for a variety of small mammals and passerine birds.

The applicant's proposed trap-and-haul facilities at Glines Canyon would impact about 0.09 acre of vegetated developed/disturbed land near the powerhouse. This

area is covered with a mixture of grasses and forbs that provides some forage for deer, small mammals, and passerine birds.

Habitat Modification

The objective of the applicant's proposed habitat enhancement program is to improve wildlife habitat quality on the 897 acres of land owned by the applicant including 810 acres adjacent to Lake Aldwell and 87 acres near the McDonald gage (James River II, 1990g). The plan focuses specifically on the protection, development, and improvement of wetlands, riparian corridors, and old growth forests. Seven habitat enhancement measures are proposed on over 189 acres of project lands (Section 4.1.4.1). These measures would be implemented once, within a year of license issuance, and not repeated. The remaining 708 acres of land owned by the applicant would be protected from development and timber harvest. In addition, the applicant proposes to decrease human disturbance to protect the delta on the south end of Lake Aldwell by fencing 0.5 mile of the project boundary. Several wetlands near the transmission line right-of-way would be protected from human disturbance by installing gates. A monitoring program would be conducted annually to determine the success of the improvement and protection measures.

In the absence of the proposed enhancement program, most of the land owned by James River would be managed for timber production. A total of 514 acres, including 235 acres of conifer forest, 175 acres of mixed conifer/deciduous forest, and 104 acres of hardwoods, would be harvested within 5 years. This area represents most of the forested land outside the 200-foot buffer around Lake Aldwell that is subject to the provisions of the Shoreline Management Act (1971). No harvest is planned within 200 feet of the reservoir.

The applicant conducted a HEP study in cooperation with resource agencies to assess the effects of enhancement measures, in terms of average annual habitat units (AAHU's) over a 50-year license period, on habitat quality for nine evaluation species (James River II, 1990g). Results of the HEP study are summarized in Table 4-10 and discussed in the following paragraphs.

Big Game

Two measures have been proposed by the applicant to enhance big game habitat on lands adjacent to Lake Aldwell: (1) improving forage production by cutting strips and patches in dense forest stands to allow browse species to regenerate naturally; and (2) creating optimum wintering habitat in forest stands by thinning subdominant trees to promote the growth of overstory trees for cover and shrubs for browse. These treatments would be implemented within a year of licensing and would not be repeated. Consequently, the increase in habitat quality due to enhancement would be temporary and would gradually decrease over the period of the license. For each year of the license period, the enhancement plan would increase the value of the lands owned by the applicant for elk and deer by 27 and

Table 4-10. Average annual habitat units provided by James River lands with and without the applicant's habitat improvement plan (Source: the staff, modified from James River II, 1990g).

Evaluation Species	AAHU's Without Improvement Plan 1/	AAHU's With Improvement Plan 2/	Net Change in AAHU's
Pileated woodpecker	202	472	270
Yellow warbler	2	6	4
Cooper's hawk	113	283	170
Douglas squirrel	346	413	66
Mink (palustrine)	29	28	-1
Mink (lacustrine)	160	168	8
Mink (riverine)	94	96	2
Beaver	83	87	4
Roosevelt elk	145	172	27
Black-tailed deer	127	150	23
Lesser scaup	38	38	0

1/ Represents the AAHU's provided by lands owned by James River without habitat improvement and protection.
2/ Represents the AAHU's provided by lands owned by James River with habitat protection and improvement.

23 AAHU's, respectively (Table 4-10). However, the staff believes that these estimates may be conservative because: (1) the models used to determine habitat quality for deer and elk tend to underestimate forage values during the winter stress period; and (2) the analysis was restricted to the lands owned by the applicant and did not account for the availability of forage on adjacent lands managed for timber production. The staff believes that protecting nearly 900 acres from timber harvest and developing and promoting the growth of old growth forest, which represents optimal habitat for deer and elk, would benefit all big game species using the lower Elwha River.

Furbearers

Three measures have been proposed by the applicant to improve aquatic furbearer habitat in the vicinity of Lake Aldwell: (1) converting a hardwood stand dominated by alders to marsh and scrub-shrub wetland; (2) thinning mature trees

along portions of the shoreline to enhance the growth of hydrophytic shrubs and trees preferred by beaver, such as willows, cottonwoods, and dogwood; and (3) establishing brush piles in shallow-water areas to provide cover. Because these treatments would be implemented within a year of licensing and would not be repeated, the increase in aquatic furbearer habitat quality due to enhancement would be temporary and would gradually decrease over the period of the license.

For each year of the license period, the enhancement plan would increase the value of the lands owned by James River for beaver and mink by 4 and 10 AAHU's, respectively (Table 4-10). The increase in habitat units for these species is due primarily to the addition of habitat resulting from the creation of 8 acres of marsh and scrub-shrub wetland. Enhancing shrub and tree cover along the reservoir shoreline has little effect on habitat quality for mink because Lake Aldwell currently provides nearly optimal habitat for this species. Similarly, use of the reservoir by beaver is generally limited by water fluctuation and would be unaffected by changes in shoreline cover. However, reducing human disturbance in the delta on the south end of Lake Aldwell and in two wetlands near the transmission line route would also benefit aquatic furbearers such as the beaver and mink.

The applicant's wildlife enhancement plan would also improve habitat quality for terrestrial furbearers that require large stands of mature forest. Species such as the pine martin and bobcat would benefit from the protection and maturation of conifer and mixed/conifer deciduous stands and creation of snags.

Small- and Medium-sized Mammals

None of the enhancement measures proposed by the applicant directly focus on habitat improvement for small- and medium-sized mammals. However, protecting conifer and mixed conifer/deciduous stands from harvest would benefit all small- and medium-sized mammals that depend on forest habitats, included the long-eared myotis, a proposed state monitor species. For each year of the license period, the enhancement plan would increase the value of the lands owned by the applicant for the Douglas squirrel by 66 AAHUs (Table 4-10). This increase is due primarily to the protection and maturation of conifer and mixed conifer/deciduous stands under the enhancement plan.

Raptors

The applicant's proposal to protect large stands of conifer and mixed/deciduous conifer from harvest would benefit raptors dependent on forest habitats, including the northern goshawk and barred owl, state proposed sensitive and monitor species, respectively. The creation of small openings in the canopy would also benefit raptors that use forests but also forage in open areas or along the forest edge.

For each year of the license period, the enhancement plan would increase the value of lands owned by the applicant for the Cooper's hawk by 171 AAHU's

(Table 4-10). This increase is due primarily to the protection and maturation of conifer and mixed conifer/deciduous stands under the habitat improvement plan. Effects on raptors with federal status, the spotted owl and bald eagle, are addressed in Section 4.1.4.3.

Waterfowl

None of the enhancement measures proposed by the applicant is designed to directly improve habitat quality for waterfowl. The enhancement plan would not affect the amount or quality of shallow water habitat used by the lesser scaup or other waterfowl wintering on Lake Aldwell. However, protection and maturation of conifer and mixed/conifer stands would result in a greater number of large trees and snags that, over the life of the license, would provide nesting habitat for wood ducks and other cavity nesting waterfowl. Fencing to reduce human disturbance by fencing in the Lake Aldwell delta and around wetlands would also benefit waterfowl using these areas.

Marine Birds

The applicant's proposed enhancement measures would not benefit marine birds because their habitat occurs primarily at the Elwha River delta.

Upland Game Birds

The applicant's proposed measures to increase shrub and forb production and to protect forest stands would temporarily improve habitat quality for upland game birds, primarily ruffed grouse and blue grouse. Blue grouse would benefit from an increase in the cover and diversity of herbaceous vegetation in upland conifer and mixed stands. Ruffed grouse are associated mainly with hardwood stands and would benefit from the increased shrub cover along the reservoir shoreline and on tributary fans.

Nongame Birds

The applicant's proposal to protect large stands of conifer and mixed/deciduous conifer from harvest would benefit nongame birds that use forest habitats, including the pileated woodpecker and Vaux's swift, both state proposed sensitive species. Many nongame birds forage in more open areas and would also benefit from the creation of small openings in the forest canopy. Species that forage or breed in dead trees would also benefit from the creation of snags. Birds that require hydrophytic shrubs and trees would benefit from the applicant's planned conversion of an alder stand to a scrub-shrub wetland and increased production of shrubs along the reservoir shoreline and in tributary fans.

For each year of the license period, the enhancement plan would increase the value of lands owned by the applicant for the pileated woodpecker by 269 AAHU's (Table 4-10). This increase is due primarily to the protection and maturation of conifer and mixed conifer/deciduous stands under the enhancement plan. Protection, in combination with thinning, would promote the growth of the

larger conifers. Within 50 years, the dbh of a number of these trees would be greater than 20 inches, the optimal size for nesting and foraging pileated woodpeckers. The enhancement plan should also increase the value of the project lands for other cavity-nesting birds such as the hairy woodpecker, flicker, and black-capped chickadee.

The enhancement plan would increase the value of lands adjacent to Lake Aldwell for yellow warbler by only 4 AAHU's. This small increase is primarily due to the conversion of hardwood forest to palustrine scrub-shrub. However, the staff believes that this estimate is conservative since the yellow warbler would also benefit from the hydrophytic shrubs along the reservoir shoreline and in tributary fans.

Reptiles

The applicant's proposed enhancement measures would have little effect on habitat quality for reptiles in the area.

Restoration of Anadromy

Studies on the fate of salmon carcasses on the Olympic Peninsula indicate that at least 22 species consume salmon carcasses, including 14 mammals and 8 birds (Cederholm et al., 1989) (Table 4-11). The effects of restoring salmon on wildlife along the river depend primarily on four factors: (1) escapement, or the total number of fish returning to the Elwha system; (2) retention of carcasses in the river and tributaries; (3) the location and timing of spawning; and (4) the length of time carcasses are available as food. The extent of the beneficial effect of the applicant's proposal on wildlife in the upper watershed depends on the success of the fisheries restoration program.

Predicted annual escapement with the applicant's proposal would be approximately 22,000 salmon, primarily fall chinook and coho (Table 4-12). This represents about 386,000 pounds of biomass, three times the amount currently available from salmon in the lower river. Steelhead would provide additional biomass. However, since this species generally moves downstream and does not die soon after spawning, relatively few carcasses would become available as food to wildlife.

Some carcasses are washed out of a river system during high flows and are not available as food for wildlife. However, a study on the fate of salmon carcasses in tributaries on the Olympic Peninsula indicates that most carcasses drifted less than 610 feet from their original location and are deposited in pools formed by large organic debris (45 percent); gravel bars (26 percent); eddies (18 percent); and riffles (11 percent) (Cederholm et al., 1989). Most salmon carcasses in the middle and upper Elwha River and along tributaries would be retained because of the abundance of pools, gravel bars, riffles, and eddies. Based on the above study, 96 percent (370,500 lbs) of salmon carcasses would be expected to be retained as consumable biomass in the Elwha system.

Table 4-11. Mammals and birds known to consume salmon carcasses (Source: Cederholm et al. 1989).

Mammals	Birds
Small and Medium Size	Raptors
Water shrew	Red-tailed hawk
Masked shrew	Bald eagle
Wandering shrew	
Mountain beaver	Nongame
Douglas-squirrel	
Northern flying squirrel	Dipper
Deer mouse	Stellar's jay
	Gray jay
Furbearers	Common raven
	Common crow
Raccoon	Northwestern crow
Weasel	Winter wren
Mink	
River otter	
Skunk	
Bobcat	
Large Mammals	
Black bear	
Coyote	

Not all of the retained carcasses would be available as food. Some would be buried or become wedged in debris at a depth that would make them unavailable to many wildlife species. On the Skagit River in northwestern Washington, only 14 percent of the salmon carcasses were deposited in locations that were accessible to bald eagles (Stalmaster, 1983). In a creek on the Olympic Peninsula, 52 percent of the salmon carcasses found were in the process of being buried in the unstable streambed (Cederholm et al., 1989). Many of these carcasses would be available only to mink and otter. However, black bear were observed retrieving carcasses in pools over 5 feet deep (Cederholm et al., 1989).

The biomass available from chinook and coho carcasses in the middle and upper reaches of the Elwha would peak in October (Table 4-13), a time when other foods such as insects, berries, and herbaceous material begin to decline.

Table 4-12. Predicted escapement and increase in biomass of salmon for the applicant's proposal.[1/]

	Predicted Escapement	Predicted Biomass (lbs)	Present Biomass (lbs)	Increase in Biomass Over Current Conditions (lbs)
Fall Chinook	7,864	212,328[2/]	94,500	117,828
Coho	14,468	173,616[3/]	26,400	147,216
Chum	0[4/]	0	0	0
Pink	0[4/]	0	0	0
Sockeye	0[4/]	0	0	0
Total	22,332	385,944		265,044

1/ Modified from Table 4-14 by the staff.
2/ Chinook = 27 lbs/fish average (James River II, 1990g).
3/ Coho = 12 lbs/fish average (James River II, 1990g).
4/ Staff assumed zero escapement, although small numbers of chum, pink and sockeye salmon are known to migrate into the river each spawning season.

Consequently, species preparing for hibernation, such as the black bear, would particularly benefit from the increase in available food. Since chinook and coho runs would continue to provide carcasses through the end of January (Table 4-13), species that are active during the winter along the Elwha River, including the bobcat, coyote, mink, and river otter, would also benefit.

The rate of decomposition is higher for salmon carcasses deposited in water compared to those on land. After five weeks, the energy content of carcasses declines by 9 percent for those deposited on land and by 59 percent for those deposited in water. After 10 weeks, only 27 and 7 percent of the original energy content of the carcass remains for land and water deposition, respectively (Stalmaster and Gessaman, 1984). Assuming that carcasses deposited on land

Table 4-13. Spawning location and timing of salmon on the Elwha (Source: the staff).

	Principal Spawning Location on the Elwha	Spawning Period	Peak Spawning	Carcass Availability[1/]
Fall Chinook	Middle and lower reaches	August to end of October	September and October	August to mid-November
Coho	Upper reaches and tributaries	October to end of December	October to end November	October to end of January
Chum	Lower and middle reaches	End October to early January	November to end December	end October to early February
Pink	Lower and middle reaches	August to early October	September	August to early November
Sockeye	Lake Sutherland	August to early October	September	August to early November

1/ Carcass availability based on maximum survivability of 6 weeks for chinook and 4 weeks for coho, chum, pink and sockeye.

contain usable energy for up to 10 weeks, restoration of the chinook and coho runs would provide food to wildlife along the tributaries and all reaches of the Elwha from early September through mid-April (7 1/2 months).

Many species, particularly scavengers (e.g., ravens) will consume even badly decayed carcasses. In addition, decayed carcasses may be consumed by some non-hibernating species in the late winter and by species coming out of hibernation in the early spring when food is in short supply. Carcasses from winter steelhead, which have a good restoration outlook under the applicant's proposal, would also provide some supplemental food in the late winter and spring.

The increase in food for wildlife that consume salmon carcasses would result in population increases for some species, particularly along the upper reaches and tributaries of the Elwha River where food during the winter is probably the most

limiting factor. Along the middle and lower reaches, disturbance and habitat may be as or more limiting than food availability, and population increases would be less likely.

The increased production of fish that would result from restoration of anadromy would benefit species that consume live small fish, such as the belted kingfisher and common merganser. Salmon and steelhead smolts and rearing juveniles would add to the young of resident trout as prey for these species in the reservoirs and lower river.

Restoration of anadromy could have a negative effect on wildlife that feed primarily on larger live resident fish, such as the osprey, a proposed state monitor species. Osprey nesting on Lake Mills currently feed on resident trout; the pair nesting by the Highway 101 bridge are probably dependent on resident trout in Lake Aldwell as well as the steelhead "jacks" (small precocious males) and salmon that currently spawn in the lower Elwha River. Restoration of salmon runs would decrease populations of resident trout in the middle and upper river but increase jack steelhead and salmon throughout the river. Since the osprey nesting period is April through August, when chinook and steelhead jacks would be available, the overall effect of loss of resident trout should be negligible.

Staff-Recommended Measures

Construction Timing

To minimize impacts on breeding birds during the construction of fish passage facilities, the staff recommends that blasting be prohibited during the nesting season. In addition, road construction near the boat launch on Lake Mills should be delayed until after the osprey nesting season. This measure would reduce the chances that the osprey nest site near the boat launch would be temporarily abandoned during road construction.

Wildlife Habitat Enhancement Plan

The proposed wildlife enhancement plan would improve habitat quality and quantity of wildlife in the vicinity of Lake Aldwell. However, the staff concurs with the WDW that the plan provides only minimal habitat improvement for most species and lacks an adequate monitoring program (letter from D. Guffler, Regional Habitat Program Manager and J. Fenton, Hydroproject Coordinator, WDW, Olympia, Washington, April 4, 1990). Consequently, the staff recommends the adoption of several additional measures to improve the plan and its chances for success.

The analysis of the effects of the wildlife enhancement plan on deer and elk has several problems that affect its accuracy. Specifically, the models used to determine habitat quality for deer and elk have an error in the winter stress component. In addition, the analyses for these species were restricted to project

lands, which are predominantly second growth forest with low forage value. Deer and elk, however, are mobile and would readily make use of the forage available on the clear-cut lands adjacent to those owned by the applicant. Consequently, the staff recommends that the applicant, in consultation with WDW, correct the deer and elk models, and rerun the HEP analysis to include forage available for these species on lands outside the project boundaries. This analysis would determine if forage during the winter period is limiting deer and elk use of the lower Elwha. The results should be used, in consultation with WDW, to plan a comprehensive habitat improvement program for deer and elk on the lands owned by the applicant.

Deer and Elk Radio-Telemetry Study

As an additional tool for developing the habitat improvement program for deer and elk, the staff recommends that the applicant, in consultation with the NPS and WDW, conduct a radio-telemetry study. The baseline results of this study would identify (1) seasonal movement patterns; (2) important forage and cover areas; and (3) level of use of the lands around both Lake Mills and Lake Aldwell. The radio-telemetry program should be continued, on a periodic basis, over the license period to determine the success of the enhancement plan for big game.

Wildlife Habitat Maintenance and Monitoring Programs

The staff also recommends implementation of maintenance and monitoring programs. The maintenance program should be designed in consultation with WDW and ensure that habitat improvements (e.g., measures designed to promote the production of hydrophytic shrubs) are continued over the license period. The monitoring program should be designed to determine the success of the enhancement plan and include goals, methods, and contingencies if the program fails.

Salmon Carcass Study

To monitor the effects of restoring salmon on wildlife, the staff recommends that the applicant, in consultation with the resource agencies, design and implement a study that would, at a minimum (1) locate important areas of carcass stranding along each of the three reaches of the Elwha; (2) determine the number of carcasses stranded in selected areas during peak spawning periods; and (3) identify the species that consume these carcasses. In addition, this study should monitor the effects of restoring salmon runs on osprey nesting along the Elwha.

Unavoidable Adverse Impacts

Approximately 1.3 acres of wildlife habitat would be lost due to new developments at both dams.

4.1.4.3 Threatened and Endangered Species

Federally Listed Species

The applicant's proposal would have no adverse impacts on bald eagles or spotted owls. The proposed wildlife enhancement plan may, over the long-term, increase available habitat for the spotted owl in the vicinity of Lake Aldwell. Restoration of runs of fall chinook and coho is not expected to attract significant numbers of bald eagles to the Elwha River.

Construction Impacts

Construction of fish passage facilities at the Elwha and Glines Canyon projects would temporarily disturb spotted owls if they occur in the vicinity of the dams and powerhouses for each project. However, the habitat near these facilities at Elwha is not suitable for spotted owls and the probability for significant disturbance is low. At Glines Canyon, construction of trap-and-haul facilities would probably not involve blasting and should not significantly disturb spotted owls.

Long-term Impacts

The primary long-term effect of the applicant's proposal on spotted owls would be a potential increase in available habitat resulting from the implementation of a wildlife enhancement plan on project lands around Lake Aldwell. The principal effect on bald eagles would be restoration of anadromy above Elwha dam.

Habitat Modification

One of the objectives of the applicant's proposed habitat enhancement program is to protect and improve the 593 acres of conifer and mixed conifer/deciduous forest adjacent to Lake Aldwell and near the McDonald gage. Most of the timber on these stands is classified as mature and is between 60 and 80 years old; average diameter breast high is about 13.5 inches. The plan focuses on protecting these forests from timber harvest and thinning to promote growth of larger, overstory trees.

With protection, the forests on lands owned by the applicant would be between 110 and 130 years old at the end of the 50 year license period. The dbh of larger trees in stands that were thinned at the beginning of the license period should exceed 20 inches (personal communication, R. Grotefendt, Forestry Consultant, Bellevue, Washington, August 15, 1990). Trees and snags of this size are used by spotted owls for nesting (Forsman et al., 1984). However, in a study of spotted owl nest sites in Oregon and Washington, only 2 out of 42 were in large trees in stands 100 to 140 years old. Typically, spotted owls were found in old growth forests that are 230 to 600 years old and characterized by a multi-layer canopy, uneven size and age structure, and high percentage of trees with structural

damage and decay (Forsman et al., 1984). Consequently, the applicant's wildlife improvement plan would provide additional but marginal habitat for the spotted owl within the next 50 years. Over the long-term (three 50-year license periods) optimal habitat for this species would be expected to develop on James River lands. However, this area would be too small to support a pair of spotted owls, which, in Washington, require a territory of 6,300 to 9,900 total acres that contain 3,300 to 4,600 acres of old growth (Thomas et al., 1990). Consequently, its use by spotted owls would be dependent on the availability of adjacent suitable habitat.

Restoration of Anadromy

The applicant forecasts a substantial increase in bald eagle use of the Elwha River due to increased salmon biomass in the watershed (James River II, 1990g). In the staff's view, the applicant's proposal would not greatly increase bald eagle use.

Bald eagles are opportunist feeders and food availability is the primary factor that determines wintering locations for this species (Stalmaster, 1987). Bald eagles are attracted to wintering locations on the Nooksack, Skagit, and other rivers in the Pacific Northwest because of the abundant salmon runs that occur in these rivers in the fall (Stalmaster, 1976; Servheen, 1975; Wiley, 1977; Biosystems Analysis, Inc., 1980; Hansen et al., 1984).

All five species of salmon spawn on the Skagit River, but chum are the primary food for wintering bald eagles (Wiley, 1977; Biosystems Analysis Inc., 1980; Hunt and Johnson, 1981). The spawning times for chinook and sockeye do not significantly overlap the wintering period for bald eagles (Table 4-13). Pinks generally spawn in early October, prior to the arrival of most bald eagles at wintering locations, and are available as food only for early winter arrivals (Wiley, 1977). Although coho spawning and die-off correspond to the wintering period for bald eagles, coho generally spawn on tributary streams, and carcasses are often deposited in areas not readily accessible to eagles (Wiley, 1977). Consequently, chum salmon, which spawn from late November to early January usually make up the bulk of the food for bald eagles wintering on the Skagit and other nearby rivers (Wiley, 1977; Biosystems Analysis Inc., 1980; Stalmaster, 1983). In fact, peak eagle counts along the primary chum salmon spawning area on the Skagit River (Rockport to Marblemount) are highly correlated ($R^2 = 0.65$) with escapement (DellaSala et al., 1990).

The applicant's proposal would not restore chum salmon, the principal food source for bald eagles wintering on other Northwest rivers. Restored runs of fall chinook on the Elwha would not provide food for wintering bald eagles since chinook spawn primarily in September and October, prior to the time when most eagles arrive in wintering areas. Coho salmon would provide less biomass and would spawn primarily in tributaries and upper reaches that are either inaccessible to bald eagles or require long flights and high energy expenditure. Consequently,

the applicant's proposal would not attract significant numbers of wintering eagles to the Elwha. Winter steelhead runs may provide supplemental food during the spring for bald eagles nesting area near the Elwha delta but no increase in nesting pairs would be expected in the valley.

Federal Candidate Species

The applicant's proposal would have no adverse impacts on the marbled murrelet, the only federal candidate species observed in the project area. The proposed wildlife enhancement plan may, over the long-term, increase available habitat for the marbled murrelet in the vicinity of the Lake Aldwell.

Construction Impacts

Construction of fish passage facilities at Elwha and Glines Canyon projects would not disturb marbled murrelets because use of the Elwha Valley by this species is confined to the tributaries and high elevations. In addition, since marbled murrelets fly between 300 and 600 feet above the canopy, it is unlikely that construction activities would disturb the daily movements of this species.

Long-term Impacts

The primary long-term effects of the applicant's proposal on marbled murrelet would be the increase in available habitat from implementing the wildlife enhancement plan on project lands around Lake Aldwell. The enhancement plan would protect existing forest stands from logging and allow the development of the old growth habitat required by the marbled murrelet. However, existing low elevation old growth in the Elwha Valley is not currently used by marbled murrelets; apparently it lacks the characteristics (e.g, stand size, isolation) of this habitat at high elevations.

4.1.4.4 Restoration of Natural Conditions in ONP

Restoration of natural conditions within ONP is one of the three principle resource objectives, as identified by the Commission staff, as relevant to licensing the Glines Canyon and Elwha projects. Restoration of natural conditions within ONP depends on restoration of the vegetation, habitats, and wildlife populations in the Glines Canyon project area to conditions approximate to those that existed prior to project construction.

The applicant's proposal does not restore the vegetation or wildlife habitat in ONP that lies within the Glines Canyon Project boundaries (Sections 4.1.4.1 and 4.1.4.2). However, partial restoration of anadromous fish to the upper reaches of the Elwha would provide an additional food source to wildlife in ONP that consume salmon carcasses and would benefit these species (Sections 4.1.4.2 and 4.1.4.3). Populations of some species would be expected to increase but not to

pre-project conditions. Consequently, the applicant's proposal partially meets the goal of restoring natural conditions in ONP.

4.1.5 Land Use

The applicant's dam retention alternative would have minor adverse effects on land use in the project area. The applicant's proposal would be generally consistent with most relevant comprehensive plans.

4.1.5.1 Construction Impacts

The construction of project modifications would minimally disturb existing uses in the project area. Residents of the Shady Tree RV park might notice some additional noise and traffic during construction of the Elwha dam fish facilities and project overlook. The construction of three boat-in campsites, which would be accomplished by boat and barge crews, would be noticeable to the occasional recreational boater.

During reconstruction of 3,000 feet of the Olympic Hot Springs Road near Glines Canyon dam, recreationists and park administrators would encounter brief delays, particularly on weekends. Improvement of the Lake Mills boat launch could potentially interfere with recreationists, but any such effects would be short term.

4.1.5.2 Long-Term Impacts

The applicant's wildlife improvement plan would require a large land area for dedication to wildlife habitat enhancement. The dedication of these lands to wildlife would preclude the future timber harvest (other than thinning) on 898 acres around Lake Aldwell and create a wildlife preserve surrounding the lake. About 6 acres of forested land would be converted to developed recreational uses at the Elwha Project overlook site and at the boat-in campground proposed by the applicant on the eastern shoreline of Lake Aldwell. The boat-in campsite is a permitted use under Clallam County's forestry zone designation for the area. There would be no changes in land uses at the Glines Canyon Project.

While it is predicted that the applicant's proposal for restoration of anadromous fisheries would have a fair chance of success for those species currently sought by anglers and commercial fishermen (Section 4.1.3.2), it is anticipated that the restoration program would result in a slightly negative effect on the recreational fishery in the project area.

In the attempt to restore the fishery, stricter fishing regulations would be placed on anglers such as shorter seasons and more limited harvests for steelhead (Section 4.1.8.2). Certain species, such as winter and summer steelhead currently caught at access sites below Elwha dam, would not be caught at the same intensities as

under existing conditions. This would lead to some abandonment of the access sites for certain recreational uses and possibly an increase in use of some access points for fish viewing purposes.

Consistency with Comprehensive and Other Resource Plans

The applicant's proposal is generally consistent with the National Marine Fisheries Service and Pacific Fishery Management Council's Fishery Management Plan, because the applicant's proposal for restoration of anadromous salmon species is predicted to achieve partial restoration of self-sustaining populations of anadromous salmon (Section 4.1.3). While restoration of lost habitat and the production of fish is not expected to reach the levels of previous years, the provision of fish passage facilities would provide access to extensive areas of habitat in the middle and upper reaches. Furthermore, the larger escapement of some salmon species is consistent with one of the objectives of the plan. The applicant's proposal would help to achieve the objective of maximizing offshore recreational catch for chinook; however, the predicted cutback in duration of season as compared to existing levels would not be consistent with the most recent plan amendment.

The applicant's proposal is fully consistent with the Northwest Power Planning Council's Protected Areas Amendments because the relicensing of existing projects is exempt from the protected areas program.

The applicant's proposal would be substantively inconsistent with the Olympic National Park plans, largely because the fishery enhancement measures are not predicted to fully restore natural conditions on lands altered by human activity. Parts of the applicant's proposal would be consistent with park resource plans in that it would restore some salmon to the upper watershed and it encourages high-intensity usage in park periphery areas by improving the Lake Mills boat launch and day use facility.

The applicant's proposal is generally consistent with the Washington Statewide Comprehensive Outdoor Recreation Plan because it would provide improvements to existing recreational facilities, and provide additional recreational improvements with provisions for future maintenance responsibility close to the urban population of Port Angeles. The applicant's proposal would provide additional recreational opportunities in the high demand activity areas such as interpretation and outdoor photography. The preservation of existing wetlands also provides consistency with the intent of the Washington Wetlands Priority Plan.

The applicant's proposal is generally consistent with WDW's Strategies for Washington Wildlife Plan. The applicant's proposal would increase the potential for fish passage, improve spawning and rearing habitat, and set aside a large

wildlife area. However, the poor chance for restoration of sea-run cutthroat and Dolly Varden trout would not meet one of the objectives of the plan.

The applicant's proposal is substantively inconsistent with the WDF Hydroelectric Project Assessment Guidelines. The applicant proposes measures such as fish passage facilities and fish restoration, and these efforts would not create a loss of existing or potential habitat nor would they create new blockage to fisheries. However, the poor-to-fair chance of restoration of certain wild anadromous species along with continued hindrance of passage through project facilities would be significant in terms of the WDF threshold criteria concerning fish passage.

The applicant's proposal is substantively inconsistent with the Clallam County Comprehensive Plan because the reduction or loss of recreational fishing opportunities resulting from the attempt to restore anadromous species is predicted to impact and reduce the number of visitors to Clallam County which is vital to the economy (Section 4.1.6.2).

The applicant's proposal is generally consistent with the Clallam County Shoreline Master Program but the applicant's proposed boat-in campground facility is not a permitted use within Lake Aldwell's natural shoreline designation. The staff's recommendation to move the facility inland (Section 4.1.5.3) would alleviate the cause of inconsistency. Other new project features appear to be consistent with the program. If the consistency problem with the boat-in campsite is not resolved, the applicant's dam retention alternative would be considered inconsistent with the policies of the State Coastal Zone Management Program.

4.1.5.3 Staff-Recommended Measures

The staff recommends that the location of the proposed boat-in campground be moved beyond 200 feet from the ordinary high water mark, to be situated outside of the natural shoreline designation.

4.1.5.4 Unavoidable Adverse Impacts

The project would result in minor impacts to recreationists accessing the upper portions of the Olympic Hot Springs road during the widening and rebuilding of a portion of the roadbed below the Glines Canyon dam. The loss to recreational fishing is predicted to be moderate and is discussed in Section 4.1.6.

4.1.6 Recreational Resources

The applicant's dam retention alternative would depend on reductions in marine and freshwater sports fishing harvests and possibly more restrictive regulations. This is attributable to the more restricted harvest rate required of anglers to achieve restoration. While the total steelhead catch would decrease by half, the

average angler's chance of catching winter-run steelhead would increase due to an increase in the number of adult steelhead returning to the river.

4.1.6.1 Construction Impacts

The construction of project facilities proposed by the applicant would have minimal effect on recreationists. The construction of fish passage facilities and the new project overlook at the Elwha dam would only slightly interfere with recreationists, since it is not in an area of high or moderate use. The construction of the boat-in campsite would only be slightly noticeable to anglers on Lake Aldwell. The transport of materials necessary for building the fish trapping facilities in combination with the rebuilding of a portion of Olympic Hot Springs Road would, on occasion, briefly impede recreationists who require passage through the area to access the Lake Mills boat launch and three trailheads.

4.1.6.2 Long-Term Impacts

Recreation Facility Improvements

The applicant has proposed a recreational plan to enhance recreational opportunities on project lands and waters. The recreational plan consists of new recreational improvements and reserving areas for potential future development at the Elwha Project, and the redevelopment of an existing site at the Glines Canyon Project (Figure 4-1).

The proposed recreational development for the Glines Canyon Project consists of improvements to the existing public boat launch facility located at the north end of Lake Mills. The boat launch access road and parking area would be regraded and graveled, and improvements made to the site drainage and launching lane. In addition, the applicant proposes installation of a new vault toilet, and interpretive signage would be placed in appropriate locations to enhance recreational enjoyment of the area.

The proposed recreational plan for the Elwha Project consists of the development of three boat-in campsites, a project overlook, a recreational trail, and interpretive signing of wetland areas and project features. The applicant proposes three boat-in campsites be located on the east side of Lake Aldwell and would consist of a firepit, tent flats, pit toilets, and shoreline improvements to facilitate access. The project overlook would consist of a parking area for six cars, vault toilets, interpretive signs, and access to the existing informal fisherman's access trail.

The applicant would rebuild the existing access trail below the Elwha dam to provide access for other recreationists. The applicant also proposes to place interpretive signs near the wetland areas at the existing WDW boat launch and at the proposed fishery passage facilities at the dam.

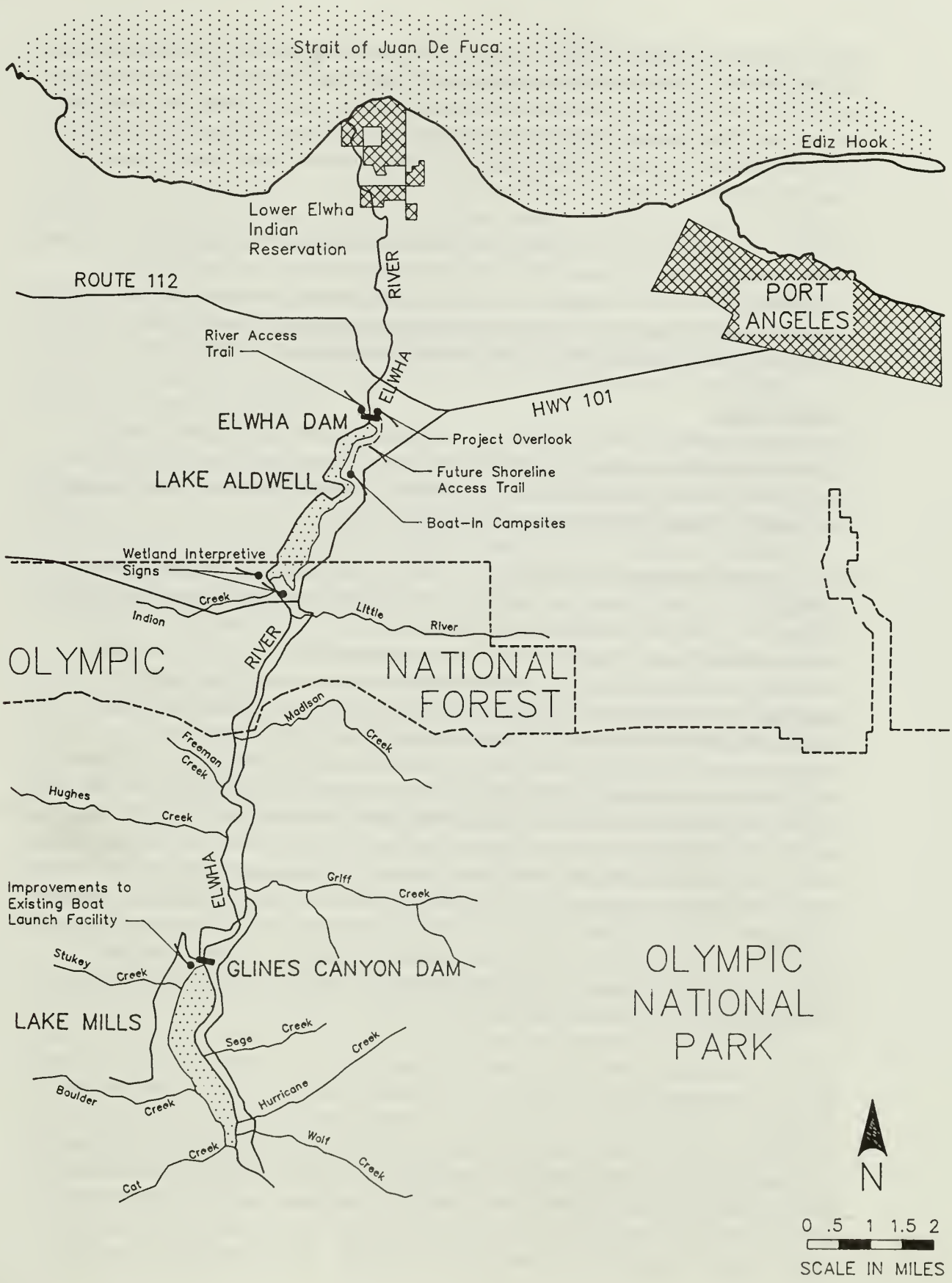


Figure 4-1. Location of applicant's proposed recreational facilities. (Source: James River, 1990c).

FIG3-2

The applicant has also proposed to reserve certain areas for future recreational development. These consist of an area along the eastern shoreline at the north end of Lake Aldwell which could be developed into a recreational trail for shoreline access and foot access to the boat-in campsite. In addition, an area would be reserved for development of up to six more campsites at the proposed boat-in campground.

Finally, the applicant proposes to limit reservoir drawdown in Lake Mills to 2 feet from Memorial Day to Labor Day. The implementation of the applicant's recreational plan would improve recreational opportunities afforded by the project, since it would provide better access to project shorelines and waters, and marginally enhance the quality of the boating experience on Lake Mills.

Sports Fishing

The second principal area of impact to recreationists centers on sports fishing. Sports fishing is particularly important to Clallam County residents as they have the highest percentage of anglers of any county in Washington and they also had the highest average catch ratio in 1987 (WDF, 1988).

The applicant's proposal is predicted to have a good chance for restoring winter steelhead and a fair chance for restoring fall chinook, coho, and summer steelhead (Table 4-4). With the restoration of anadromous fish to the middle and upper reaches of the Elwha River, it is generally anticipated that more fish would be produced, which in the case of chinook salmon, means more fish would be available for marine harvest. While restoration may produce more chinook salmon available for harvest, in order to achieve the required minimum escapement level necessary to sustain populations, rates of harvest for anglers would need to be reduced (Section 4.1.8.2). In the case of steelhead, the rate of harvest required is so restrictive that harvest would be restricted to 50 percent of existing levels in order to maintain an adequate level of spawner escapement to the river. Total harvest reductions can be achieved through more stringent regulations on season length, open locations and gear restrictions. While these more stringent regulations would negatively affect the steelhead fishery, the increased escapement to the river would provide an increased chance of fishing success. Steelhead fishing could be extended to the middle and upper reaches of the Elwha River with the addition of fish passage facilities.

While the marine sports fishery for fall chinook and coho salmon would benefit from an increased Elwha contribution, the more restrictive harvest rates necessary to protect wild stocks from the Elwha and other rivers would reduce the harvest of non-Elwha stocks. More restrictive harvest rates would probably be implemented by shortening the season available to anglers or reducing the bag limit, closing portions of the offshore fishery, or limiting the number of days a week open to fishing. Based on salmon punch card data, in 1987 there were 160,000 marine angler trips to East Strait of Juan De Fuca Fishery, an area extending from Port

Townsend to the Lyre River (WDW, 1988). These anglers had an average success rate of 0.52 salmon per trip with a catch made up of mostly coho salmon (45,614) and chinook (31,215). While it is not possible to apportion the contribution of the Elwha stocks to this marine sports fishery, it is likely that the whole fishery would have to be curtailed in terms of harvest rate, in order to protect the Elwha wild fish escapement. The reductions in harvest would be very important during the initial stages of restoration when extensive curtailment in the marine and river sport fishery harvest would be required.

With anadromous fish migrating upstream past the two dams, there would be an increase in resident and anadromous competition (Section 4.1.3.2). This would cause the resident trout populations to be less productive than under current conditions. Because of a resulting decreased catch per unit effort, trout fishing would be negatively impacted.

Overall, the impact to the freshwater angler would be slightly negative due to a decrease in total allowable harvest of steelhead, potential greater restrictions on steelhead and coho fishing, and a less productive resident trout fishery. These adverse effects would outweigh an increase in escapement of steelhead allowing the individual angler a better chance of catch success and an increase in river miles for salmon and steelhead fishing.

For the offshore marine sports fishery, restoration of chinook and coho should provide a greater contribution from the Elwha River. However, in order to allow the necessary chinook and coho escapement to the river, the marine harvest rate would have to be curtailed in zones frequented by Elwha salmon, which would reduce the overall harvest of all stocks from these zones. Higher total production from the Elwha River should provide the individual angler a better chance of success. The impact to the marine sports fishery would be negative because of overall harvest and harvest rate reductions necessary to protect wild stocks. However, since present management plans already call for reductions in harvest and harvest rates to protect wild stocks (Section 4.1.3), the additional effect of the applicant's proposal on angling would likely be minor.

The addition of anadromous fish to the middle and upper reaches of the Elwha would likely result in more sightseeing and wildlife observation visits to the river shoreline areas and this would be considered a positive impact of the restoration plan.

4.1.6.3 Staff-Recommended Measures

The staff recommends the applicant make provisions for visitor viewing at the proposed Elwha dam fish ladder and adult salmon capture and counting station.

4.1.6.4 Unavoidable Adverse Impacts

The loss of the winter river sport fishery harvest of hatchery and wild steelhead would be an unavoidable adverse impact, as would be the reduction in marine harvest and harvest rates on salmon due to the necessity of protecting wild Elwha salmon stocks. The reduction in quality of the resident trout fishery and further limitations on the inriver coho fishery would represent additional unavoidable adverse impacts.

4.1.7 Aesthetic Resources

The applicant's proposal would result in very little change in the aesthetic quality of the environment. The potential for viewing migrating salmon at various river access points would represent a beneficial effect.

4.1.7.1 Construction Impacts

The construction of fish passage and recreational enhancement facilities would have a minor adverse impact on the aesthetic quality of the project area. Most notably, the movement of construction vehicles in ONP would look out of place to many visitors, slightly diminishing the value of their recreational experience.

4.1.7.2 Long-Term Impacts

The addition of fish passage facilities at the Elwha dam would add to the cluttered image of the structure, slightly degrading its appearance. The proposed project overlook would allow sightseers a new location to view points of interest. The passage of fish up the fish ladder would provide a new viewing opportunity for sightseers and wildlife enthusiasts. The fish passage facilities at the Glines Canyon Project would not be visible to most visitors, but the residences of the project operations personnel, due principally to the color of the structures, would continue to appear inconsistent within the ONP setting.

The new boat-in campsite would offer recreationists a new landscape to view which would generally provide a more remote camping experience than most nearby campgrounds.

4.1.7.3 Staff-Recommended Measures

The staff recommends that the applicant modify the residences at the Glines Canyon dam to bring their appearance more in conformance with national park standards. This should at least involve painting the structures with park service authorized colors.

4.1.7.4 Unavoidable Adverse Impacts

There would be no unavoidable adverse aesthetic impacts associated with the dam retention alternative.

4.1.8 Socioeconomics

Implementation of the applicant's proposal would have a variety of economic effects, some of which have important social implications. Under the applicant's proposal, fall chinook and coho salmon, and winter and summer steelhead runs have at least a fair chance of restoration (Section 4.1.3), and only the fall chinook salmon population would be able to sustain the existing or a slightly increased fishery harvest. Harvest of coho salmon and steelhead would have to be reduced to protect wild stocks from overharvest. Furthermore, during the restoration period, commercial, tribal, and sport harvest would be curtailed to even lower levels to allow runs to build to their full potential. Tribal fisheries would be the most adversely affected. Reduction in the tribal harvest would exacerbate the tribe's current poverty and associated social problems.

Both construction and operation of the projects would provide a limited amount of additional employment opportunities, while taxes paid by the project would not be appreciably affected. The cost of power to Daishowa America Mill would increase substantially.

4.1.8.1 Construction Impacts

The overall impacts associated with the construction period are expected to be slightly beneficial. Employment and material purchases associated with construction of fish passage and other facilities would have a minor favorable impact on the local economy. Construction would provide the equivalent of eight jobs per year for each of the four years of the construction period, for a total of 32 person-years of employment.

The required workforce could be provided within the local commuting area, so that no relocation of workers to the local area is anticipated. Local services such as schools, housing, police, and fire protection would not be adversely affected.

4.1.8.2 Long-Term Impacts

Long-term socioeconomic impacts of the applicant's proposal are expected to be negative, primarily because total fish harvest would have to be reduced in order to restore and maintain wild, self-sustaining fish stocks. The reduction in the total harvest would adversely affect commercial, sport and tribal fisheries, and would exacerbate the Lower Elwha Klallam Tribe's existing economic and social problems. The cost of power to Daishowa America Mill would increase

substantially. Any economic benefits under this alternative, such as minor increases in employment, would not be sufficient to offset the adverse socioeconomic effects.

Fisheries

As explained in Section 1.4, one of three principal resource objectives is restoring wild, self-sustaining anadromous fish stocks. For purposes of comparing the various alternatives, the staff has assumed that harvest management would be directed toward maximizing sustained yield of the wild stocks (Section 4.1.3.2). The role of hatcheries are assumed to be limited to supporting the restoration program.

Socioeconomic impacts from changes in fisheries were evaluated from two perspectives: (1) changes in total harvest in commercial, sport, and tribal fisheries; and (2) changes in fishing regulations that affect local and regional economies (e.g., tourism) through fishery closures or restrictions imposed to protect Elwha stocks.

Total harvest was predicted by multiplying the allowable harvest rate by the total potential run size as estimated from JFWA predictions (JFWA, 1988). The midpoint of the range (low and high) of potential run size provided by JFWA was used for total potential run size.

The allowable harvest rate (HR) was derived using the following formula:

HR	=	1-SR, where:
SR	=	required survival rate, and
SR	=	(1-OSR) (SS) (AS), where:
OSR	=	optimum exploitation rate, as derived from available fisheries stock-recruitment curves (see Appendix B for details);
SS	=	survival of smolts, as affected by loss in reservoirs, dam passage, and habitat available; and
AS	=	adult upstream passage survival.

The following discussion describes the effects of the applicant's proposal on commercial, sport, and tribal fisheries of the Pacific Northwest. Emphasis is placed on fall chinook and coho salmon, and winter steelhead, because they are the species for which passage survival was calculated, and which provide the most significant existing fisheries from the Elwha River (Section 3.9.3.1).

Chinook Salmon

The present total harvest of Elwha fall chinook salmon can be increased slightly under wild fish production with the applicant's proposal. This would be possible because total production would substantially increase to over 19,000, while the harvest rate would be restricted to 59 percent (Table 4-14). Escapement would approximately double. At an allowable harvest rate of 59 percent, total harvest would average about 15 percent higher than the existing average of 10,000. Nearly all of the harvest would be from the marine commercial and sport fishery, since it is not likely that the marine harvest rate, which is approximately 80 percent at present, could be reduced much below 59 percent. Therefore, as at present, only a small proportion of the harvest would be available to the inriver tribal and sport fisheries. River harvest by tribal and sport fishermen would likely remain restricted unless the marine harvest were reduced below 59 percent, which appears unlikely. The inriver tribal fishery harvest of 200 to 800 fish taken in the personal use test fishery would be jeopardized.

During the initial restoration period, marine harvests could be curtailed below 59 percent to maximize initial escapement to the river. Such curtailment would reduce regional harvest of salmon in sport and commercial fisheries. Sport fishing in the Strait of Juan de Fuca and Puget Sound would be further restricted, and charter boat and commercial fishing revenues in the region would be reduced.

If restoration were unsuccessful, either by lack of control on the harvest rates or the inability of the river to produce the number of smolts predicted, the existing fall chinook harvests would decline without hatchery supplementation. The applicant proposes to continue funding the WDF hatchery in the event restoration goals are not met.

Restoration of spring chinook runs in the Elwha is also a possibility under the applicant's proposal, although the potential for success is poor (Section 4.1.3). Attempts to restore spring chinook would add to the existing catch of chinook salmon in the marine fisheries. Like fall chinook, harvest rates would necessarily have to be restricted to protect the productive capacity of the wild stock. If an adequate stock can be identified for restoration, some low level of production could be expected from the river, which would add a small number of fish to the marine fisheries. Inriver tribal and sport fisheries would remain restricted, as they are now, to protect the small number of adult fish returning to the river. Further restrictions on marine fisheries to protect the spring chinook would probably be instituted.

Coho Salmon

Under the applicant's proposal, total harvest of Elwha coho salmon would be reduced from an average near 20,000 to an average just above 15,000 at a

Table 4-14. Present and predicted future total adult production, harvest, and escapement of fall chinook, coho, winter steelhead, chum, and pink salmon under the applicant's proposal (Source: the staff).

	Chinook		Coho		Steelhead		Chum		Pink	
	Present	Future	Present	Future	Present	Future	Present	Future	Present	Future
Adult Production	13,500	19,351	22,000	30,146	4,000	7,344	<1,000	<1,000	<100	<1,000
Harvest Rate	0.80	0.59[1/]	0.90	0.52	0.90	0.17	____	____	____	____
Harvest	10,000	11,487	19,800	15,678	3,600	1,231	____	____	____	____
Escapement	3,500	7,864	2,200	14,468	400	6,113	____	____	____	____

1/ Rate required to provide optimum sustained yield.

Note: "____" equals unknown.

maximum sustained yield harvest rate of 52 percent (Table 4-14). Total production of coho salmon would increase approximately 35 percent to about 30,000 adults, and escapement would increase from 2,200 to about 14,500. Such production is possible if the harvest rate could be reduced from the present 90 to 52 percent (Table 4-14). The marine fishery harvest rate is approximately 80 percent and the tribal inriver harvest constitutes the remainder. Assuming the marine harvest rate could be reduced to 52 percent, no tribal harvest would be possible. The average annual tribal harvest of approximately 7,000 coho during the 1980's (Table 3-8), with an approximate annual average value of $55,000, would be jeopardized unless the marine harvest rate could be curtailed to about 29 percent, leaving 23 percent for the tribal inriver harvest. However, such a low marine harvest rate is not likely achievable.

Restrictions necessary to reduce the marine harvest to 52 percent would result in a decline in commercial catch and revenue from other coho stocks and further restrict marine sportfishing and reduce regional tourism derived from the marine sport fishery.

As with chinook salmon, the present small in-river sport fishery would likely be restricted to optimize spawning escapement.

Applicant funds would be available to support the restoration effort; however, no specific funds have been allocated for hatchery supplementation in the event restoration of a wild run is unsuccessful. The availability of Bureau of Indian Affairs (BIA) funds to continue support of the existing coho tribal hatchery is unknown.

Steelhead

Under the applicant's proposal, winter steelhead production could increase nearly 85 percent to about 7,300 adult fish (Table 4-14) if the total harvest rate could be reduced from 90 percent to 17 percent. Such a reduction is possible if the inriver tribal and sport fisheries are severely restricted. The existing tribal inriver harvest of approximately 2,000 fish valued at $20,000 per year would be reduced by about two-thirds if the harvest were split with sports fishermen as it is now. The allowable sport inriver harvest would be likewise reduced; however, since escapement upriver past tribal nets would increase nearly threefold, the opportunity for sports fishermen to catch and release winter steelhead would increase.

Wild summer-run steelhead production would increase by allowing passage to the upper watershed, although the potential for successful restoration of a wild summer run at optimal yields is considered only fair (Section 4.1.3). The existing small harvest by tribal and sports fisheries, which is supported by WDW stocking of smolts, would have to be curtailed to ensure the maximum number of adults escape to spawn. If restoration is successful, the sports fishery and local tourism

would at least benefit from the higher escapement of adult fish to the river, as it would allow a potentially high quality wild-steelhead-release fishery.

Applicant funds would also be available to support the winter and summer run steelhead restoration effort. In the event restoration fails, the availability of long-term support for supplemental hatchery production of summer and winter run steelhead by WDW is unknown. The availability of BIA funds for the tribal winter steelhead hatchery is also unknown.

Pink, Sockeye, and Chum Salmon

Under the applicant's proposal, the potential is poor for restoring runs of pink, sockeye, and chum salmon to the river (Table 4-14; Section 4.1.3). Any small harvest of these species that may be occurring at present in the tribal inriver fishery would have to be curtailed to maximize the number of adults allowed to spawn. The inriver sport fishery harvest would remain restricted even if restoration were successful.

Sea-run Cutthroat and Dolly Varden Trout

Some increase in sea-run cutthroat and Dolly Varden trout is possible under the applicant's proposal, although the outlook for restoration at maximum sustained yield is poor (Section 4.1.3). Tribal and sports fisheries are not likely to benefit from the increases because harvest would have to be limited to maximize the restoration potential. Catch-and-release or restricted harvest sport fisheries could be possible in the river, thus possibly improving the existing sea-run sport fishery.

Resident Trout Fisheries

Resident trout fisheries concentrated in the middle and upper river reaches would be negatively affected by reductions in resident populations of Dolly Varden and rainbow trout populations due to competition from anadromous salmon and trout. Overall, tourism should not be measurably affected because of the availability of anadromous fish in addition to remaining resident fish.

Overall Effect on Fisheries

Overall, the effect on marine commercial, marine sport, inriver tribal, and inriver sport fisheries under the applicant's proposal would be predominantly negative with some positive aspects. Marine commercial and sport fisheries would benefit from a small increase in Elwha chinook and coho salmon in their harvest; however, overall harvest rates would have to be reduced to protect Elwha escapement, which would result in an overall reduction in total harvest of fish from other rivers. Since a reduction in the marine harvest rates is already a management objective for regional fisheries managers, the potential increase in total harvest from Elwha fish could be a net benefit. Tribal inriver fisheries would suffer from a reduction in salmon and steelhead subsistence and commercial harvest. The inriver sports fishery would benefit from a greater availability of salmon and steelhead, although total harvest would be more restricted than at

present. Quality inriver sport fisheries could be maintained for steelhead and possibly salmon by restricted harvest or catch-and-release regulations.

The above predictions are based on long-term population equilibriums, which in most cases would require an interim period of restoration for the various wild fish runs. Over the short term, it may be necessary to severely curtail harvest to build runs to self-sustaining levels. Such interim requirements are considered a necessity in management agencies' efforts to restore wild stocks (PSC, 1989).

Tribal Social Effects

As noted above, tribal inriver fisheries would be particularly affected by the harvest reductions required to restore wild, self-sustaining anadromous fish runs. Tribal members would benefit economically only in so far as they could capture part of any increased commercial harvest of fall chinook. The overall economic implications of the harvest changes are clearly negative. Additionally, the tribe would lose the current income and employment associated with the fish hatchery if hatchery production were terminated or cut back to alleviate the potential adverse effects of hatchery production on wild stocks (Section 4.1.3). Moreover, the applicant's proposal would not provide any restoration of shellfish habitat valued by the tribe (Section 4.1.3.2).

The social implications are complex, because the social fabric of the tribe is interwoven with the economic, cultural, and religious well-being of the tribal members. Restoration of the anadromous fish runs is of great cultural and religious significance to the Lower Elwha Klallam Tribe (Section 3.10), and the measure of restoration achieved under the applicant's proposal would be significantly beneficial in that sense (Section 4.1.9). Despite this cultural benefit, the staff concluded that the overall tribal socioeconomic effect of the applicant's proposal would be significantly negative because of the adverse economic effect on a population that already has a number of social problems related to their existing poverty (Section 3.9.2).

Cost of Power

The cost of project power to Daishowa America Mill would increase substantially under the applicant's proposal. At current levels of power use, the cost of project power to the mill from 1996 through 2005 would increase from an average 17.9 mills/kWh to an average 39.0 mills/kWh (Table 2-16). The average weighted cost of power from all sources over the same period would increase from 29.9 to 38.9 mills/kWh (Table 2-18). The staff estimates that the overall cost of operating the plant would increase by about 5 percent. Such an increase in cost would adversely affect the mill's competitiveness in the market, unless other cost saving measures could be instituted. If the increased power cost were enough to affect the mill's production rate, the effect would carry through to the mill's employees

and wood chip and pulp suppliers. No data are available to the staff to permit a forecast of how mill production would be affected by an increase in operating cost. In the most extreme case, complete mill closure caused by higher energy costs would cause the loss of up to 1,200 jobs among mill employees, suppliers, and other local businesses.

Project Employment

The applicant's proposal would create a small increase in long-term employment. Fourteen persons, four more than currently employed for the projects, would be required for routine operation and maintenance, including operation of the trap-and-haul facility.

Other Effects

Overall effects on recreation and tourism would be at least slightly negative (Section 4.1.6), with a corresponding negative effect on tourist and recreation-based income. Due to data limitations, it is not possible to differentiate between the economic effects on recreation and tourism related specifically to Elwha River changes, and changes brought about by future fishery management practices associated with restoring or protecting wild fish stocks in other river systems in the Strait of Juan de Fuca and Puget Sound.

About 898 acres of forest near Lake Aldwell would be restricted from any timber harvest other than thinning, reducing its timber value. Another 6 acres of forest would be developed for recreational use, eliminating its future timber production value. No major changes in water quality or quantity are expected; therefore, there should be no effect on the cost or reliability of water supplies to the City of Port Angeles. Similarly, there would be no change in the likelihood of flooding property adjacent to the river.

The applicant's proposal would result in a continued erosion of Ediz Hook (Section 4.1.1.2). The U.S. Army Corps of Engineers has addressed this condition through periodic beach replenishment at an annual cost of about $100,000.

Taxes paid by the project to Clallam County would not be appreciably affected by the applicant's proposal.

4.1.8.3 Staff-Recommended Measures

To ameliorate adverse economic and social impacts on the Lower Elwha Klallam Tribe, the applicant should institute an affirmative action program designed to improve tribal employment opportunities associated with project construction and operation.

4.1.8.4 Unavoidable Adverse Impacts

Harvest rates in existing commercial, tribal, and sport fisheries would have to be reduced to protect Elwha escapement, which would result in an overall reduction in total harvest of coho and steelhead from the Elwha River, and chinook, coho, pink, and chum salmon from other rivers. Since a reduction in the marine harvest rates is already a management objective for regional fisheries' managers, the potential reduction in total regional salmon harvest due specifically to regulations to protect Elwha fish would be minimal. Tribal inriver salmon and steelhead subsistence and commercial harvest would decline, amplifying the tribe's existing economic and social problems. The inriver sports fishery allowed harvest would decline, although some enhancement of winter and summer run steelhead and sea-run cutthroat fisheries is possible under restricted harvest regulations.

The presence of the project dams would allow further degradation of Ediz Hook, thus requiring periodic beach replenishment to protect Ediz Hook from storm damage.

The cost of project power to Daishowa America Mill would more than double, creating a 30 percent increase in the average weighted cost of power from all sources.

4.1.9 Cultural Resources

The applicant's dam retention alternative may adversely affect the Elwha and Glines Canyon dams, which are listed on the National Register of Historic Places. This alternative has a reasonable potential of restoring four wild stocks of anadromous fish species important to Native Americans, though restoration and protection of these wild stocks would result in some curtailment of tribal in-river fishing.

4.1.9.1 Construction Effects

This alternative involves construction of new facilities at Elwha and Glines Canyon dams, which are listed on the National Register of Historic Places. At Elwha dam, planned construction includes new facilities for upstream fish passage, downstream fish passage, and recreation. Upstream passage facilities include an inclined bar rack at the powerhouse tailrace exit portals and a fish ladder with a barrier weir, entrance, and holding and sorting pools. Upstream passage facilities include modification of two gate bays and spillway gate bottom seals, installation of a new spillway gate hoist, a dc power system for spillway gate automation, 9-foot Eicher screens installed in the penstocks, a bypass pipe and vertical traveling screen facility, an open channel flume, and concrete pool-and-weir structure. New recreational facilities include three boat-in campsites on the east

side of Lake Aldwell, a project overlook with parking, and a trail to the pool below Elwha dam.

At Glines Canyon, new construction includes a barrier weir; a tailrace rack; a vertical slot fish ladder with holding, sorting, and transport pools and a fish hoist; 3,000 feet of roadway stabilization and resurfacing to accommodate the fish trap-and-haul program; improvements to the boat launch area; and installation of a dc power system for automating operation of the spillway gate.

At both dams, the new construction is compatible with existing use. Nevertheless, these changes would affect the qualities of the dams that make them eligible for the National Register of Historic Places.

4.1.9.2 Long-term Effects

Restoration of wild anadromous fish stocks would culturally benefit Native Americans. In terms of the Klallam world view, stewardship of the natural ecosystem, particularly the anadromous fishery, is of paramount importance and restoration of wild fish stocks is consistent with Klallam ideas about natural resources stewardship. Elimination of natural anadromous runs brought about by Elwha dam construction disrupted the fishery and Klallam culture, and in the view of the Lower Elwha Klallam Tribe, violated the Treaty of Point No Point. Fishery restoration would bring a restoration of treaty rights and would partly compensate the Klallam for the loss of cultural values and practices brought about by dam construction.

Under this alternative, levels of harvestable wild fall chinook salmon would increase slightly over existing levels of nonwild hatchery stock. Maintaining the wild chinook stocks, however, would require restrictions on tribal in-river fishing during the restoration period, and perhaps afterwards (under wild stock management, existing hatchery production is assumed to be stopped).

Average numbers of harvestable wild stock coho salmon would be lower under this alternative than the current numbers of harvestable nonwild coho. Maintaining this wild stock would mean curtailment or elimination of the existing in-river coho harvest, unless there were additional cutbacks in the marine harvest rate for this species.

Average harvestable numbers of wild stock steelhead under this alternative would be one-half the harvest provided by the tribal hatchery production.

4.1.9.3 Staff-Recommended Measures

The potential effects of this alternative on the National Register Elwha and Glines Canyon hydroelectric sites could be mitigated by recording the existing condition of the dams to the standards of the Historic American Engineering Survey.

If buried archaeological sites were discovered during construction, work in the immediate vicinity of the find should be halted until the applicant can evaluate the find in consultation with the SHPO.

4.1.9.4 Unavoidable Adverse Impacts

Curtailment of the in-river tribal chinook, coho, and steelhead fisheries and the concomitant loss of tribal income and subsistence fishery would be unavoidable and adverse.

VAL OF BOTH DAMS

presents an assessment of the effects associated with removal of both
lternative is described generally in Section 2.3 and more fully in
art 3.

4.2.1 Geology, Soils, and River Morphology

This alternative would result in the introduction of the natural sediment load to the middle and lower reaches of the Elwha River. If uncontrolled, the erosion of reservoir sediments could result in a significant build-up of sands in the middle and lower reaches of the Elwha, decreasing channel stability, increasing flood risks, and reducing fish spawning habitat. The precise magnitude and areal distribution of aggradation would depend primarily on how fast and how much of the stored reservoir sediment is released.

Storage and reduced erosion of the reservoir sediments can be achieved by controlled erosion and excavation of a stable floodway and channel through the reservoir sediments during regulated drawdown, prior to removal of the dams. This excavated channel would replicate as closely as possible the pre-project river as shown in lake sediment surveys and on historical maps of the river. The excavated sediments would be stabilized within the reservoirs by placing them on existing broad, low-angle terraces along the river channel (Figures A-29 and A-33 in Appendix A). Aggressive erosion control and vegetation programs would be required to reduce surface erosion. Side slopes have been designed to a 4:1 slope in the sandy delta deposits and 15:1 for the lake bottom silts to preclude large-scale mass-failures. The excavation and terracing of sediment would be carried out in phases over a 3-year period at Glines Canyon prior to total dam removal, at progressively lower water levels, so that most of the delta sediment eroded from the upper part of the reservoir basin would settle out in the remaining reservoir to be excavated and stabilized on the terraces. Excavation and terracing of sediment would be carried out in 2 years in Lake Aldwell prior to dam removal. The primary loss of sediment from the reservoirs during removal would be in the form of sediment so fine (silt and clay) that very little would settle in the slow-moving reservoir water or in the higher-velocity flow in the middle and lower reaches of the Elwha River. Most of the fine sediments would be transported through the river system to the coastal zone.

4.2.1.1 Construction Impacts

Removal of the Elwha Project and Glines Canyon Project would take place over a 5-year period. The construction sequence is summarized in Table 4-15 with further details presented in Appendix A, Part 3.

Table 4-15. Construction sequence summary for dam removal (Source: the staff).

Season	Activity
Season 1	Construct Glines Canyon river bypass tunnel and control gates. The lake tap could be constructed the same year as the initial drawdown (step 2 below).
Season 2	Move equipment onto the Lake Mills delta and build levees to train the river to the west side of the delta. Lower Lake Mills to 510 elevation with the bypass tunnel. This would result in incision of the delta, and the deposition of a new delta with its head at the 510 to 520 level (the 520 delta). Rapid incision of the river would move much of the sediment on the west side of the delta to the middle and lower end of the reservoir. This eliminates the need to mechanically move the sediment down the reservoir where storage area is available. A drawdown rate of 1 to 2 feet per day starting in April is proposed. Dredge and grade the exposed portions of the Lake Mills delta on the east side of the valley to provide stable slopes; seed, mulch with erosion control blankets on the slopes, and plant trees. Construct the Lake Mills bypass channel (Figure A-32). Construct the Elwha Project bypass tunnel, lake tap, and control gates.
Season 3	With the Lake Mills bypass tunnel in operation, progressively lower the lake level an average of 1 to 2 feet per day from the 510 level to elevation 460; excavate the new river channel; grade stable slopes

Table 4-15. Construction sequence summary for dam removal (Continued) (Source: the Staff)

Season	Activity
	and tributary channels; seed, mulch and plant trees. Place excavated delta material on the exposed, natural terraces. Place sediment excavated from the 520 delta on the Lower Hurricane and Boulder sediment storage terraces (Figure A-33). With the Lake Aldwell bypass tunnel in operation, progressively lower the lake level 1 foot per day from the 188 level (project datum) to nearly empty, leaving a small ponded area to trap sand in the lower end of the reservoir. Excavate the new river channel progressively moving down the reservoir as the water level is lowered; grade stable slopes; seed, mulch with erosion control blankets, and plant trees. Place excavated delta material on the exposed natural terraces (Figure A-29).
Season 4	Progressively lower the Lake Mills level 0.3 foot per day from the 460 level to nearly empty, leaving a small ponded area to trap sand in the lower end of the reservoir. As the reservoir is lowered, the river will erode a channel through the lake bottom sediments. A barge loaded dredge will help control the river locations. Working from the stable channel area, excavate the final grade for the new channel; grade stable slopes and tributary channels; seed, mulch with erosion control blankets, and plant trees. Continue Lake Aldwell sediment stabilization in the lower end of the reservoir.
Season 5	Remove Glines Canyon and Elwha dams and associated structures.

Tunnel Construction

Groundwater seeping from the reservoir through joints in the bedrock would likely be encountered during tunnel construction. Dewatering for construction of the tunnel would transport fine sediment created during drilling, blasting and excavation of rock. Sand-size and larger sediment would be contained on the construction site with standard erosion control methods.

Dam Removal

Dam removal for all but the foundation area would be in the dry, thereby permitting containment and control of erosion to the river. Removal of the dam would require drilling, cutting, and blasting activities that would generate some fines and sand but would primarily create 1- to 4-foot concrete fragments which would be excavated and stockpiled off-site.

Lake Drawdown and Sediment Stabilization

Clay and most of the silt that is suspended during lake drawdown and sediment dredging would pass through the lowered (or partial) Glines Canyon reservoir and Lake Aldwell downstream to the coastal zone. Clay and silt would tend to stay fully suspended in the high gradient energetic flow in the middle and lower Elwha River channel. Up to 1,000 cfs of flow would be bypassed around the Lake Mills work area to dilute turbid flow from the Glines Canyon bypass tunnel.

During the active drawdown and construction periods, March to October, it is anticipated that response of the Elwha River to the high loads of suspended sediment would be very similar to glacial streams, except that only silt and not large amounts of sand and gravel would pass downstream. Sand and gravel would be trapped in the lowered reservoirs and be dredged to storage locations on the terraces. At present, the Elwha River has only minor contributions from glacial meltwater relative to snowmelt, surface runoff, and shallow groundwater.

As is observed in glacial streams, a layer of fine sediment builds up on portions of the bed and on channel bars during periods when suspended sediment supply is high. During highly turbid periods, silt and clay is deposited and resuspended from the bed as flow turbulence constantly varies. In glacial streams, summer runoff is very turbid with high suspended sand and silt concentrations between 150 and 35,000 tons per day (600 and 17,000 mg/l) and typically between 1,000 and 2,000 mg/l (Fahnestock, 1963; Stoker, 1988). Sand and silt drapes the flood bars, terraces, and channel banks and accumulates in the lower velocity portions of the channel. HEC-6 modeling of the reservoir response to erosion of the delta (without dredging) indicates concentration levels of 400 to 3,500 tons per day in the lower Elwha (U.S. Army Corps of Engineers, 1990).

Limited intrusion beyond the pavement layer would occur in the Elwha River because the coarse pavement material is not moving at flows of less than about 9,000 cfs. Observation of the channel conditions during the 500 to 12,000 cfs flood discharges of 1989 (James River II, February 1990j) indicates the threshold for cobble transport and high bedload transport rates is between 5,000 and 9,000 cfs. At these flows, clay and silt transport is so aggressive that typically only a fraction of a percent remains mixed in the sub-pavement material. For example, the sub-pavement samples from the upper Elwha River only have between 0.8 and 1.8 percent silt and clay (less than 0.06 mm). The fines are mostly stored in the water column as they flow downstream, whereas the sand, gravel and cobbles spend most of their time sitting on the bed waiting for high flows to move them further downstream.

During the winter months, on glacial and snowmelt streams such as the Elwha River, the sediment supply from glacial activity and snowmelt is reduced because of freezing watershed conditions. The high suspended sediment supply rate and suspended sediment concentration fall in the winter months. Between the active reservoir drawdown seasons, during November to February, the fine grain sediment supply rate would be reduced to levels of about 400 to 800 tons per day. Fine sand and silt temporally stored in the Elwha substrate armor layer would be flushed downstream to the coastal zone during winter flood flows.

One aspect of the construction phase sediment conditions that contrasts with the glacial runoff analogy is that the Elwha River experiences its lowest flows during the later half of the traditional summer/fall northwest construction season, whereas glacial streams experience intermediate flows during high sediment concentration periods due to glacial meltwater and high elevation snowmelt. This would lead to increased deposition of fines on the bed during the low-flow periods of August through September.

When reservoir drawdown is completed, a stable channel established, and mulch and vegetation applied, the supply of sediment from the reservoir would be about the same as other sediment sources in the watershed. For example, the high cliffs in the lower half mile of the Elwha are about 2,000 feet long by 100 feet high. Ravel from the cliffs builds a deposit at the foot of the cliffs that is typically wedge shaped, about 5 to 10 feet high by an equal width. An armor on the portion in the channel indicates flow levels of the recent past. Some of the deposit can wash away in small floods but it is not until the flood is large enough to move the armor (5,000 to 9,000 cfs) that the cliff deposit could all wash away. Floods of 10,000 to 20,000 cfs occur about every year and could wash most of the cliff deposit away which would be equivalent to 4,000 cubic yards or 3,000 tons per day. This would be equivalent to an average thickness of a few inches to a foot of ravel each year from the cliff.

Another example of an existing natural source of sediment supply is the debri slides and ravel off the high cliffs of glacial Lake Elwha sediments on the southwest end of Lake Mills. A wedge of colluvium at the base of the cliffs eroded by floods supplying sediment to the left bank channel of the Lake Mil delta. It delivers sand and gravel to the river which at present remains in the lake. The new sediment storage terraces would develop channel banks similar to the two sediment sources mentioned above.

Erosion from the Lake Mills sediments would go through 3 phases: (1) active construction phase with intensive erosion and dredging in the reservoirs; (2) construction phase without active work in the reservoirs during the winter months; and (3) near-term post-dam removal.

Construction Phase With Intensive Erosion and Earth Moving Activity in the Reservoirs

Sediment would be introduced into the river from active dredging of the channel, rapid main and tributary channel erosion, rilling, sheetwash erosion, and slumping of terrace material into the river. Active dredging in and near the channel would stir up sand, silt, and clay with most of the silt and clay washing downstream to the coastal zone. Rapid channel erosion of delta and lake sediments would occur with cobbles, gravel, sand, and 20 percent of the silt that is suspended remaining in the partially lowered reservoir and most of the suspended silt and clay flushing downstream. During season 2, as the Lake Mills delta erodes, about 30,000 cubic yards of delta sediment would be reworked by erosion and dredging. Five to ten percent is silt and clay which would tend to remain suspended in the partially lowered reservoir. About 20 percent would settle in the partially lowered reservoir and 80 percent would wash downstream.

The HEC-6 model indicates sediment transport rates downstream of between 1,000 and 1,500 tons per day, or about 300 to 500 mg/l, for typical discharge rates for the summer work season. The partial reservoir, in place during all but the last months of the fourth construction season, would trap all of the boulder through sand-size material from the natural upstream sediment supply and the reservoir construction activity. When the bypass channel is constructed in the Lake Mills reservoir following drawdown to the 510-foot level, erosion of the new river channel through the lake bottom and delta sediments would be controlled because much of the river water would be diverted around the active work area.

Windy periods during active work on the terraces would create elevated dust levels in areas of exposed soils.

Construction Phase Without Work Activity in the Reservoir

During the winter season, active and passive erosion control measures would maintain erosion to levels similar to other sediment sources in the watershed. Winter period erosion from the exposed terraces would be very high if substantial

mulching, matting, and seeding are not aggressively applied and maintained. With a reasonable erosion control program, erosion from the stored sediments can be maintained to a scale comparable to natural sediment supply to the river.

Winter downstream transport rates through the reservoir would be dominated by the passage of silt and clay from the natural upstream sediment supply. The lowered reservoir would trap all of the boulder through sand-size material from upstream and reservoir sediment erosion. Additionally, the partial reservoir would trap about 20 percent of the silt and 1 percent of the clay.

HEC-6 model results indicate the transport rates would not be extreme compared to typical natural conditions. The silt and clay deposits that had been deposited on the downstream bed from high suspended loads during the construction season would flushout because of elevated winter discharges and the reduced winter supply of sediment. Occasional slumps along the channel as it migrates during the winter would introduce periods of increased turbidity. Sand and about 20 percent of the silt suspended from slumps would remain in the partial reservoir, with most of the silt and all of the clay flushing downstream to the coastal zone.

Near-Term Post-Dam Removal

During the near-term period of 4 to 10 years following the dam removal, new vegetation and soil litter would have begun to develop. The new channels would be forming in the main river and tributaries, forming new bars, pools, riffles, channel and bank armor layers, all gradually reaching typical stability levels as armor and woody debris become established. Heavily harvested foothill areas (low to moderate slopes) in the project region would generally recover, in terms of vegetation and litter effects to runoff response, in 4 to 10 years. During this period the supply of silt, sand, and gravel from the new Elwha terraces would gradually decline from an estimated 1,000 tons per year to 500 tons per year (estimate based on twice the average upstream sediment supply rate per square mile and the Universal Soil Loss Equation, Goldman et al., 1986).

In the 3 or 4 years after dam removal, the bar tops and channel bed would have more sand and suspended load would carry more fine sand to silt size material. As the terraces and new channels stabilize, the sand supply would quickly be dominated by the natural upstream sediment supply, and the sands temporally stored in the channels would flush downstream in a few winter seasons. Conditions on the terraces and in the channel would approach a stability level comparable to conditions upstream or pre-project within 4 to 6 years.

The new Elwha River channel in Lake Mills and Lake Aldwell would migrate laterally over time eroding sand and silt from the new terraces. As coarse bed substrate and woody debris develop into an armor layer, lateral migration would tend to occur only during floods. Even though the new terrace slopes are

designed against mass failure in saturated conditions, undercutting the toe of the slope at meander turns would cause some slumping.

To assess what could occur as the worst case, it was assumed that a wedge-shaped slump, similar to those observed during the drawdown erosion test on the Lake Mills delta (James River II, 1990j), occurred along each meander turn in the new Elwha River channel in Mills reservoir. This was estimated to be 7 slumps for a total distance along the channel of 6,200 feet that averaged 30 feet in depth and 250 feet back from the channel floodway edge. Assuming the slumps would occur during a 5,000 or 10,000 cfs flood (1 to 2 year recurrence interval flood) and all slumps would occur within a 24-hour period, sediment transport from the Lake Mills area would be similar in magnitude to the estimated sediment discharge from the upper Elwha in a 2 to 5 year recurrence interval flood, 100,000 tons per day or 86,000 cubic yards per day.

With the natural upstream sediment supply combined with the slump inputs, sand and silt transport would be at the maximum carrying capacity of the stream, and deposition of sand and gravel in the slower velocity zones would be occurring. Sediment concentrations on the order of 7,000 to 14,000 milligrams per liter could be expected. Dunes and ripples of sand would be actively moving downstream with heavy turbulence and suspended load from the very high flood discharges.

Following a large flood there is always a lot of bank slumps and downed trees, which supply the river with sediment and additional structure, and there would be two distinct changes. First, there would be 2 to 5 feet of gravelly sand deposited on the tops of the bars and edges of the channels. These are typical deposits for rivers which at present are noticeably missing from the middle and lower Elwha reaches. Second, a portion of the cobble to boulder bedload material stored in Rica Canyon would move downstream and be strewn out along the channel. Channel dredging would contact the old Elwha channel and terrace deposits exposing sandy gravelly cobbles and gravelly sands, respectively. In a large flood the channel would find its new form as the flood bars of cobbles, boulders, and trees develop. The large rocks and trees move sporadically in the peak floods and often accumulate in piles 2 to 10 feet thick (channel deposits) with much of the sand and gravel flushed from them.

Elwha Project

Most aspects of the Elwha project tunnel construction, reservoir sediment stabilization, and near- and long-term impacts are similar to those previously discussed for removal of the Glines Canyon Project. Lake drawdown and sediment stabilization for Lake Aldwell would be similar to the Glines Canyon Project except there is far less sediment to deal with, 4 million cubic yards compared to 11 million in Lake Mills. Lake drawdown is proposed for the third work season, at 0.5 to 1 foot per day. The Lake Aldwell delta is only 20 feet

thick and lake sediments are only 1 to 6 feet thick. Clay and silt suspended during the summer construction season would pass out of the lowered reservoir downstream to the coastal zone. A small reservoir to trap sand would be maintained for the fourth season of construction to trap sand arriving from the Glines Canyon Project area and from the newly formed channels in the Aldwell reservoir area.

Elwha dam removal for all but the foundation area would be in the dry, permitting containment and control of erosion to the river. Removal of the dam would require drilling, cutting, and blasting activities as in the Glines Canyon Project. Concrete fragments would be excavated and stockpiled.

4.2.1.2 Long-Term Impacts

Elwha River

Both the Lake Aldwell and Lake Mills areas would have 10 to 70 foot thick (mostly 30 foot) deposits of sand and silt on the existing terraces. Over hundreds of years, the Elwha River would migrate within the valley eroding portions of the terrace deposits. Terrace remnants, as with natural terraces, could remain for thousands of years. Increased sediment loads from the natural upstream sediment supply and from construction and near-term erosion would aggrade the bed 2 to 5 feet and increase the channel migration rate. Channel substrate would contain 10 to 20 percent more sand and gravel and channel surface armor would contain more gravel. Channel flood levels for the 200-year recurrence interval flood could be an average of 2.5 feet higher, possibly threatening several structures and the upper one-half mile of the lower Elwha levee.

Within an estimated 4 to 10 years, as the stored reservoir sediment and new channels mature, the Elwha River sediment supply would be fully dominated by the much larger supply rate from upstream. The natural sediment supply would increase channel activity and develop substrate conditions similar to the reaches upstream of the project such as upper Rica Canyon and Press Valley. Increased amounts of fine sand to gravel would deposit on the channel bars and terraces. Shoaling of sand to cobble size material would develop coastal bars at the river mouth similar to conditions shown on the 1926 NOAA map of the Elwha delta (James River II, 1989, Appendix 5, Attachment 4).

The channel substrate composition and channel activity would rapidly approach pre-project conditions following dam removal and development of forest cover and channel armor. River systems generally recover from extreme sediment events within 2 to 7 years from the time of reduced sediment supply (Pfeifer and Fletcher, 1976; Platts et al., 1989; Platts and Megahan, 1975; Thomson, 1988; Knutzen et al., 1978). With careful planning and detailed erosion control and

vegetation plans, recovery of the Elwha River to levels comparable to upstream conditions is estimated at 2 to 4 years following the construction period.

Following dam removal and near-term stabilization, channel substrate in the middle and lower river would have between 10 and 20 percent sand in the subpavement, approaching conditions above Goblins Gate (RM 18), compared to about 5 percent sand at present. The channel, because of the restored sediment supply, would be more active. Channel bars and overbank deposits would grow at increased rates causing more channel shifting, increased bank erosion, and more channel diversity because of large woody debris, natural levees, and more active side channels. The height of the mid-channel and point bars and the depth of the pools are typically 5 to 10 feet. As the pools, riffles and flood bars become more active and shift more often, the bed elevation at any given point would be changing on the same scale, 5 to 10 feet.

The new channel would migrate laterally and erode the old terrace edges in the reclaimed reservoirs, except now the old terraces in the upper reservoir areas would have an additional 20 to 30 feet of sediment on their tops. Erosion into the terraces would be most active during floods when the armor layer is moved. The sediment stored on the terraces would, on a scale of hundreds of years, be eroded and moved downstream much like the sediment stored on the old natural terraces have responded. Erosion of the silt terraces of the middle and lower reservoir areas would increase suspended sediment the most.

Increased sediment transport through the river means more sediment would be stored on the bar tops and in the channels. The average bed elevation could rise from 1 to 5 feet (average of 2.5 feet in the lower 2 miles of the river) because of the increased in-channel storage of sediment. Along the lower section of the lower Elwha set-back levee, the water surface elevations for the 200-year recurrence interval flood (56,000 cfs) would be 0.5 to 1 foot higher, well within the freeboard limits of the levee. Along the upstream section of levee (RM 1 to 1.5), the floodway is constrained and a hydraulic control at RM 1 backs up flow in a pool. Because of the deeper slower water, 3 to 5 feet of deposition is predicted to occur, based on the HEC-6 model. Flood protection here would be reduced to about a 30,000-cfs flood. The levee would need to be raised an average of 5 feet to maintain present flood protection and levee freeboard.

Coastal Zone and Ediz Hook

Sediment supply to the coastal zone would be increased by an average of 209,000 cubic yards per year. Sand, gravel, and cobbles would deposit at the mouth of the Elwha creating barrier bars that would be worked by the tidal, wave, and river currents. Sediment supply to the Angeles Point and Ediz Hook areas would increase. Supply of the bedload sediment (sand, gravel, cobbles, and boulders) has been greatly reduced by dam construction from about 150,000 cubic yards per

year to 2,400 cubic yards per year. This has affected the coastal zone by reducing the total sediment supply by 36 percent. The present supply of sediment from erosion of the coastal bluffs between the Elwha River and Ediz Hook is estimated at 40,000 cubic yards per year (U.S Army Corps of Engineers, 1971). Return of the bedload sediment supply from the Elwha would increase the total supply rate to 190,000 cubic yards per year which is about one-half the supply rate prior to construction of the dams and armoring of the bluffs. With this alternative, bedload sediment supply would be returned to the coastal zone and begin to contribute to the Ediz Hook supply rate within 10 to 20 years. Eventually, beach nourishment of the Ediz Hook area would no longer be needed.

4.2.1.3 Staff-Recommended Measures

Dredging and grading new channels and terraces would not by itself stabilize any of the reservoir sediment. Development of detailed plans, specifications, and contracts for grading, drainage, erosion, sediment control, revegetation and near-term maintenance plans would be required to stabilize the reservoir sediments.

Detailed geotechnical explorations should be conducted at both projects for the diversion tunnel alignments and lake tap areas, and for the bypass channel alignment at the Glines Canyon Project, as a basis for the development of detailed designs for the diversion facilities. These facilities must be capable of dependable operation throughout the construction period.

Return of the natural upstream sediment supply would impact the frequency with which civil works along the river are in jeopardy of damage. Several structures, (the fisheries spawning channel, industrial water supply intakes, and the lower Elwha setback levee) would be impacted by the new channel conditions. Increased channel shifting would move the main channel into the vicinity of the lower Elwha levee more often, necessitating additional maintenance. Channel aggradation between RM 1 and 1.5 would reduce flood protection from about 56,000 cfs to about 30,000 cfs. To maintain current levels of flood protection, the levee would need to be raised an average of 5 feet along the upstream one-half mile of the levee, at a cost of approximately $570,000. NPS facilities at RM 12.25 would be at risk from large floods, channel bank erosion, channel shifting, and elevated flood levels. Design details of modifications to these operations and facilities should be prepared and conducted as a part of the dam removal alternative.

4.2.1.4 Unavoidable Adverse Impacts

Even with the best construction period design and control measures, and return of the natural upstream sediment supply after construction, increased rates of sediment supply and transport would occur leading to high sediment concentration

levels far more often than at present. Modifications to the fisheries spawning channel operations, the Port Angeles industrial water supply treatment systems, and the lower Elwha set-back levee would be needed to meet present operating requirements.

4.2.2 Water Quantity and Quality

Suspended sediment concentrations would be substantially increased in the Elwha River below Glines Canyon dam following drawdown of Lake Mills and Lake Aldwell, during excavation and stabilization of the river channel in each reservoir, and during periods of high flow in the late fall and early winter. Turbidity values in the river would be adversely impacted by increased suspended sediment loads. High turbidity levels would occur for relatively short periods of time, ranging from several hours to many days. Suspended sediment and turbidity values would gradually decrease following the construction period due to stabilization of the river channels in the Lake Mills and Lake Aldwell reaches. Turbidity levels in the middle and lower reaches of the river would be moderated by a turbidity management plan, which would include using reservoir storage capacity during peak flows to prevent high suspended sediment loads from entering the lower river, and the operation of a bypass channel at Lake Mills which would lower suspended sediment concentrations in reservoir release waters during summer construction periods.

Increased turbidity would have an adverse impact on industrial water supplies, and a potentially adverse impact on domestic water supplies for the City of Port Angeles. Organic matter concentrations, bacterial levels, and nutrient concentrations would significantly increase in the river during and following dam removal. Dissolved oxygen concentrations would be adversely impacted in Lake Mills and Lake Aldwell during summer construction periods, but would not be affected in the middle and lower reaches of the river.

Water temperatures in the river would largely benefit from removal of both dams, and would be lowered by 2 to 4°C during summer low-flow periods in comparison to existing conditions. The Elwha River would assume a natural, run-of-river pattern of discharge following dam removal.

4.2.2.1 Construction Impacts

Water Quantity

River discharge would be moderated during the 5-year dam removal period by reservoir drawdown during summer low-flow periods, and by reservoir storage during peak-flow periods. Discharge moderation would substantially decrease after removal of Glines Canyon dam after the fourth project year.

Drawdown of Lake Mills would start in April during the first year of the dam removal project schedule. During the 3-month drawdown period, discharge would increase an average of 139 cfs below Glines Canyon dam. Increases in discharge at this same level would also occur for a 2-month period during the second and third year of construction. Prior to removal of Elwha dam during the fourth project year, Lake Aldwell would be drawn down over a 7-month period, also beginning in April. During drawdown, outflows from Lake Aldwell would exceed inflows by an average of 31 cfs.

Gated diversion tunnels constructed to allow drawdown of Lake Mills and Lake Aldwell would provide considerable flexibility in maintaining either a constant discharge or a constant pool elevation. Flexibility in pool operation would allow for release of minimum flows when required during critical low-flow conditions, and for a constant minimum pool elevation during dam destruction.

Storage capacity in each reservoir during construction (resulting from the drawndown condition) would minimize impacts of flood events in Lake Aldwell and middle and lower reaches of the river during the construction period. Reservoir storage would provide protection for up to a 50-year flood event. A pool elevation fluctuation exceeding 100 feet would be expected in Lake Mills during the construction period based on historical river discharge patterns. Lake Aldwell, which has far less storage capacity than Lake Mills, would be expected to reach a full pool elevation given a 2-year flood event or greater.

Water Quality

Construction and subsequent removal of the Elwha and Glines Canyon dams would result in adverse impacts to the water quality of the Elwha River. Construction would result in temporally high turbidity levels during the summer channel excavation and stabilization period. High turbidity levels would be minimized by a suspended sediment management plan, which would include storage of waters in Glines Canyon dam during summer and winter storm runoff periods, and the use of a bypass channel to route relatively clean inflow waters around the Lake Mills construction site. Following removal of both dams, high concentrations of suspended sediments would be expected during winter high-flow periods. Suspended sediments would be largely derived from silt and clay deposited on river banks, and within the river bed, during the construction phase of the project. High turbidity levels would result from high suspended sediment loads during and after dam removal.

High turbidity levels would adversely impact water diverted for industrial use and the WDF fish rearing channel, and could potentially impact waters diverted by the City of Port Angeles for domestic use, and by the Lower Elwha Klallam Tribe for their fish hatchery. Organic matter concentrations in the river would be elevated in association with transport of lake sediments. Increased biological oxygen

demand (BOD) and bacteria densities (coliform and non-coliform) would result from increased organic matter loads into the river. Nutrient concentrations would also increase in association with high suspended sediment loads.

Water temperature regimes in the river would benefit from dam removal, and would be on average 2 to 4°C lower during summer and early fall low-flow periods.

Construction impacts, including installation of diversion tunnels and dam demolition, would introduce concrete wastes into the river. Potential oil, diesel, and chemical spills from use of heavy equipment during dam removal would adversely impact water quality, and would potentially threaten potability of city water supplies; effective implementation of monitoring and control programs would limit the extent of these effects.

Incision, bank degradation, and mobilization of reservoir sediments stored behind Glines Canyon and Elwha dams would result in extremely high loads of suspended sediments in waters flowing through the Lake Mills, middle, Lake Aldwell, and lower reaches. High suspended sediment loads would be transitory in nature, and would be sustained for a period of time ranging from several hours to several days. High turbidity levels would occur during the initial release of water from the diversion tunnel at Lake Mills and Lake Aldwell, during initial and final drawdown of each reservoir, and during fall and winter storms immediately following each summer construction period. For winter storm events, high suspended sediment loads would be expected to occur for peak discharges exceeding 3,000 cfs. A flood event of this magnitude is equaled or exceeded 10 percent of the time on a daily basis on the Elwha River (staff analysis based on USGS gaging records at McDonald Bridge). Consequently, adverse sediment loads during the dormant seasons (October through February) of the multi-year construction period would be expected to occur for approximately 35 days per year. Sediment loads during storm runoff periods would appreciably decrease during the later years of the construction period, which would result from channel stabilization in the Lake Mills and Lake Aldwell reaches.

Based on HEC-6 model predictions (Section 4.2.1), suspended sediment loads of 300 to 500 mg/l would be expected to occur throughout the summer construction period. These values for suspended sediment concentration would also apply to peak winter storm runoff periods during the 5-year dam removal period. Suspended sediment loads would remain consistently high in the Lake Mills, middle, Lake Aldwell, and lower reaches of the river. This would occur because silt and clay derived from lake sediments would remain in suspension throughout the entire river. Suspended sediment concentrations would only be slightly reduced (< 20 percent) due to settling of silt in reservoir waters retained behind Elwha dam and Glines Canyon dam during the construction period (Section 4.2.1).

Turbidity would be adversely impacted by increased suspended sediment loads. Turbidity values of 100 to 200 NTU would be predicted to occur during the dam removal period, and would change in direct proportion to suspended sediment loads. These turbidity levels would be significantly higher than peak turbidity values of 70 NTU currently existing in the Elwha River (USGS water quality records), and would consequently violate state water quality standards. State standards require that turbidity values not exceed 10 percent of natural values [Washington Administrative Code, 1989 (WAC Sec. 173-201-045)].

Increased turbidity following dam removal would substantially degrade water diverted for industrial use by the City of Port Angeles and to the WDF fish rearing channel. Water diverted for municipal use by the City of Port Angeles would probably not be affected by increased turbidity values, due to the considerable filtration and hydraulic isolation provided by a 55-foot-deep riverbed, above the city's Ranney collectors are. Sand layers packed around the Ranney collectors would provide further filtration capabilities. State health department criteria for drinking water would be violated if domestic water supplies acquired from these collectors increased beyond 1 NTU [Washington Administrative Code, 1989 (WAC Sec. 248-54-175)]. The municipal water is presently unfiltered, and only treated by chlorination prior to use (Washington Department of Ecology, 1989). Because of chlorine sorption by sediments, higher turbidity values in the city's water supply would result in a need for additional chlorination to meet disinfection requirements.

The city's Ranney collectors could potentially be blocked by high sediment loads and require backflushing to clear intake pores. High turbidity values would also require higher maintenance and backflushing cycles of water filtration systems employed by industrial users, including ITT Rayonier and Daishowa America, who must filter water obtained from the Elwha River.

Particulate and dissolved organic material residing in lake sediments would be increased in direct proportion to suspended sediment concentrations. The organic matter content of Lake Mills and Lake Aldwell is relatively low, due to the pristine condition of the Elwha River watershed. Assuming an organic matter concentration of 5 percent in lake sediments, organic matter loads in the river following dam removal are predicted to be 0.3 mg/l at 500 cfs, 0.6 mg/l at 1,000 cfs, and 61 mg/l at 10,000 cfs.

High organic matter concentrations would result in increased BOD levels. Increased BOD levels would have an adverse impact on the quality of water retained behind Glines Canyon dam and Lake Aldwell during construction. Dissolved oxygen concentration would be expected to decline below 5 mg/l during low-flow summer construction periods due to lack of adequate reservoir flushing. Anaerobic conditions would potentially occur in Lake Mills if all inflow water was routed around the reservoir by the diversion channel during the dam removal

period. For this reason, a sufficient level of flow would be diverted through waters remaining in Lake Mills to maintain dissolved oxygen concentrations during construction. BOD levels would not result in decreased dissolved oxygen values in the river below Glines Canyon dam because of the reaeration provided by turbulent water flow in the middle reach.

Inmatter concentrations would result in increased aerobic bacterial production in the river below Glines Canyon dam. Increased dissolved organic matter concentration may also pose a health problem to domestic water obtained from the river, since chlorination of water contaminated with organics can result in formation of carcinogenic trihalomethanes and other halogenated hydrocarbons.

Higher nutrient concentrations, particularly phosphorous and ammonia, would result from mobilization of lake sediments into the river. Consequently, increased populations of periphyton would be expected in the middle and lower reaches of the river. Increased phytoplankton growth would also be expected in Lake Aldwell. However, because of the rapid flushing of this lake, algae would not be expected to grow to nuisance levels.

During the drawdown phase of dam removal, slightly decreased water temperatures would occur in the middle, Lake Aldwell, and lower reaches of the Elwha River. Temperatures would decline below existing conditions for two reasons. First, drawdown would augment discharge in the river, resulting in a decreased travel time of water in each reach during low-flow periods. Since water would be exposed to air temperatures for a shorter length of time at higher flows, it would not heat as much. Second, the surface area of each reservoir would be substantially reduced with lowered pool elevations. Reduced surface areas, in addition to a shorter residence time of water in the reservoirs at lower pool elevations, would result in less heating from warm air during the summer and early fall.

4.2.2.2 Long-Term Impacts

Water Quantity

With removal of both dams, discharge of the Elwha River would achieve a true run-of-river pattern of flow. Flow augmentation would not be possible during critical low-flow periods due to the lack of storage currently provided by Lake Mills. Consequently, extremely low minimum flows (<200 cfs) would occur during drought conditions in the lower reach below the City of Port Angeles' water diversion at RM 3.1.

Water Quality

Suspended sediment concentrations would continue to remain high for approximately 3 years following removal of Glines Canyon dam, whose reservoir would be the principal contributor of sediments into the middle and lower reaches of the river. Sediment concentrations would gradually decline due to stabilization of the newly developed river channel in the Lake Mills and Lake Aldwell reaches. River banks along the middle and lower reach, in addition to the reclaimed terraced slopes of the Lake Mills and Lake Aldwell reaches, would serve as a source of sediments to the river for an extended period of time. Suspended sediment concentrations would be approximately the same as those encountered for glacial rivers in the region (Section 4.2.1). Ultimately, suspended sediment concentrations in the Lake Mills, Lake Aldwell, and middle and lower reaches would be the same as those currently observed in the upper river. Turbidity values in the river result from clay and silt fractions, which are currently held in suspension and subsequently pass through Lake Mills and Lake Aldwell. Consequently, long-term turbidity values in the middle and lower reaches of the Elwha River after dam removal would not be significantly different from currently existing conditions. Erosion of silt terraces in the Lake Mills and Lake Aldwell reaches during flood events could add substantially to already expected high natural silt and clay loads.

Particulate organic matter (POM) would increase in Lake Aldwell, and middle and lower reaches of the river. Transport of POM from upper reaches of the river is currently interrupted primarily by settling in Lake Mills. In addition to POM, additional organic matter would be added to the river on a seasonal basis by salmon and steelhead trout carcasses after dam removal.

Maximum daily temperatures would slightly increase over existing conditions in the river below Glines Canyon dam from mid-July to mid-August (James River II, 1988f; staff analysis). Lake Mills currently provides limited cooling of inflow waters during this period as a result of mixing with cold water remaining in the reservoir from spring and early summer snowmelt runoff.

Water discharged from Lake Mills into the river below Glines Canyon dam also comes from deeper, cooler waters of the reservoir.

From the middle of August to early November, maximum daily water temperatures in the river below Glines Canyon dam would be from 2 to 4°C cooler than existing conditions (James River II, 1988f; staff analysis). Cooling would be greater in September and October, with particular importance for salmon egg survival (Section 4.2.3.2). Cooler water temperatures would result from an absence of reservoir heating, and from the lack of heat storage provided by Lake Mills.

Daily water temperature fluctuations in Lake Mills and the middle and lower reaches would increase due to a lack of mixing of inflow waters currently provided by the two reservoirs. Mixing of inflow waters in Lake Aldwell would minimize temperature fluctuations in Lake Aldwell and the lower reach.

4.2.2.3 Staff-Recommended Measures

The staff recommends a water quality monitoring program during the 5-year construction period and the 3 years following dam removal. Water temperature and dissolved oxygen should be measured daily in the reservoirs during the construction period. If water temperature and dissolved oxygen exceed state water quality standards, additional flow should be provided (if available from bypass channel) through the reservoir. Turbidity should be measured in the reservoir, middle and lower reaches during the 5-year construction period and the 3 years following dam removal. Organic matter concentration should be monitored in the lower reach near the municipal water supply intake during the 5-year construction period and the 3 years following dam removal. The monitoring program should be developed in consultation with the JFWA and municipal and industrial water users.

4.2.2.4 Unavoidable Adverse Impacts

Treatment of domestic water supplies could be necessary to prevent degradation of potable water during the 5-year dam removal period. Municipal water supplies for the City of Port Angeles are obtained from Ranney collectors which are located in gravels and sand approximately 60 feet below the river channel. In addition, the city's Ranney collectors are lined with sand. Consequently, sediment loads in the city's municipal water supply should increase only slightly under dam removal alternative, and a need for additional filtration facilities is not anticipated. Water quality treatment costs would be expected to increase, however, due to the need for increased chlorination when turbidity levels increase, and for increased backflushing of Ranney collectors. Increased operation and maintenance costs incurred by the city would be approximately $30,000 per year with an initial capital cost of approximately $100,000 (Culp et al., 1986).

Increased sediment loads in the Elwha River under the dam removal alternative would result in substantially increased water treatment costs for industrial water users, as a consequence of their diverting surface water. Increased treatment costs would be greatest for the ITT Rayonier pulp mill and Daishowa America papermill since these two plants use a majority of the water diverted from the Elhwa River for industry. ITT Rayonier currently uses between 25 and 35 million gallons per day, while Daishowa America uses approximately 10 million gallons per day. Both plants currently treat water obtained from the Elwha River prior to use. ITT Rayonier has more stringent water quality requirements, and consequently a more extensive treatment facility, because its wood pulp products

are used as a food product (e.g., toothpaste and diet drinks). ITT Rayonier has a mixed-media water treatment facility in which water is first subjected to polymer and alum flocculation in a settling basin for clarification and, then, run through a coal filter bed to remove remaining impurities (e.g., dissolved organic matter) (personal communication, Brian Jones, ITT Rayonier, October 31, 1990). Daishowa America's water treatment facility is composed of a flocculant settling basin and a sand filter (personal communication, Orville Cambell, James River Inc., December 18, 1990). Both facilities backflush their filters approximately once a day during normal operation. When the Elwha River has a high sediment load, backflushing may be increased to twice per work shift (i.e., six times per day).

Increased sediment loads resulting from dam removal would require modification to existing treatment facilities and would result in greater operation and maintenance costs. Capital costs would include upgrading alum and polymer treatment facilities, which would cost between 1 to 2 million dollars for each plant (personal communication, Brian Jones, ITT Rayonier, October 31, 1990). Operating and maintenance costs would include increased dosages of alum and polymer, increased backflushing cycles, and hauling alum sludge wastes to landfills. During the dam removal period, annual operation and maintenance costs at the ITT Rayonier water treatment plant would increase by approximately $550,000 (Culp et al., 1986). This cost would gradually decrease as sediment loads in the river declined after dam removal. The Daishowa America plant would incur additional annual maintenance and operating costs of approximately $200,000. At present, both plants are backflushing sediments into the Strait of Juan de Fuca. This practice is currently under scrutiny by the Washington Department of Ecology. If DOE requires hauling of alum laden sediments to local landfills, operating costs during the dam removal period would increase by an additional $260,000 per year for ITT Rayonier and $87,000 per year for Daishowa.

Increased sediment loads during peak flows would be adverse to rearing fish in the WDF fish rearing facility, prohibiting the use of the facility during the 5-year construction period and for several years following dam removal. On-site mitigation would not be possible for the WDF fish rearing facility, since water is diverted directly from the river to rearing channels. Filtration of water would not be economically feasible for the rearing facility. Off-site mitigation in the form of a rearing facility on a nearby river would be necessary to maintain fish stocks from the WDF rearing facility on the Elwha River.

4.2.3 Aquatic Communities

During the 5-year construction period and for 2 to 4 years thereafter, Glines Canyon and Elwha dam removal would negatively affect salmon and trout egg and fry survival and aquatic invertebrate abundance due to high suspended sediment

concentrations. Over the long term, there would be a good potential for restoring all original salmon runs, except sockeye, and good-to-excellent potential for restoring summer and winter steelhead and sea-run cutthroat and Dolly Varden trout. Resident trout would decline from the added competition from anadromous salmon and trout.

4.2.3.1 Construction Impacts

Moderate to severe impacts from high sediment concentrations would occur to resident fish in the middle reach and anadromous fish in the lower reach during the construction period. Sediment impacts would be primarily spawning and rearing habitat quality, and food supply. Anadromous fish restoration would be delayed at least 5 years because construction activity and the presence of Elwha dam would preclude successful passage of adults and juveniles during construction. Middle reach resident trout reproduction would be minimally affected since most spawning habitat there is in the tributaries. Trout growth and survival in the middle reach would decline because of reduced invertebrate production, poor feeding visibility, and infrequent mortality from high suspended sediment loads resulting from slope failures. Anadromous fish spawning and rearing would be moderately affected in the lower reach, although Lake Aldwell would buffer the effects of Glines Canyon dam removal until Elwha dam was removed. Highest impacts would occur in the reaches below the dams during the first year after Elwha dam removal when sand bed and suspended load would increase. These effects would be greatly reduced within one year after dam removal, as the sand supply from the reservoir deltas was exhausted (Section 4.2.1).

Passage Effects

During the 5-year construction period, passage for both adult and juvenile anadromous fish would be impeded, delaying anadromous fish restoration for at least 5 years. Adult passage would not occur because no passage facility would be constructed at Elwha dam. Juvenile passage survival would be reduced from the passage through the Lake Mills turbine and the Lake Aldwell tunnel.

Direct Sediment Effects on Fish

Dam removal would increase lower and middle river suspended sediment for a period of up to 7 to 9 years, which would have moderate-to-severe adverse effects on fish and their habitat. Sediment concentrations between 300 and 500 mg/l would be present only for a few days at a time. Both of these normally expected concentrations would be acceptable to fish if they were not persistent. Only at the maximum levels expected near slope failures (greater than 17,000 mg/l) would fish direct mortality be expected (Alabaster and Lloyd, 1982; Noggle, 1978; Stober et al., 1981).

Sediment Effects on Eggs and Fry Survival

High sediment concentrations would have an adverse effect on salmonid egg and fry survival during the fall and winter development period when eggs and fry reside in the gravel. Because spawning salmon and trout can remove large quantities of fines from spawning gravels (Chapman and McLeod, 1987), confining the construction periods to the summer months prior to the spawning period could reduce direct construction effects, but fall and winter rainstorms would raise flow enough to mobilize sand and silt, potentially reducing egg and fry survival for fish which had already spawned (salmon and Dolly Varden trout).

Construction-related sediment impacts on middle-reach resident trout would be limited because most resident trout in this reach spawn in tributary streams. The greatest impacts would be on fall spawning Dolly Varden, because fine sediment would be most settleable during the fall low-flow period. Rainbow trout could also be affected, but high spring flows would moderate the effects of any early-spring fine material deposits.

In the lower reach, adverse impacts on salmon eggs and fry would occur during the 5-year construction period and for 2 to 4 years after the dam is removed. The effect would be the worst during the last 2 construction-period years when Lake Aldwell would be dewatered and Elwha dam removed, during which period large amounts of sand would enter the lower river. Of the lower reach anadromous species, fall chinook salmon would be the most affected because considerable natural spawning occurs in the lower river. Also, chinook spawn in the early fall, low-flow period when finer sediments would be more likely to settle in gravel spawning beds. Pink salmon also would be similarly affected, although few currently spawn naturally in the lower river. Small numbers of chum and coho salmon also currently spawn naturally in the lower river, but since they spawn later during higher flow, they would be less affected because sediment would be more likely to remain in suspension than deposit in the gravel beds. Steelhead would also be affected less than chinook because they are late winter or early spring spawners.

Reservoir Trout Mortality

High mortality would occur to trout presently in the reservoirs because of high turbidity, reduced food supply, low dissolved oxygen, and possible injury when passing through the temporary reservoir outlets. Losses would be greatest in Lake Mills because fish would be able to leave the reservoir only through the tunnel; they could not escape upstream because of the temporary diversion dam at the head of the reservoir. Because no diversion dam will be present at the head of Lake Aldwell, fish would be able to escape upstream during construction.

Rearing Channel Effects

The WDF chinook salmon rearing channel may be unusable during the 5-year construction period and up to 2 years thereafter because of sedimentation and high turbidity (Section 4.2.2.1). Feeding effectiveness in the channel would be reduced during high turbidity periods, affecting survival and growth sufficiently to make use of the channel for rearing impractical. Use of the channel to collect adult fish for egg-taking would not be affected.

4.2.3.2 Long-Term Impacts

Removal of both dams would cause changes in the Elwha River's sediment dynamics, channel configuration, and substrate composition, which would have major effects upon existing aquatic habitat. In Section 4.2.1, these changes are discussed from a geomorphological and river dynamic standpoint. This section provides a description of these physical characteristics in terms of fish habitat. The descriptions apply generally to all the anadromous fish. It is known that sand is an unsuitable substrate for almost all salmon or trout spawning and for invertebrate production; similarly boulders are unsuitable because of their large size, immovability, and lack of interstices. Therefore, general salmon spawning and rearing habitat will be discussed in this section relative to availability of sand, gravel, cobble and boulders. In addition to substrate size as a fish habitat component, river channel morphology and stability are also habitat components, and will also be described when appropriate. Finally, construction effects on river channel characteristics are not discussed because fish restoration will not begin during the construction period. Dam removal habitat characteristics are discussed with respect to near-term conditions (from 4 to 10 years after construction) and long-term conditions (after the 4 to 10 years of recovery throughout the license period).

Channel Characteristics and Stability

The Elwha River after dam removal would be less stable than with dam retention. With increased sediment transport and more natural flow regime associated with dam removal, the river would meander more particularly in the middle and lower reaches where the channel becomes less confined. This meandering would cause

more undercutting of bankside vegetation with an increased contribution of large woody debris throughout the river's length. With the dams in place and with the present stable channel, which is not undercutting middle and lower reach trees and shrubs, the only woody debris contributed to the lower river is that which is spilled over the reservoirs periodically. With dam removal, woody debris would increase both from the previously described undercutting and from remobilization of woody debris, currently trapped on or in the sediment deltas of Lake Mills and Lake Aldwell.

The more active channel dynamics after dam removal would also result in the creation of more side channels, again most notably in the middle and lower reaches. These side channels would be potentially excellent spawning and rearing habitat for all salmon species, particularly coho and chinook.

Substrate composition would change dramatically throughout the middle and lower reaches after dam removal. Results of HEC-6 modeling and comparison of processes in the lower river to those in the unaffected upper reach indicate that approximately 10 to 20 percent more sand and gravel would be present in middle and lower reach substrate after dam removal. In the near term (4 to 10 years after completion of dam removal construction), sand may dominate substrate compositions in the lower reach and at the bottoms of present-day pools or other deep areas. This sand would be transported from surface areas of the current deltas, Lake Mills, and Lake Aldwell and would move through the system fairly rapidly. After attainment of sand stability (expected within 4 to 10 years after completion of dam removal) the large, armored substrate of the middle reach and lower reach would gradually gain more gravel and lose the excess sand. The pavement layer and the suitable gravel and cobble substrate areas should be similar in proportion to those in the upper reach, with finer particle percent more typical of the rivers in the region. In both the middle and lower reaches overall substrate composition should be highly suitable for all salmon species spawning within 4 to 10 years after the completion of dam removal.

With the removal of both dams, there would be an increase in available anadromous fish habitat (Table 4-16) and an excellent potential for restoring wild, self-sustaining populations of fall run chinook and winter run steelhead. There would be a good potential of restoring spring chinook, coho, chum and pink salmon, and sea-run cutthroat and Dolly Varden trout (Table 4-17). Improvements in these prospects over the applicant's proposal would be due to improved passage survival and spawning and rearing habitat. The prospect for restoring wild, self-sustaining runs of sockeye salmon would remain poor as in the applicant's proposal. Populations of resident rainbow and Dolly Varden trout in the middle and upper river would decline due to increased competition with salmon and steelhead for spawning and rearing habitat, as with the applicant's proposal.

Table 4-16. Habitat distribution of chinook and coho salmon and steelhead in the Elwha River drainage for the dam removal alternative (Source: the staff).

Region	Chinook Stream miles [1/]	Steelhead Stream miles [1/]
Below Elwha (lower reach)	4.9	4.9
Between Elwha and Glines Canyon (middle reach)	18.4	18.4
Above Glines Canyon (upper reach)	51.5	51.5
Total	74.8	76.4

1/ Stream miles potentially accessible.

Approach and Methods

The approach and methods used to evaluate the dam removal alternative fisheries impacts were the same as described in Section 4.1.3.2 (applicant's proposal). For this alternative, passage survival was assumed to be 100 percent since the dams and reservoirs and their associated mortalities would not be present.

Habitat was evaluated as for the applicant's proposal, considering number of available stream miles after dam removal. For this alternative, habitat evaluations also incorporated improvements in middle and lower reach habitats due to improved sediment recruitment and replacement of inundated reservoir areas with productive stream habitat. Harvest and restoration stock availability evaluations were performed as for the applicant's proposal.

Chinook Salmon

Restoration potential of fall chinook was judged to be excellent. Without dam-associated mortality, particularly those factors related to downstream juvenile passage through reservoirs and dam including spillway situations, fall chinook salmon would survive in numbers sufficient to sustain reasonable harvest rates. The restoration potential for spring chinook was rated fair due to a marginally

Table 4-17. Summary of potential restoration of anadromous salmonid stocks above the Elwha and Glines Canyon dams, removal of both dams alternative (Source: the staff).

Species	Passage	Allowable Harvest Rate	Habitat	Available Stock	Restoration Overall Outlook
Fall Chinook	favorable	favorable	favorable	favorable	EXCELLENT
Spring Chinook	favorable	marginal	favorable	marginal	GOOD
Coho	favorable	favorable	favorable	marginal	GOOD
Winter Steelhead	favorable	favorable	favorable	favorable	EXCELLENT
Summer Steelhead	favorable	favorable	favorable	marginal	GOOD
Pink	favorable	favorable	favorable	marginal	GOOD
Chum	favorable	favorable	favorable	marginal	GOOD
Sockeye	favorable	marginal	unfavorable	marginal	POOR
Sea-run Cutthroat	favorable	marginal	favorable	marginal	GOOD
Sea-run Dolly Varden	favorable	marginal	favorable	marginal	GOOD

achievable allowable harvest rate (59 percent) and marginal potential availability of a stock for restoration.

Allowable Harvest Rate

With passage survival improved significantly over the dam retention alternatives, the allowable harvest rate for chinook salmon would not be reduced by passage losses. The allowable rate would equal the OER of 78 percent for fall chinook and 59 percent for spring chinook, which would be reasonably achievable and marginally achievable, respectively, under present and future planned fishery management agency goals (PSC, 1989).

Habitat

Chinook salmon habitat after dam removal would be improved due to substantial increases in spawning and rearing habitat. The middle reach would undergo the greatest spawning habitat improvement because it presently has the highest proportion of armored large cobble substrate that would be used little by chinook salmon for spawning. Without Lake Mills and Glines Canyon dam to block recruitment of gravel from the upper river, the middle reach would receive new gravels from the upper reach, which would improve spawning habitat. The lower reach would also receive gravel from upstream, thus improving its spawning habitat. The reaches currently inundated by Lake Mills and Lake Aldwell would become productive stream habitat, although it is not possible to determine the prospective habitat quality in these reaches.

Water temperature reductions in the middle and lower river during the late summer and early fall from removal of the dams and reservoir heat storage (Section 4.2.2) would also improve spawning habitat. Existing maximum daily water temperatures (15 to 20°C) in these reaches during low-water years are potentially lethal to chinook and pink salmon eggs, and could delay spawning until temperatures were low enough for optimum egg development and survival. During low-water years without the dams, late summer and early fall temperatures would be 2 to 4°C cooler on average in the middle and lower reaches than current temperatures, which could improve egg survival.

Some improvement in rearing habitat quantity and quality would occur in the middle and lower reaches with dam removal. Although change in the reservoir reaches to riverine habitat would provide more stream rearing habitat, the rearing potential of these areas would not be markedly different because chinook can rear and feed successfully in reservoirs. The primary difference would be due to decreased mortality of downstream migrating smolts. Reduction in summer water temperatures, by decreasing the residence time and surface area of the reservoir reaches, would also benefit rearing habitat by providing better summer rearing temperatures for juvenile salmon.

Expansion of the estuary after dam removal would provide some benefit to chinook rearing habitat (Section 4.2.1). Although the estuary size increase cannot be estimated based on the historical maps, the estuary may build out approximately 0.5 mile and take the shape similar to that presented in the 1926 map of the delta area (James River II, 1988b). This area would be used by rearing chinook, and would serve as a transition area from fresh to marine waters. The overall size of the estuary would still be relatively small, possibly resembling that of some of the coastal streams such as the Queets, which has a delta form similar to that shown on the 1926 map of the Elwha. The Queets estuary was considered "limited" for salmon utilization by Phinney and Bucknell (1975).

Removal of the dams would increase the amount of nutrients and organic matter reaching the middle and lower river from the upper river, as reservoirs are known to block the downstream transport of these materials (Webster et al., 1979; Newbold, 1987). These additional organic materials would increase benthic invertebrate production in the middle and lower rivers, which would improve growth and survival of juvenile chinook salmon.

The dam removal alternative would probably reduce disease potential from Dermocystidium compared to the dam retention alternative. Dermocystidium could remain in the system, however, because the disease can occur in systems without reservoirs (Olson and Holt, 1990; personal communication, Robert Olson, Fishery Biologist, Oregon State University, July 27, 1990). Dam removal would have two potentially beneficial effects which could reduce the incidence of the disease. First, middle and lower river water temperature would be reduced during the summer and early fall. Although water temperature is considered to have only secondary effects on this disease (James River II, 1990e), in the staff's opinion the 2 to 4°C lower average late summer water temperatures (Section 4.2.2) would reduce the incidence of the disease, especially in the lower river. Second, dam removal would allow fish to disperse more than if the dams were in place, thus reducing crowding and the potential for spreading the disease.

Stock Selection and Availability

The stock selection and availability factors would remain as in the applicant's proposal; favorable for fall chinook, and marginally favorable for spring chinook (Section 4.1.3.2).

Coho Salmon

The restoration potential for coho salmon with removal of both dams was judged to be good. While highly favorable passage, allowable harvest rates, and habitat conditions would be present, availability of a stock for restoration was rated only marginally favorable.

Allowable Harvest Rate

Without upstream or downstream passage mortality, the allowable harvest rate for coho salmon would not be reduced by passage losses. The allowable harvest rate would equal the OER of 65 percent, which would be achievable based on its current implementation in similar unimpounded Washington rivers.

Habitat

Coho salmon habitat would be favorably improved with dam removal. The poor quality spawning habitat of the middle reach (WDF, 1971), with its large-sized and armored substrate, would be improved with increased gravel transport from upriver. Since the upper reach is not currently limited by spawning habitat for coho (WDF, 1971), and contains most of the river's coho spawning habitat, the addition of spawning habitat in the middle river would have limited potential benefit to the coho population. Lower reach habitat would also improve, but the benefit would again be limited because most coho spawning habitat occurs in the upper reach.

As with chinook salmon, the minor improvements in juvenile rearing habitat quantity and quality that would occur in all reaches would have only minor benefits over the dam retention alternatives (Section 4.2.2.1). The effects of Dermocystidium would be slightly reduced with dam removal compared to the applicant's proposal for the same reasons discussed for chinook. This disease has not been reported as a major cause of coho mortality, although it does occasionally infect the fish. It should be less of a problem with dam removal because fish would be less crowded and thus less likely to contract and spread the disease.

Stock Selection and Availability

The stock selection and availability would be only marginally favorable due to lack of a wild native stock.

Steelhead

The restoration potentials for winter and summer run steelhead under the dam removal alternative would be excellent and good, respectively. Winter run steelhead, which were given an excellent restoration prospect under the applicant's proposal, would fare even better with both dams' removal because of slightly reduced mortality. Restoration potential, however, would be the same. Summer run restoration prospect would be good due to lack of an available stock for restoration.

Allowable Harvest Rate

With passage survival improved significantly over the dam retention alternatives, the allowable harvest rate for winter and summer run steelhead would not be

reduced by passage losses. The allowable rate would equal the OER of 43 percent, which would be reasonably achievable.

Habitat

Overall, the habitat suitability would be highly favorable for winter and summer run steelhead. Spawning and rearing habitat would be improved slightly for summer and winter run steelhead as it was for coho and chinook salmon. Again, the overall positive effect would be limited since the upper river would provide most of the spawning and rearing habitat for both summer and winter steelhead.

Stock Selection and Availability

Stock selection and availability would be favorable for winter run steelhead due to the current availability of a wild stock, and only marginal for summer run steelhead due to the lack of a wild or native stock in the river or nearby region.

Pink Salmon

Restoration potential for pink salmon with dam removal would be good due to favorable passage and habitat conditions. Adult passage to all expected spawning areas in the upper, lower, and middle reaches would be unimpeded; downstream smolt passage would be unimpeded from all spawning areas to the ocean.

Allowable Harvest Rate

With no passage hindrance from dams, the current average harvest rates on pink salmon of 60 percent could reasonably be achieved. The OER for pink salmon is not known for these stocks, but would probably be in this range. Given the uncertainties in achievable harvest rates, the allowable harvest rate for pink salmon is rated marginally favorable.

Habitat

Habitat suitability is rated highly favorable due to improvements in spawning and rearing habitat. Spawning habitat would improve in all reaches significantly improving the potential pink salmon production. In the upper reach, the area formally inundated by Lake Mills (about 2.5 miles) would be available for spawning. Since the Lake Mills inundation area is the expected upper limit of pink salmon utilization, the expected improvements in spawning habitat in the middle reach should benefit pink salmon spawning. The former Lake Aldwell area (about 2.8 miles) would also be usable for spawning. Improvements in the spawning gravel quality in the upper one to two miles of the lower river should also improve pink salmon spawning habitat. Overall, dam removal would provide significant pink salmon benefits compared to the applicant's dam retention proposal, primarily because of the removal of Elwha dam and its associated downstream mortality factors. Expansion of the estuary, as for chinook salmon, would slightly improve the rearing habitat of pink salmon fry.

Stock Selection and Availability

Currently, there is no plan for pink salmon stock restoration if dams were removed. Because of the very low abundance of the native pink salmon stock (less than 50 fish) and high harvest rate, this process might take many years and even then might not be successful. Given these uncertainties, the availability of a stock for restoration is judged only marginally favorable.

Chum Salmon

Restoration potential of a chum salmon stock would be good due to favorable passage, allowable harvest, and habitat factors.

Allowable Harvest Rate

As for the applicant's proposal, current harvest rates are not considered a threat to potential restoration because of the limited marine harvest of chum salmon and because the inriver harvest can be more readily controlled. Although the OER is not known for this stock, the expected low ocean harvest rates should make the allowable harvest rate favorable.

Habitat

Like pink salmon, spawning and rearing habitat for chum salmon would be significantly improved with removal of both dams.

Stock Selection and Availability

The stock selection and availability would be marginally favorable as for the applicant's proposal. Currently, there is no stock restoration. Past efforts at increasing run size of chum in the Elwha system have not been successful, so relying on natural unassisted propagation may not work. Because of the very low abundance of Elwha River chum salmon and past enhancement failures, this process may take many years and may not be successful.

Sockeye

As for the applicant's proposal, the restoration potential for sockeye salmon in the Elwha River system would be poor due to lack of suitable spawning habitat and a suitable stock for introduction.

Sea-Run Cutthroat and Dolly Varden Trout

The restoration potential for sea-run trout would be good given favorable passage and habitat, and marginally favorable allowable harvest and availability of stocks for restoration. Because little is known of cutthroat and Dolly Varden harvest rates, the allowable harvest rates were judged marginally favorable. The availability of stocks for restoration is questionable.

Resident Trout

Resident trout populations in the middle and upper reaches would be adversely affected despite some habitat improvements. Improvements in spawning and rearing habitat would result in minor increases in potential production. The increased nutrients and organic matter from dam removal could increase production in the lower and middle reaches. Spawning habitat would be improved in the middle reach. Rearing habitat could be reduced from the loss of reservoir areas presently used by both resident rainbow and Dolly Varden trout. Based on data from Collins (1983), catch per linear mile of Lake Aldwell was nearly the same as the middle reach, while Lake Mills catch per linear mile was about twice that of the middle reach. Assuming catch is a direct measure of abundance, then little change would occur in trout abundance with conversion of Lake Aldwell to a river reach, while a 50 percent reduction would occur in the Lake Mills reach. Competition from introduced anadromous species would significantly reduce resident trout populations primarily because high densities of juvenile anadromous fish would both compete with and predate juvenile resident trout.

Fish Community

Removal of both dams would bring about an overall positive change in the fish community of the Elwha River. Diversity would improve from more species of fish residing in all reaches of the river. Overall, abundance and production would increase. Competition from anadromous fish is expected to reduce the abundance and production of juvenile resident fish.

Stream Ecology

Overall, the ecology of the river would change significantly with removal of both dams. Many of the changes would benefit anadromous and resident fish. The dams and reservoirs would no longer control habitat conditions in the middle and lower river. Changes in water quality (Section 4.2.2) would improve stream productivity of the middle and lower river. Average water temperatures in the middle and lower river during the summer and early fall would be lower than present, which would benefit salmon by bringing about higher survival of eggs and possibly juveniles in low-water years when temperatures are high. The productivity of the upper and middle reaches would also improve with the addition of salmon carcasses to the middle and upper river.

There are also potentially adverse effects from removal of the dams. Maximum daily water temperatures in summer could increase during warm, low-flow periods, with a greater frequency of daily maximum temperatures in the lower river in the range of 16 to 20°C. Such temperatures could interfere with downstream migrating juvenile salmon and delay or inhibit spawning in the lower river. Spawning anadromous fish may reduce benthic invertebrate production

slightly in the upper and middle reaches by disturbing substrate, although the overall impact would be minor, since the effects would be temporary and limited to spawning areas.

The applicant's proposed flow augmentation, which involves the release of stored water from Lake Mills in late summer to reduce potential adverse effects of low flow and high water temperature in the lower river, would not be possible with removal of the dams. Since the potential benefits of flow augmentation are questionable (Section 4.1.3.2), no adverse effects from the loss of this alternative are anticipated unless problems associated with low summer/fall flows in the lower river are aggravated by increased diversion of water in the future.

Shellfish

Small changes in the existing estuary shellfish population and nearby marine waters would be anticipated with dam removal and its associated habitat changes. Minor increases in marine intertidal shellfish would occur with this alternative, because the restoration of sediment transport would increase the delta size and the proportion of sand and gravel in the substrate composition, and reduce the proportion of cobbles and boulders (Section 4.2.1).

Surveys of subtidal clam beds in Puget Sound showed that higher densities of butter clams and little neck clams were found in substrate from pea gravel to boulders with overall highest density in gravel (Goodwin, 1973). The lowest densities were found in sand and mud. Al Sholz (personal communication, Shellfish Biologist, WDF, April 14, 1990) noted that the best populations were found in coarse gravel. The amount of such coarse gravel along the coast between Point Angeles and Ediz Hook would increase with dam removal. Another important clam species used recreationally is the horse clam, which is more common in sandy areas than the other two species. The abundance of sand would also increase with dam removal.

4.2.3.3 Staff-Recommended Measures

A detailed fish restoration plan should be developed, and responsibilities assigned for funding and implementation as defined in Section 4.1.3.3.

4.2.3.4 Unavoidable Adverse Impacts

An increase in sediment input into the river during the 5-year construction period and 2 to 4 years thereafter would have a moderate adverse effect on resident and anadromous fish spawning and rearing in the middle and lower reaches including high loss of resident trout currently in the reservoirs and potentially high mortality of naturally spawned salmon and steelhead eggs and fry in the lower reach. The

WDF chinook channel would be variously affected for up to 7 years because of high turbidity levels.

Anadromous fish restoration would be delayed for at least 5 years during the construction period because upstream passage would not be provided and because of the bypass tunnel at Glines Canyon and the Elwha dam turbines.

The introduction of anadromous fish into the middle and upper reaches would reduce the productivity of the resident trout populations in these reaches of the river.

4.2.4 Terrestrial Resources

4.2.4.1 Vegetation

Removal of both dams would have minor long-term adverse impacts on existing vegetation. Rubble disposal, staging areas, and new access roads would cause the temporary loss of vegetation. Removal of the reservoirs may eliminate or degrade several associated wetlands, although new wetlands would be created along the river. Increased water volume and erosion may also remove and/or disturb vegetation along the river in Sweets Bottom and downstream of the current location of Elwha dam, but eventually these areas would stabilize. Reclamation of the reservoirs and project facility locations would revegetate areas that are currently inundated or developed.

Surveys of construction areas that would be affected by dam removal activities, including the rubble disposal site, did not locate any plant species with state, federal, or NPS status. However, removal of the transmission line could eliminate habitat for a species considered unique in the Elwha Valley by the NPS.

Construction Impacts

The new access road and staging area associated with removal of the Elwha Project would impact 0.87 acre of mature conifer forest. The access road and staging area for removal of Glines Canyon would impact 2.65 acres, including 0.37 acre of mature conifer forest, 1.14 acres of mature mixed conifer/deciduous forest, and 1.14 acres of mature hardwood.

The concrete rubble from the diversion tunnels and facilities at both Elwha and Glines Canyon would be buried at the base of the north side of Kelly Mountain. About 200 acres of this area was clear-cut about 5 years ago and not replanted, although the slash was removed. A palustrine emergent wetland, consisting primarily of reed-canary grass (Phalaris arundinacea), three-square bulrush (Scirpus americanus), and Indian pond lily (Nuphar polysepalum), occupies approximately 10 acres of the southeast corner of the clear-cut. The rubble

disposal site would require about 8 acres and would be located in the central or northern portions of the clear-cut, areas currently dominated by red alder, huckleberry, blackberry (Rubus spp.), bracken fern (Pteridium aquilinum), and fireweed (Epilobium angustifolium). The new access road to the disposal site would involve removal of an additional 0.6 acre of mature conifer forest.

Long-term Impacts

The primary long-term effects of the dam removal alternative would be (1) reclamation of about 268 and 416 acres currently occupied by Lake Aldwell and Lake Mills, respectively; (2) reclamation of about 31 acres currently occupied by project facilities, roads, and landscaping; (3) loss of wetlands associated with the reservoirs; (4) potential loss or modification of plant communities along the river due to increased erosion; and (5) potential loss of habitat for a species considered unique in the Elwha Valley by the NPS.

Reservoir Reclamation

Accumulated sediment from the deltas of Lake Aldwell and Lake Mills would be graded into terraces while the finer siltier sediments in the lower portions of both reservoirs would be protected from surface erosion (Appendix A, Part 3). The terraces of the upper portions of each reservoir would have slopes of about 1V:4H and consist of mostly sand and gravel. The more gently slopes (1V:10H or higher) in the middle and lower portions of both reservoirs would consist mostly of silt. These terraces and slopes would resemble the original terraces that were formed by the erosive action of the Elwha River on the valley fill. The entire reclaimed area would be revegetated.

Ultimately, it is expected that these terraces would support plant communities similar to those that existed in the valley and along the river prior to construction of Elwha and Glines Canyon dams. However, the process of reestablishing mature conifer, mixed conifer/deciduous, and hardwood stands in the areas currently occupied by the reservoirs would probably require several hundred years (Fonda, 1974; McKee et al., 1982; Swanson and Lienkaemper, 1982).

Initially, the sediment disposal terraces of the delta areas would be not be conducive to plant survival and growth due to little or no organic matter, low fertility, high erodability, low moisture retention, and lack of reliable groundwater. Similar areas in western Washington, such as gravel bars and quarry sites generally support red alder, Douglas-fir, and a variety of weedy species such as Scot's broom (Cytisus scoparius). Newly established gravel bars on the west side of the Olympic Peninsula, along the lower Hoh River, are characterized by less than 20 percent plant cover. Principal species include western witchgrass (Panicum occidentale), field sorrel (Rumex acetosella), and Scouler willow (Salix scouleriana). Older gravel bars have sand over the cobbles and are dominated by dense stands of red alder and Scouler willow (Fonda, 1974).

The lowest river terraces develop from these gravel bars and, consequently, are dominated by nearly pure stands of red alder. The understory is dominated by grasses and vines. Soils gradually improve due to the nitrogen-fixing capabilities of red alder and litter fall, which adds organic material as well. On the Hoh, these pure red alder stands generally persist for 65 to 75 years, and are then gradually invaded by Sitka spruce (Picea sitchensis), bigleaf maple, and black cottonwood. The understory remains dominated by grasses and forbs (Fonda, 1974). As this mixed stand matures and downed logs occur, western hemlock enters the seral pattern. It remains a minor component of the community on first-level terraces even those that are 400 years old. However, as the climax community, western hemlock dominates the older, higher terraces along the Hoh River that are over 750 years old (Fonda, 1974).

Studies conducted along the South Fork Hoh River indicate that flooding is responsible for some of the major differences in vegetation observed on first terraces. Localized deposition of fine sediment may provide a seedbed for species that may not otherwise be established. Large organic debris can batter and destroy vegetation during floods, but when stabilized, may provide protected sites conducive to vegetation establishment and survival during the next flood (Swanson and Lienkaemper, 1982). Consequently, flooding and erosion would be expected to affect the successional rate of the vegetation that establishes in different areas of the terraces along the Elwha River.

With several exceptions, the successional pattern on the sediment disposal terraces in the delta areas of both reservoirs would be expected to be similar to that on the terraces along the Hoh. The reclamation program would promote the establishment of red alder, dryland willow, and other drought-tolerant species within about 10 to 20 years of dam removal, and this community would be expected to persist for about 100 years. As soil structure, chemistry, and moisture-holding capacity improve over the next 100 years, other species, including bigleaf maple and black cottonwood, would invade. Since Sitka spruce does not occur in the Elwha Valley, its pioneering role would probably be fulfilled by grand fir, a species tolerant of droughty soils and shade that has been observed growing with red alder along the river. Finally, after several hundred years, western hemlock would begin to establish. Although this community-type is considered the successional climax in the Elwha Valley, its development in most areas is long delayed due to the relatively dry conditions that are characteristic of the valley. These dry conditions are responsible for the high frequency of fire in the Elwha Valley, which creates sites that favor the establishment of Douglas-fir (Fonda and Bliss, 1969).

The more gentle slopes of the middle and lower reservoirs with their finer sediment and higher organic content would be more initially conducive to forming grasslands and wetlands, followed by the more typical riparian bottomland vegetation communities of the Elwha valley.

Based on this successional pattern, the terraces along the Elwha River would be expected to support three principal forest communities within 400 to 600 years after dam removal: (1) mixed stands of grand fir, western hemlock, and bigleaf maple on uplands that have not burned; (2) stands dominated by Douglas-fir that have become established in areas that have been burned or disturbed; and (3) hardwood stands on flat bottomlands and wetlands created by erosion along the river. Estimates of the area of pre-project cover types indicate that conifer and mixed stands would represent 64 percent of the current reservoir area and hardwood and palustrine would cover another 12 percent. The river and unvegetated gravel bars would represent an additional 16 percent of the reservoir area and other plant communities, such as grasslands, would cover the remaining 8 percent (Table 4-18). These cover type proportions and the successional rate and pattern would be greatly different if the area currently covered by Lake Aldwell were to be logged and/or developed. The vegetation pattern would also be influenced by logging or development activity on adjacent James River land that surrounds the lake.

Facility Reclamation

Removal of project facilities, including powerhouses, roads, transmission lines, parking lots, and dams, would result in about 31 additional acres for reclamation. Restoration of these areas would be achieved much sooner than reclamation of the reservoirs because of the proposed revegetation program, intact soil structure, and lower erosion and flood potential. It is expected that most of these areas would eventually support the same plant communities growing on adjacent undisturbed sites.

Potential Loss of Wetlands

The dam removal alternative would potentially eliminate or degrade about 42.7 acres of wetlands that are associated with the reservoirs. A total of 38 acres of these wetlands occur in the delta at the tail of Lake Aldwell, including 36 acres of palustrine forest, 1.1 acres of palustrine marsh, and 0.9 acre of palustrine shrub. The functions served by the wetlands in the Lake Aldwell delta probably include wildlife habitat, shoreline stabilization, recreation, sediment trapping, and nutrient retention and removal. These wetlands are dependent on the slow water that occurs in the delta and the continual source of sediment deposited as the river enters the reservoir. Dam removal would increase the water velocity in this area and reduce the amount of sediment.

The only wetland potentially affected by the removal of Lake Mills is a 4.7 acre palustrine forest near the current boat launch. However, this wetland appears to be maintained by seeps that occur on the adjacent hillside and would not be affected by dam removal, provided that the water table is not lowered significantly. Several other small wetlands along Lake Aldwell and Lake Mills are associated with tributaries and would probably reestablish at the new tributary-

Table 4-18. Cover types expected to develop in the restored reservoir areas[1/] (Source: the staff, modifed from James River II, 1988d).

Cover Type	Lake Aldwell (acres)	Lake Mills (acres)	Total (acres)	Percent of Total
Conifer forest	145	273	418	61
Mixed forest	9	11	20	3
Hardwood forest	24	28	52	8
Palustrine forest	11	13	24	4
Palustrine scrub/shrub	11	13	24	4
Grassland	11	13	24	4
River/stream	27	30	57	8
Cobble/gravel	30	35	65	8
Total	268	416	684	

1/ Based on the estimated area of cover types in the reservoirs under pre-project conditions.

river confluence. Some wetlands would establish on the gentle slopes of the middle and lower reservoir terraces.

Despite the initial loss of wetlands in the Lake Aldwell delta, no net loss of wetland quantity or function is expected from the dam removal alternative. Wetlands would establish along the meanders, sloughs, and backwater areas that eventually develop along the new river channel. As part of the HEP conducted in the project area, the applicant estimated that the reservoir areas originally supported about 48 acres of wetlands, including 24 acres of palustrine forest and 24 acres of palustrine shrub (Table 4-18). Reclamation of the reservoir areas would probably result in the establishment of wetlands that would be of similar type and quantity to those of pre-project conditions. However, the equilibrium proportion of palustrine shrub to forest may be higher in a riverine system than a reservoir due to increased flood frequency and magnitude and periodic changes in

channel morphology. The eventual functional contribution of these wetlands to the Elwha system would include wildlife habitat, shoreline stabilization, sediment trapping, nutrient retention and removal, flood desynchronization, and energy transfer and removal.

Potential Changes Along the River

Removal of both dams would increase the erosive capability of the Elwha River below the current site of Glines Canyon due to reduced stability of the river channel (Section 4.2.1). Potential effects on plant communities adjacent to the river, particularly in Sweets Bottom along the middle reach of the river, include reductions in area from erosion as well as changes in structure and composition due to flooding. Existing wetlands in Sweets Bottom, including 106 acres of palustrine forest and 22 acres of palustrine scrub-shrub, would likely be subject to siltation and/or inundation until river channel stabilization occurs. However, once the river stabilizes, new plant communities would establish on exposed gravel beds and abandoned channel sections and wetlands would develop in backwater areas, sloughs, and oxbows. Therefore, no net loss of vegetation would be expected with the dam removal alternative.

Potential Loss of Rare Plant Habitat

Surveys of the transmission line corridor identified a population of bicolored linanthus, a plant species considered unique in the Elwha Valley by the NPS (Section 3.5.3.5). This species appears to require open areas with very little cover, habitat that would be eliminated by the encroachment of trees into the right-of-way after the current maintenance procedures are stopped when the line is deactivated.

Staff-Recommended Measures

Rare Plant and Wetland Surveys

Prior to beginning any dam removal activities, the potential location of access roads, staging areas, and the rubble disposal site should be surveyed to ensure that all wetlands are identified and avoided, and that the hydrology of any nearby wetlands is maintained. In addition, these areas should be resurveyed for plants with state, federal, or NPS status. Similar surveys should also be conducted along the river corridor in Sweets Bottom and below the current location of Elwha dam in areas that could be affected by erosion and flooding. If possible, construction in locations containing any of these plants should be avoided. The staff also recommends that mowing in the transmission line right-of-way be continued at the location of the population of bicolored linanthus to preserve its habitat. This area is very near the road and preserving the open habitat would require only a slight expansion of the area currently mowed for road maintenance.

Revegetation Plan

The staff recommends the development of a detailed plan to revegetate the following: (1) access roads, staging areas, and other sites temporarily disturbed by removal activities at the Elwha and Glines Canyon projects; (2) the rubble disposal site; (3) the current reservoir areas; and (4) project facility sites. The revegetation plan should include (1) species mixes appropriate for each restoration area, given location, slope, aspect, and substrate; (2) fertilization requirements; (3) planting density and spacing for each area; (4) planting methods; and (5) provisions to control erosion, exotic species, and grazing by deer.

Wetland Creation

The staff recommends that restoration for Lake Aldwell include provisions for grading the sediments at the tail of the reservoir that are conducive to the development of a wetland at the mouth of Indian Creek. This plan would aid in the establishment of a wetland in this area that would compensate for the loss of the existing 38 acres of palustrine forest, marsh, and scrub-shrub wetlands and may increase the net amount of wetlands in the project area.

Monitoring and Maintenance Plan

Finally, the staff recommends the development of a comprehensive monitoring, maintenance, and contingency plan for all restoration areas as well as Sweets Bottom, and the vegetation along the river below the current location of Elwha dam. This plan should include the following: (1) goals for determining the success of revegetation efforts; (2) methods for preventing the long-term encroachment of weeds and exotic species; (3) a schedule for monitoring the effects of erosion, flooding, and grazing by wildlife; (4) criteria for determining the need for surface stabilization and revegetation; and (5) permanent plots to study succession in the Elwha Valley.

Unavoidable Adverse Impacts

No long-term unavoidable adverse impacts on plant communities would be expected with the dam removal alternative. Staff recommendations would ensure that impacts to vegetation due to removal activities are temporary and would protect some habitat for a plant species considered unique to the Elwha Valley by the NPS.

4.2.4.2 Wildlife

The dam removal alternative would have minor adverse impacts on wildlife. New access roads, staging areas, and the rubble disposal site would cause the temporary loss of wildlife habitat. Dam removal and restoration activities would disturb wildlife in the vicinity of each reservoir for about 5 years. Removal of the reservoirs may temporarily eliminate or degrade habitat in wetlands adjacent to Lake Aldwell, and along the river downstream of the current locations of the

dams. Loss of the reservoirs would adversely affect some species of waterfowl and aquatic furbearers. However, restoration of the area occupied by reservoirs and project facilities would result in additional wildlife habitat in the Elwha Valley. Since the dam removal alternative has an excellent chance of restoring runs of fall chinook, and a good chance of restoring three of the other four native salmon runs, populations of some wildlife dependent on salmon carcasses would increase in the middle and upper reaches of the Elwha River.

Construction Impacts

New access roads and staging areas associated with removal of the Elwha and Glines Canyon projects would impact 4.1 acres of habitat, including 1.8 acres in mature conifer forest, 1.2 acres in mature mixed conifer/deciduous forest, and 1.1 acres in mature hardwood. The rubble disposal site and access road would impact about 8 acres of a shrubland habitat in a clearcut. The forested areas probably provide cover for deer and elk as well as habitat for small mammals and passerine birds. Clearcuts in forested areas are generally important forage habitat for deer and elk. However, the habitat directly affected by dam removal activities is small patches, less than 13 acres, and would be available for use at the completion of the process. Small mammal populations may temporarily decline but habitat temporarily lost during removal activities should have no adverse effects on larger, more mobile species.

Removal activities would disturb wildlife in the vicinity of the dams, powerhouses and reservoirs for each project over a period of about five years. These areas would be avoided by mobile species during construction, and disturbance during the nesting season would cause nest site abandonment. At Glines Canyon, dam removal activities would disturb osprey, a state monitor species, nesting along Lake Mills. This nest site would probably not be used during removal activities and would likely be permanently abandoned because restoration of the reservoir area may alter the suitability of this site.

Long-term Impacts

The primary long-term impacts of the dam removal alternative on wildlife would be: (1) loss of the reservoirs and restoration of about 715 acres currently occupied by Lake Aldwell (248 acres), Lake Mills (416 acres), project facilities, roads, and landscaping (31 acres); (2) restoration of salmon above Elwha dam; and (3) loss or degradation of habitat along the river in Sweets Bottom and the lower Elwha due to increased erosion, siltation, or changes in hydrology.

Reservoir and Facility Removal and Restoration

As described in Section 4.2.4.1, the sediment disposal terraces are ultimately expected to support plant communities similar in composition, structure, and habitat value to those that existed in the reservoir areas prior to construction of the

dams. However, until the vegetation on the terraces stabilizes and matures, a process expected to take several hundred years, the value of these areas as wildlife habitat will vary, depending on successional stage and disturbance. Restoration of the areas currently occupied by project facilities, roads, and landscaping that would be reclaimed would be expected to proceed at a faster rate and these sites should resemble the surrounding habitat within 100 years or so.

In conjunction with the resource agencies, the applicant conducted a HEP study that determined the original value of the habitat in the project area for nine evaluation species, in terms of average annual habitat units (AAHU's) (James River II, 1988a, 1990i). The results of this HEP were used to determine the effects of the dam removal alternative on wildlife, since it is expected that habitat quality in the restored reservoir and project areas would, over the long term, be similar to pre-project conditions. This expectation was based on the assumption that the land currently covered by Lake Aldwell would be protected from clear cutting and/or development. The application of the pre-project HEP results to the dam removal alternative are summarized in Table 4-19 and discussed in the following paragraphs. The AAHU's presented represent only the long-term gain or loss expected due to restoration of the reservoir areas and do not include any changes in habitat quantity or quality that would occur due to succession or logging on other lands in the Elwha Valley.

Big Game - Within about 10 to 20 years following the completion of the dam removal process, the sediment disposal terraces are expected to be dominated by alder and drought-tolerant willow species, with an understory of grasses and forbs. Silt terraces are expected to be dominated by similar species, plus some wetland and riparian species. Because many of these species are preferred by deer and elk, the reclaimed terraces would provide forage for big game within a short time of dam removal. As conifers invade and understory composition changes, forage quality may decrease over time, but the addition of 715 acres of low-elevation habitat to the Elwha Valley would be expected to benefit big game. Since existing forage habitat for deer and elk in the project vicinity is of low quality, the additional habitat provided by the disposal terraces could result in an increase in populations of deer and elk in the Elwha Valley, particularly during the winter.

Based on the results of the applicant's HEP, the reservoir area provided 80 and 125 AAHU's for elk and deer, respectively, under pre-project conditions (Table 4-19). Assuming that vegetation on the reclaimed terraces would ultimately resemble pre-project conditions, this additional area would increase the long-term habitat in the Elwha Valley for elk and deer by 16 and 20 percent, respectively.

Furbearers - The restoration of a riverine environment would be expected to benefit most aquatic furbearers, although most of these species would temporarily lose suitable habitat during the dam removal process, and while the river shorelines are stabilizing. However, the stands of alder and willow that would

Table 4-19. Average annual habitat units in the terrestrial study area for removal of both dams (Source: the staff, modified from James River II, 1988a, 1990i).

Evaluation Species	AAHU's Without Both Dams[1/]	AAHU's With Both Dams[2/]	Net Gain in AAHU's due to Dam Removal
Pileated woodpecker	941	635	306
Yellow warbler	16	12	4
Cooper's hawk	839	747	92
Mink (palustrine)	47	49	2
Mink (lacustrine)	0	186	(186)
Mink (riverine)	263	95	168
Beaver	127	99	28
Roosevelt elk	593	513	80
Black-tailed deer	773	648	125
Lesser scaup	0	40	(40)
Douglas squirrel	1,689	1,345	344

1/ Represents AAHU's ultimately expected with dam removal, based on pre-project conditions.

2/ Represents AAHU's in the terrestrial study area under current conditions.

dominate the sediment disposal terraces of the upper reservoirs shortly after dam removal would provide excellent forage for beaver as well as cover for river otter and mink. The composition of the disposal terraces should also allow burrows and bank-dens for these species. As the vegetation matures and conifers invade, the quality of forage for beaver may decrease in some areas, but since hardwoods would remain in many of the flat bottomlands and gentle sloping terraces of the middle and lower reservoirs, and the area immediately adjacent to the river, forage for this species should remain adequate over time.

Restoration of the Elwha River would provide an additional 29 AAHU's for the beaver, a 29 percent increase over current conditions. However, because Lake Aldwell currently provides a long shoreline with excellent cover for mink, removal of this reservoir would result in a loss of 20 AAHU's for this species because of the shorter river shoreline. This loss represents a 10 percent decrease in habitat compared to current conditions (Table 4-19).

Over the long term, restoration of the reservoir area would also benefit terrestrial furbearers that require large stands of mature forest. Species such as the pine martin and bobcat would gain nearly 396 acres of habitat as the conifers that establish within the reservoir areas mature and snags develop.

Small- and Medium-sized Mammals - Restoration of the area currently occupied by the reservoirs and project facilities would create about 713 acres of additional habitat for small- and medium-sized mammals. Small mammals such as mice and voles would gradually invade the alder and willow stands on the sediment disposal terraces. As conifers invade and mature, the terraces would provide habitat for squirrels, chipmunks, and other small- and medium-sized mammals that depend on forests, including the long-eared myotis, a state proposed monitor species. Once the forests on the sediment terraces mature and resemble those of pre-project conditions, the reservoir areas would be expected to provide an additional 344 AAHU's for the Douglas squirrel, a 26 percent increase over current conditions (Table 4-19).

Raptors - Restoration of the areas currently occupied by reservoirs and project facilities would, in the long term, benefit raptors that use forest habitats, including the northern goshawk and barred owl, proposed sensitive and monitor species, respectively. The Cooper's hawk, sharp-shinned hawk, and screech owl would also benefit from an increase in mature forest habitat. Specifically, the conifer and mixed conifer deciduous forests that eventually establish on the sediment disposal terraces would provide an additional 92 AAHU's for the Cooper's hawk, an increase of 12 percent over current conditions (Table 4-19). Effects on raptors with federal status, the spotted owl and bald eagle, are covered in Section 4.2.4.3.

Removal of the reservoir would also eliminate 663 acres of forage habitat for the osprey, a proposed state monitor species. In addition, water clarity and fish

biomass would temporarily be decreased in the restored riverine habitats during, and for some time after, dam removal. There is also a high probability that the current nest site along Lake Mills would be permanently abandoned because it may no longer have a suitable orientation to the water and prey base. However, since prey of suitable size and density would be available in the river and clarity restored, no long-term effects on osprey are expected from the loss of the reservoirs. Although it would take several hundred years before the terraces would support trees suitable for perching and nesting osprey, other trees adjacent to the terraces, in Sweets Bottom, or along the lower Elwha River would probably be used if the current nest site at Lake Mills is abandoned.

Waterfowl - Dam removal would benefit waterfowl that use riverine environments but would have a negative effect on species that are dependent primarily on the slower, shallower water found in lacustrine environments. Waterfowl that would gain habitat include the common merganser, harlequin duck, and other species observed on the river in Krause Bottom and Sweets Bottom. Loss of lacustrine habitat would have a negative effect on species that are commonly observed wintering on the reservoirs, primarily in the shallow water of the delta at the tail of Lake Aldwell. These species include the trumpeter swan, a proposed state monitor species, as well as the lesser scaup, mallard, and bufflehead. Specifically, the lesser scaup would lose the 40 AAHU's currently provided by the delta area. Since wintering habitat for waterfowl is currently not limited in western Washington, it is unlikely that the loss of the reservoirs would have a negative effect on the populations of these species.

Marine Birds - Restoration of the reservoir area should not affect most marine birds because their habitat occurs primarily at the Elwha delta. The marbled murrelet, a federal candidate species, is covered in Section 4.2.4.3.

Upland Game Birds - The long-term development of conifer, mixed conifer/deciduous, and hardwood stands on the reclaimed terraces would provide habitat for upland game birds, primarily ruffed grouse and blue grouse. Blue grouse would benefit from the addition of about 396 acres of upland conifer and mixed stands. Ruffed grouse would benefit from the approximate 87-acre increase in bottomland hardwood stands. This species would also probably use the alder and willow stands that would develop on the terraces soon after dam removal and revegetation.

Nongame Birds - The species of nongame bird species that benefit from restoration of the reservoir area and project facilities would depend on the successional stage of the associated vegetation. Initially, the alders and willows on the sediment disposal terraces would be expected to provide high quality habitat for the yellow warbler and other birds that are dependent on dense stands of shrubs near water. As conifers invade the terraces, the amount of habitat for the yellow warbler would decrease, restricted primarily to stands of palustrine or

bottomland hardwoods with well-developed shrub layers. As the conifers mature and large snags develop, the terraces would provide habitat for the pileated woodpecker and Vaux's swift, both proposed state sensitive species, as well as other birds that require large trees and/or snags for nesting and foraging.

There is currently little suitable yellow warbler habitat in the project area. Because the amount of suitable habitat for the yellow warbler would decrease over time, restoration of the reservoirs and project facilities would ultimately provide only 4 additional AAHU's for this species (Table 4-19). However, since conifer habitat would increase and mature over time, restoration would provide an additional 307 AAHU's for the pileated woodpecker, a 48 percent improvement compared to current conditions (Table 4-19).

Loss of the reservoirs could also affect nongame birds that forage in or above the reservoirs, including the great blue heron, a proposed state monitor species, as well as the belted kingfisher and violet green swallow. Effects could be particularly acute while the river in the restoration area is in the process of stabilizing due to decreased water clarity and reduction of fish and insect biomass. Populations of these species along the Elwha River may be temporarily depressed but should recover, once the river stabilizes and anadromy is restored.

Reptiles - Restoration of the reservoir areas would increase the amount of habitat available to reptiles and populations of some species would be expected to increase, depending on the successional stage of the vegetation on the sediment disposal terraces.

Restoration of Anadromy

The factors responsible for the effects of restoring anadromy on wildlife were described in Section 4.1.4.2. Predicted annual escapement with removal of both dams would be about 135,300 salmon, which would provide approximately 931,900 pounds of biomass to the Elwha River (Table 4-20). This represents about eight times the currently available biomass. Based on a retention rate of 96 percent, 900,346 pounds of salmon carcasses would be retained as consumable biomass in the Elwha system if predicted escapement is achieved.

The restoration outlooks with the dam removal alternative are excellent for fall chinook and good for spring chinook, coho, chum, and pink salmon, while the outlook for sockeye is poor (Section 4.2.3.2). The coho runs would provide biomass primarily to the tributaries and upper reaches of the Elwha. The chinook, pink and chum runs would increase the biomass available in the lower and middle reaches. Most of the biomass from the restored salmon runs would be available to wildlife in the fall and winter, when food is limited. Carcasses from steelhead runs would provide some supplemental food to wildlife during the spring and summer. Consequently, population increases would be expected for wildlife

Table 4-20. Predicted escapement and increase in biomass of salmon for the dam removal alternative.[1/]

	Predicted Escapement	Predicted Biomass (lbs)	Increase in Biomass Over Current Conditions (lbs)
Fall Chinook	7,480	201,960[2/]	107,460
Coho	13,825	165,900[3/]	139,500
Chum	18,000	180,000[4/]	180,000
Pink	96,000	384,000[5/]	384,000
Sockeye	0	0	0
Total	135,305	931,860	810,960

1/ Source: the staff, modified from Table 4-21
2/ Chinook = 27 lbs./fish average (James River II, 1990g)
3/ Coho = 12 lbs./fish average (James River II, 1990g)
4/ Chum = 10 lbs./fish average (Stalmaster, 1983)
5/ Pink = 4 lbs./fish average

species that consume salmon carcasses, particularly along the tributaries and upper reaches of the Elwha where winter food is probably most limiting (see species list in Table 4-11, Section 4.1.4.2). Along the middle and lower reaches, habitat and disturbance may be limiting and the effects of increased food on populations would be less significant.

As described in Section 4.1.4.2, increased salmon production would also benefit species that feed on live fry and smolts, such as common merganser, great blue heron, and belted kingfisher. Populations of these species would also be expected to increase primarily along the middle and upper reaches of the Elwha and its tributaries. Since salmon and steelhead jacks would replace part or all of resident trout lost as prey for the osprey, no long-term negative effects are expected on this species.

Potential Changes in Habitats Along the River

Removal of both dams would increase the erosive capacity of the Elwha River below the current site of Glines Canyon dam. Potential adverse effects on habitats adjacent to the river, particularly in Sweets Bottom, include a number of short-term changes: (1) reduction in area from erosion; (2) changes in structure and composition due to flooding; (3) loss of snags and large trees due to under-cutting of banks; (4) loss or destabilization of banks and shorelines; (5) reduction in water clarity; and (6) loss of fish biomass.

Uplands lost due to erosion would be expected to be replaced by new habitats that eventually establish on exposed gravel beds and abandoned channel sections. Wetlands lost due to siltation would be replaced by habitats that would develop in backwater areas, sloughs, and oxbows. Consequently, no long-term net loss of wildlife habitat would be expected with the dam removal alternative.

Habitat for some species may temporarily decrease while the river channel stabilizes and new plant communities establish and mature. In particular, denning habitat for aquatic furbearers could be reduced. In addition, snags and large trees available for perching or cavity nesting species could decline due to bank erosion. Species that currently forage in the river would be affected by decreases in water clarity and fish biomass that would occur while the river is stabilizing and anadromous runs are becoming established. Species that may temporarily lose forage habitat include the belted kingfisher, great blue heron, and aquatic furbearers. However, in the long term, these species would benefit from the development of side channels with slower water and fine sediment.

Staff Recommendations

Staff recommendations for the placement and revegetation of the rubble disposal site, new roads, and staging areas (Section 4.2.4.1) would ensure that loss of wildlife habitat during the dam removal process is only temporary. In addition, the staff recommends that blasting be prohibited during the nesting season to avoid disturbing birds nesting in the project vicinity.

The staff recommendations to monitor the vegetation on the reclaimed terraces should ensure that the development of wildlife habitat in the reservoir areas would support, over time, a wide variety of species. However, in order to monitor the effects of dam removal on deer and elk, the staff recommends that a radio-telemetry study be conducted. The baseline results of this study would identify: (1) seasonal movement patterns; (2) important forage and cover areas; and (3) level of use of the lands around Lake Mills and Lake Aldwell. The radio-telemetry program should be continued, on a periodic basis, to determine: (1) the new areas used by these species; (2) the length of time between vegetation establishment; and (3) the effects of dam removal on migratory patterns, wintering use, and populations.

To monitor the effects of restoring anadromy on wildlife, the staff recommends the implementation of a study that would, at a minimum: (1) locate important areas of carcass stranding along each of the three reaches of the Elwha; (2) determine the number of carcasses stranded in selected areas during peak spawning periods; (3) identify the species that consume these carcasses; and (4) note changes over time in the location and use of stranding areas.

Staff recommendations to stabilize the sediment disposal terraces, control siltation, and restore anadromy would ensure that the effects of reduced water clarity and reduction in fish biomass on wildlife that forage in the river are temporary.

Unavoidable Adverse Impacts

Removal of the reservoirs would also adversely affect some species of waterfowl and aquatic furbearers presently associated with the reservoirs due to the loss of lake habitat.

4.2.4.3 Threatened and Endangered Species

Federally Listed Species

Removal of both dams would have no adverse impacts on bald eagles or spotted owls. The restoration of the reservoir areas and project facilities may, over the long term, increase available habitat for the spotted owl. Since the dam removal alternative has a good chance of restoring runs of chum salmon, the number of bald eagles wintering along the middle of the Elwha River is expected to increase.

Construction Impacts
Removal activities at the Elwha and Glines Canyon projects would temporarily disturb spotted owls if they occur in the vicinity of the reservoirs, dams, and powerhouses. However, the habitat adjacent to Lake Aldwell and near the Elwha facilities is not suitable for spotted owls and the probability for significant disturbance is low. At Glines Canyon, blasting associated with dam removal and terrace construction may disturb spotted owls, particularly during nesting season.

Long-term Impacts
The primary long-term effect of the dam removal alternative on spotted owls would be the increase in available habitat from the restoration of the reservoirs and project facilities. The primary effect on bald eagles would be restoration of anadromous fish, particularly chum salmon.

Reservoir Restoration
Restoration of the reservoir areas is expected to result in the eventual addition of about 396 acres of conifer and mixed conifer/deciduous forest to the Elwha Valley, 156 acres at Elwha, and 240 acres at Glines Canyon. Assuming that these

areas remain protected, it may take 400 to 600 years for these habitats to establish, mature, and develop the characteristics of old growth (Section 4.2.4.1). Until this process is complete, the reservoir areas would not be suitable spotted owl habitat. In the interim, however, these areas would provide a buffer from disturbance for owls using adjacent territories. Once old growth characteristics develop, the reservoir areas would be too small to support a pair of spotted owls, which require about 7,000 to 9,000 acres in the Pacific Northwest (Hamer, 1988; Brewer and Allen, 1985), without adjacent available habitat. Consequently, although dam removal would eventually increase the amount of habitat suitable for the spotted owl, the number of nesting pairs in the Elwha Valley would not be expected to increase without adjacent, available habitat.

Restoration of Anadromy

The probability is good that removal of both dams would restore runs of chum salmon, the principal food source for bald eagles wintering on other Northwest rivers. Chum escapement is predicted to be about 18,000, but would vary, depending on the year and harvest. On the Skagit River, chum escapement between 1979 and 1988 varied between 3,200 and 150,000, with a median value of about 45,000. Peak bald eagle counts along the primary wintering area on the Skagit (Rockport to Marblemount) ranged from 68 to 330, with a median value of 180 (DellaSala et al., 1989). Based on the high correlation ($R^2=.65$) between chum escapement and peak bald eagle counts on the Skagit, an escapement of 18,000 would attract a peak of about 140 wintering eagles (DellaSala et al., 1990). During the winter of 1990, only six observations of bald eagles were documented on the Elwha River (James River II, 1990h). Lack of food appears to be the primary reason for lack of bald eagle use of the upper and middle reaches (James River II, 1990h). Conditions vary, depending on the river, but since the number of bald eagles wintering along rivers in the Northwest appears to be generally increasing (DellaSala et al., 1990), it is likely that the addition of a significant food source to the Elwha River would greatly increase the number of bald eagles wintering in the valley. Because chum would spawn primarily along the middle reach of the Elwha, this stretch would become the most important area for bald eagles wintering along the river.

The restoration outlooks for fall chinook are excellent with the dam removal alternative, and good for runs of coho and pink. Restoration of fall chinook and pink salmon would not provide significant biomass for wintering bald eagles since these species spawn primarily in September and October, prior to the time when most eagles arrive in wintering areas. However, pinks and chinook would likely provide food for eagles arriving on the Elwha early in the wintering season. Coho salmon would provide less biomass and often spawn in tributaries that are inaccessible to bald eagles or that require long flights and high energy expenditure. Restoration of this species would add biomass to the tributaries and upper reaches of the Elwha and would likely attract some eagles to these areas, particularly in years when chum runs are low.

Despite the potential availability of salmon carcasses along the river through the restored reservoirs shortly after dam removal, it may take over 100 years before these stretches are used by wintering bald eagles because of a lack of perch trees close to the water. Along the Nooksack River, 94 percent of the wintering bald eagles observed were perched in trees within 160 feet (49 m) of the water. Preferred perch trees were big leaf maple, black cottonwood, and Sitka spruce which were significantly taller than the more abundant red alder (Stalmaster and Newman, 1979). Bald eagles may perch in some of the larger alder expected to occur on the reclaimed terraces within 100 years or so, but use of the river adjacent to these areas may be limited until black cottonwood and big leaf maple invade and mature.

The restoration outlooks for steelhead are excellent. Carcasses for these runs would provide supplemental food in the spring and summer to bald eagles nesting near the Elwha delta, but no nesting pairs would be expected in the valley.

Staff Recommendations

Staff recommendations suggested for wildlife should minimize disturbance to federally listed threatened or endangered species and increase the success of any restoration benefits for the bald eagle and spotted owl.

Unavoidable Adverse Impacts

The dam removal alternative would have no unavoidable adverse impacts on the bald eagle or spotted owl.

Federal Candidate Species

Removal of both dams would have no adverse impacts on the marbled murrelet, the only federal candidate species observed in the project area. Restoration of the reservoirs and project facilities may, over the long term, increase available habitat for the marbled murrelet in the Elwha Valley.

Construction Impacts

Because marbled murrelets nesting in the Elwha drainage are confined to tributaries and the upper elevation reaches, dam removal activities are not expected to disturb this species. In addition, since marbled murrelets generally fly between 300 and 600 feet above the canopy, it is unlikely that dam removal activities would disturb the daily movements of this species.

Long-term Impacts

The primary long-term impacts of the dam removal alternative would be a potential increase in available habitat from the restoration of the reservoir areas and the eventual establishment of old growth. However, the existing old growth in the area around Lake Mills is not currently used by nesting murrelets; apparently, it lacks characteristics found along higher-elevation tributaries.

Staff-Recommended Measures

Staff recommendations suggested for wildlife should minimize disturbance to the marbled murrelet and increase the success of restoration benefits for this species.

Unavoidable Adverse Impacts

The dam removal alternative would have no unavoidable adverse impacts on the marbled murrelet.

4.2.4.4 Restoration of Natural Conditions Within ONP

Removal of both dams would fully meet the overall licensing goal of restoration of natural conditions in ONP. Removal of Glines Canyon dam and the revegetation of the area currently occupied by Lake Mills would ultimately return the natural vegetation and habitats on project lands within ONP. Vegetation and wildlife habitats would be returned to natural conditions within 20 years and to pre-project conditions in several hundred years (Section 4.2.4.1 and 4.2.4.2).

Removal of both dams would also restore all anadromous fish run, except sockeye, to the middle and upper reaches of the Elwha. These runs would contribute a large amount of additional food to wildlife that consume salmon carcasses and would be expected to restore populations of these species to natural levels.

4.2.5 Land Use

The dam removal alternative would involve 5 years of heavy construction activities which would negatively affect transportation and recreational uses in the area. The removal of the hydroelectric projects would essentially remove an industrial use from the river and create large areas for wildlife and river protection uses. Some areas of Elwha Project lands would be used for timber production and management. The long-term restoration of shoreline areas and anadromous fisheries would be compatible with most land uses and relevant comprehensive plans.

4.2.5.1 Construction Impacts

The construction impacts resulting from decommissioning the Glines Canyon Project would be slightly different than those predicted for the Elwha Project. In addition, since both dams would be removed on schedules independent from one another (although only one year apart initially), construction impacts resulting from each are treated separately.

Glines Canyon Dam Removal

The 5 years of construction associated with dam removal at Glines Canyon would have a significant adverse impact on recreational and park administrative uses in

the Elwha River Valley. The construction effort would probably close the upper roaded areas of ONP for short periods of time, contribute significant amounts of noise to front and back country hikers, and decrease the attractiveness and quality of the river for fishing and whitewater rafting activities. These construction effects would occur throughout the summer season of the 5-year construction period for the Glines Canyon Project removal. Additional traffic on Olympic Hot Springs Road including the movement of heavy equipment and haul trucks would reduce the scenic quality of the roaded environment and possibly disrupt traffic flows.

About 6,300 cubic yards of spoils from the boring of the diversion tunnel would be hauled away to the Kelly Mountain disposal site, located north of Highway 101 and west of Lake Aldwell. Additionally, concrete rubble from the Glines Canyon dam and powerhouse structure would be hauled to the Kelly Mountain site. In addition to the hauling off of scrap metal to be sold and recycled, there would be thousands of truck loads passing through the park on Olympic Hot Springs Road and potentially disrupting traffic flow at the intersection of Olympic Hot Springs Road and Highway 101.

The boring of the diversion tunnel, blasting of the diversion tunnel outlet and dam structures, and continual movement of large dredges, loaders, earthmovers, and trucks would create substantial noise, dust, and emissions from internal combustion engines in the national park environment. Currently, the ONP is in a federal class I area under the Clean Air Act's Prevention of Significant Deterioration (PSD) program. The PSD program gives the NPS the responsibility to ensure that construction projects and large facility developments do not have an adverse impact on air quality related values of an area, including visibility (NPS, 1989a). Air quality would be affected by emissions from dredging equipment, earthmoving tractors and loaders, large trucks and tunnel boring equipment. Dust generation would be most extensive during the dry periods of summer when sediment moving is occurring in the middle, silt laden portions of the reservoir bottom.

Elwha Project Dam Removal

The construction period for the Elwha dam removal process would be 4 years, commencing one year after the Glines Canyon Project construction start. There are few receptors for noise and dust generated by construction activities although the Shady Tree RV park, the Elwha and Indian Creek Resorts, and some residences off Highway 101 and Dan Kelly Road would be slightly affected by construction activities. There would be over one thousand truck loads of tunnel spoils and dam rubble to be hauled away to the Kelly Mountain disposal site. This would involve extensive use of the gravel-surfaced State Forest Road located

above the west side of Lake Aldwell. The additional traffic on this road would result in a minor inconvenience to residences on Dan Kelly Road and to logging operations on the state owned forest lands around Kelly Mountain.

4.2.5.2 Long-Term Impacts

The removal of both dams, reservoirs, transmission lines and project support facilities would convert 759 acres of project occupied lands into alternative uses.

The 462 acres occupied by the Glines Canyon Project facilities would be restored to natural conditions which would continue to be available for recreational uses. The types of recreational activities on these lands would change and is described in Section 4.2.6.2. The 160 acres owned by the applicant would probably be acquired by the NPS, and all buildings and structures associated with the dam tenders residence would likely be removed and the grounds would be returned to natural conditions. The right-of-way once occupied by the transmission line would also revert to natural conditions.

The 297 acres occupied by the Elwha Project would be restored to natural conditions. The project occupied lands and adjacent lands owned by the applicant would probably be managed for timber production, similar to the adjoining lands east of Highway 101, and west of Lake Aldwell. Over 1,000 acres would be available for production and harvest, of which the mature second growth timber, located around Lake Aldwell, would probably be cut first. The area would still receive light recreational use, with whitewater boating opportunities replacing the existing flatwater boating uses.

The existing 1.6-acre WDW boat launch facility on Lake Aldwell would be abandoned by recreationists since shoreline access would no longer be possible.

In the long term, the middle reach of the Elwha River could be potentially eligible for federal wild and scenic river designation, or state scenic river designation. The lower reach of the Elwha would still not be eligible for wild and scenic river status because of the presence of the low diversion dam, associated with the municipal and industrial water withdrawal, at RM 3.4 (USFS, 1990).

An approximately 8-acre parcel at the base of Kelly Mountain would be taken out of production for timber, and become an earthen and concrete rubble landfill.

In the long term, the dam removal alternative would be fully consistent with the National Marine Fisheries Service and Pacific Fishery Management Council's Fishery Management Plan, because fisheries restoration measures would greatly contribute to the principal objective of restoring lost habitat and boosting fish production toward previous levels.

As with the other alternatives, the dam removal alternative is fully consistent with the Northwest Conservation and Electric Power Plan's Protected Areas Amendments. It is possible that the middle and upper reaches of the Elwha River would be designated "protected" in order to fully protect the newly established wild fish habitats.

The dam removal alternative is generally consistent with ONP plans, because the restoration effort is expected to restore natural conditions on lands and waters previously altered by human activity. The removal of the Lake Mills boat launch and day use facility would, however, represent a net loss to the recreational facilities in park periphery areas, which support high intensity uses.

The dam removal alternative is fully consistent with the SCORP and generally consistent with the Clallam County Comprehensive Plan. While there would be a loss of two boat ramp facilities, the addition of 5.3 miles of free flowing river opportunities for recreationists, and the tremendous increase in the quantity and quality of the recreational fishery would enhance recreational opportunities and tourism.

The dam removal alternative is fully consistent with the WDF Hydroelectric Project Assessment Guidelines and WDW Strategies for Washington's Wildlife, because of the significant restoration of wild anadromous fish to the river system without significant hindrance or blockage to fish passage.

The dam removal alternative would be substantially inconsistent with the Shorelines Master Program because dredging and land filling is prohibited in the natural zone assigned to the river and shoreline areas of Lake Aldwell. However, since the alteration of the water course would restore the river to a more natural condition, and the 200-foot shoreline area would essentially be moved waterward hundreds of feet, a temporary exception may be granted. The use of shoreline protection measures to stop erosion is, however, allowed as a conditional use. While the dam removal alternative would have some technical inconsistencies with the state shorelines program, the substantial benefit of increased sediment supply to offshore areas would be a very positive effect, helping to lessen the erosion processes at Ediz Hook. This long-term benefit would contribute to the alternative's consistency with the state's Coastal Zone Management program.

4.2.5.3 Staff-Recommended Measures

If possible, provisions should be made for new public access lands on the new shorelines of the Lake Aldwell river reach by a land exchange with the existing 1.6-acre WDW parcel located on the Lake Aldwell shoreline.

Contractors involved with dam removal at the Glines Canyon Project should employ the best available emission control technology and implement dust control measures to preserve the air quality in ONP.

The staff also recommends that any required closures of the Olympic Hot Springs Road in the Glines Canyon Project area be scheduled on weekdays with public notification provided in area and regional newspapers.

4.2.5.4 Unavoidable Adverse Impacts

The short-term degradation of air quality and increased traffic congestion associated with construction vehicle operations would be adverse and unavoidable.

4.2.6 Recreational Resources

The dam removal alternative would greatly benefit both marine and freshwater sports fishing in the area. Recreationists visiting the Elwha sub-district of ONP would be inconvenienced during the first four years of construction and significantly affected during the last year of construction due to park closures. In the long term, there would be a loss of recreational boating opportunities on the project reservoirs, but an increase of 5.3 miles of free flowing river would be available to whitewater boating enthusiasts.

4.2.6.1 Construction Impacts

Construction impacts to recreationists would affect angling, whitewater boating, hikers, and other users in ONP. Impacts would result from noise and air emissions, traffic increases, and closures of Olympic Hot Springs Road.

There would be a decrease in the clarity of water during the construction period at both projects which would decrease the attractiveness and suitability of the river for angling, whitewater boating, and other passive uses. The increased turbidity during all seasons would affect angling in the middle and lower reaches. High turbidity would reduce angler effectiveness and the quality of the angler experience.

Increased traffic, noise, dust, and vehicle emissions would be readily apparent to most day and overnight hikers using trails in the Elwha River Valley. The use of the West Lake Mills Trail would probably decrease, as the two-mile trail is close to the reservoir construction area. Other trails which would be slightly affected by air and noise impacts include the Upper Lake Mills Trail, Hurricane Hill Trail, Griff Creek Trail, Happy Lake Ridge Trail, Wolf Creek Trail, and the Geyser Valley Trails. Other than the Geyser Valley Trails, most of these trails receive fairly light use, as compared to main Elwha Valley trails and Boulder Creek/Appleton Pass trails.

The closures of Olympic Hot Springs Road would create the greatest construction period impact, as this would affect all recreational users of the Elwha sub-district. Periodic closures would be required during the hauling period for removal of tunnel spoils and concrete rubble as a result of dam demolition at Glines Canyon. The most significant closure would probably be during the fifth year of dam removal at Glines Canyon when approximately 18,000 cubic yards of concrete rubble would need to be hauled to the Kelly Mountain disposal site. The staff estimates that the Olympic Hot Springs Road could be closed to public use for up to two months during the fifth year of construction. This closure would require a partial summer closure of the Elwha sub-district recreational facilities which could displace up to 30,000 recreationists.

Since both Elwha campgrounds would be closed, campers would seek other camping opportunities at other national park, county, and private facilities potentially causing overcrowding at those facilities. Anglers would have to seek angling opportunities at nearby Lake Sutherland, Lake Crescent, the Dungeness River, the Lyre River, and the Quillayute River. Hikers, sightseers, and picnickers would probably utilize facilities in the Hurricane and Soleduck sub-districts, potentially causing some crowding at those facilities. Whitewater boaters would have few other comparable rivers in the area to choose from and would have to either use the Soleduck or Bogachiel rivers or travel over 75 miles to the Queets, Quinault or Humptulips rivers for rafting opportunities.

4.2.6.2 Long-Term Impacts

The removal of both dams would result in a significant positive impact in both the quantity and quality of the recreational fishery. Both coho and chinook salmon would be available for harvest in marine and inriver fisheries at much higher levels than present conditions allow; however, the harvest rate would have to be somewhat curtailed, possibly resulting in more restrictions on seasons or bag limits. However, the significant increases in escapement for all but one salmon species (sockeye) would mean the average angler would have a much greater chance of success both inriver and offshore. A reduction in the resident trout fishery would occur due to competition with anadromous fish in the middle and upper reaches.

The restoration of pink and chum salmon, sea-run cutthroat, and Dolly Varden trout would provide additional angling opportunities to anglers, resulting in a substantial increase in angler days expended in the Elwha River system.

Both winter and summer steelhead fishing would be better in quality and quantity, and additional miles of river would be available for steelhead anglers in the middle and upper reaches.

There would be a loss of reservoir boating opportunities so that those recreationists who engage in reservoir fishing, openwater canoeing, and pleasure boating would no longer be able to participate in these activities in the Elwha River. However, there is a variety of other boating opportunities available on the Olympia Peninsula and the loss of flat water boating would be partially offset by the addition of 5.3 miles of more free flowing river opportunities for kayakers and possibly rafters.

4.2.6.3 Staff-Recommended Measures

Staff land use recommendations (Section 4.2.5.3) would apply and help to reduce impacts to recreation. By allowing the Elwha sub-district to remain open on weekends during rubble and waste hauling periods, the total displacement of recreationists could be reduced by an estimated 15,000 persons.

4.2.6.4 Unavoidable Adverse Impacts

The temporary closures of Olympic Hot Springs Road and increased dust, noise, and other air emissions would be adverse to recreationists in ONP during the construction period. The decline in the utility and attractiveness of the West Lake Mills Trail would be an adverse impact. The increase in turbidity would unavoidably impact anglers in the middle and lower river reaches. There would be a reduction in the quality of the resident trout fishery in the middle and upper river.

4.2.7 Aesthetic Resources

In the short term, the dam removal alternative would adversely affect the aesthetic environment, particularly in ONP. Outside the park, the removal of the Elwha Project facilities would be less noticeable to viewers.

4.2.7.1 Construction Impacts

The 5 years of construction at the Glines Canyon Project and 4 years of construction at the Elwha Project would result in adverse visual impacts to residents and tourists visiting the Elwha River Valley.

The first year of construction, associated with the tunneling effort at both dams, would not greatly alter the viewshed at either project, and would only induce minor adverse impacts to residents, sightseers and other recreationists. The remaining 3 and 4 years of construction at both projects would, however, create adverse impacts to the visitors and residents of the area. The lowering of water levels at both project reservoirs would expose old stumps, mud and debris and would create a large visual contrast with the dense vegetation along reservoir shorelines. The exposure of the barren, debris-strewn reservoir bottom would be

highly offensive to most viewers. Large equipment moving sediments in the area would also degrade the scenic environment at both project sites, particularly at Glines Canyon. Visitors to the Elwha sub-district would not expect to view such an extensive construction operation in a national park. This would degrade the quality of the scenic environment and may turn away many visitors.

The added turbidity to the Elwha River and added dust load to the surrounding air shed would further degrade the scenic quality of the environment during the 4 years of site reclamation.

4.2.7.2 Long-Term Impacts

It would take several decades of vegetation growth for the 682 acres, currently occupied by project reservoirs, to blend into the existing mature forests found in the area. Many viewers would consider the revegetation, succession, and natural river channelization an interesting process worthy of examination. Once the first stages of vegetative succession take hold, the appearance of the reservoir areas would be similar to recently logged areas and other disturbed lands in the region. The presence of alder, cottonwood, blackberries and other weedy shrubs would generally not be as scenic as the existing large water bodies. However, the river channel itself would probably be very scenic and new whitewater boating opportunities would provide new viewing areas. At Lake Aldwell, private property may limit shoreline access, but at Lake Mills the presence of national park lands ensure such access, and eventually the NPS could reestablish the original Elwha River Trail used by early visitors to the upper watershed. The increase in wintering elk use in the Lake Mills bottomland could, in turn, allow visitors more wildlife viewing opportunities during the winter months. Overall, however, the replacement of vegetative covers to areas currently occupied by the reservoir would not be beneficial to the aesthetic environment.

4.2.7.3 Staff-Recommended Measures

The staff recommends the placement of temporary interpretive signs to inform ONP visitors about the removal and restoration process.

4.2.7.4 Unavoidable Adverse Impacts

The 4 to 5 years of construction at each project would involve reservoir drawdown and active sediment management, which would unavoidably adversely affect the visual environment. Also, the loss of large scenic waterbodies would be unavoidable.

4.2.8 Socioeconomics

Removal of both dams would increase the potential of restoring wild sea-run salmon and trout to the Elwha River. The allowable harvest of these sea-run fish would be greater than at present. This alternative offers the greatest economic benefit to commercial, sport, and tribal fisheries, and the greatest opportunity for improvement in tribal social conditions.

Some employment benefits would accrue during the construction period, but the long-term operational and maintenance workforce would decline compared to current conditions. Daishowa America Mill would have to replace power from the projects with more expensive power purchased from other sources.

4.2.8.1 Construction Impacts

The construction period under the removal of both dams alternative would have minimal effects on the existing commercial, tribal, and marine sport fisheries. Higher sediment loads in the river during the removal period would have short-term minor adverse effects on existing sport fishing in the reservoirs and river.

Workforce requirements would vary from 20 to 78 workers at any given time, averaging 22 persons per year for each of the 5 years of the construction period. This workforce would be available within the local commuting area, and therefore would not require community services beyond those already available locally.

4.2.8.2 Long-Term Impacts

There would be positive and negative long-term socioeconomic impacts of the dam removal alternative. This alternative would provide the greatest potential for restoring anadromous fish runs to the river, and increased allowable harvests would create increased income for commercial and tribal fishermen. The recreational industry would benefit from improved sport fishing. Increased income to the tribe could help alleviate the existing poverty, and improve social conditions. Several jobs would be eliminated because the existing project operations and maintenance workers would not be needed. The cost of power to Daishowa America Mill would increase substantially.

Fisheries

Removal of both dams would provide the greatest potential of restoring the various wild runs of fish to the river (Section 4.2.3), as well as increase the fisheries harvest over present conditions due to the potential improvements in fish passage and spawning and rearing habitat without the dams.

Total fall chinook production and allowable harvest rates would increase about 2.5 times that of present levels (Table 4-21), and would be substantially higher than the applicant's dam retention proposal (Table 4-14). Assuming about 60 percent of the marine harvest is commercial, the additional commercial harvest would amount to approximately 10,000 fish worth more than $220,000 annually in revenue to the fishermen. The allowable sport harvest would also increase, possibly compensating, at least partially, for effects of expected future fishery restrictions to protect wild stocks throughout the region. If overall harvest rates of chinook salmon were reduced as planned in the marine fisheries so that harvest falls below the optimal sustained yield level (78 percent), the extra projected escapement to the river could be harvested by inriver tribal and sport fisheries. If total marine harvest of chinook salmon were reduced to 60 percent, for example, the extra harvest to the tribal and sport inriver fisheries could represent about 6,000 fish. If shared equally with the inriver sport fishery, the 3,000 fish would represent a revenue of up to $67,000 annually to the tribe.

Restoration of a spring chinook run would provide an additional benefit to marine and inriver fisheries. The extent of such benefits is unknown, since the potential for successful restoration depends on maintenance of relatively low harvest rates. However, given the excellent habitat of the upper basin for spring chinook, a viable wild run could be sustained, especially if harvest rates are carefully controlled. Some nominal benefit would be expected in the marine and inriver fisheries.

With removal of both dams, coho salmon production would be nearly double present production, and total harvest could increase 30 percent over present conditions (Table 4-21). Although most of these fish would be harvested in the marine fishery, some surplus could be available to the tribal fishery, depending on the rate of marine harvest. If the marine harvest rate were held to 50 percent, for example, the inriver tribal harvest could be maintained near present levels.

Steelhead production would increase on average 150 percent above present levels and harvest could increase about 20 percent over present levels (Table 4-21). The additional harvest would increase tribal revenues about $2,000 per year and sport harvest about 200 fish per year.

With removal of both dams, the potential for restoration of pink salmon and chum salmon is good, with possible production levels of about 274,000 and 36,000 (Table 4-21), respectively, compared to negligible present levels. Escapement to the river would likely be sufficient to allow some harvest by the inriver tribal fishery, if marine harvest rates are maintained below 65 percent for pink salmon and 50 percent for chum salmon. Assuming all the pink and chum harvest would

Table 4-21. Present and predicted future total adult production, harvest, and escapement of fall chinook, coho, winter steelhead, chum, and pink salmon under the removal of both dams alternative (Source: the staff).

	Chinook		Coho		Steelhead		Chum		Pink	
	Present	Future	Present	Future	Present	Future	Present	Future	Present	Future
Adult Production	13,500	34,000	22,000	39,500	4,000	10,200	<1,000	36,000	<100	274,286
Harvest Rate	0.80	0.78	0.90	0.65	0.90	0.43	____	0.50	____	0.65
Harvest	10,000	26,520	19,800	25,675	3,600	4,386	____	18,000	____	178,286
Escapement	3,500	7,480	2,200	13,825	400	5,184	____	18,000	____	96,000

Note: "____" equals unknown.

be allocated to the marine commercial and inriver tribal fishery, the added revenue from the additional 178,000 average harvest of pink salmon and 18,000 chum salmon would be approximately $475,000 and $126,000, respectively.

The potential of restoring summer-run steelhead, cutthroat, and Dolly Varden trout would be substantially increased over the applicant's dam retention proposal. Since the production potential of these fisheries is unknown, the potential expansion of their fisheries is also unknown. The primary benefit of the expansion of these populations would probably be to the sport fishery, which would provide a further benefit to local tourism.

Tribal Social Effects

As noted above, tribal fisheries would improve under the dam removal alternative. Both marine and inriver tribal harvests of fall chinook could increase, the steelhead harvest could increase by about 10 percent, and there would be some commercial and/or subsistence fishery available in spring chinook, pink and chum salmon. The current coho harvest could be eliminated, however, and the income and employment associated with the hatchery could be eliminated as well. The concurrent restoration of steelhead and pink and chum salmon harvest with the loss of the coho harvest would have an indeterminate effect on the seasonal distribution of fishing and on the subsistence fishermen. The increase in cash income from commercial fishing, the availability of a year-round high quality food source, and the cultural significance of fish restoration would have social benefits for the tribe.

Because the increased sediments flowing down river would help build up the river delta, this alternative offers the greatest potential of restoring shellfish habitat valued by the tribe (Section 4.2.3).

Cost of Power

With dam removal, the Daishowa America Mill would have to reduce power needs and/or purchase power elsewhere. Assuming replacement power would be purchased from BPA through Port Angeles City Light (Section 2.7.3), Daishowa's average weighted cost of power from 1996 through 2005 would increase from the reference case 29.9 mills/kWh to 38.9 mills/kWh (Table 2-18). This latter figure equals the average weighted cost of power that would be experienced under the applicant's proposal, and would have a similar negative effect on the mill's overall operating cost. Negative effects on the mill's competitive position could carry through to their employees and suppliers. No data are available to the staff to permit estimates of how mill production would be affected by increased operating costs. In the most extreme case, complete mill closure caused by higher energy costs would cause the loss of up to 1,200 jobs among mill employees, suppliers, and other local businesses.

Project Employment

One employee would be required following the removal of both dams to monitor and maintain the revegetated reservoirs. This represents a loss of 9 jobs compared to the existing operations and maintenance workforce at the projects, and is 13 fewer jobs than required under the applicant's proposal.

Other Effects

Overall effects on recreation and tourism would be positive, offering the greatest potential increase in recreation and tourism-based income. Because of data limitations, it is not possible to differentiate between the economic effects on recreation and tourism related specifically to Elwha River changes, and changes brought about by future fishery management practices associated with restoring or protecting wild fish stocks in the other river systems in the Strait of Juan de Fuca and Puget Sound. Improvements identified for recreation (Section 4.2.6) would have substantial potential benefits to the local and regional tourism industry.

Timber owned by James River II, Inc. could be logged in the vicinity of Lake Aldwell, providing income to the owner and loggers.

The threat of flooding would be slightly greater in the upper one-half mile of the lower Elwha levee, possibly threatening several homes, primarily homes of tribal members, in the event of a 200-year flood or greater (Section 4.2.1).

The Port Angeles water supply system could possibly be adversely affected for 2 to 5 years due to the increased sediment load in the river (Section 4.2.2).

The restoration of normal sediment flow from the river would help restore coastal processes, leading to increased sediment deposition at Ediz Hook. This would eventually reduce current beach replenishment costs that average $100,000 annually (Section 4.2.1).

Taxes paid on the projects would drop to zero, a loss of $266,000 annually (1990 dollars) for Clallam County.

4.2.8.3 Staff-Recommended Measures

An affirmative action plan should be prepared and implemented to improve tribal employment opportunities associated with dam removal.

4.2.8.4 Unavoidable Adverse Impacts

No unavoidable adverse impacts to fisheries are anticipated from the removal of both dams. Some interim curtailment of harvest may be necessary during the run restoration period. Present allocation of harvests could be altered depending on the specific management scenario adopted by resource agencies.

The cost of replacement power to the Daishowa America Mill would be more than double the reference case cost, creating a 30 percent increase in the average weighted cost of power to the mill. The additional cost would be close to that of the applicant's proposal.

4.2.9 Cultural Resources

Dam removal would destroy the Elwha and Glines Canyon dams, which are listed on the National Register of Historic Places. Restoration of nine anadromous fish stocks and the improvement of shellfish beds at the Elwha River mouth would be beneficial to Native Americans.

4.2.9.1 Construction Impacts

The removal of the Elwha and Glines Canyon dams would have a direct, significant, and adverse effect on these National Register properties.

It is also possible that previously undiscovered archaeological sites could be affected during construction. At Elwha dam, construction areas for this alternative include the access road for the diversion tunnels and the upland diversion tunnel spoil disposal pile, located east of Lake Aldwell, which would also receive rubble from the dam, powerhouse, and other facilities. At Glines Canyon dam, these new facilities would include an access road and spoil pile for the diversion tunnel as well as a 2-acre staging area north of the dam. These facilities are located in areas previously surveyed and of low probability for containing archaeological sites.

The excavation of Lakes Mills and Aldwell sediments would result in disturbance of approximately 25 percent of the original ground surface within the new channel dredge zone, because of the inherent difficulty in accurately excavating and dredging to original ground surface. Any archaeological sites buried under the lake sediments could be adversely affected.

4.2.9.2 Long-Term Effects

Restoration of wild anadromous fish stocks would significantly benefit Native American culture because of the cultural significance of fish and fishing to members of the Lower Elwha Klallam Tribe. In terms of the Klallam world view,

stewardship of the natural ecosystem, particularly the anadromous fishery, is of paramount importance and restoration of wild fish stocks is consistent with Klallam ideas about natural resources stewardship. Elimination of natural anadromous runs brought about by Elwha dam construction disrupted the fishery and Klallam culture, and in the view of the Lower Elwha Klallam Tribe, violated the Treaty of Point No Point. Fishery restoration would bring a restoration of treaty rights and would partly compensate the Klallam for the loss of cultural values and practices brought about by dam construction.

The dam removal alternative would create excellent opportunities for the restoration of fall run chinook salmon and winter steelhead; good opportunities for restoration of spring chinook, chum, coho, and pink salmon, summer steelhead and sea-run cutthroat and Dolly Varden trout; and poor opportunity for restoration of sockeye salmon (Section 4.2.3.2). Such increases would benefit tribal marine and inriver fisheries (Section 4.2.8).

The dam removal alternative would also result in restoration of shellfish beds at the Elwha River mouth. Shellfish are of cultural importance to the Lower Elwha Klallam Tribe, and dam removal would result in an increase in the deposition of fines and gravel, which would improve shellfish habitat (Section 4.2.3.2).

4.2.9.3 Staff-Recommended Measures

The potential effects of this alternative on the National Register Elwha and Glines Canyon hydroelectric sites could be mitigated by recording the existing condition of the dams to the standards of the Historic American Engineering Record.

Reservoir excavation and dredging should be monitored by a professional archaeologist to determine whether the construction process is affecting archaeological sites.

If buried archaeological sites were discovered during construction, work in the immediate vicinity of the find should be halted pending consultation with the SHPO.

4.2.9.4 Unavoidable Adverse Impacts

There would be no unavoidable adverse impacts to cultural resources under this alternative as long as the proposed mitigative measures were applied.

4.3 GLINES CANYON REMOVAL WITH RETENTION OF ELWHA

This section contains an evaluation of the beneficial and adverse effects associated with a third principal alternative, removal of the Glines Canyon Project and retention of the Elwha Project (Section 2.4).

4.3.1 Geology, Soils, and River Morphology

Methods and potential impacts from tunnel construction at the Glines Canyon dam, reservoir drawdown, sediment stabilization, and removal of the Glines Canyon dam would be accomplished as previously discussed for removal of both dams (Section 4.2.1.) Fish passage modifications to the Elwha dam and potential impacts would be as summarized previously under the applicant's proposal (Section 4.1.1.).

4.3.1.1 Construction Impacts

The Glines Canyon removal alternative would have temporary sedimentation impacts while work in Lake Mills is underway (see Section 4.2.1.1 for details). Minor construction phase erosion and sedimentation effects would be expected at the Elwha Project due to construction of the fish passage facilities on very steep terrain and the proximity of proposed structures to the river (see Section 4.1.1.1 for details).

4.3.1.2 Long-Term Impacts

Natural upstream sediment supply would be returned to the middle reach of the Elwha (Section 4.2.1.2). The proposal would result in status quo conditions with regard to sediment transport in the lower Elwha and coastal zone (Section 4.1.1.2). The Elwha River would continue to deposit all but the finest sediment in Lake Aldwell, resulting in its filling being accelerated over the next 40 to 60 years. The lower reach of the Elwha River would continue to be sediment starved, maintaining the current armored nature of the river bed which results from a lack of gravel- and sand-size sediments moving downriver. The river channel would remain highly stable between Lake Aldwell and RM 2 while returning to a natural unstable character in the middle reach.

4.3.1.3 Staff-Recommended Measures

Development of detailed plans, specifications, and contracts for grading, drainage, erosion, sediment control, vegetation and near-term maintenance plans would be required to stabilize the Lake Mills reservoir sediments as described in Section 4.1.1.3. To limit increased suspended concentrations during construction and operation of the fish passage facilities at the Elwha dam and the removal of the

Glines Canyon Project, an erosion and sediment control plan should be developed in consultation with the WDOE, WDF, NPS, and WDW.

Detailed geotechnical explorations should be conducted of the diversion tunnel alignment, lake top area, and of the bypass channel alignment for the Glines Canyon project, as a basis for the development of detailed designs for the diversion facilities.

4.3.1.4 Unavoidable Adverse Impacts

Adverse impacts would include construction phase silting of the middle and lower Elwha, flood levels 1 to 2 feet higher in the middle reach over the long term, and the acceleration of the filling of Lake Aldwell by the increase in river borne sediment supply.

4.3.2 Water Quantity and Quality

Water quality impacts under this alternative would be very similar to those predicted under the removal of both dams (Section 4.2.2). During the 5-year construction period, the Lake Mills, middle, Lake Aldwell, and lower reaches of the river would be adversely impacted by high turbidity from increased suspended sediment loads. Suspended sediment and turbidity values would decline to natural levels within several years after the construction period because of the stabilization of the Lake Mills reach river channel. Organic matter concentrations, bacterial levels, and nutrient concentrations in the middle and lower river would be significantly increased during and for several years after the construction period. Increased turbidity and dissolved organic matter levels would have an adverse impact on the quality of industrial water supplies and water diverted to the WDF fish rearing channel, and a potentially adverse impact on domestic water supplies. Dissolved oxygen concentrations would be adversely impacted in Lake Mills during summer construction periods, but would not change in the middle and lower reaches of the river. During late summer and fall low-flow periods, water temperatures in the middle reach would be reduced by 2 to 4°C from existing conditions. The Elwha River would assume a natural, run-of-river discharge pattern following the removal of Glines Canyon dam since existing agency requested flow augmentation in late summer and fall, and the applicant proposed drawdown of Lake Mills for power purposes would not be possible.

4.3.2.1 Construction Impacts

Water Quantity

Alteration of river discharge patterns under the Glines Canyon dam removal alternative would be very similar to those expected under removal of both dams (Section 4.2.2.1). River discharge would be moderated during the 4-year dam

removal period. Drawdown of Lake Mills would start in April during the first year of the dam removal project schedule. During the 3-month drawdown period, discharge would increase by 139 cfs in the middle, Lake Aldwell, and lower reaches of the river. Increases in discharge at this same level would occur for a 2-month period during the second and third year of construction. The Glines Canyon dam diversion tunnel constructed for dam removal would provide considerable flexibility in maintaining either a constant discharge or a constant pool elevation as required for river channel excavation, grading, and stabilization, and for alleviating sedimentation impacts in the river below Glines Canyon dam.

Water Quality

Removal of Glines Canyon dam would result in water quality impacts very similar to those described in Section 4.2.2.1 for removal of both dams. Construction would result in high turbidity levels during reservoir drawdown and channel excavation. Water temperatures and dissolved oxygen levels could exceed state standards in Lake Mills during the construction period. Following removal of Glines Canyon dam, high concentrations of suspended sediments would be expected during winter high-flow periods. Only about 2 percent of the suspended silt would settle in Lake Aldwell; most would pass down to coastal waters. High turbidity levels would adversely impact water diverted for industrial use at Port Angeles and the WDF fish rearing channel, and would potentially impact waters diverted by the City of Port Angeles for domestic use. Increased BOD and bacteria densities (coliform and non-coliform) would result from the organic component of the silt. Nutrient concentrations would also increase in association with high suspended sediment loads. Existing high summer and early fall water temperature during summer low flow periods would be reduced 2 to 4°C.

4.3.2.2 Long-Term Impacts

Water Quantity

With removal of Glines Canyon, discharge of the Elwha River would follow a natural, run-of-river discharge pattern. Operation of Lake Aldwell would have very little influence on a run-of-river discharge pattern in the lower reach, since a constant reservoir pool elevation would be maintained during the entire year. Flow augmentation would not be possible during critical low-flow periods due to the lack of storage currently provided by Lake Mills. Consequently, extremely low minimum flows would occur during drought conditions in the lower reach below the WDF rearing facility water intake, City of Port Angeles' water diversion, as they do under existing conditions without augmental flows from Lake Mills storage (Section 4.2.2.2).

High suspended sediment concentrations would occur during storm runoff events for up to several years following dam removal of Glines Canyon Dam. Sediment concentrations would gradually decline because of stabilizing the newly developed river channel in the Lake Mills reach. River banks along the middle reach would serve as a storage area for sediments transported from Lake Mills, and would continue to contribute sediments in the river for an extended period of time. Suspended sediment concentrations would be the approximately the same as those encountered for glacial rivers in the region (see Section 4.2.1.2 for a more detailed discussion). Ultimately, suspended sediment concentrations in the Lake Mills, middle, Lake Aldwell, and lower reaches of the Elwha River would be the same as the natural background level of the upper river. Turbidity values in the river result from clay and silt fractions, which are currently held in suspension and subsequently pass through Lake Mills and Lake Aldwell. Consequently, long-term turbidity values in the middle and lower reaches of the Elwha River after Glines Canyon dam removal would not be significantly different from currently existing conditions.

POM would increase in the middle reach and Lake Aldwell, following the removal of Glines Canyon dam. Course leaf material and woody debris transported from reaches above Elwha dam would settle in Lake Aldwell. POM in the lower reach would be slightly higher than existing conditions because fine particulate organic matter (< 1 mm diameter) would remain in suspension through Lake Aldwell at higher flows. In addition to POM, additional organic matter would be added to the Lake Aldwell and the middle and lower reaches by salmon and steelhead trout carcasses from fish passage at Elwha dam.

Maximum daily temperatures would slightly increase in the Lake Mills and middle reaches of the river from mid-July to mid-August after removal of Glines Canyon dam (James River II, 1988f; staff analysis). Lake Mills currently provides limited cooling of inflow waters during this period as a result of mixing with cold water remaining in the reservoir from spring runoff and early summer snowmelt runoff.

From the middle of August to late October, maximum daily water temperatures in the Lake Mills and middle reaches or the Elwha River would be from 2 to 4°C cooler than existing condition (James River II, 1988f; staff analysis). Cooler water temperatures would result from an absence of heating and heat storage provided by Lake Mills.

Daily water temperature fluctuations in the middle reach would increase due to a lack of mixing of inflow waters by Lake Mills. Mixing inflow waters in Lake Aldwell would minimize temperature fluctuations in Lake Aldwell and the lower reach; consequently, temperature fluctuations in these sections of the river would not change considerably from existing conditions.

4.3.2.3 Staff-Recommended Measures

To mitigate for expected changes in water quality during the removal period for Glines Canyon dam, the staff recommends the same measures as prescribed for removal of both dams (Section 4.2.2.3). A water quality monitoring program should be implemented to monitor reservoir water quality during construction and to monitor water quality in lower river near intakes of domestic and industrial water supplies.

4.3.2.4 Unavoidable Adverse Impacts

Increased silt loads in the river water would be adverse to rearing fish in the WDF fish rearing facility, prohibiting the use of the facility during construction and for several years following dam removal. On-site mitigation would not be possible for the WDF fish rearing facility, since water is diverted directly from the river to rearing channels. Filtration of water for the rearing facility would not be economically feasible. Off-site mitigation in the form of a rearing facility on a nearby river would be necessary to maintain fish stocks from the WDF rearing facility on the Elwha River.

High turbidity levels during construction would require increased cycles in the industrial water supply filtration systems, resulting in increased maintenance costs of these facilities. This would be expected mainly during the summer construction period, and during winter storm events, when the highest suspended sediments are expected in the river. Because of the relatively high quantity of water required by industrial users, alternative sources of water would not be feasible.

Treatment of domestic water supplies may be necessary during the 4-year dam removal period to prevent degradation of potable water.

4.3.3 Aquatic Communities

As under removal of both dams (Section 4.2.3), removal of Glines Canyon dam would result in adverse effects on salmon and trout eggs and fry survival and lower aquatic invertebrate production in the middle and lower reaches because of high suspended sediment transport during the 5-year construction period and at least 2 to 4 years thereafter. Over the long term, with removal of Glines Canyon dam and retention of Elwha dam, there would be a favorable potential for restoring spring and fall chinook, and coho salmon, winter and summer steelhead, and sea-run cutthroat and Dolly Varden trout. There would be a poor potential of restoring pink and chum salmon because of passage problems at Elwha dam and Lake Aldwell. Resident trout would decline from the addition of competition from anadromous salmon and trout to the middle and upper reaches of the river as in the other alternatives.

4.3.3.1 Construction Impacts

Removal of the Glines Canyon dam and Lake Mills would have an adverse impact on aquatic habitat and resources of the Elwha River very similar to that associated with removal of both dams. There would be an increase in suspended and settleable sediment input to the lower and middle river for the construction period and several years thereafter. Moderate adverse impacts would occur to resident fish in the middle reach and anadromous fish in the lower river during this period as a result of reduced quality of spawning habitat, food supply, rearing habitat, and possibly direct mortality. Restoration of anadromous fish to the upper reach would be delayed for 5 years compared to 1 year under the applicant's dam retention proposal, because of lack of passage at Glines Canyon dam. Major losses of resident trout could occur in Lake Mills during construction due to poor water quality. Resident trout reproduction in the middle reach would be minimally affected since most spawning habitat is in the tributaries. Trout growth and survival in the middle reach would decline from reduced invertebrate production and poorer feeding visibility and direct mortality. Anadromous fish spawning and rearing would be moderately affected in the lower reach, although Lake Aldwell would buffer the effects of Glines Canyon Project removal especially the amount of sand entering the lower reach. Since spawning habitat in the lower river is limited and most production is from hatcheries, adverse impacts on anadromous fish production during the construction period would be minor.

4.3.3.2 Long-Term Impacts

With removal of the Glines Canyon dam and the addition of fish passage facilities at Elwha dam, there would be an expansion in the available anadromous fish spawning and rearing habitat in the Elwha River similar to that of the removal of both dams alternative (Section 4.2.3.2). There would be an excellent potential for restoring wild self-sustaining runs of fall chinook salmon and winter steelhead, and a good potential for restoring spring chinook salmon, coho salmon, and summer steelhead (Table 4-22), as in the removal of both dams alternative. Compared to the applicant's dam retention proposal increased passage survival due to removal of Glines Canyon project provides for an improved restoration potential of these specific runs for reasons given in the Section 4.2.3.2. Passage survival with removal of Glines Canyon dam would be favorable for chinook, coho and steelhead (Table 4-23). The prognosis for restoring runs of pink and chum salmon is judged poor because of the passage problems at Lake Aldwell and Elwha dam, as outlined in the discussions of the effects of the applicant's proposal (Section 4.1.3.2). Sea-run cutthroat and Dolly Varden trout restoration potential is judged fair compared to the poor potential under the applicant's dam retention proposal because of improved passage survival with the removal of the Glines Canyon Project and habitat improvements in the middle reach. The prognosis for restoring wild self-sustaining runs of sockeye salmon would remain poor as in the other alternatives because of lack of adequate habitat. Also, as in the other

Table 4-22. Summary of potential restoration of anadromous salmonid stocks above the Elwha and Glines Canyon dams, Glines Canyon dam alternative (Source: the staff).

Species	Passage	Allowable Harvest Rate	Habitat	Available Stock	Restoration Overall Outlook
Fall Chinook	favorable	favorable	favorable	favorable	EXCELLENT
Spring Chinook	marginal	favorable	favorable	marginal	GOOD
Coho	favorable	favorable	favorable	marginal	GOOD
Winter Steelhead	favorable	favorable	favorable	favorable	EXCELLENT
Summer Steelhead	favorable	favorable	favorable	marginal	GOOD
Pink	unfavorable	unfavorable	marginal	marginal	POOR
Chum	unfavorable	marginal	marginal	marginal	POOR
Sockeye	marginal	marginal	unfavorable	marginal	POOR
Sea-run Cutthroat	marginal	marginal	marginal	marginal	FAIR
Sea-run Dolly Varden	marginal	marginal	marginal	marginal	FAIR

Table 4-23. Passage mortality (percent) and cumulative survival (percent) of fall and spring chinook, coho, and winter and summer steelhead for the Glines Canyon dam removal proposal (Source: the staff).

Lifestage/Region	Fall Chinook	Spring Chinook	Coho	Winter Steelhead	Summer Steelhead
Smolts					
Lake Aldwell/Elwha dam	15	15	3	12	12
Adults					
Lake Aldwell/Elwha dam	7.5	10	7.5	7.5	10
Total Mortality	20 1/	22	10	18	20
Total Survival	80	78	90	82	80

1/ Note: Total mortality is multiplicative, not additive.

alternatives, populations of resident rainbow trout in the middle and upper river would decline with the increase in competition from salmon and steelhead for spawning and rearing habitat.

4.3.3.3 Staff-Recommended Measures

The staff recommends the development of an anadromous fish restoration plan to guide the restoration program.

4.3.3.4 Unavoidable Adverse Impacts

An increase in sediment input into the river during the construction period would have a moderate adverse effect on resident and anadromous fish spawning and rearing habitat in the middle and lower reaches for 5 to 9 years.

Delay in anadromous fish restoration would occur for the 4-year construction period from lack of fish passage at Elwha dam. The introduction of anadromous fish into the middle and upper river would slightly reduce the productivity of the resident trout populations in these reaches of the river as under the removal of both dams alternative.

4.3.4 Terrestrial Resources

4.3.4.1 Vegetation

Removal of Glines Canyon dam with retention of Elwha dam would have minor adverse impacts on existing vegetation. Rubble disposal, staging areas, and new access roads would cause the temporary loss of vegetation. Construction of fish passage facilities at Elwha dam would cause the permanent loss of vegetation. Removal of Lake Mills may eliminate or degrade associated wetlands. Increased water volume and erosion may also remove and/or disturb vegetation along the middle reach. Removal of the transmission line between the Glines Canyon and Elwha projects could eliminate habitat for a species considered unique in the Elwha Valley by the NPS. Reclamation of the reservoir and project facility locations would revegetate areas that are currently inundated or developed. In addition, the applicant's wildlife improvement plan would be implemented and would modify the species composition and structure of some plant communities.

Construction Impacts

Construction of fish passage facilities at the Elwha Project would temporarily disturb small amounts of vegetation, primarily near the dam and powerhouse (see Section 4.1.4.1). The new access road and staging area for removal of Glines Canyon dam would impact 2.65 forested acres and the concrete rubble from the

diversion tunnels and facilities would be buried at an 8-acre site located in a clearcut at the base of Kelly Mountain (see Section 4.2.4.1.).

As described in Section 4.1.4.1, timber clearing operations for the wildlife enhancement plan would require temporary roads and landings involving 26.5 acres, which would be closed and revegetated upon completion of the enhancement program.

Long-term Impacts

There would be eight primary long-term effects of the Glines Canyon dam removal alternative: (1) reclamation of about 416 acres currently occupied by Lake Mills (Section 4.2.4.1); (2) the permanent loss of 1.14 acres of vegetation from construction of fish passage facilities and a project overlook at the Elwha Project (Section 4.1.4.1); (3) changes in vegetation composition and structure associated with the wildlife enhancement plan at the Elwha Project (Section 4.1.4.1); (4) reclamation of about 9 acres currently occupied by Glines Canyon Project facilities, roads, and landscaping (Section 4.2.4.1); (5) potential loss of wetlands associated with Lake Mills (Section 4.2.4.1); (6) potential loss or modification of plant communities along the middle reach of the river because of decreased channel stability (Sections 4.2.4.1 and 4.3.1); (7) potential loss of habitat with reclamation of the Glines Canyon Project transmission line for a species considered unique in the Elwha Valley by the NPS (Section 4.2.4.1); and (8) disturbance from increased recreational activity in the vicinity of Lake Aldwell (Section 4.1.4.1).

Staff-Recommended Measures

Wetland and Rare Plant Surveys

As described in Sections 4.1.4.1 and 4.2.4.1, surveys for wetlands and rare plants should be conducted at the potential location of the fish passage facilities and project overlook at Elwha, access roads, staging areas, and the rubble disposal site. Staff recommendations suggested in Section 4.2.4.1 to preserve the habitat of bicolored linanthus along the Glines Canyon Project transmission line right-of-way should also be applied.

Revegetation Plan

The staff recommends the development of a detailed plan to revegetate (1) access roads, staging areas, and other sites temporarily disturbed by removal activities at Glines Canyon or construction at the Elwha Project; (2) the rubble disposal site (3) the current area of Lake Mills; (4) project facility sites; and (5) the Glines Canyon Project transmission line right-of-way. The principal elements of the revegetation plan were described in Section 4.2.4.1.

Maintenance and Monitoring Plan

Finally, the staff recommends the development of a comprehensive monitoring, maintenance, and contingency plan for all restoration areas as well as Sweets Bottom along the middle reach. The principal elements of this plan were described in Section 4.2.4.1.

Unavoidable Adverse Impacts

No unavoidable adverse impacts on plant communities would be expected with the Glines Canyon removal alternative. Staff recommendations would ensure that impacts to vegetation due to removal activities are temporary and that impacts to plants with state or NPS status are avoided.

4.3.4.2 Wildlife

Removal of the Glines Canyon Project with retention of the Elwha Project would have minor adverse impacts on wildlife. New access roads, staging areas, and the rubble disposal site would cause the a temporary loss of wildlife habitat as in the removal of both dams alternative. Construction of fish passage facilities at the Elwha Project would cause the loss of wildlife habitat, primarily near existing project developments. Dam removal and restoration activities would disturb wildlife in the Glines Canyon vicinity of the reservoir for about 5 years. Removal of the reservoir may temporarily eliminate or degrade habitat in a wetland adjacent to Lake Mills, and along the river in Sweets Bottom.

Restoration of anadromy would change the prey-base of wildlife that feed on live fish. However, restoration of the area occupied by reservoir and project facilities would result in the addition of wildlife habitat to the Elwha Valley. In addition, the applicant's wildlife enhancement plan would be implemented and would improve habitat adjacent to Lake Aldwell for most species. Since the dam removal alternative has an excellent chance of restoring runs of fall chinook, and a good chance of restoring coho runs, populations of wildlife dependent on salmon carcasses would increase, primarily in the upper reaches of the Elwha River.

Construction Impacts

As described in Section 4.2.4.2, the habitat directly affected by dam removal activities is in small patches, which would total less than 12 acres for Glines Canyon, and which would be available for use at the completion of the process. Implementation of the applicant's wildlife enhancement plan would also temporarily eliminate 26.5 acres of habitat in the vicinity of Lake Aldwell because of required road and landing construction (Section 4.1.4.2).

Removal of the Glines Canyon Project and construction of new facilities at the Elwha Project would disturb wildlife in the vicinity of the projects over a period

of about 5 years. Dam removal activities and subsequent loss of prey would probably result in the permanent abandonment of an osprey nest site on Lake Mills near the boat launch. In addition, timber clearing and thinning operations associated with the applicant's wildlife enhancement plan would temporarily disturb wildlife in the vicinity of Lake Aldwell (Section 4.1.4.2).

Long-term Impacts

The primary long-term wildlife impacts associated with the removal of Glines Canyon with the retention of Elwha would be (1) loss of the reservoir and restoration of about 425 acres currently occupied by Lake Mills (415 acres) and project facilities (9 acres) (Section 4.2.4.2); (2) loss of about 1.14 acres of wildlife habitat from the construction of fish passage facilities and a project overlook at Elwha (Section 4.1.4.2); (3) improvements in habitat quality on land adjacent to the current site of Lake Aldwell due to implementation of the applicant's wildlife enhancement plan (Section 4.1.4.2); (4) restoration of salmon runs above Elwha dam (Sections 4.1.4.2 and 4.2.4.2); (5) loss or degradation of habitat along the river in Sweets Bottom due to increased erosion, siltation, or changes in hydrology (Section 4.2.4.2); and (6) disturbance from improved recreation opportunities (Section 4.1.4.2).

Reservoir and Facility Removal and Restoration

As described in Section 4.2.4.1, the sediment disposal terraces in Lake Mills would ultimately be expected to support plant communities similar in composition, structure, and habitat value to those that existed on the Lake Mills site prior to construction of the dams. Consequently, the results of the applicant's pre-project HEP were used to determine the long-term effects of the Glines Canyon removal alternative on wildlife, in terms of AAHU's. In the interim prior to full restoration, the value of wildlife habitat would vary, depending the successional stage and disturbance. The application of the pre-project HEP results to the Glines Canyon removal alternative are summarized in Table 4-24 (James River II, 1988a, 1990i). The AAHU's presented represent only the long-term gain expected due to restoration of the reservoir area and do not include any changes in habitat quantity or quality that would occur due to succession or logging on other lands in the Elwha Valley.

Habitat Modification

For the Glines Canyon removal alternative the staff assured implementation of the applicant's proposed wildlife enhancement plan (James River II, 1990g). Without this plan, most of the land owned by the applicant would be managed for timber production. The habitat improvement proposed by the plan would benefit most wildlife species in the vicinity of the current site of Lake Aldwell. As proposed, some of the habitat improvements would be performed only once, and the

Table 4-24. Expected habitat gains from Glines Canyon removal alternative.

	Long-Term Gain [1/, 2/]	Wildlife Enhancement Plan Gain [3/, 4/]
Pileated woodpecker	168	269
Yellow warbler	5	4
Cooper's hawk	52	171
Douglas squirrel	217	66
Mink (palustrine)	19	(1)
Mink (lacustrine)	0	8
Mink (riverine)	30	2
Beaver	63	4
Roosevelt elk	62	27
Black-tailed deer	81	23
Lesser scaup	0	0

1/ Data modified by staff from James River II, 1988a, 1990i.
2/ AAHU's expected over the long term with removal of Elwha dam.
3/ James River II, 1990g.
4/ AAHU's expected on lands owned by James River for each year of the next license period with mitigation.

expected benefits would be short term. However, the protection of lands adjacent to Lake Aldwell from logging would result in long-term habitat improvement and benefits for species dependent on mature and old-growth forest. A description of the wildlife enhancement plan and its affects on wildlife, including species with state status, is presented in Section 4.1.4.2. The habitat improvements expected

on lands adjacent to Lake Aldwell over the next license period from the wildlife enhancement plan, in terms of AAHU's, are also shown in Table 4-24.

Restoration of Anadromy

The factors responsible for the effects of restoring anadromous fish runs to the middle and upper river on wildlife were described in Section 4.1.4.2. Predicted annual escapement with the removal of the Glines Canyon Project and retention of the Elwha Project would be about 22,300 salmon, primarily fall chinook and coho. This represents about 385,800 pounds of biomass, or about 3 times the amount currently available from salmon in the lower Elwha River (Table 4-25). Based on a retention rate of 96 percent, 370,400 pounds of salmon carcasses would be retained as consumable biomass in the Elwha system as compared to an estimated 900,000 pounds under the removal of both dams alternative and 370,500 pounds under the applicant's proposal.

With removal of the Glines Canyon Project and retention of the Elwha Project, the restoration outlooks are excellent for fall chinook and good for spring chinook and coho. As discussed in Section 4.1.4.2, restoration of chinook and coho would increase populations of wildlife species that consume salmon carcasses, smolts, and fry, primarily along the upper reaches of the Elwha and the tributaries. Steelhead would provide supplemental biomass during the spring and summer.

Potential Changes in Habitats Along the River

Removal of Glines Canyon dam would increase the erosive capability of the Elwha River through Sweets Bottom, potentially causing some short-term adverse effects on adjacent habitats. These effects were described in Section 4.2.4.2 and no long-term net loss of wildlife habitat would be expected with this alternative.

Disturbance

The recreational facilities proposed for the Elwha Project would increase disturbance to wildlife in some areas along Lake Aldwell because of higher hiking, camping, and boating use (see Section 4.1.4.1).

Staff-Recommended Measures

Staff recommendations for the Glines Canyon removal alternative would be similar to those proposed for both the applicant's proposal (Section 4.1.4.2) and the dam removal alternative (Section 4.2.4.2):

(1) placing and revegetating the rubble disposal site, new roads, and staging areas to ensure that loss of wildlife habitat during the dam removal process is only temporary;

(2) prohibiting blasting during the nesting season;

Table 4-25. Predicted escapement of salmon and increase in biomass with removal of Glines Canyon and retention of Elwha (Source: the staff).

	Predicted Escapement	Predicted Biomass (lbs)	Change in Biomass Over Current Conditions (lbs)
Fall Chinook	7,844	211,788[1/]	117,288
Coho	14,498	173,976[2/]	147,576
Chum	0	0[3/]	0
Pink	0	0	0
Sockeye	0	0	0
Totals	22,342	385,764	264,864

[1/] Chinook = 27 lbs/fish average (James River II, 1990g)
[2/] Coho = 12 lbs/fish average (James River II, 1990g)
[3/] Chum = 10 lbs/fish average (Stalmaster, 1983)
[4/] Pink = 4 lbs/fish average

(3) monitoring the vegetation on the sediment disposal terraces to ensure the development of wildlife habitat in the reservoir areas that would support, over time, a wide variety of species;

(4) correcting the deer and elk models and rerunning the HEP analysis to include forage for these species on land adjacent to those currently owned by the applicant;

(5) planning a comprehensive habitat improvement program for deer and elk on the lands owned by the applicant, in conjunction with the WDW;

(6) conducting a radio-telemetry study, in consultation with the NPS and WDW, to monitor deer and elk use of the Elwha Valley;

(7) implementing a study to determine the effects of restoring anadromy on wildlife; and

(8) implementing maintenance and monitoring programs for the wildlife enhancement plan.

Staff recommendations to stabilize the sediment disposal terraces, control siltation, and restore anadromous fish runs would ensure that the effects of reduced water clarity and fish biomass on wildlife that forage in the river are temporary. Staff recommendations would ensure that impacts to wildlife habitat due to removal activities are temporary.

Unavoidable Adverse Impacts

Construction of fish passage facilities and a project overlook at Elwha would result in the permanent loss of about 1.14 acres of wildlife habitat. Loss of the reservoir would result in habitat loss for the small number of waterfowl that winter on Lake Mills. Staff recommendations would ensure that impacts to wildlife habitat due removal activities are temporary.

4.3.4.3 Threatened and Endangered Species

Federally Listed Species

Removal of the Glines Canyon Project with retention of the Elwha Project would have no adverse impacts on bald eagles or spotted owls. The applicant's proposed wildlife enhancement plan and restoration of the reservoir area and project facilities may, over the long term, increase available habitat for the spotted owl. Restoration of chinook and coho salmon and steelhead runs is not expected to attract significant number of bald eagles to the Elwha River.

Construction Impacts
Blasting associated with dam removal and terrace construction at the Glines Canyon Project may disturb spotted owls, particularly during nesting season. Since the forests adjacent to the Elwha Project are not currently suitable habitat for spotted owls, the probability for disturbance during construction of new facilities is low.

Long-term Impacts
The primary long-term effect of the Glines Canyon removal alternative on spotted owls would be the long-term increase in available habitat from the applicant's wildlife improvement plan and restoration of Lake Mills and project facilities. As discussed in Section 4.2.4.3, restoration of Lake Mills is expected to result in the eventual addition of about 240 acres of conifer and mixed conifer/deciduous forest to the Elwha Valley. In addition, the applicant's wildlife enhancement plan

would add about 593 acres of potentially suitable habitat within about 150 years (see Section 4.1.4.3). However, the number of nesting pairs in the Elwha Valley would not be expected to increase without adjacent available habitat.

The primary effect on bald eagles would be restoration of anadromous fish runs above Elwha dam. There is a low probability that removal of the Glines Canyon Project with retention of Elwha would restore runs of chum salmon, the principal food source for bald eagles wintering on other Northwest rivers. As described in Section 4.1.4.3, successful restoration of fall chinook and coho would not provide a significant food source for wintering bald eagles. Consequently, removal of Glines Canyon with retention of the Elwha Project would not result in a significant increase in the number of bald eagles along the Elwha.

Federal Candidate Species

Removal of the Glines Canyon Project with retention of the Elwha Project would have no adverse impacts on the marbled murrelet, the only federal candidate species observed in the project area. Restoration of Lake Mills and the project facilities may, over the long term, increase available habitat for the marbled murrelet in the Elwha Valley.

Construction Impacts
The marbled murrelet would not be affected by construction associated with dam removal or new facilities (Sections 4.1.4.3 and 4.2.4.3).

Long-term Impacts
The primary long-term impacts of the dam removal alternative would be a potential increase in available habitat from the restoration of the Lake Mills area and the eventual establishment of old growth (Section 4.2.4.3). However, the existing old growth in the around Lake Mills is not currently used by nesting murrelets, apparently lacking characteristics found along higher-elevation tributaries.

4.3.4.4 Restoration of Natural Conditions in ONP

Removal of Glines Canyon dam would partially meet the licensing goal of restoring natural conditions within ONP. Removal of the dam and revegetating the area currently occupied by Lake Mills would ultimately restore vegetation and wildlife habitat to pre-project conditions. Vegetation and habitats would be restored to natural conditions within 20 years. Restoration of pre-project conditions would require several hundred years.

Removal of the Glines Canyon Project would partially restore anadromous fish runs to the middle and upper reaches of the Elwha River and would provide additional food to wildlife that feed on salmon carcasses. These runs would be

expected to benefit wildlife but would not provide the amount of biomass needed to restore populations to pre-project conditions.

4.3.5 Land Use

The Glines Canyon removal alternative would involve some short-term closures of the Elwha sub-district, negatively affecting recreational and administrative use in the district during at least the last summer construction season when dam removal actually occurs. The long-term contribution of restoring anadromous fish would be a substantial benefit to the sports fishery and highly consistent with ONP plans.

4.3.5.1 Construction Impacts

The construction impacts for the Glines Canyon removal alternative would be the same as those described in the Glines Canyon dam removal section of the removal of both dams alternative (Section 4.2.5.1). During the 5-year construction period there would be additional traffic, noise, and air emissions as well as temporary closures of the Elwha sub-district negatively affecting residents and visitors in the area. The construction impacts for the Elwha Project fish and recreation enhancement facilities would be the same as those described in the applicant's dam retention alternative (Section 4.1.5.1). The construction of Elwha Project enhancement facilities would minimally disturb residents and recreationists in the Lake Aldwell area.

4.3.5.2 Long-Term Impact

The removal of the Glines Canyon Project facilities would create over 460 acres of land available for wildlife protection and enhancement and dispersed recreation use. The 160 acres owned by the applicant would probably be acquired by the NPS and all buildings and structures associated with the dam tender's residence would likely be removed and the area would be restored to natural conditions. For the Elwha Project, a large land area around Lake Aldwell would be dedicated to wildlife habitat enhancement, and about 6 acres of forested land would be converted to developed recreational uses.

Restoration of chinook, coho salmon, and steelhead runs above Elwha dam would be beneficial to recreationists both in onshore and offshore fisheries. With fish passage available at Elwha dam, more shoreline areas would be available for additional angling opportunities in the middle and upper reaches.

The river area potentially eligible for wild and scenic river status would increase as the whole middle and upper reach could be considered as potentially eligible.

The Glines Canyon removal alternative is generally consistent with the National Marine Fisheries Service and Pacific Fishery Management Council's Fishery

Management Plan because restoration of self-sustaining populations of anadromous salmon would be achieved. The existing blockage of fish passage would be alleviated by the addition of fish ladders and screen facilities at the Elwha Project and complete removal of the Glines Canyon Project.

The Glines Canyon removal alternative would be fully consistent with the Northwest Power Planning Council's Protected Areas Amendments as described in Section 4.2.5.2.

The Glines Canyon removal alternative would be generally consistent with ONP plans because removal of the Glines Canyon Project facilities and addition of fish passage facilities at the Elwha Project would contribute significantly to the restoration of natural conditions on lands altered by human activity. However, full restoration of native anadromous fish runs is not achievable under this alternative because pink and chum salmon cannot be restored with the Elwha Project facilities in place.

The Glines Canyon removal alternative would be generally consistent with the Washington SCORP, WDW Strategies for Washington's Wildlife, and Clallam County's Comprehensive Plan. Implementation of this alternative would provide recreational opportunities that are shown to be in high demand, benefit the sports fishery in Clallam County, and provide restoration of wild steelhead trout and other sea-run trout species with enhancement of wildlife habitat at both project sites.

Similar to the dam retention alternatives, the Glines Canyon removal alternative is substantially inconsistent with the WDF Hydroelectric Power Assessment Guidelines because with Elwha dam in place, there would still be some hindrance to the migration of salmon species.

As with the applicant's dam retention proposal, the proposal to site the boat-in campground on the shoreline of Lake Aldwell is not consistent with the Clallam County Shoreline Master Program because the natural shoreline designation does not allow overnight campgrounds. This inconsistency can be resolved with the recommended staff mitigative measure of moving the site 200 feet inland (Section 4.1.5.3). Other aspects of the alternative are generally consistent with the shoreline program. If the consistency problem with the boat-in campsite is not resolved, the Glines Canyon alternative could be considered inconsistent with the policies of the state Coastal Zone Management Program.

4.3.5.3 Staff-Recommended Measures

The staff recommends that contractors involved with dam removal at the Glines Canyon Project employ the best available emission control technology and implement dust control measures to preserve the air quality in ONP.

The staff recommends that the location of the proposed boat-in campground be moved 200 feet from the ordinary high water mark to be situated outside of the natural shoreline designation.

The staff also recommends that any required closures of the Olympic Hot Springs Road in the Glines Canyon Project area be scheduled on weekdays with public notification provided in area and regional newspapers.

4.3.5.4 Unavoidable Adverse Impacts

The short-term degradation of air quality and increased traffic congestion associated with construction vehicle operations would create a minor, unavoidable impact to residents and resort and ONP users.

4.3.6 Recreational Resources

The Glines Canyon removal alternative would benefit both marine and freshwater sports fishing in the area. Recreational facilities proposed for the Elwha Project would also benefit recreationists and continue to provide the opportunity for flat water boating, which would be lost at the Glines Canyon Project. In the short term, extensive hauling of dam rubble would require park closures in the Elwha Valley which would negatively affect recreationists.

4.3.6.1 Construction Impacts

Construction impacts for the Glines Canyon removal alternative would be similar to those described under the removal of both dams alternative (Section 4.2.6.1). High turbidity during construction and several years after would affect angling in the middle and lower reaches. The primary difference between the construction impacts associated with removal of both dams and removal of only the Glines Canyon dam, is that angling opportunities in Lake Aldwell and downstream of Elwha dam would be available for anglers displaced from Lake Mills and the middle reach of the river.

4.3.6.2 Long-Term Impacts

The restoration of chinook and coho salmon, summer and winter steelhead, and sea-run cutthroat and Dolly Varden trout would greatly benefit anglers. The available harvest for chinook and coho salmon would increase while the harvest available for steelhead would remain about the same. The increased chance of catch success for salmon and steelhead and the greater shoreline area available for steelhead fishing would benefit anglers. There would be a reduction in the quality of the resident trout fishery in the middle and upper reaches due to the effects of competition from anadromous fish (Section 4.3.3.2).

There would be a loss of Lake Mills reservoir boating opportunities, however, there would also be 2.5 more miles of free-flowing river boating opportunities. Flat water boaters and anglers would be displaced and would probably turn to using Lake Aldwell, Lake Sutherland, and Lake Crescent for boating.

4.3.6.3 Staff-Recommended Measures

The staff recommendations for removal of Glines Canyon dam (Section 4.2.5.3) would help to reduce impacts to recreation. These involve reducing dust and air emissions and keeping park areas open to the public on weekends.

4.3.6.4 Unavoidable Adverse Impacts

The temporary closures of Olympic Hot Springs Road and increased dust, noise, and other air emissions would be adverse to recreationists in ONP during the construction period. The decline in the use and attractiveness of the West Lake Mills trail would be an adverse impact. The increase in turbidity in the middle and lower reaches would be an adverse impact during construction and several years after.

4.3.7 Aesthetic Resources

Effects of removal of the Glines Canyon Project would be as described in Section 4.2.7. The Glines Canyon dam removal alternative would significantly alter the landscape of the Lake Mills area initially, creating a barren, rock and silt exposed surface. Eventually, the alternative would create a varied landscape of multiple terraces, and a wide riverine bottom with wooded side slopes.

4.3.7.1 Construction Impacts

The Glines Canyon removal alternative would adversely affect visual resource value in the Elwha sub-district for at least 4 years. The presence of a large construction project in a national park would seem greatly out of place to most viewers. Air quality impacts from dust and diesel emissions and increased noise would negatively affect hikers and sightseers in the area. The lowering of Lake Mills would create a desolate debris-strewn barren landscape, completely out of character with the heavily wooded side slopes.

4.3.7.2 Long-Term Impacts

The 415 acres of Lake Mills occupied by water would be replaced with native vegetation, particularly alder and cottonwood trees and weedy shrubs and brush. The appearance of the newly vegetated area would be distinct from the adjacent hillsides for at least 100 years. The removal of the dam would create a deep canyon that could be viewed from pullouts on Olympic Hot Springs Road and

Whiskey Bend Road. The views of the reservoir area from Griff Creek Trail, West Lake Mills Trail, upper Lake Mills Trail, and Observation Point would all be altered from a distinct blue water and tall green forested landscape to a fully forested landscape sloping into a U-shaped valley bottom with prominent terraces. During the winter months, viewers might be able to see Roosevelt elk in the newly vegetated areas. The new boat-in campsite on Lake Aldwell would offer a new landscape view and a more remote camping experience than most nearby campgrounds.

4.3.7.3 Staff-Recommended Measures

The staff has not identified any measures to mitigate the short-term adverse impacts or the visual quality of the Glines Canyon Project area.

4.3.7.4 Unavoidable Adverse Impacts

The short-term and long-term degradation of visual quality in the Lake Mills area would be unavoidable and adverse.

4.3.8 Socioeconomics

The Glines Canyon removal alternative would provide economic benefits associated with increased chinook and coho production and harvest, but the steelhead harvest would be reduced. The potential for restoring pink, chum and sockeye salmon would be limited. Social effects on the Lower Elwha Klallam Tribe would be marginally favorable. A moderate level of construction employment would be provided and the cost of power to the Daishowa America Mill would increase substantially.

4.3.8.1 Construction Impacts

The socioeconomic impacts associated with the construction period would be beneficial. Employment and material purchases associated with constructing the fish passage facilities at Elwha dam and removing Glines Canyon dam would have a favorable effect on the local economy. A workforce of about 19 persons per year for 5 years, or a total of 95 person-years of employment, would be required. The required workforce could be provided within the local commuting area and therefore would not lead to any increase in demand for services such as police, fire protection, and other services.

4.3.8.2 Long-Term Impacts

Removal of Glines Canyon dam alone would provide an increased harvest of fall chinook and coho salmon, but a reduction in the steelhead harvest. The cost of power to the Daishowa America Mill would increase substantially.

Fisheries

Overall, marine commercial and sport fisheries would benefit over existing conditions from higher harvests of chinook and coho salmon. Tribal inriver fisheries would also benefit from increased allowable harvest of chinook salmon. Inriver sport fisheries could benefit slightly from higher chinook harvests. Steelhead harvest would be about 28 percent below present levels; however, higher escapement and opening the middle and upper river would improve the overall sport fishing opportunity. Removal of the Glines Canyon dam would provide benefits for chinook and coho production and harvest (Table 4-26). Removal of only the Glines Canyon dam would limit the potential of restoring pink and chum salmon, while providing a reasonable potential for restoration of fall and spring chinook salmon, coho salmon, winter and summer run steelhead, and sea-run cutthroat and Dolly Varden trout (Section 4.3.3).

Tribal Social Effects

Overall, the Glines Canyon removal alternative appears to offer a small benefit to the Lower Elwha Klallam Tribe. The tribe would benefit economically from the increased fall chinook and spring chinook harvests, but could lose the current hatchery employment, a portion of the inriver coho harvest, and part of the steelhead harvest. Some of the seasonal distribution of the harvest would be similarly offsetting. The improvement in the wild runs of spring chinook and summer and winter steelhead would be culturally favorable (Section 4.3.9). There would be no improvement in shellfish habitat valued by the tribe, because there would be no increase in sand and gravel loads reaching the river delta.

Cost of Power

The 10-year average cost of project power under the Glines Canyon removal alternative would increase from an average 17.9 mills/kWh to 71.1 mills/kWh, nearly a 300 percent increase (Table 2-16). When averaged with the cost of other power, this would lead to an average weighted cost of power of 45.3 mills/kWh, about a 50 percent increase over the reference case 29.9 mills, and about a 15 percent increase over the cost under the applicant's proposal (Table 2-18). Staff estimates that the overall cost of operating the plant would increase by about 9 percent, a negative effect that could carry over to the mill's employees and suppliers. The data necessary to estimate any loss of the mill's competitive position due to this increase are unavailable. In the most extreme case, complete mill closure caused by higher energy costs would cause the loss of up to 1,200 jobs among mill employees, suppliers, and other local businesses.

Table 4-26. Present and predicted future total adult production, harvest, and escapement of fall chinook, coho, winter steelhead, chum, and pink salmon under the Glines Canyon dam removal alternative (Source: the staff).

	Chinook		Coho		Steelhead		Chum		Pink	
	Present	Future	Present	Future	Present	Future	Present	Future	Present	Future
Adult Production	13,500	28,363	22,000	37,166	4,000	8,707	<1,000	<1,000	<100	<1,000
Harvest Rate	0.80	0.72	0.90	0.61	0.90	0.30	___	___	___	___
Harvest	10,000	20,519	19,800	22,668	3,600	2,610	___	___	___	___
Escapement	3,500	7,844	2,200	14,498	400	6,097	___	___	___	___

Note: "___" equals unknown.

Project Employment

Seven people would be required for the long-term operational and maintenance workforce under this alternative, three fewer than under existing conditions and seven fewer than called for under the applicant's proposal.

Other Effects

Effects on recreation and tourism would be positive, with associated opportunities for increased recreation and tourism-related income. Due to data limitations, it is not possible to differentiate between the economic effects on recreation and tourism related specifically to Elwha River changes and changes brought about by future fishery management practices associated with restoring or protecting wild fish stocks in other river systems in the Strait and Sound.

Nearby landowners would not be affected by the Glines Canyon removal alternative. No increase in flooding frequency would occur for at least 40 to 60 years, when Lake Aldwell would become filled with sediment (Section 4.3.1).

The effects on the Port Angeles water supply would be similar to the removal of both dams alternative; filtration of the water supply could be necessary for 2 to 5 years, and additional costs would be incurred for possible adverse water quality effects on the Port Angeles industrial water supply and WDF fish rearing facility.

The continued presence of the Elwha Project would continue the degradation process of Angeles Point and Ediz Hook (Section 4.3.1), thus requiring continuation of the U.S. Army Corps of Engineers maintenance program for Ediz Hook.

Taxes paid by the project owner to Clallam County would decrease by about half, to $133,000 annually (1990 dollars).

4.3.8.3 Staff-Recommended Measures

An affirmative action plan should be prepared and implemented to improve tribal employment opportunities associated with construction and activities project operation.

4.3.8.4 Unavoidable Adverse Impacts

Removal of Glines dam would cause a slight reduction in the inriver tribal and sport harvest of winter steelhead and hatchery coho salmon. Some short-term curtailment of harvest would be necessary during the restoration period.

The overall cost of power to the Daishowa America Mill over the first 10 years would increase about 50 percent over existing conditions, or about 15 percent over the cost under the applicant's proposal.

4.3.9 Cultural Resources

This alternative would adversely affect the Glines Canyon dam National Register site by destroying it, and the Elwha dam by modifying it. It would likely restore seven wild stocks of anadromous fish species important to Native Americans.

4.3.9.1 Construction Impacts

Under this alternative, the National Register Glines Canyon dam would be destroyed, and new construction would adversely affect the Elwha damsite, also on the National Register. This planned new construction would be the same as under the applicant's dam retention proposal.

In addition, deposition of dam rubble and bypass tunnel muck at the upland disposal site may have an adverse effect on undiscovered archaeological sites by compacting them, or by changing chemical composition due to sediment leaching. This is unlikely, however, since previous surveys of this area did not result in site discovery.

The excavation and dredging of Lake Mills would result in disturbance of approximately 25 percent of the original ground surface within the new channel zone, because of the inherent difficulty to accurately excavate and dredge to desired levels. Dredging may thus affect archaeological sites buried under lake sediments could be adversely affected.

4.3.9.2 Long-Term Effects

Restoration of wild stocks of anadromous fish species would significantly benefit Native American culture because of the paramount significance of fish and fishing, historically and economically, to members of the Lower Elwha Klallam Tribe (Section 4.1.9.2). This alternative would create excellent opportunities for restoration of fall run chinook salmon and winter run steelhead, good opportunities for restoration of spring run chinook and coho salmon and summer steelhead, and fair opportunities for restoration of sea-run cutthroat and Dolly Varden trout.

4.3.9.3 Staff-Recommended Measures

The potential effects of this alternative on the National Register Glines Canyon and Elwha hydroelectric sites could be mitigated by recording the existing

condition of the dams to the standards of the Historic American Engineering Record.

Reservoir excavation and dredging should be monitored by a professional archaeologist to determine whether the work is affecting archaeological sites.

If buried archaeological sites were discovered during construction, work in the immediate vicinity of the find should be halted until the applicant can evaluate the find in consultation with the SHPO.

4.3.9.4. Unavoidable Adverse Impacts

With application of the proposed mitigative measures, there would be no unavoidable adverse impacts to cultural resources under this alternative.

4.4 ELWHA REMOVAL WITH RETENTION OF GLINES CANYON

This section addresses the final principal alternative, removal of the Elwha Project and retention of the Glines Canyon Project as proposed by the applicant.

4.4.1 Geology, Soils, and River Morphology

Methods and potential impacts from tunnel construction at the Elwha dam, reservoir drawdown, sediment stabilization and removal of the dam would be accomplished as previously discussed with removal of both dams (Section 4.2.1). Fish passage modifications and potential impacts to the Glines Canyon dam would be as discussed previously with the applicant's dam retention proposal (Section 4.1.1).

Minor construction phase erosion and sedimentation effects would be expected at the Glines Canyon Project due to construction of the fish passage facilities on very steep terrain and the proximity of proposed structures to the river.

4.4.1.1 Construction Impacts

Glines Canyon Project

Temporary and short-term increases in suspended sediment concentration would be expected during instream and near-stream construction phases as described in Section 4.1.1.1. Construction of the fish passage facilities at the Glines Canyon dam would cause short-lived increases in river suspended load due to construction occurring directly in and near to the Elwha River. Standard erosion methods would likely be successful in reducing temporary sediment effects downstream.

Elwha Project

The construction impacts of removal of the Elwha Project were described in Section 4.2.1.1. Dewatering for construction of the Elwha bypass tunnel would transport fine sediment created during drilling, blasting and excavation of rock. The sand-size sediment could be contained on the construction site with standard erosion control methods. Clay and most of the silt that is suspended during lake drawdown and sediment excavation would pass downstream to the coastal zone. The clay and silt would tend to stay fully suspended in the lower Elwha River channel with some depositing on the bed until winter storms flush it downstream. Limited intrusion of the fine sediment into the pavement layer will occur because the coarse pavement material is not moving at flows less than about 9,000 cfs. The HEC-6 model of the Elwha River indicates sediment transport rates downstream of between 1,000 and 1,500 tons per day or about 300 to 500 mg/l for typical summer work season discharge rates.

4.4.1.2 Long-Term Impacts

The natural upstream Elwha River sediment supply would continue to be retained in Lake Mills. The Lake Mills delta would continue to grow, eventually filling the lake in an estimated 260 years. All boulders, cobbles, gravel, sand, about 30 percent of the silt supply, 1 percent of the clay supply and all woody debris, supplied from the upper Elwha watershed would continue to be trapped in Lake Mills. The middle reach of the river would continue to be stable and armored without the natural upstream sediment supply. The lower reach would receive additional sediment from the Little River and Indian Creek drainages, and sediment eroded from the substrate of Lake Aldwell would lead to an increased amount of sand and gravel in the substrate below RM 8.5. Erosion processes in the coastal zone, because of reduced sediment supply, would continue. Delivery of reduced quantities of cobbles, gravel and sand to the Elwha delta and coastal zone would continue to aggravate the coastal erosion in the Ediz Hook area.

4.4.1.3 Staff-Recommended Measures

Development of detailed plans, specifications, and contracts for grading, drainage, erosion, sediment control, vegetation and near-term maintenance plans would be required to stabilize the reservoir sediments. To limit increased suspended sediment concentrations during construction and operation of the modifications at the Glines Canyon dam and the removal of the Elwha Project, an erosion and sediment control plan should be developed in consultation with the Washington Department of Ecology (WDOE), the Washington Department of Fisheries (WDF), The National Park Service (NPS), and the Washington Department of Wildlife (WDW).

Detailed geotechnical explorations should be conducted of the diversion tunnel alignment and lake tap area for the Elwha Project removal as a basis for the development of detailed design for the gated diversion facilities, which must be capable of dependable operation throughout the construction period.

4.4.1.4 Unavoidable Adverse Impacts

Temporary construction phase silting of the lower Elwha River would occur during the summer work season, and elevated suspended sediment levels would be experienced downstream of the Elwha dam site for up to 10 years.

The natural sediment supply from upstream would continue to be trapped in the Glines Canyon reservoir, and the coastal zone sediment supply from the Elwha Basin would continue at reduced levels, creating a continued need for beach replenishment at Ediz Hook.

4.4.2 Water Quantity and Quality

Suspended sediment concentrations in the lower river would substantially increase during and following removal of Elwha dam. During the removal period, Lake Aldwell turbidity would substantially increase. Suspended sediment would gradually decline after dam removal due to stabilization of the Lake Aldwell river channel. Organic matter concentrations, bacterial levels, and nutrient concentrations in the lower river would increase during and after dam removal. Increased turbidity and organic matter would adversely impact the quality of water diverted for industrial use and the WDF fish rearing channel, and would potentially impact domestic water supplies.

4.4.2.1 Construction Impacts

Water Quantity

Discharge in the river below Lake Mills would assume run-of-river conditions as described in Section 4.1.2.1. Drawdown of Lake Aldwell during the second year of construction would supplement discharge in the lower reach by an average of 31 cfs. This additional flow in the lower reach would occur during the 7-month drawdown period beginning in March. Lake Aldwell would expect to fluctuate in water level throughout the construction period, and would influence low and peak discharges in the lower reach. Because of the limited storage capacity in Lake Aldwell, this influence would be relatively minor.

The Elwha dam diversion tunnel constructed for dam removal would provide considerable flexibility in maintaining either a constant discharge or a constant pool elevation as required for river channel excavation, grading, and stabilization, and for alleviating downstream sedimentation impacts. Impacts of diversion tunnel operation on water quality are provided in Section 4.2.2.1.

Water Quality

For the Lake Mills and middle reaches, water quality impacts occurring under the Elwha dam removal alternative would be the same as those described under the applicant's dam retention proposal (Section 4.1.2.1). For Lake Aldwell and lower reaches, water quality impacts would be similar to, but not as intensive as those described for these reaches under removal of both dams in Section 4.2.2.1.

Impacts on water quality in the lower reach of the Elwha River would be adverse from high suspended sediment loads resulting from channel excavation, grading, and stabilization activities, and from rapid incision in Lake Aldwell sediments during higher discharges. Increased turbidity following removal of Elwha dam would degrade the quality of water diverted for industrial use at Port Angeles. Water diverted to the WDF fish rearing channel would also be adversely impacted

by high turbidity levels resulting from dam removal. High turbidity levels would potentially degrade the potability of water diverted for municipal use by the City of Port Angeles. Potential impacts of increased suspended sediment and turbidity levels on water use are further described in Section 4.2.2.1. Impacts on turbidity, organic matter concentrations, BOD, bacteria densities, and nutrient concentrations would occur as in the removal of both dams alternative (Section 4.2.2.1).

Concentrations of particulate and dissolved organic matter would slightly increase in the lower reach. Organic matter loads would be expected to be far less than that expected under removal of both dams, since organic matter concentrations in Lake Aldwell sediments are much lower than those in Lake Mills. Nutrient concentration would also slightly increase in the lower reach.

4.4.2.2 Long-Term Impacts

Water Quantity

Discharge patterns of the Elwha River below Glines Canyon dam would be the same as those described under the applicant's dam retention proposal with staff recommended mitigation (Section 4.1.2). Because water surface elevations would normally be maintained at a constant level in Lake Mills, the river would follow a run-of-river discharge pattern, except during occasional periods of Lake Mills drawdown for agency-requested flow augmentation, or during the applicant's proposed drawdowns for power purposes.

Water Quality

Changes in water quality in Lake Mills and middle reach of the river would be the same as those described under the applicant's dam retention proposal (Section 4.1.2.2).

For Lake Aldwell and the lower reaches, increased suspended sediment concentrations would occur during storm runoff events for approximately 3 years following Elwha dam removal. The magnitude and frequency of these events would be the same as that described under removal of both dams (Section 4.2.2.2). Sediment concentrations would gradually decline due to stabilization of the newly developed river channel in the Lake Aldwell reach.

Water temperatures in Lake Aldwell and lower reaches of the river would experience higher fluctuations due to a lack of mixing in Lake Aldwell when compared to the dam retention alternative. When compared to existing conditions, mean temperatures in the lower reach would slightly decrease due to a lack of reservoir heating in the absence of Lake Aldwell. Mean daily temperatures would be expected to be from 0.5 to 1°C less than existing temperatures from

mid-August to October. Temperature in the lower reach would remain unchanged from existing conditions during the remainder of the year.

Particulate organic matter (POM) would increase slightly in the lower reach, since leaf matter and woody debris originating from the middle reach would pass unimpaired through the Lake Aldwell reach. However, POM loads originating from the middle reach would be very small compared to that originating from the upper watershed, which would continue to settle in Lake Mills.

4.4.2.3 Staff-Recommended Measures

To mitigate for expected changes in water quality during the Elwha dam removal period, the staff recommends the same measures as prescribed for removal of both dams (Section 4.2.2.3). A water quality monitoring program should be implemented to monitor reservoir water quality during construction and to monitor water quality in the lower river near intakes of domestic and industrial water supplies.

4.4.2.4 Unavoidable Adverse Impacts

Increased sediment loads during peak flows would be adverse to rearing fish in the WDF fish rearing facility, prohibiting the use of the facility for several years following removal of the Elwha dam. On-site mitigation would not be possible for the WDF fish rearing facility, since water is diverted directly from the river to rearing channels. Filtration of water would not be economically feasible for the rearing facility. Off-site mitigation in the form of a rearing facility on a nearby river might serve as a possible temporary replacement to maintain fish stocks from the WDF rearing facility on the Elwha River.

Industrial water supply filtration systems would require increased cycles resulting in increased maintenance costs. This would be expected mainly during the summer construction period, and during winter storm events, when high suspended sediments are expected in the river. Because of the relatively high quantity of water required by industrial users, alternative sources of water to the Elwha River would not be feasible.

Treatment of domestic water supplies may be needed to prevent degradation of potable water.

4.4.3 Aquatic Communities

During the construction period, Elwha dam removal would result in adverse effects on salmon and steelhead egg and fry survival and reduced aquatic invertebrate production due to high suspended and bed load sediment transport. These effects would occur during the two years of Elwha dam removal and Lake

Aldwell drawdown and would continue for 2 to 4 years following construction. Over the long term, there would be a favorable potential for restoring winter and summer run steelhead, sea-run cutthroat and Dolly Varden trout, and all salmon runs except sockeye. The overall restoration prospects would be similar to those associated with the removal of both dams, and substantially improved over the applicant's proposal. These long-term restoration prospects would depend very heavily upon establishment of suitable spawning habitat in the middle reach. Resident trout would decline due to competition with anadromous salmon and trout in the middle and upper reaches.

4.4.3.1 Construction Impacts

Removal of the Elwha dam with retention of the Glines Canyon dam would increase suspended and settleable sediment input to the lower river for 4 to 5 years. Moderate adverse impacts would occur to anadromous fish in the lower river during this period as a result of reduced spawning habitat quality, food supply, and rearing habitat. Since lower river spawning habitat is limited and most production is from hatcheries, adverse impacts on anadromous fish reproduction during the construction period would be limited. Of the lower reach anadromous stocks, the fall chinook salmon and winter steelhead would be most affected, because considerable natural spawning occurs in the lower reach. Chinook also spawn in the late summer, early fall, low-flow period when finer sediments would be more likely to settle in gravel spawning beds. Pink salmon would be similarly adversely affected, although few spawn naturally in the lower river. Small numbers of chum and coho salmon also spawn naturally in the lower reach, but since they spawn later during higher flow, they would be less adversely affected. Steelhead would be affected less than chinook because they are late winter or spring spawners. Substantial loss of resident trout in Lake Aldwell would occur during construction from adverse reservoir turbidity conditions.

Increased turbidity in the lower reach during the construction period and several years thereafter would have a moderate adverse effect on resident trout and wild anadromous fish early growth and survival by limiting prey and feeding effectiveness and possibly causing direct mortality.

The WDF chinook salmon rearing channel would probably be unusable during construction and for 2-3 years thereafter because turbidity would reduce feeding effectiveness, thereby affecting survival and growth sufficiently to make the channel impractical for rearing purposes. Use of the channel to collect adult fish for egg-taking would not be affected.

4.4.3.2 Long-Term Impacts

With removal of the Elwha dam and the addition of fish passage facilities at the Glines Canyon dam, there would be an expansion in the spawning and rearing habitat available to anadromous fish in the Elwha River. There would be an excellent potential for restoring winter run steelhead; good potentials for restoring fall chinook, coho salmon, and summer steelhead; and fair potentials for restoring spring chinook, pink and chum salmon, sea-run cutthroat and Dolly Varden trout (Table 4-27). Restoration potentials would be slightly less than those associated with removing both dams (Table 4-17) due to passage-related mortalities at Glines Canyon dam and Lake Mills, and poor spawning habitat in the middle and lower reaches. Restoration prognosis would be considerably better than with the applicant's proposal (Table 4-4), particularly for pink and chum salmon and sea-run cutthroat and Dolly Varden trout due to removal of Elwha dam and its associated passage problems. The prospects for restoring wild, self-sustaining runs of sockeye salmon would remain poor as for the other alternatives. Resident rainbow trout populations in the middle and upper reaches would decline from the increased competition with salmon and steelhead for spawning and rearing habitat.

Removal of Elwha dam and restoration of the reach currently inundated by Lake Aldwell would increase the productive portion of river from 5 to 14 miles and provide anadromous fish unobstructed access to four potential spawning tributaries. The restoration potential for sea-run cutthroat and Dolly Varden trout, and pink and chum salmon would improve significantly over the applicant's proposal with this improved access. Most of the river believed originally accessible to these fish (up to RM 16 at Rica Canyon) would be available. Problems associated with passage through Lake Aldwell and Elwha dam (Section 4.1.3.2) would be eliminated. Passage problems at Glines Canyon dam and Lake Mills (Table 4-7) would reduce the anadromous fish production potential to less than that expected if both dams were removed. Poor middle reach spawning habitat would remain a problem, particularly for pink and chum salmon, which are more likely to spawn in the middle and lower reaches. Higher August and September water temperatures (1 to 3°C) in the middle and lower reaches due to retention of Glines Canyon dam would potentially delay chinook and pink salmon spawning, and affect chinook and pink salmon egg survival in the middle and lower reaches.

4.4.3.3 Staff-Recommended Measures

An anadromous fish restoration plan should be developed in consultation with the resource agencies (Section 4.1.3.3). To alleviate the poor spawning habitat in the middle and lower reaches, the plan should include spawning habitat enhancements such as gravel introductions, side-channel modification, construction of spawning channels in the middle and lower reaches. Sources of gravel include the Lake Aldwell delta, natural supplies along the middle and lower reaches, and numerous

Table 4-27. Summary of potential restoration of anadromous salmonid stocks above the Elwha and Glines Canyon dams, Elwha removal alternative (Source: the staff).

Species	Passage	Allowable Harvest Rate	Habitat	Available Stock	Restoration Overall Outlook
Fall Chinook	marginal	favorable	marginal	favorable	GOOD
Spring Chinook	marginal	marginal	marginal	marginal	FAIR
Coho	favorable	marginal	favorable	marginal	GOOD
Winter Steelhead	favorable	favorable	favorable	favorable	EXCELLENT
Summer Steelhead	favorable	favorable	favorable	marginal	GOOD
Pink	marginal	marginal	marginal	marginal	FAIR
Chum	marginal	marginal	marginal	marginal	FAIR
Sockeye	marginal	marginal	unfavorable	marginal	POOR
Sea-run Cutthroat	marginal	marginal	marginal	marginal	FAIR
Sea-run Dolly Varden	marginal	marginal	marginal	marginal	FAIR

gravel pits located in the valley. Because of uncertainties in any proposed habitat enhancement plan, the staff has downgraded the overall restoration potential of this alternative. More favorable evaluation would result from the applicant's provision of a detailed, highly researched and documented enhancement plan.To minimize the higher late summer water temperatures in the middle and lower reaches from retention of Lake Mills, the staff recommends the following measures:

1. Minimizing spill over Glines Canyon dam from late August through September to reduce the amount of warm upper layer Lake Mills water entering the middle reach;

2. Increasing spill over Glines Canyon dam during July and early August to reduce the buildup of warm water in Lake Mills and to encourage juvenile anadromous fish downstream migration; and

3. Lowering the intake point, if necessary, for the Glines Canyon turbine intake in Lake Mills to release colder hypolimnetic waters to the middle reach.

4.4.3.4 Unavoidable Adverse Impacts

An increase in sediment input into the river during the construction period would have a moderate adverse effect on anadromous fish spawning and rearing in the lower river.

There would be a possible loss of use of the WDF channel for the rearing of chinook salmon during and a few years after the construction period because of high turbidity levels.

The introduction of anadromous fish into the middle and upper river would slightly reduce the productivity of the resident trout populations in these reaches of the river.

4.4.4 Terrestrial Resources

4.4.4.1 Vegetation

Removal of the Elwha Project with retention of Glines Canyon would have minor adverse impacts on existing vegetation. Rubble disposal, staging areas, and new access roads would cause the temporary loss of vegetation. Construction of new facilities at Glines Canyon would cause the permanent loss of vegetation and could potentially affect a state-listed sensitive plant. Removal of Lake Aldwell would eliminate or degrade associated wetlands. Increased erosion would also remove and/or disturb vegetation along the river below the current location of the dam.

Reclamation of the reservoir and project facility locations would revegetate areas that are currently inundated or developed. In addition, the applicant's wildlife improvement plan would be implemented and would modify the species composition and structure of some plant communities.

Construction Impacts

Construction of new facilities at Glines Canyon would temporarily disturb small amounts of vegetation along both sides of the bypass reach (Section 4.1.4.1). The new access road and staging area for removal of the Elwha Project would impact 0.87 acre of mature conifer, and the concrete rubble from the diversion tunnels and facilities at Elwha would be buried in an 8-acre clearcut at the base of Kelly Mountain (Section 4.2.4.1).

As described in Section 4.1.4.1, timber clearing operations for the wildlife enhancement plan would require temporary roads and landings, involving 26.5 acres, which would be closed and revegetated upon completion of the enhancement program.

Long-Term Impacts

There would be seven primary long-term effects of the Elwha dam removal alternative: (1) reclamation of about 268 acres currently occupied by Lake Aldwell (Section 4.2.4.1); (2) the permanent loss of 0.09 acre of vegetation from construction of trap-and-haul facilities at Glines Canyon (Section 4.1.4.1); (3) changes in vegetation composition and structure associated with the wildlife enhancement plan on lands owned by James River (Section 4.1.4.1); (4) reclamation of about 22 acres currently occupied by Elwha Project facilities, roads, and landscaping (Section 4.2.4.1); (5) potential loss of a wetland associated with Lake Aldwell (Section 4.2.4.1); and (6) potential loss or modification of plant communities along the river below the current location of Elwha dam due to increased erosion and water volume (Section 4.2.4.1).

Staff-Recommended Measures

Wetland and Rare Plant Surveys

As described in Section 4.2.4.1, wetlands and rare plant surveys should be conducted at the potential location of new facilities at Glines Canyon, access roads, staging areas, and the rubble disposal site.

Revegetation Plan

The staff recommends the development of a detailed plan to revegetate (1) access roads, staging areas, and other sites temporarily disturbed by construction at Glines Canyon or removal activities at the Elwha Project; (2) the rubble disposal

site; (3) the current area of Lake Aldwell; and (4) project facility sites. The elements of this plan were described in Section 4.2.4.1.

Wetlands Creation

The restoration plan for Lake Aldwell should include provisions for grading the sediments at the tail of the reservoir that are conducive to the development of a wetland at the mouth of Indian Creek. This plan would aid in the establishment of a wetland in this area that would compensate for the loss of the existing 38 acres of palustrine forest, marsh, and scrub-shrub wetlands and may increase the net amount of wetlands in the project area.

Maintenance and Monitoring Program

Finally, the staff recommends the development of a comprehensive monitoring, maintenance, and contingency plan for all restoration areas as well as the lower Elwha. The elements of this plan were described in Section 4.2.4.1.

Unavoidable Adverse Impacts

With staff-recommended mitigation, no unavoidable adverse impacts on plant communities would be expected with the Elwha Project removal alternative. Staff recommendations would ensure that impacts to vegetation due to removal activities are temporary and would avoid a net loss of wetlands.

4.4.4.2 Wildlife

Removal of the Elwha Project with retention of Glines Canyon would have minor adverse impacts on wildlife. New access roads, staging areas, and the rubble disposal site would cause the temporary loss of wildlife habitat. Construction of new facilities at Glines Canyon would cause the loss of wildlife habitat, primarily near existing project developments. Dam removal and restoration activities would disturb wildlife in the vicinity of Lake Aldwell for about 4 years. Removal of the reservoir may temporarily eliminate or degrade habitat in a wetland adjacent to Lake Aldwell, and along the lower Elwha.

The loss of Lake Aldwell, changes in prey-base due to restoration of anadromous fish runs, and increased siltation may affect species that feed on live fish and other aquatic species. However, restoration of the area occupied by reservoir and project facilities would result in the addition of wildlife habitat to the Elwha Valley. In addition, the applicant's wildlife enhancement plan would be implemented and improve habitat adjacent to the current site of Lake Aldwell for most species. Since the Elwha removal alternative has a good chance of restoring runs of salmon, populations of wildlife dependent on salmon carcasses would increase, primarily in the upper reaches of the Elwha River.

Construction Impacts

As described in Section 4.2.4.2, the habitat directly affected by dam removal activities is in small patches, which would total less than 10 acres for the Elwha Project, and which would be available for use at the completion of the process. Implementation of the applicant's wildlife enhancement plan would also temporarily eliminate 26.5 acres of habitat in the vicinity of Lake Aldwell due to required road and landing construction (see Section 4.1.4.2).

Removal activities at Elwha and construction of new facilities at Glines Canyon would disturb wildlife in the vicinity of the projects over an approximate 5-year period. These areas may be avoided by mobile species during construction and disturbance during the nesting season may cause nest site abandonment. In addition, timber clearing and thinning operations associated with the wildlife enhancement plan would temporarily disturb wildlife in the vicinity of Lake Aldwell.

Long-Term Impacts

The primary long-term wildlife impacts associated with removal of the Elwha Project with retention of Glines Canyon would be: (1) loss of the reservoir and restoration of about 290 acres currently occupied by Lake Aldwell (268 acres) and project facilities (22 acres) (Section 4.2.4.2); (2) permanent loss of about 0.09 acre of wildlife habitat from the construction of new facilities at Glines Canyon (Section 4.1.4.2); (3) improvements in habitat quality on land adjacent to the current site of Lake Aldwell due to implementation of the applicant's wildlife enhancement plan (Section 4.1.4.2); (4) restoration of anadromy above Elwha dam, if successful (Sections 4.1.4.2 and 4.2.4.2); and (5) loss or degradation of habitat along the lower reach of the river due to increased erosion, siltation, or changes in hydrology (Section 4.2.4.2).

Reservoir and Facility Removal and Restoration

As described in Section 4.2.4.1, the sediment disposal terraces in Lake Aldwell would ultimately be expected to support plant communities similar in composition, structure, and habitat value to those that existed on the Lake Aldwell site prior to construction of the dams. Consequently, the results of the applicant's pre-project HEP were used to determine the long-term effects of the Elwha removal alternative on wildlife, in terms of AAHU's (James River II, 1988a, 1990i). In the interim prior to full restoration, the value of wildlife habitat would vary, depending on the successional stage and disturbance. The application of the pre-project HEP results to the Elwha removal alternative is summarized in Table 4-28. The AAHU's presented represent only the long-term gain expected due to restoration of the reservoir area and do not include any changes in habitat quantity or quality that would occur due to succession or logging on other lands in the Elwha Valley.

Table 4-28. Expected habitat gains from Elwha removal alternative.

	Long-Term AAHU's [1/, 2/]	Short-Term AAHU's [3/, 4/]
Pileated woodpecker	100	269
Yellow warbler	4	4
Cooper's hawk	37	171
Douglas squirrel	117	66
Mink (palustrine)	16	(1)
Mink (lacustrine)	(186)	8
Mink (riverine)	26	2
Beaver	54	4
Roosevelt elk	38	27
Black-tailed deer	49	23
Lesser scaup	(40)	0

1/ Data modified by staff from James River II, 1988a, 1990i.
2/ AAHU's expected over the long-term with removal of Elwha dam.
3/ James River II, 1990g.
4/ AAHU's expected on lands owned by James River for each year of the next license period with mitigation.

Habitat Loss

As described in Section 4.1.4.2, the fish passage facilities at Glines Canyon would impact about 0.09 acre of vegetated developed/disturbed habitat.

Habitat Modification

The Elwha Project removal alternative would include implementing the applicant's proposed wildlife enhancement plan (James River II, 1990g). Without this plan, most of the land owned by James River would be managed for timber production. The habitat improvement proposed by the plan would benefit most wildlife species in the vicinity of the current site of Lake Aldwell. As proposed, some of the habitat improvements would be performed only once, and the expected benefits would be short term. However, the protection of lands adjacent to Lake Aldwell from logging would result in long-term habitat improvement and benefits for

species dependent on mature and old-growth forest. A description of the wildlife enhancement plan and its effects on wildlife, including species with state status, are presented in Section 4.1.4.2. The habitat improvements expected on lands adjacent to Lake Aldwell over the next license period from the wildlife enhancement plan, in terms of AAHU's, are also shown in Table 4-28.

Restoration of Anadromy

The factors responsible for the effects of restoring anadromy on wildlife were described in Section 4.1.4.2. Predicted annual escapement with removal of the Elwha Project and retention of Glines Canyon would be about 63,100 salmon, including fall chinook, coho, chum and pinks. This represents about 585,000 lbs of biomass, nearly 5 times the amount currently available from salmon in the lower reach (Table 4-29). Based on a retention rate of 96 percent, 562,000 lbs of salmon carcasses would be retained as consumable biomass in the Elwha system.

With removal of the Elwha Project and retention of Glines Canyon, the restoration outlooks are good for fall chinook and coho, and fair for chum and pink. Restoration of steelhead runs would provide some supplemental food to wildlife during the spring and summer. As discussed in Section 4.1.4.2, restoration of these runs would increase populations of wildlife species that consume salmon carcasses, smolt, and fry, particularly along the tributaries and upper reaches of the Elwha (see species list in Table 4-11, Section 4.1.4.2).

Potential Changes in Habitats Along the River

Removal of the Elwha Project would increase erosive capability of the river through the lower reach, potentially causing some short-term changes in adjacent habitats. These effects were described in Section 4.2.4.2 and no long-term net loss of wildlife habitat would be expected with this alternative.

Staff Recommendations

Staff recommendations for the Elwha Project removal alternative would be similar to those proposed for the applicant's proposal (Section 4.1.4.2) and the dam removal alternative (Section 4.2.4.2):

(1) placing and revegetating of the rubble disposal site, new roads, and staging areas to ensure that loss of wildlife habitat during the dam removal process is only temporary;

(2) prohibiting blasting during the nesting season;

(3) monitoring the vegetation on the sediment disposal terraces to ensure the development of wildlife habitat in the reservoir areas would support, over time, a wide variety of species;

Table 4-29. Predicted escapement of salmon and increase in biomass with removal of Elwha Project and retention of Glines Canyon (Source: the staff).

	Predicted Escapement	Predicted Biomass (lbs)	Change in Biomass Over Current Conditions (lbs)
Fall Chinook	7,520	203,040[1/]	108,540
Coho	13,900	166,800[2/]	140,400
Chum	8,100	81,000[3/]	81,000
Pink	33,600	134,400[4/]	134,400
Sockeye	0	0	0
Totals	63,120	585,240	464,340

1/ Chinook = 27 lbs/fish average (James River II, 1990g)
2/ Coho = 12 lbs/fish average (James River II, 1990g)
3/ Chum = 10 lbs/fish average (Stalmaster, 1983)
4/ Pink = 4 lbs/fish average

(4) correcting the deer and elk models and rerunning the HEP analysis to include forage for these species on land adjacent to those currently owned by the applicant;

(5) planning a comprehensive habitat improvement program for deer and elk on the lands owned by the applicant, in conjunction with the WDW;

(6) conducting a radio-telemetry study, in consultation with the NPS and WDW, to monitor deer and elk use of the Elwha Valley;

(7) implementing a study to determine the effects of restoring anadromy on wildlife and;

(8) implementing maintenance and monitoring programs for the wildlife enhancement plan.

Staff recommendations to stabilize the sediment disposal terraces, control siltation, and restore anadromous fish would ensure that the effects of reduced water clarity and fish biomass on wildlife that forage in the river are temporary. In addition, staff recommendations to grade the sediments near Indian Creek in a way that is conducive to the establishment of a wetland in this area may increase the amount of available habitat for waterfowl and aquatic furbearers. Staff recommendations would also ensure noise disturbance and impacts to wildlife habitat would be minimized and temporary due to construction and removal activities.

Unavoidable Adverse Impacts

Removal of Lake Aldwell would adversely affect some species of waterfowl, such as the trumpeter swan. However, since wintering waterfowl habitat is not limiting in the Northwest, no significant impacts on dabbling ducks or wintering waterfowl are expected. The mink would also permanently lose habitat due to the removal of Lake Aldwell, with resulting decreases in population. Construction of new facilities at Glines Canyon would result in the permanent loss of 0.09 acre of wildlife habitat.

4.4.4.3 Threatened and Endangered Species

Federally Listed Species

Removal of the Elwha Project with retention of the Glines Canyon Project would have no adverse impacts on bald eagles or spotted owls. The applicant's proposed wildlife enhancement plan and restoration of the reservoir area and project facilities may, over the long term, increase available habitat for the spotted owl. Since the Elwha Project removal alternative has a fair chance of restoring runs of chum, the number of bald eagles wintering along the middle and upper reaches of the Elwha River may increase.

Construction Impacts

Blasting associated with construction of new facilities at Glines Canyon may disturb spotted owls, particularly during nesting season, if they occur in the vicinity of the dam and powerhouse. The habitat adjacent to Lake Aldwell is not suitable for spotted owls and the probability for significant disturbance during removal and restoration is low.

Long-Term Impacts

The primary long-term effect of the Elwha Project removal alternative on spotted owls would be the long-term increase in available habitat from the applicant's proposed wildlife enhancement plan and restoration of Lake Aldwell and project

facilities. The primary effect on bald eagles would be the restoration of chum salmon above Elwha dam.

As discussed in Section 4.2.4.3, restoration of Lake Aldwell is expected to result in the eventual addition of about 154 acres of conifer and mixed conifer/deciduous forest in the Elwha Valley. In addition, the applicant's wildlife enhancement plan would add about 593 acres of potentially suitable habitat within about 150 years (see Section 4.1.4.3). However, the number of nesting pairs in the Elwha Valley would not be expected to increase without adjacent available habitat.

There is a moderate probability that removal of the Elwha Project with retention of the Glines Canyon Project would restore runs of chum salmon, the principal food source for bald eagles wintering on other Northwest rivers. Chum escapement is predicted to be about 8,100. As discussed in Section 4.2.4.3, an escapement of 8,100 could attract a peak of about 100 wintering eagles, primarily to the middle reach where chum spawn. Despite the potential availability of salmon carcasses, along the river through the current location of Lake Aldwell, lack of perch trees close to water could limit bald eagle use of this stretch until large trees are established.

Federal Candidate Species

Removal of the Elwha Project with retention of Glines Canyon would have no adverse impacts on the marbled murrelet, the only federal candidate species observed in the project area. The applicant's wildlife protection plan and restoration of Lake Aldwell and the project facilities may, over the long term, increase available habitat for the marbled murrelet in the Elwha Valley.

Construction Impacts

The marbled murrelet would not be affected by construction associated with dam removal or new facilities (Sections 4.1.4.3 and 4.2.4.3).

Long-Term Impacts

The primary long-term impacts of the Elwha dam removal alternative would be a potential increase in available habitat from the restoration of the Lake Aldwell area and the eventual establishment of old growth. However, the existing old growth in the lower Elwha Valley is not currently used by nesting murrelets; apparently, this area lacks characteristics found along higher-elevation tributaries.

4.4.4.4 Restoration of Natural Conditions in ONP

Removal of Elwha dam would partially meet the licensing goal of restoring natural conditions within ONP. With the removal of Elwha dam, there is a fair chance of restoring all but one of the native salmon runs to the middle and upper reaches of the Elwha River. These runs would provide the biomass necessary to restore the

natural populations of these species in ONP. However, because the Glines Canyon Project would remain, the habitat necessary to support increased populations of wildlife would not be available. In addition, the natural vegetation of ONP on the lands occupied by the Glines Canyon Project would not be restored.

4.4.5 Land Use

The Elwha Project removal alternative would change the primary use of over 1,000 acres of project-owned lands from hydroelectric power generation to alternative uses such as timber production. An existing 1.6-acre WDW shoreline access facility on Lake Aldwell would be abandoned by recreationists, as there would be no shoreline to access. The restoration of chinook, coho, pink and chum salmon and winter and summer steelhead would be generally consistent with most relevant comprehensive plans.

4.4.5.1 Construction Impacts

The construction impacts resulting from removal of the Elwha Project facilities would have minimal effects on land uses in the project area. The increased traffic, noise, and dust resulting from construction operations would be slightly noticeable to residents of the Shady Tree RV park and residents along Highway 101 and Don Kelly Road. Some traffic congestion would be noticeable at the junction of Lower Dam Road and Highway 112. Haul trucks using the State Forest Road to access the Kelly Mountain disposal site would slightly interfere with logging operations on state and privately owned lands. The construction of fish passage facilities, and a second powerhouse at the Glines Canyon Project would slightly inconvenience recreationists in Olympic National Park.

4.4.5.2 Long-Term Impacts

Removal of the Elwha Project facilities would change the primary use of over 1,000 acres of project controlled lands. It is likely that the Elwha Project lands, now part of hydroelectric project operations, would be converted into timber production uses similar to adjacent areas. The addition of 2.8 miles of free flowing river to the middle reach of the Elwha could increase the potential eligibility of the river for inclusion in the Wild and Scenic River System. The existing WDW boat launch and river access site on the south end of Lake Aldwell would no longer be used for recreational access and would probably be abandoned. Additional areas and opportunities for angling would be available in the middle reach with restoration of chinook, coho, pink and chum salmon and winter and summer steelhead. Lake Mills would continue to provide opportunities for recreation.

The Elwha Project removal alternative would be generally consistent with the National Marine Fisheries Service and Pacific Fishery Management Council's

Fishery Management Plan, because restoration of up to four species of salmon is possible, and this would help meet the objective of maintaining natural production and providing compensation for developmental losses.

The Elwha Project removal alternative would be fully consistent with the Northwest Power Planning Council's Protected Areas Amendment as described in Section 4.2.5.2.

The Elwha Project removal alternative would be generally consistent with ONP plans because there would be significant gains in restoring anadromous fish to the national park. Under this alternative, restoration of wild, self-sustaining runs of chinook, coho, pink and chum salmon would be possible with the restoration of all trout species. However, no other measures are proposed to help restore natural conditions on lands altered by human activity.

The Elwha Project removal alternative would be generally consistent with the Washington SCORP, WDW strategies for Washington Wildlife, and Clallam County Comprehensive plan because there would be restoration of salmon and trout species in portions of the watershed and this would lead to more recreational fishing opportunities in the region.

The Elwha Project removal alternative would be substantially inconsistent with the WDF Hydroelectric Project Assessment Guidelines because there would still be some hindrance and disruption of upstream and downstream migration of fish.

The Elwha Project removal alternative would be substantially inconsistent with the Clallam County Shorelines Master Program because dredging and land filling is prohibited in the natural zone assigned to the river and shoreline areas of Lake Aldwell. However, since the alteration of the water course would restore the river to a more natural condition, the alternative may merit consideration for a temporary exception to the program conditions. Likewise, if the dam removal program is determined to provide exception benefits to the water and shoreline areas of the river, then the alternative would be considered consistent with the policies of the state's Coastal Zone Management Program.

4.4.5.3 Staff-Recommended Measures

The staff recommends that provisions be made for 1.6 acres or more of new shoreline public access lands in the Lake Aldwell river reach by implementing a land exchange with the existing WDW parcel located on the Lake Aldwell shoreline.

4.4.5.4 Unavoidable Adverse Impacts

The increases in traffic, noise, and dust around Lake Aldwell during construction would create a minor, unavoidable adverse impact to residents and resort users in the area.

4.4.6 Recreational Resources

The Elwha Project removal alternative would provide significant benefits to anglers since there would be increases in the number of salmon and steelhead available in the marine and inriver sports fishery. There would be a loss of flatwater boating and fishing opportunities on Lake Aldwell; however, Lake Mills could accommodate any displaced users. There would be a significant increase in the amount of shoreline areas with good steelhead fishing opportunities.

4.4.6.1 Construction Impacts

The primary construction impact from the Elwha Project removal alternative would be an increase in turbidity in the lower river reach. The increase in turbidity would greatly decrease the river's clarity and make the river less suitable for angling and other recreational activities. The increase in turbidity is expected to occur during the last 3 years of construction work in Lake Aldwell. The turbidity problem would be most severe in the summer low-flow season, but with construction ending in fall, one high fall flow would flush most of the turbid water out. By the time the winter steelhead fishing effort is underway, the turbidity would be at its lowest, creating only a slight inconvenience to anglers.

There would be a slight disruption of traffic flow on Olympic Hot Springs Road and Whiskey Bend Road during construction of the Glines Canyon second powerhouse and fish passage facilities. This could provide some inconvenience to recreationists accessing trailheads at Whiskey Bend and Appleton Pass.

4.4.6.2 Long-Term Impacts

The removal of the Elwha Project facilities would greatly benefit anglers because restoration of all salmon species, except sockeye and all trout species would likely be achieved. There would be more chinook available for marine harvest; however, the total harvest would be slightly less than that for the Glines Canyon dam removal alternative. As with other alternatives, to achieve and protect restoration, the harvest rate would have to be decreased resulting in some restrictions on sports seasons, areas open, or bag limits. With increased production of adult fish, the angler's chance of catch success would greatly increase and more anglers would be accommodated. The inriver harvest of chinook salmon would be possible, but coho, pink and chum salmon harvest would need to be curtailed in the river to protect the wild stocks. There would be

a reduction in the quality of the resident trout fishery due to increased competition between wild resident trout and wild anadromous salmon and steelhead.

For steelhead, there would be a higher allowable harvest with a greatly reduced harvest rate. The reduced harvest rate would be offset by greater numbers of fish available for harvest, a higher catch success rate, and more shoreline areas available for angling. The additional benefits from the restoration of pink, chum, and sea-run trout species are also a positive impact to the sports fishery. With restoration of the five salmon runs, there would likely be the opportunity for sightseers and wildlife viewers to view annual fish migrations at certain points on the river.

The removal of Lake Aldwell would displace flatwater boaters and fishermen. Boaters and anglers would, however, have Lake Mills, Lake Sutherland, and Lake Crescent available for comparable boating opportunities nearby.

The loss of flatwater boating opportunities would be slightly offset by the addition of 2.8 miles of free flowing whitewater boating opportunities. Rafters would now be able to raft from the Altaire Campground to the mouth of the Elwha River, a distance of 12.4 miles. This increase in rafting opportunities has the potential of doubling the rafting use on the Elwha River.

4.4.6.3 Staff-Recommended Measures

The staff recommends visitor access to Glines Canyon dam facilities be enhanced to make provisions for fish viewing at the top of the fish ladder facility.

4.4.6.4 Unavoidable Adverse Impacts

The slight increase in traffic in Olympic National Park due to construction and the temporary increase in turbidity in the lower river reach would create an adverse impact to recreationists during the construction period.

4.4.7 Aesthetic Resources

The Elwha Project removal alternative would slightly degrade the aesthetic environment in the short term. In the few places from which Lake Aldwell is visible, viewers would see a newly vegetated landscape sloping steeply into narrow channels occupied by the river.

4.4.7.1 Construction Impacts

During the 4-year construction period, noise, dust, and exhaust emissions would slightly degrade views in the river basin. Only very few people would notice construction within the reservoir, as visibility of the lake is low. Visitors to the

Elwha Resort and downstream anglers would notice the construction activities. The construction activities would be similar to a large logging and clearing operation, with moderately negative visual impacts. Other effects of construction are similar to those described in Section 4.1.7.1.

4.4.7.2 Long-Term Impacts

The 267-acre area now occupied by the waters of Lake Aldwell would be covered with native vegetation. The resulting loss of the waterbody would mainly affect the few boaters that fish the waters; otherwise, few sightseers or other viewers would be affected. New opportunities for whitewater boating would allow new viewing opportunities for many recreationists. The newly reclaimed lands would eventually blend into the surrounding landscape and probably become part of large tracts managed for timber production. The burial of the southern half of the Glines Canyon to Elwha transmission line would create a more natural looking right-of-way in Olympic National Park, where the transmission line follows the road.

4.4.7.3 Staff-Recommended Measures

The staff recommends the residences and outbuildings of the Glines Canyon Project operating staff be modified to be more in conformance with NPS standards.

4.4.7.4 Unavoidable Adverse Impacts

The short-term decrease in visual quality in the Lake Aldwell viewshed would be an unavoidable adverse impact.

4.4.8 Socioeconomics

The Elwha Project removal alternative would provide some employment benefit during the construction period. It would increase the potential harvest of fall chinook salmon. Harvest of coho salmon and steelhead would be reduced slightly. Inriver and commercial tribal fisheries in fall chinook would improve enough to offset economic losses in the inriver coho and steelhead harvest, and seasonal distribution of tribal fisheries would be improved by the restoration of some pink and chum salmon. The cost of power to the Daishowa America Mill would increase substantially.

4.4.8.1 Construction Impacts

The construction period under the removal of Elwha dam alternative would have minimal effects on the existing commercial, tribal and sport fisheries. Higher

sediment loads in the river during the removal period would have short-term minor effects on existing sport fishing in the reservoirs and river.

The construction workforce required to remove the Elwha dam would equal 13 persons per year for 4 years, a total of 52 person-years of employment. A workforce of that size would be available locally and would not place any additional demands on the existing services provided in the area.

4.4.8.2 Long-Term Impacts

The Elwha Project removal alternative would increase the potential harvest of chinook, pink, and chum salmon. The cost of power to the Daishowa America Mill would be adversely affected to a substantial degree.

Fisheries

Removal of only Elwha dam would provide benefits from increased fall chinook production and harvest, but result in a lower allowable coho and winter steelhead harvest (Table 4-30). There would be positive effects on pink and chum salmon production, but not to the level possible with the removal of both dams alternative (Table 4-21). This alternative would provide a lower allowable harvest of fall chinook and coho, and a marginally higher allowable harvest of steelhead than removal of only Glines Canyon dam.

Tribal Social Effects

Overall, this alternative appears to be socially beneficial to the tribe. The overall economic impact of this alternative could be positive, with an increase in the fall chinook, pink and chum salmon harvest offsetting the loss of the hatchery income and the coho and steelhead harvests. As noted under other alternatives, the restoration of anadromous fish runs would be culturally beneficial to the tribe (Section 4.4.9). No measurable improvement is expected in shellfish resources.

Cost of Power

The cost of project power for the remaining project (Glines Canyon) would increase to 26.8 mills/kWh for the period 1996 to 2205, 30 percent lower than the comparable estimate for the applicant's proposal (Table 2-16). The weighted 10-year average cost of power to the Daishowa America Mill would increase to 35.9 mills/kWh, a 20 percent increase over the reference case estimate of 29.9 mills/kWh for the same period (Table 2-18). The staff estimates

Table 4-30. Present and predicted future total adult production, harvest, and escapement of fall chinook, coho, winter steelhead, chum, and pink salmon under the Elwha dam removal alternative (Source: the staff).

	Chinook		Coho		Steelhead		Chum		Pink	
	Present	Future	Present	Future	Present	Future	Present	Future	Present	Future
Adult Production	13,500	23,083	22,000	32,327	4,000	8,632	<1,000	16,200	<100	96,000
Harvest Rate	0.80	0.67	0.90	0.57	0.90	0.32	____	0.50	____	0.65
Harvest	10,000	15,652	19,800	18,427	3,600	2,787	____	8,100	____	62,400
Escapement	3,500	7,520	2,200	13,400	400	5,845	____	8,100	____	33,600

Note: "____" equals unknown.

that the overall cost of operating the mill would increase by about 3 percent, a negative effect that could carry through to the mill's employees and suppliers. The data necessary to estimate any loss of the mill's competitive position due to this increase are unavailable. In the most extreme case, complete mill closure caused by higher energy costs would cause the loss of up to 1,200 jobs among mill employees, suppliers, and other local businesses.

Project Employment

The Elwha Project removal alternative would require a long-term workforce of seven persons, three less than are currently employed, but six more than required by the removal of both dams.

Other Effects

Overall effects on recreation and tourism would be positive, with associated opportunities for increased recreation and tourism-based income. Because of data limitations, it is not possible to differentiate between the economic effects on recreation and tourism related specifically to Elwha River changes, and changes brought about by future fishery management practices associated with restoring or protecting wild fish stocks in other river systems in the Strait of Juan de Fuca or Puget Sound.

As under most of the other alternatives, no significant effects on area landowners are anticipated. No change in the frequency or severity of flooding is anticipated (Section 4.4.1).

Some filtration of the Port Angeles water supply system could be required, lasting for 1 to 2 years, and additional costs would be incurred for possible mitigation of adverse water quality effects on the Port Angeles industrial water supply and WDF fish rearing facility (Section 4.4.2).

The continued presence of the Glines Canyon Project would continue the degradation process of Angeles Point and Ediz Hook (Section 4.4.1), thus requiring continuation of the U.S. Army Corps of Engineers maintenance program at Ediz Hook.

Taxes paid by the project owner to Clallam County would decline to $133,000 annually (1990 dollars), compared to the current payment of $266,000 a year.

4.4.8.3 Staff-Recommended Measures

An affirmative action plan should be prepared and implemented to improve tribal employment opportunities associated with construction activities and project operation.

4.4.8.4 Unavoidable Adverse Impacts

Harvest rates in existing commercial, tribal, and sport fisheries would have to be reduced to protect Elwha escapement, which would result in reduction in total harvest of coho salmon and steelhead from the Elwha River and salmon from other rivers. Since a reduction in the marine harvest rates is already a management objective for regional fisheries managers, the potential reduction in total regional salmon harvest due specifically to regulations to protect Elwha fish would be minimal. Tribal inriver steelhead and coho harvest would decline, although chinook, pink, and chum salmon would be improved. The inriver sports fishery harvest for steelhead would also decline, although there may be some possible increase in the harvest of chinook salmon.

The average weighted cost of power to the Daishowa America Mill over the first 10 years would increase by 20 percent over the reference case.

4.4.9 Cultural Resources

This alternative would adversely affect the Elwha dam National Register site by destroying it, and the Glines Canyon dam National Register site by modifying it. It would likely allow the restoration of nine wild stocks of anadromous fish species important to Native Americans.

4.4.9.1 Construction Impacts

Under this alternative the Elwha dam National Register site would be destroyed, and new construction would adversely affect the Glines Canyon dam, also on the National Register. This planned new construction would be the same as under the modified dam retention alternative.

In addition, deposition of dam rubble and bypass tunnel muck at the upland disposal site may have an adverse effect on undiscovered archaeological sites by compacting them, or by changing chemical composition due to sediment leaching. Placing the transmission line from Glines Canyon dam to the Olympic National Park boundary underground could also lead to the disturbance of buried archaeological sites. These disturbances are unlikely, however, since previous surveys of these areas did not result in surface site discovery.

The excavation and dredging of Lake Aldwell would result in disturbance of approximately 25 percent of the original ground surface within the new channel zone, because of the inherent difficulty to accurately excavate and dredge to desired levels. Thus, any archeological sites buried under lake sediments could be adversely affected.

4.4.9.2 Long-Term Effects

Restoration of anadromous fish species would significantly benefit Native American culture because of the cultural significance of fish and fishing to members of the Lower Elwha Klallam Tribe (Section 4.1.9.2).

Under wild stock management, the allowable harvest of chinook salmon would increase. The inriver tribal harvest of coho salmon and steelhead would decrease from that provided by current hatcheries.

4.4.9.3 Staff-Recommended Measures

The effects of this alternative on the National Register Elwha and Glines Canyon hydroelectric sites could be mitigated by recording the existing condition of the dams to the standards of the Historic American Engineering Record.

Reservoir excavation and dredging should be monitored by a professional archaeologist to determine whether the work is affecting archaeological sites.

If buried archaeological sites were discovered during construction, work in the immediate vicinity of the find should be halted until the applicant can evaluate the find in consultation with the SHPO.

4.4.9.4 Unavoidable Adverse Impacts

With application of the proposed mitigative measures, there would be no unavoidable adverse impacts to cultural resources under this alternative.

4.5 ENVIRONMENTAL IMPACTS OF REPLACING ELWHA AND GLINES CANYON GENERATION

4.5.1 Regional Impacts

The loss of generation from the Elwha and Glines Canyon projects, whether partial or complete, would represent an increased regional load, and resources additional to those that would otherwise have been required would need to be called upon to meet the region's electrical energy requirements. These resources include a wide variety of conservation and generation alternatives (Section 2.7). The environmental consequences of alternative resources may be localized as in the case of specific generating projects, or widely distributed throughout the region in the case of conservation practices. In the case of measures such as improving transmission or generation efficiency, environmental consequences may be insignificant after project construction is completed.

Generally, conservation resources would have no adverse environmental consequences beyond periods of construction when transitory impacts on air quality, water quality, and traffic are common characteristics of construction activities. One exception is residential weatherization programs where substantial space heating savings can be obtained at the expense of decreased ventilation. Buildup of indoor air pollutants, carbon monoxide, and especially radon can be experienced if appropriate design measures are not implemented (BPA, 1983). Conservation measures in direct service industries, mainly aluminum reduction plants, may benefit the environment by decreasing air pollution emissions at the plants. Conservation measures in irrigation would benefit the environment by reducing water usage and runoff.

Transmission and distribution efficiency improvements would be obtained at very little consequential environmental impact beyond that experienced in the construction stage. To the extent that generating resources can be reduced by this savings, a net environmental benefit would be realized throughout the region. Similarly, conservation voltage regulation and hydropower system efficiency improvements would have minor local impacts during construction, and widespread but small regional environmental benefits.

Making better use of the existing hydropower system's nonfirm energy is associated with installation of combustion turbines and combined cycle plants. Single-cycle combustion turbines are identified as cost-effective for the first 1,000 MW in the Council's Power Plan. Environmental impacts from combustion turbines are most often identified with air emissions, since water discharges are minimal and little or no solid waste is generated (Table 4-31). Generally, combustion turbines produce significant quantities of nitrogen oxides but use fuels low in sulfur and ash. Regional impacts from combustion turbines used to

Table 4-31. Thermal powerplant emissions[1/].

Pollutant powerplants	Emission factor (tons per MW-yr) Gas turbines	Coal-fired
TSP	0.119	1.76
SOx	0.029	1.97
NOx	7.87	16.9
CO	1.91	1.69
CO^2	5,000.0	10,226.0

1/ Source: Northwest Power Planning Council, The Staff Issue Paper 90-1, New Resource: Supply Curves and Environmental Effects, February 28, 1990.

augment hydropower resources would be minimized by mitigative measures required on a case-by-case basis during permitting of new units. Generally, permitting would be problematic within approximately 30 miles of the region's Class I Prevention of Significant Deterioration areas (national parks over 6,000 acres and wilderness over 5,000 acres). These areas require special analysis to ensure that ambient concentrations are low, and that visibility, vegetation, and soils are protected. In no case could a combustion turbine facility be constructed that was modeled to exceed a federal, state, or local air quality standard. The Council's reference plant, located near Hermiston, Oregon, consists of twin units (about 140 MW each) fueled with natural gas and utilizing cooling towers for heat dispersion.

New hydroelectric development is highly site specific in environmental impacts. Characteristic impacts of hydropower development in the Pacific Northwest can be discerned from the discussion earlier in this section on the potential impacts of the Elwha and Glines Canyon projects.

Cogeneration resources are difficult to characterize since they depend on specific industrial installations. Such installations may include gas turbines operated as simple or combined cycle plants, and fossil fuel-fired boilers. Impacts of such facilities are most often associated with air emissions. Solid waste disposal of coal and biomass combustion residues is an issue that must be addressed on a case-by-case basis. As in the case of combustion turbines, impacts must be most carefully assessed for sites near Class I areas. Again, permits cannot be issued for any facility that is modeled to exceed an air quality standard.

Reference coal-fired powerplants in the Council's Power Plan consist of twin, 603 MW units sited at Hermiston, Oregon. Large coal-fired powerplants are identified as major sources of air, water, and solid waste discharges. They are subject to strict environmental regulations under federal, state, and local laws. The reference powerplant would utilize coal from the Powder River Basin in Wyoming transported to the site by unit trains of 100 cars each. Generic impacts of such a facility have been determined by the Council (Table 4-31). Air pollutants that would be emitted in significant quantities include nitrogen oxides, sulfur oxides, and suspended particulates (fly ash and fugitive coal dust, ash, and scrubber sludges). It is assumed that cooling towers would be utilized, avoiding thermal discharges to water bodies. Land disposal of large quantities of bottom and fly ash and scrubber sludges would be required. Properly engineered disposal sites utilizing liners and leachate collection systems coupled with the semiarid conditions of the Columbia Basin can be expected to minimize land disposal impacts.

Emerging air quality issues, which are not necessarily completely analyzed by air pollution permitting procedures, include acid rain and acid deposition and greenhouse gas emissions (mainly carbon dioxide). These issues would have to be addressed on a regional, and perhaps national, basis if coal-fired generating resources were to be implemented.

4.5.2 Impacts on the Port Angeles Power Supply System

In addition to the foregoing potential environmental impacts of replacement power, the loss of generation from the Elwha and Glines Canyon projects would be associated with electrical energy supply effects in the Port Angeles area. These would be of two types, voltage control and transmission capability.

Port Angeles, located at a terminus of the Puget Sound area transmission system, is particularly susceptible to voltage stability problems. While conditions at present are generally satisfactory, voltage control is relatively difficult because of the long transmission line bringing BPA power to the Port Angeles area (personal communication, John Weiss, Electrical Engineer, BPA, April 11, 1990). The hydroelectric turbine generators at the Elwha and Glines Canyon projects, by their nature, are helpful in maintaining voltage control and an adequate power factor. Loss of the Elwha and/or Glines Canyon projects would degrade the area's voltage stability situation and necessitate corrective action. Accordingly, dam removal alternatives have been formulated by the staff to include the addition of capacitors to maintain acceptable power factor (95 percent), and the costs of the capacitor banks have been included in the estimated costs of the alternatives (Sections 2.4, 2.5 and 2.6). Nonetheless, since hydroelectric turbine generators are able to follow load fluctuations, while capacitors must be switched on and off in discrete blocks, loss of the Elwha and Glines Canyon projects would result in slightly less

voltage control than presently exists in the Port Angeles area, and in an associated increased potential for voltage stability problems.

The existing electrical transmission facilities serving the Port Angeles area are approaching their capacity as the area's load grows. BPA plans to add an additional Fairmont-to-Port Angeles transmission line sometime within the next 10 years to accommodate anticipated normal load growth. Additionally, replacements of capacitors and transformers are planned (personal communication, John Weiss, Electrical Engineer, BPA, April 11, 1990). In the event that the Daishowa mill were to expand appreciably, the need for transmission line upgrade would be triggered immediately. The loss of both the Elwha and Glines Canyon projects, which represent a local power source, would advance the need for transmission upgrade in approximately 5 years (personal communication, Stewart Clark, Electrical Engineer, BPA, July 5, 1990). Loss of a single project would advance the need about 2 to 3 years.

4.6 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The Elwha River race of spring chinook salmon, if it exists at all, exists at extremely low levels (Section 4.1.3.2). Assuming it does exist, the failure to take positive action to restore this run would likely ensure its extinction. With the applicant's proposal there would be a poor outlook for restoration of spring chinook, principally because of anticipated passage mortality. Thus, retention of both dams could contribute to the extinction of the race.

Alternatives that include removal of one or both dams would result in the loss of reservoir-based recreational opportunity and the lacustrine habitat represented by the two reservoirs.

Alternatives that include removal of one or both dams would also result in the loss of the hydroelectric potential created by the impoundment of water behind the dams.

With dam retention, sediment buildup in Lake Mills over the next 50 years would amount to about 9 million cubic yards. With this amount of additional sediment, dam removal could still be effectively applied with in-reservoir storage, but with some modifications. As the reservoirs continue to fill, the additional sediment would make storage on in-reservoir terraces more difficult as the needed terrace thickness increases. If the dam removal were to be pursued at a future time, other restoration methods such as partial off-site or channel stabilization at higher elevations with hydraulic control check dams and channel or bank armor would be needed.

4.7 RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

The choices among alternatives represent stark tradeoffs between electrical energy generation, at least for the duration of any licenses, and the long-term aquatic and wildlife resource productivity of the Elwha River Basin. Each alternative represents a unique combination (Table 4-32).

Table 4-32. Summary of power generation and long-term productivity (Source: the staff).

Alternative	Average Annual Energy (GWh)	Anadromous Fish Races With Fair or Better Chance Restoration	Terrestrial Habitat Improvement Index of (AAHU's)	
			Immediate[1/]	Long Term[2/]
Applicant's Proposal	168	4	573	0
Removal of Both Dams	0	9	0	1,040
Glines Canyon Removal	68	7	573	697
Elwha Removal	100	9	573	215

1/ Immediate = The average annual increase in habitat quantity and/or quality over each year of the next license period in James River lands with the applicant's wildlife enhancement plan realized during or shortly after the construction period.

2/ Long Term = The average annual increase in habitat quantity and/or quality expected from the land in the reservoir areas once each year after habitats similar to pre-project conditions have become established (200 to 400 years).

5.0 SUMMARY AND STAFF CONCLUSIONS

The Commission is considering whether to issue or deny licenses for the continued operation of two existing hydroelectric projects owned by James River II. James River II has applied for a new license for the Glines Canyon Project, because the original license issued by the Commission has expired, and for an original license for the Elwha Project since it is presently unlicensed but under Commission jurisdiction (see Section 1.2).

Both projects are located on the Elwha River in the northwest portion of Washington State. The Elwha River originates in mountainous terrain of Olympic National Park and flows north to the Strait of Juan de Fuca (Figure 5-1). The Elwha dam is located about 5 miles from the mouth of the Elwha River, while the Glines Canyon dam is approximately 7 miles further upstream. The Glines Canyon Project, with the exception of a portion of its transmission line, is located within the boundaries of Olympic National Park.

The projects are operated in a coordinated fashion and annually provide about 172 GWh of electrical energy to the Daishowa America Mill in Port Angeles. The projects satisfy approximately 38 percent of the mill's total electrical energy requirement.

Both the Elwha and Glines Canyon dams are major structures. Constructed in 1927, the Glines Canyon dam is a 210-foot-high concrete arch that impounds a 40,000 acre-foot reservoir, called Lake Mills. While less dramatic, the Elwha dam is approximately 450 feet long and about 105 feet high. It was completed before Glines Canyon dam, in 1912, and its reservoir is called Lake Aldwell (refer to Section 2.1 for descriptions of the projects).

The Elwha River was once a major wild salmon and sea-run trout producing stream, with anadromous fish traveling as many as 43 miles upstream from the river mouth in order to spawn (Section 3.4). Because the Elwha and Glines Canyon dams lack any means for fish passage, there has been no anadromous fish access to the upper watershed since the projects were constructed, limiting such fish to the lower 4.9 miles of the river.

At issue in this EIS, principally, is the extent to which anadromous fish restoration would be realized with the applicant's proposal. In applying for licenses, James River II proposes to continue operating both projects for power purposes, but to make accommodation for fish passage and to assist in the restoration of natural self-sustaining anadromous fish populations (Section 2.2). Anadromous species and stocks of concern to the resource agencies and Lower Elwha Klallam Tribe are spring and fall chinook salmon, coho salmon, pink salmon, chum salmon, sockeye salmon, steelhead, and sea-run cutthroat and Dolly Varden trout. The resource agencies and the tribe have been unwilling to suggest that one species or stock is more important, in terms of restoration, than

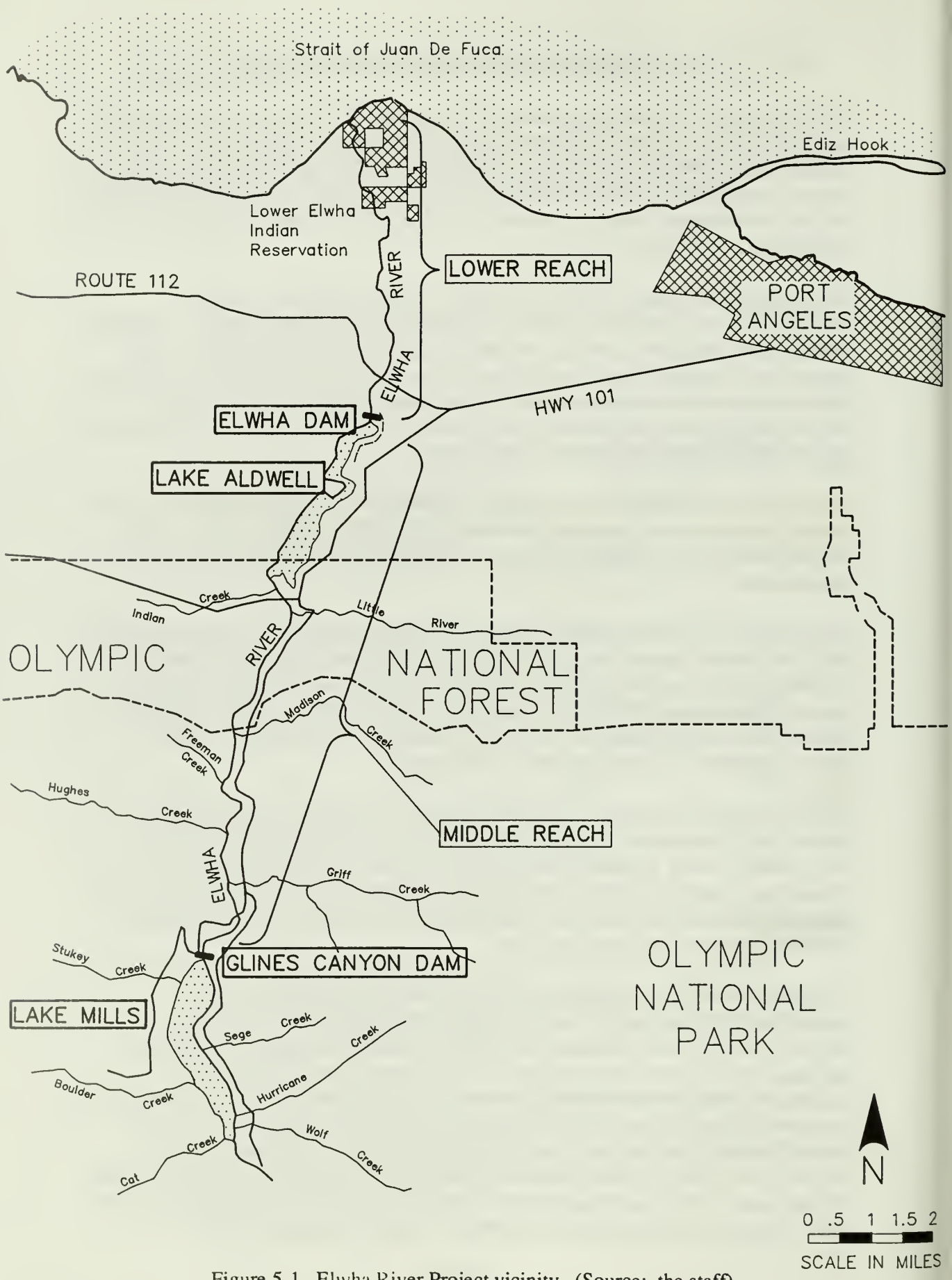


Figure 5-1. Elwha River Project vicinity. (Source: the staff).

FIG5-1

another, and this EIS does not assign greater importance to any particular anadromous fish species.

Comments received during the EIS scoping process led the Commission staff to evaluate the applicant's proposal in comparison with three alternate plans (Table 5-1).

One alternative consists of the removal of both dams to allow unimpeded fish passage (Section 2.3). A necessary byproduct of this alternative is that the river's hydroelectric potential would be foregone, and the Daishowa America Mill would have to rely upon other sources of electrical energy.

The second and third alternatives consist of intermediate plans, wherein one project would be removed and the other modified to allow fish passage, Glines Canyon removal with retention of Elwha (Section 2.4) and Elwha removal with retention of Glines Canyon (Section 2.5).

As shown in Table 5-1, the four alternatives represent a wide range of capital costs ($14.7 million to $64.2 million) and of power output (168 GWh to zero).

The following sections summarize the four alternatives in relation to: (1) achievement of the principal resource objectives; (2) other environmental effects; (3) consistency with comprehensive plans; (4) long-term cost impacts; and (5) approaches to implementation. The final section presents the staff's preliminary findings based on the results of the DEIS.

5.1 COMPARATIVE ACHIEVEMENT OF PRINCIPAL RESOURCE OBJECTIVES

The Commission staff has concluded that there are three principal resource objectives relevant to the licensing of the Glines Canyon and Elwha projects: (1) restoration of wild anadromous fish production throughout the Elwha River Basin; (2) restoration of natural environmental conditions within Olympic National Park; and (3) provision of renewable hydroelectric energy. In the licensing of existing projects, the Commission staff is interested in a full reconsideration of all power and nonpower aspects in relation to society's present-day priorities and goals. To identify these priorities and goals, the staff has relied upon public, agency, and intervenor comments received during the EIS scoping process and upon published resource plans of responsible agencies (Federal Energy Regulatory Commission, Scoping Document 2, April 1990).

No alternative performs well on all three resource objectives (Table 5-2), and stark tradeoffs are involved in the choice of one alternative over another. Relatively high levels of achievement of the anadromous fish and natural ecosystem restoration goals would come at the expense of hydroelectric generation. Conversely, reasonably full utilization of the river's hydroelectric potential would be associated with lesser achievement of the restoration objectives.

Table 5-1. Principal alternatives (Source: the staff).

Alternative	Initial Capital Cost ($1990)	Average Annual Generation (KWh)
Applicant's dam retention proposal	14,670,000	168,000,000
Removal of both dams	64,245,000[1/]	- 0 -
Glines Canyon removal and Elwha modified	49,138,000[1/]	68,000,000
Elwha removal and Glines Canyon modified	30,372,000[1/]	100,000,000

1/ The approach to dam removal is subject to refinement based upon further detailed engineering investigations.

Table 5-2. Rank order of alternatives in relationship to achievement of principal resource objectives (Source: the staff).

	Resource Objectives		
Alternative	Fish Restoration	Ecosystem Restoration	Hydroelectric Generation
Applicant's dam retention proposal	4	4	1
Removal of both dams	1	1	4
Glines Canyon removal	3	2	3
Elwha Project removal	2	3	2

5.1.1 Restoration of Anadromy

Salmon and steelhead are of considerable regional importance in the Pacific Northwest as biological, commercial, and cultural resources, and the rebuilding of salmon and steelhead stocks is a regional priority (Section 1.4.1). The construction of Elwha and Glines Canyon dams early in this century contributed to the decline of fall and spring chinook, coho, chum, pink, and possibly sockeye salmon, along with steelhead, cutthroat, and Dolly Varden trout. Allowing these anadromous fish access to the middle and upper river habitat offers the potential for once again providing for the production of wild fish on a self-sustaining basis.

The applicant's proposal would provide sufficient passage opportunity and habitat improvements over existing conditions to allow a fair chance of restoring productive wild runs of fall chinook and coho salmon, and a good and fair chance, respectively, for winter and summer run steelhead. The outlook would be poor for restoring pink, chum, sockeye, and spring chinook salmon, and sea-run cutthroat and Dolly Varden trout because of continuing passage and habitat problems (Table 5-3). Supplemental measures recommended by the staff (Section 4.1.3.3) would only marginally improve the performance of the applicant's proposal.

With removal of both dams, passage and habitat problems would be essentially eliminated, after an initial 10-year restoration period, thereby allowing good to excellent chances of restoring all but sockeye salmon. The restoration outlook for sockeye salmon would remain poor because of limited available habitat for this species in the Elwha River Basin.

Removal of Glines Canyon dam with retention of Elwha dam would provide a good to excellent outlook for restoration of chinook and coho salmon and steelhead. Sea-run Dolly Varden and cutthroat trout would have a fair chance at restoration. The prognosis for pink and chum salmon, however, would remain poor because of the presence of the Elwha Project.

Removal of Elwha dam with retention of Glines Canyon dam would provide at least a fair chance of restoring productive runs of all but sockeye salmon, the same outlook as with removal of both dams. The adult production potential would not be as great as with removal of both dams because of passage and habitat limitation associated with Glines Canyon dam and Lake Mills. Elwha removal offers better potential for anadromous fish restoration than does Glines Canyon removal, because Elwha removal would provide unimpeded access to a presently inaccessible portion of the river (the middle reach). With only Glines Canyon removal anadromous fish would continue to have to contend with the limited mortality associated with fish passage facilities.

Overall, the dam removal alternative (both dams) would most fully achieve the anadromous fish restoration goal. Next best would be the Elwha removal

Table 5-3. Anadromous fish restoration potential (Source: the staff).

	Applicant's Proposal	Removal of Both Dams	Glines Canyon Dam Removal	Elwha Dam Removal
Fall Chinook	Fair	Excellent	Excellent	Good
Spring Chinook	Poor	Good	Good	Fair
Coho	Fair	Good	Good	Good
Winter Steelhead	Good	Excellent	Excellent	Excellent
Summer Steelhead	Fair	Good	Good	Good
Pink	Poor	Good	Poor	Fair
Chum	Poor	Good	Poor	Fair
Sockeye	Poor	Poor	Poor	Poor
Sea-Run Cutthroat	Poor	Good	Fair	Fair
Sea-Run Dolly Varden	Poor	Good	Fair	Fair

alternative, followed by Glines Canyon removal and, finally, the applicant's proposal.

5.1.2 Restoration of the ONP Ecosystem

Restoration of natural ecosystem conditions in the Olympic National Park (ONP) is the second principal objective. The basis for this objective is found in NPS goals and policy. The primary goal of the NPS in managing national parks is to preserve or, where necessary, to recreate the environment as viewed by the first European visitors (Section 1.4.2). Restoration of the natural ecosystem within ONP is dependent on two factors: (1) restoration of the area currently occupied by the Glines Canyon Project and Lake Mills to topographic and terrestrial conditions approximating those that existed prior to project construction; and (2) restoration of the food source for wildlife provided by anadromous fish in the middle and upper reaches of the Elwha River Basin (Table 5-4).

The applicant's proposal would not return the Glines Canyon Project area to a natural condition, but it would provide a fair chance of restoring two of the native salmon runs to the river above Elwha dam. This would contribute additional biomass to wildlife that consume salmon carcasses and benefit wildlife populations (Table 5-4).

The dam removal alternative would involve restoring the 715-acre area currently occupied by the Glines Canyon Project facilities and Lake Mills. Additionally, in relation to the applicant's proposal, it has a much improved chance of restoring wild self-sustaining salmon runs to the Elwha drainage. These runs would be expected to provide the biomass necessary to restore populations of species that consume salmon carcasses. Therefore, this alternative comes closest to meeting the goal of restoring the natural ecosystem of ONP.

The Glines Canyon removal alternative would also make a significant contribution toward restoring the natural ecosystem of ONP because of the gain in habitat from restoration of areas occupied by project facilities and Lake Mills. However, because of the lower available biomass due to the poor restoration outlook for two salmon runs under this alternative, it is less responsive to the resource objective than removal of both dams.

The Elwha dam removal alternative has a fair or better chance of restoring all but one of the native salmon runs to the upper Elwha watershed, which would provide the biomass necessary to restore populations of species that consume salmon carcasses. However, because the Glines Canyon Project would not be returned to a natural condition, this alternative would not restore the natural habitat of the park occupied by the Glines Canyon Project.

Table 5-4. Contribution of each alternative to the goal of restoring the ONP ecosystem (Source: the staff).

Alternative	Contributing Factors: Restoration of Glines Canyon Project Area	Contributing Factors: Restoration of Biomass/ Wildlife Populations	Restoration of ONP Ecosystem
Applicant's dam retention proposal	No	Fair	Partial
Removal of both dams	Yes	Good-Excellent	Full
Glines Canyon removal	Yes	Good	Partial
Elwha Project removal	No	Fair-Good	Partial

5.1.3 Hydroelectric Generation

Continued use of the Elwha River's hydroelectric potential to provide renewable, nonpolluting electrical energy represents the third principal resource objective identified through the EIS scoping process. The importance of this objective arises from two considerations. First, the electrical energy provided by the Glines Canyon and Elwha projects would provide part of the region's projected firm energy requirement. Second, the Elwha River's hydroelectric developments reduce the quantity of atmospheric pollutants associated with the combustion of fossil fuels in thermal power plants in the region (Section 1.4.3).

On an average annual basis the applicant's proposal would provide about 168 GWh of electrical energy (Table 5-1), an amount equivalent to about 20 percent of the total electrical energy requirements of the Port Angeles area. Removal of both dams would mean the elimination of hydroelectric generation on the Elwha River, while the Glines Canyon removal and Elwha removal alternatives would provide 68 and 100 GWh, respectively.

5.2 COMPARATIVE ASSESSMENT OF OTHER ENVIRONMENTAL EFFECTS

Each of the four alternatives would be associated with positive and negative environmental effects that are not directly related to achievement of the principal resource objectives addressed in the previous section. The most important

distinction among the alternatives are summarized in the paragraphs that follow. Section 4.0 presents a full discussion of effects.

5.2.1 Sediment and River Channel Effects

A major concern with all of the alternatives concerns the fate of the river's natural sediment supply. Sediment conditions in the Elwha River have substantial effects on fish habitat, river channel stability, and flooding potential.

With the dam retention alternative, upstream sediment supply would continue to accumulate in the reservoirs, thus starving the middle and lower river of cobble, gravel, and sand supply. Channel substrate in the middle and lower reaches would remain very coarse, being dominated in the pavement layer by boulders and cobbles with sparse patches of gravel. The channel configuration would continue in a very stable condition.

With removal of both dams, an increase in clay and silt suspended sediment discharge would be expected in the middle and lower Elwha River reaches during the latter 3 to 4 years of the dam removal process and several years thereafter. Natural upstream sediment supply of cobbles, gravel, sand, and silt would be returned to the middle and lower Elwha River and to the coastal zone. Because of the greater supply of sediment to the middle and lower river, the river bed would rise 1 to 5 feet, thus increasing risks of flooding along the lower river. The channel would be more active, with increased migration and shifting into side channels. Side channels would be more active with increased frequency of significant flow.

Removal of just the Glines Canyon dam would result in return of the natural sediment load to the middle reach and rapid infilling of Lake Aldwell (30 to 50 years). Removal of only the Elwha dam would result in a relatively small increase in sediment supply to the lower Elwha River.

5.2.2 Water Quality

The Elwha River currently possesses exceptionally high water quality, which can be attributed to the pristine status of the upper watershed in ONP. The water quality of the Elwha River has been designated as Class "AA" Waters by the state of Washington for "extraordinary" status, and the Elwha is used as a benchmark water quality monitoring station by the U.S. Geological Survey. High water quality is important in maintaining resource values of the river, which include anadromous and resident fish populations, recreational opportunities including fishing and swimming, and aesthetic qualities. Additionally, the Elwha River is the most important source of water for the City of Port Angeles, which relies upon high quality water for drinking and industrial uses.

The applicant's proposal would result in relatively little change in the existing Elwha River flow regime or water quality. Proposed fish passage spills of 100 cfs

would slightly increase water temperature in the middle reach, while reservoir drafting for flow augmentation would have a slightly adverse effect on dissolved oxygen concentrations in the middle reach.

With removal of both dams, suspended sediment concentrations would substantially increase in the Elwha River below Glines Canyon dam. High suspended sediment concentrations would occur during the dam removal process, and several years following, and would adversely affect water quality by increasing turbidity values. Deterioration of these water quality characteristics would have an adverse impact on water diverted for industrial users by the City of Port Angeles, and for the WDF fish rearing facility. Also, City of Port Angeles drinking water supplies obtained from Ranney collectors would be potentially degraded by increased turbidity levels, a condition which would require increased water treatment prior to distribution. Suspended sediment levels would gradually decline to natural background levels several years following dam removal, and high water quality conditions would be reestablished.

Changes in water temperatures following dam removal would be generally beneficial to salmon and trout, with an average reduction of 2 to 4°C occurring during the later summer and early fall in the middle and lower reaches.

Water quality effects under the Glines Canyon dam removal alternative would be very similar to those predicted for removal of both dams, except that the severity of adverse impacts resulting from increased suspended sediments would be slightly reduced by leaving the Lake Aldwell sediments intact.

Impacts on water quality with removal of Elwha dam would be reduced from those occurring from removal of both dams, as there would be no change occurring in the middle reach and only Lake Aldwell sediments would reach the lower river.

5.2.3 Resident Trout

The aquatic environment of the Elwha and Glines Canyon Project areas includes a regionally significant wild trout population consisting mostly of rainbow and Dolly Varden. The Elwha River currently contains the largest length of undeveloped stream without anadromous stocks in the ONP, allowing good populations of resident trout to develop without competition from anadromous fish.

All of the alternatives would result in a significant decrease in the resident trout population because of the newly introduced competition for space, food, and spawning habitat. The degree of impact would be directly proportional to the numbers of anadromous fish restored to the middle and upper reaches (see Section 5.1.1). In addition, the dam removal process would result in moderate adverse impact to the trout population residing in the reservoirs.

5.2.4 Terrestrial Resources

The Elwha Valley supports a unique mix of plant communities that are transitional between those occurring on either side of the crest of the Olympic Mountains. The habitats in the Elwha Valley are regionally important to wildlife, particularly wintering deer and elk. The vegetation and wildlife habitats in the vicinity of Glines Canyon are essentially pristine because they have been protected and managed as part of ONP. Most of the land adjacent to the Elwha Project has been logged and supports stands of second-growth timber, 20 to 80 years in age.

While the dam retention alternatives would involve some minor vegetation and habitat losses due to construction of new project facilities at both Glines Canyon and Elwha, the proposed wildlife enhancement plan would provide important protection and habitat improvement for most wildlife species using the lands owned by James River II in the vicinity of Lake Aldwell.

The dam removal alternative would add 715 acres of terrestrial habitat to the Elwha drainage. Ultimately, this land would support plant communities similar in composition, structure, and habitat value to those that existed in the reservoir areas prior to construction of the dams. This increase in the amount of low-elevation forest habitat would benefit a variety of species, including wintering deer and elk. The dam removal alternative has a good-to-excellent chance of restoring salmon runs to the middle and upper reaches of the Elwha. Consequently, this alternative, more than the others, would greatly benefit wildlife that consume salmon carcasses, particularly wintering bald eagles.

5.2.5 Land Use

The Glines Canyon Project is fairly unique in a land use perspective in that the project facilities occupy an extensive area of one of the more accessible valleys of the highly visited ONP. In contrast, the Elwha Project is close to major transportation corridors, affords fewer recreational opportunities than the Glines Canyon Project, and is situated amidst timber lands typical of the area with a few nearby rural residential and recreational uses.

The applicant's proposal would only slightly change overall land use patterns in the project area, while the alternatives involving dam removal would all have moderately adverse short-term impacts because of transportation and recreational disruptions and impacts to air quality. Also, the landfilling of rubble and spoils from any of the dam removal alternatives would take a small area out of timber production at the base of Kelly Mountain, slightly reducing the available timber base in the area.

5.2.6 Recreational Resources

The upper Elwha River is well known for its high quality resident trout fishery. The lower reach of the Elwha River has an important hatchery based fishery

utilized by marine and freshwater anglers. The middle reach of the Elwha River is utilized for whitewater boating during the late spring and summer months.

The stringent harvest restrictions necessary to restore self-sustaining fish runs under the applicant's proposal would result in less salmon and steelhead available for harvest by freshwater and marine anglers. On the positive side, the addition and improvement of recreational facilities planned by the applicant would provide a small contribution to the recreational opportunities in the area.

Removal of both dams would, over the long term, greatly benefit both marine and freshwater angling because of much higher production and available harvest of most species. In the short term, construction would create disruptions and closures affecting recreationists in the Elwha sub-district of ONP. Removal of both dams would create 5.3 miles of new whitewater opportunities in the middle reach and provide much longer rafting runs, but it would take away the current flat water boating opportunities on Lake Mills and Aldwell.

5.2.7 Aesthetics

The Elwha River valley has extensive areas of relatively undeveloped landscapes offering excellent viewing opportunities in ONP. Within this setting, the Glines Canyon Project is highly visible. Outside the park, the river passes through moderately disturbed areas with clear cuts easily evident to viewing along the major transportation corridors. Lake Aldwell and other Elwha Project facilities are isolated, with few vantage points to observe the project.

The dam retention alternative would provide some new viewing opportunities with the addition of new recreational facilities and with the introduction of anadromous fish migrating upstream through project facilities.

Removal of both dams would be moderately negative to the visual environment because of the extensive short-term disturbance to large areas currently occupied by project reservoirs. In addition, the replacement of the blue waters of Lake Mills with an early successional forest on large terraces would be considered an adverse effect by most viewers.

5.2.8 Socioeconomic Effects

Providing about 40 percent of the Daishowa America mill's total electrical energy requirement at projected costs less than half other sources, the Elwha and Glines Canyon dams, as presently configured and operated, provide a competitive advantage for the mill, one of the ten largest employers in Clallam County. At the same time, the dams obstruct anadromous fish passage, thus limiting the Elwha River's potential economic contribution to inriver and marine commercial, tribal, and sport fisheries. Commercial and subsistence fishing are major resources for the Lower Elwha Klallam Tribe, a tribe characterized by high unemployment, low incomes, and few economic assets. Additionally, the

presence of the projects makes other economic contributions to the local economy, including taxes paid to Clallam County and several jobs for the operations and maintenance workforce.

The applicant's proposal would result in an approximate doubling of the cost of power of the Elwha and Glines Canyon projects and a significant (30 percent) increase in the overall cost of electrical energy to the Daishowa America Mill. Restoration efforts with dam retention would likely result in an overall decline in the number of fish that could be harvested (Section 4.1.8). The lower harvests would adversely affect inriver tribal and sport fisheries, although marine commercial fisheries could benefit. Reduction of the inriver harvest would have a particularly adverse effect on tribal subsistence fishermen. Taxes paid to Clallam County would not change, and the operations workforce would increase by four people.

The removal of both dams would force the Daishowa America Mill to cut back production, develop other energy conservation or generating resources on site, and/or purchase additional power from the City of Port Angeles. Assuming increased power purchases and no production cut-back, the mill would experience a significant increase in the overall cost of power, similar in magnitude to the cost increase that would occur with the applicant's proposal. Additionally, the applicant, James River II, would have to absorb all or a portion of the substantial capital cost of removal ($64.3 million), depending upon the ultimate allocation of cost among affected entities.

Commercial, tribal, and sport fisheries would benefit with removal of both dams more than under any other alternative, based on an increased available harvest of salmon and steelhead (Section 4.2.8). Sport fisheries would also benefit from the potential restoration of salmon and steelhead, and cutthroat and Dolly Varden trout. Tribal commercial and subsistence fisheries would improve, and the seasonal distribution of harvest would improve. A return to natural sediment flows in the river would help build up the river delta, producing shellfish habitat valued by the Lower Elwha Klallam Tribe. Over time, sediment deposition on Ediz Hook would reduce or eliminate the need for protection, along with its associated cost to the federal government. During dam removal, increased sediment in the river could create a need for increased treatment of the Port Angeles water supply and upgraded treatment facilities for industrial users, increasing the cost of those supplies. Project property taxes paid to Clallam County would be eliminated, and the 10-person operational workforce would be reduced to only 1 person.

5.2.9 Cultural Resources

The Elwha River and its anadromous fishery are a significant aspect of the individual and collective cultural identity of the Lower Elwha Klallam Tribe. The dam retention alternative would have a somewhat beneficial effect on Native American culture because it would likely restore some species of anadromous fish.

The beneficial cultural effects of dam removal, since all but one of the native anadromous fish runs would likely be restored, would be measurably greater.

The Elwha and Glines Canyon dams and associated facilities are listed on the National Register of Historic Places and, as such, are of regional significance as historical, architectural, and engineering landmarks. Modification of project structures to provide for fish passage would represent a minor adverse impact because of the dams' historical character. Removal of the projects would result in the elimination of National Register sites.

5.2.10 Effects Anticipated from the Loss of Elwha and Glines Canyon Power Generation

The loss of generation, whether partial or complete, would represent an increased regional load, and electrical energy resources additional to what would otherwise have been required would need to be called upon to replace the Elwha and Glines Canyon hydroelectric output. The precise result cannot be forecasted, but any of a wide variety of conservation and electrical generating resources could be affected in terms of timing or extent of development (Section 2.6). The associated environmental consequences may be localized, as in the case of specific generating projects, or widely distributed, as in the case of conservation practices.

The principal potential adverse impact of replacing Elwha River hydroelectric generation would be air quality degradation, an impact associated with several cost-effective generating alternatives available to the region. Combustion turbines, cogeneration installations, and coal-fired powerplants are all associated with air emissions. Combustion turbines produce significant quantities of nitrogen oxides. Cogeneration resource impacts would be dependent upon the specific industrial installation. Air pollutants that would be emitted in significant quantities from coal-fired powerplants include nitrogen oxides, sulfur oxides, and suspended particulates. Permits would not be issued for any facility that was modeled to exceed air quality standards, but air quality issues not completely addressed by air pollution permitting procedures include acid rain and acid deposition, and greenhouse gas emissions.

Additionally, each of the conservation and electrical generating resources would result in transitory, localized construction impacts, and certain generating resources could result in significant aquatic impacts (hydroelectric projects) and land disposal impacts (coal plants).

In addition to the foregoing potential environmental impacts of replacement power, the loss of the Elwha and Glines Canyon projects would result in adverse electrical energy supply effects in the Port Angeles area. The hydroelectric projects help in maintaining voltage control and an adequate power factor in an area particularly susceptible to voltage stability problems. While system modifications would partially compensate for the loss of the projects' reduced

voltage control, an associated increased potential for voltage stability problems would necessarily result.

The foregoing comparative summary of environmental impacts is recapitulated in Table 5-5.

5.3 COMPARATIVE CONSISTENCY WITH COMPREHENSIVE AND OTHER RESOURCE PLANS

Section 10(a)(2) of the Federal Power Act requires the Commission to consider the extent to which a project is consistent with comprehensive plans (where they exist) for improving, developing, or conserving a waterway or waterways affected by the project. Other resource plans are also examined under Section 10(a).

Five Section 10(a)(2) comprehensive plans were determined relevant to this proceeding, of which two are federal plans and three are state of Washington plans with aspects that address comprehensive development of the rivers of the state. The five relevant Section 10(a)(2) comprehensive plans are: (1) the Pacific Fishery Management Council and National Marine Fisheries Service Fishery Management Plan for Commercial and Recreational Salmon Fisheries off the Coasts of Washington, Oregon, and California; (2) the Northwest Power Planning Council's Protected Areas Amendments to the Northwest Conservation and Electric Power Plan; (3) the Washington's Interagency Committee for Outdoor Recreation Statewide Comprehensive Outdoor Recreation Plan (SCORP); (4) WDW's Strategies for Washington's Wildlife; and (5) WDF's Hydroelectric Project Assessment Guidelines.

Three other resource plans were also deemed relevant: Clallam County's Comprehensive Plan, the county's Shorelines Master Program, and a series of plans by the NPS for ONP. The Clallam County Shorelines Master Program is an important part of Washington's Coastal Zone Management Program.

No alternative would be entirely consistent with all plans (Table 5-6), but in the staff's view, the removal of both dams would be most consistent with the overall direction of the relevant plans.

All four alternatives are generally consistent with the Fishery Management Plan for Commercial and Recreational Salmon Fisheries Off the Coasts of Washington, Oregon, and California, because of the addition and restoration of wild salmon species to the river system. The removal of both dams alternative provides the most consistency because of the forecasted substantial gains in production of wild fish.

All of the alternatives are also fully consistent with the Protected Areas Amendments because the Elwha River has been designated unprotected, largely because of the presence of the existing dams.

Table 5-5. Comparative environmental impacts (Source: the staff).

	Applicant's Proposal	Dam Removal Alternative	Glines Canyon Dam Removal Alternative	Elwha Dam Removal Alternative
WATER QUANTITY	Run-of-river discharge except for 10-ft drafting of Lake Mills for power production and low-flow augmentation.	Natural run-of-river discharge pattern.	Run-of-river discharge pattern.	Run-of-river discharge except for 10-ft drafting of Lake Mills for power production and low-flow augmentation.
WATER QUALITY				
Suspended Sediments	Short-term increase during construction, otherwise no change.	High suspended sediments during and several years following construction.	Same as dam removal alternative.	Same as dam removal alternative except that impacts only apply to Lake Aldwell and lower reaches. Impacts in these reaches slightly less than under dam removal alternative.
Turbidity	Short-term increase during construction, otherwise no change.	High turbidity levels during and immediately following construction. Gradual reduction in concentrations until natural background levels attained.	Same as dam removal alternative.	Same as dam removal alternative except that impacts only apply to Lake Aldwell and lower reaches. Impacts in these reaches slightly less than under dam removal alternative.
Organic Matter	No change.	High organic matter concentrations during and immediately following construction. Increased particulate organic matter load over long term.	Same as dam removal alternative, except for lowered particulate organic matter concentrations in lower reach.	High organic matter concentrations in lower reach during and immediately following dam removal. No change in particulate organic matter over long term.
Dissolved Oxygen	Decreased dissolved oxygen concentrations in middle reach during flow augmentation. Otherwise no change.	Low dissolved oxygen concentrations in Lake Mills and Lake Aldwell during dam removal period.	Low dissolved oxygen concentrations in Lake Mills during dam removal period.	Low dissolved oxygen concentrations in Lake Aldwell during dam removal period.
Water Temperature	Slight increase in middle reach during summer reservoir stratification periods due to surface spill at Lake Mills.	Beneficial reduction in water temperature of 2 to 4°C during late summer and early fall. Increased daily temperature fluctuations.	Same as dam removal alternative, except for reduced daily temperature fluctuations in Lake Aldwell and lower reaches.	Increased temperature fluctuations in Lake Aldwell and lower reaches.

Table 5-5. (Continued)

	Applicant's Proposal	Dam Removal Alternative	Glines Canyon Dam Removal Alternative	Elwha Dam Removal Alternative
Nutrients	No change.	Increased nutrient levels in river during and following dam removal.	Same as dam removal alternative.	Same as dam removal alternative, except that increases only apply to lower reach.
AQUATIC RESOURCES				
Anadromous Fish	Good chance of restoring winter steelhead. Fair chance of restoring fall chinook, coho, and summer steelhead. Poor chance of restoring spring chinook, pink, chum, sockeye, cutthroat, and Dolly Varden.	Excellent chance of restoring winter steelhead and fall chinook. Good chance of restoring coho, spring chinook, pink, chum, summer steelhead, cutthroat, and Dolly Varden. Poor chance of restoring sockeye.	Excellent chance of restoring winter steelhead and fall chinook. Good chance of restoring coho, spring chinook, and summer steelhead. Fair chance of restoring cutthroat and Dolly Varden. Poor chance of restoring pink, chum, and sockeye.	Excellent chance of restoring winter steelhead. Good chance of restoring fall chinook, coho, and summer steelhead. Fair chance of restoring spring chinook, pink, chum, cutthroat, and Dolly Varden. Poor chance of restoring sockeye.
	Passage provided to middle and upper river would provide additional spawning and rearing habitat. Higher turbidity during construction would slightly reduce salmon and steelhead egg and fry survival.	Much improved passage and habitat over applicant's proposal. Adverse effects on salmon and steelhead eggs, fry and aquatic invertebrates during construction, and several years thereafter from high sediment loads in river.	Same as dam removal alternative.	Same as dam removal alternative except adverse effects confined to a two rather than three-year period of construction.
Resident Trout	Negative effect on survival from competition with anadromous species in middle of upper reach.	Large negative effect on survival from competition with anadromous species moderated by improved habitat condition in middle and lower reaches. Moderate negative effect during construction from high turbidity.	Same as dam removal alternative.	Similar to but slightly less than dam removal alternative.

Table 5-5. (Continued)

	Applicant's Proposal	Dam Removal Alternative	Glines Canyon Dam Removal Alternative	Elwha Dam Removal Alternative
TERRESTRIAL RESOURCES				
	No restoration of natural conditions at the Glines Canyon Project. Fair restoration potential of wildlife populations that consume chinook and coho carcasses.	Restoration of natural conditions at the Glines Canyon Project. Good-to-excellent chance of restoring wildlife populations that consume salmon carcasses.	Restoration of natural conditions at the Glines Canyon Project. Good chance of restoring wildlife populations that consume chinook and coho carcasses.	No restoration of natural conditions at the Glines Canyon Project. Fair-to-excellent chance of restoring wildlife populations that consume salmon carcasses.
	Minor vegetation and habitat losses. Protection and improvement of wildlife habitat adjacent to Lake Aldwell. Fair chance of benefitting wildlife that feed on salmon carcasses and live fish.	Addition of 715 acres of terrestrial habitat to the Elwha drainage. Good-to-excellent chance of benefiting wildlife that consume salmon carcasses and live fish.	Addition of 425 acres of terrestrial habitat to the Elwha Valley. Good chance of benefiting wildlife that consume salmon carcasses and live fish.	Addition of 290 acres of terrestrial habitat to the Elwha Valley. Fair-to-excellent chance of benefiting wildlife that consume salmon carcasses and live fish.
LAND USE	No significant change, addition of large wildlife protection lands.	Short-term increases in air quality degradation and transportation disruption, small area taken out of timber production on Kelly Mountain.	Short-term increase in air quality degradation and transportation disruption, small area taken out of timber production and large area dedicated to wildlife.	Minor short-term transportation disruption, addition of lands to timber base of the area.
RECREATIONAL RESOURCES				
Angling	Reduction in harvest and open seasons and/or gear and area limitations in marine and inriver fisheries. Expansion of angling opportunities for summer and winter run steelhead.	Great increase in harvest of chinook, coho, steelhead and the addition of pink salmon angling opportunities. Potential improvement in sea-run cutthroat and Dolly Varden. Reduction in quality of resident trout fishery in middle and upper river.	Same as dam removal alternative, except for slightly lower harvest of chinook, coho, and steelhead, and no additional pink salmon opportunity.	Same as dam removal alternative, except for moderately lower harvest of chinook, coho, pink, and steelhead.
Whitewater boating	No change.	Addition of 5.3 miles of whitewater opportunities, although most benefit is downstream of Lake Mills area.	No great change, due to lack of vehicular accessibility above Lake Mills.	Addition of 2.8 miles of whitewater opportunities allowing a 12.4 mile long run from Altaire campground to the river mouth.

Table 5-5. (Continued)

	Applicant's Proposal	Dam Removal Alternative	Glines Canyon Dam Removal Alternative	Elwha Dam Removal Alternative
Recreational facilities	General improvement over existing conditions for recreationists.	A net loss in developed recreational sites with abandonment of boat launch sites.	General improvement over existing conditions, although a small loss due to loss of Lake Mills.	Slight improvements of Lake Mills boat launch but loss of WDW facility at Lake Aldwell.
Aesthetics	Addition of new points of interest and viewing opportunities.	Extensive short-term reduction in scenic quality and slight long-term reduction due to loss of scenic waterbodies.	Same as dam removal alternative.	Small short- and long-term reduction in visual quality. Slight reduction in project visibility.
SOCIOECONOMICS				
Fisheries	Overall decline in the value of harvestable fish with more fall chinook and fewer coho salmon and steelhead. Marine commercial fisheries would benefit while inriver tribal and sport fisheries would be adversely affected.	Significant increase in the value of harvestable fish, benefitting commercial, tribal, and sport fisheries. Increased harvest of fall and spring chinook, coho salmon, winter and summer steelhead, pink and chum salmon, and sea-run cutthroat and Dolly Varden trout.	Same as dam removal alternative, except benefits would not be as great. Pink and chum salmon harvest would not increase, and steelhead harvest would decline.	Same as dam removal alternative except benefits would not be as great. Coho salmon and steelhead harvest would decline.
Tribal Social Effects	Lower Elwha Klallam Tribe would be adversely affected, given lower fish harvest and less favorable seasonal distribution of fish harvest compared to existing condition.	Benefits to tribe would include higher fish harvest, improved seasonal distribution of fish, and possibly improved shellfish habitat at river delta.	Same as dam removal alternative, except tribal harvest would not be as great and no improvement in shellfish habitat would occur.	Same as dam removal alternative except tribal harvest would not be as great and no improvement in shellfish habitat would occur.
Cost of Power	Daishowa America Mill's average weighted cost of power from all sources would increase by approximately 30 percent.	Daishowa America Mill's average weighted cost of power from all sources would increase approximately 30 percent.[1/]	Daishowa America Mill's average weighted cost of power from all sources would increase approximately 50 percent.[1/]	Daishowa America Mill's average weighted cost of power from all sources would increase approximately 20 percent.[1/]

Table 5-5. (Continued)

	Applicant's Proposal	Dam Removal Alternative	Glines Canyon Dam Removal Alternative	Elwha Dam Removal Alternative
Employment	Construction employment would equal 32 person years. Long-term employment would equal 14 persons annually, 4 more than under existing conditions.	Construction employment would equal 110 person years. Long-term employment would be reduced to 1 person annually.	Construction employment would equal 95 person years. Long-term employment would be reduced to 7 persons annually.	Construction employment would equal 52 person years. Long-term employment would be reduced to 7 persons annually.
Other Effects	No change in project taxes paid, flood protection, downstream water supply filtration costs, or Ediz Hook beach replenishment costs.	Taxes paid by the project would be reduced to zero. There would be a slight increase in the chance of flooding, possibly higher short-term costs for downstream water supply filtration, and possibly lower long-term costs for Ediz Hook Beach replenishment.	Taxes paid by the project would decrease by about 50 percent. There would be no appreciable change in flood protection, downstream water supply filtration costs, or Ediz Hook beach replenishment costs.	Taxes paid by the project would decline about 50 percent. There would be no appreciable change in flood protection, downstream water supply filtration costs, or Ediz Hook beach replenishment costs.
CULTURAL RESOURCES	Benefits to Native Americans from restoration of wild anadromous fish runs. Small impacts to National Register Elwha and Glines Canyon dams.	Greater potential for restoration of wild fish runs. National Register Elwha and Glines Canyon dams destroyed. Possible disturbance of buried archaeological sites.	Benefits to Native Americans from restoration of wild anadromous fish runs. National Register Glines Canyon dam destroyed. Small impacts to National Register Elwha dam. Possible disturbance of buried archaeological sites.	Benefits to Native Americans from restoration of wild anadromous fish runs. National Register Elwha dam destroyed. Small impacts to National Register Glines Canyon dam. Possible disturbance of buried archaeological sites.

1/ This estimate assumes the cost of dam removal is absorbed by entities other than the Daishowa America Mill (e.g., the applicant).

Table 5-6. Elwha/Glines Canyon consistency summary of comprehensive and other resource plans (Source: the staff).

	Applicant's Dam Retention	Removal of Both Dams	Removal of Glines Canyon	Removal of Elwha
Fishery Management Plan[1/]	Generally Consistent	Fully Consistent	Generally Consistent	Generally Consistent
Protected Areas Amendments[1/]	Fully Consistent	Fully Consistent	Fully Consistent	Fully Consistent
Olympic National Park Plans	Substantively Inconsistent	Generally Consistent	Generally Consistent	Generally Consistent
SCORP[1/]	Generally Consistent	Fully Consistent	Generally Consistent	Generally Consistent
Strategies for Washington's Wildlife[1/]	Generally Consistent	Fully Consistent	Generally Consistent	Generally Consistent
WDF Hydroelectric Project Assessment Guidelines[1/]	Substantively Inconsistent	Fully Consistent	Substantively Inconsistent	Substantively Inconsistent
Clallam County Comprehensive Plan	Substantively Inconsistent	Generally Consistent	Generally Consistent	Generally Consistent
Clallam County Shorelines Master Program	Generally Consistent	Substantively Inconsistent	Generally Consistent	Substantively Inconsistent

1/ Comprehensive Plans pursuant to Section 10 (a)(2)(A) of the Federal Power Act.

The dam retention alternative is not consistent with certain aspects of the ONP plans because full restoration of all species would not be achievable and no restoration of natural conditions on lands altered by human induced change would occur. The three alternatives involving dam removal, on the other hand, would be generally consistent with ONP plans due to the achievement of restoration of all salmon species and/or the restoration of natural conditions on lands currently occupied by Lake Mills.

All four alternatives would also be generally consistent with policies and recommendations in the Washington SCORP. The addition of recreation facilities at the Elwha Project and/or the renovation of the Lake Mills boat launch would provide consistency under all of the alternatives except the removal of both dams. Under the removal of both dams alternative, the addition of free-flowing river opportunities would provide consistency with the SCORP.

All four alternatives were also found to be consistent with the WDW's Strategies for Washington's Wildlife. Each alternative would restore wild runs of steelhead, and under the dam removal alternative would also restore other trout species. In addition, the provisions for protection and enhancement of wildlife around Lake Aldwell provides consistency under all alternatives other than the removal of both dams. Under the removal of both dams alternative, the greatest restoration potential for sea-run Dolly Varden and cutthroat trout species would clearly provide consistency with the plan.

Only the removal of both dams alternative would be consistent with the WDF's Hydroelectric Project Assessment Guidelines because it is the only alternative which eliminates all project hindrance to the migration of salmon species.

The only alternative which would not be consistent with the Clallam County Comprehensive Plan would be the applicant's proposal. This is attributable to a predicted negative effect on recreational fishing in the area, which is one of the many recreational resources important to Clallam County.

The dam retention alternative and the Glines Canyon removal alternative would be generally consistent with Clallam County's Shoreline Master Program. This consistency is predicted upon staff's recommendation to move the proposed boat-in campsite at a location outside the Natural Shoreline designation. The removal of both dams and Elwha dam removal alternatives would be inconsistent with the shorelines program because the required sediment management effort in Lake Aldwell would not be permitted under the current shoreline designations for that area.

5.4 COMPARATIVE ECONOMIC COSTS OF THE ALTERNATIVES

To assess the full cost impact of construction activities, project operation, and replacement power, net present value analysis was applied to the 50-year stream of costs and benefits associated with each of the four principal alternatives

(Section 2.7.2). The elements comprising the cost and benefit streams were: (1) the capital cost of constructing (or removing) project facilities; (2) increases or decreases in the base operation and maintenance expenses attributable to the alternatives; and (3) the value of power generation foregone as a result of implementing the alternatives.

As indicated in Table 5-7, by far, the least costly alternative would be the applicant's proposal ($39 million).

Table 5-7. Present value of costs and benefits (in thousands of 1996 dollars) (Source: the staff).

Alternative	Incremental Costs		Total Net Costs
	Capital and O & M Costs	Value of Foregone Generation	
Applicant's dam retention alternative	35,583	3,530	39,113
Removal of both dams	80,855	164,221	245,076
Glines Canyon removal with retention of Elwha	84,383	99,960	184,343
Elwha removal with retention of Glines Canyon	35,088	67,881	102,969

At $245 million, the highest cost alternative would be removal of both dams. Approximately two-thirds of this alternative's total cost would be associated with the loss of all power generation, while the remaining one-third would consist largely of the capital cost of dam removal.

The two alternatives consisting of removal of one dam would result in costs at intermediate levels, $182 million for Glines Canyon removal and $128 million for Elwha removal. The large difference in the total cost of these two alternatives, both of which involve removal of one dam and installation of fish passage facilities in the other, is due primarily to the difference in estimated capital costs. The Glines Canyon Project would be substantially more expensive to remove than would Elwha, while the capital cost of Elwha fish passage facilities would be more expensive than the proposed passage facilities at Glines Canyon. The result is that Glines Canyon removal with retention of Elwha would be significantly more expensive than Elwha removal with retention of Glines Canyon.

No attempt has been made in this DEIS to allocate the foregoing costs of the various alternatives to any particular entity, but the range of possible cost allocation arrangements are suggested in the following section.

5.5 IMPLEMENTATION OF THE COMMISSION'S DECISION

The manner in which the Commission's ultimate licensing decision is implemented could be influenced by the nature of that ultimate decision. If the projects remain in operation and fish passage facilities are added, it can be presumed that the licensee would fund the project modifications, retain or transfer ownership, and continue to be responsible, directly or via a license transferee, for effective implementation of license terms. If, on the other extreme, the Commission were to determine that the public interest was best served by the removal of both projects, the implementation responsibility may need to be allocated among multiple parties.

The staff envisions three potential implementation scenarios:

(1) Full Licensee Responsibility. Under this scenario, the licensee would bear full responsibility and cost for implementing the Commission's decision;

(2) Federal Takeover. Upon receipt of a recommendation from any federal department or agency, or based on the Commission's own initiative, the Commission may determine that a project should be taken over by the United States, publish its findings, and advise Congress. If Congress were to authorize the federal takeover, the existing licensee would be given at least 2 years prior notification, and the licensee would be afforded an opportunity to present a claim for compensation. To date, there has been no request by a federal department or agency for federal takeover of the Glines Canyon or Elwha projects; and

(3) Allocated Cost Responsibility. Under this scenario, the state and/or federal government would contribute funds for implementing certain aspects of the Commission's decision. A situation can be envisioned where several parties agree that certain costly steps are in the public interest, and those parties, for the purpose of assuring timely and effective implementation, step forward and contribute money for that purpose in a shared arrangement.

5.6 PRELIMINARY FINDINGS

This section presents the staff's findings based on the information contained in the DEIS.

(1) The principal resource objectives identified during EIS scoping are, for the most part, mutually exclusive. The Elwha River cannot support a high degree of anadromous fish and ecosystem restoration, while, at the same time, continuing to provide meaningful amounts of hydroelectric power. This conclusion is reached after an extensive search for options which would be responsive to all three principal objectives.

(2) The applicant's proposal, while not providing a high degree of achievement of the restoration objectives, would result in meaningful improvement over current conditions with respect to both fish and wildlife. The applicant's proposal would:

- Provide for potential anadromous fish access to the river reaches above the dams, but with a fair or better outlook for restoration limited to 4 of the 10 races of salmon and trout having restoration potential.

not substantial!

- Provide important wildlife protection and habitat improvement on 897 acres owned by the applicant.

(3) The applicant's proposal for dam retention can be improved only marginally. In the event that dam retention were to be the selected course of action, the staff would recommend several modifications to the applicant's proposal.

- Modified Elwha Fish Ladder Design. The applicant's proposed conceptual design does not offer the necessary conditions for optimal passage and maximum survival. While the modified design developed by the staff is estimated to result in $1.3 million additional cost over the life of the facility, on balance, it is considered a worthwhile modification of the applicant's plan.

- Elwha Downstream Fish Passage. The applicant's proposal to rely on Eicher screens at the Elwha Project should be supplemented with a definitive contingency plan consisting of intake screens. Intake screening would be implemented in the event the applicant cannot demonstrate through further testing that the Eicher screens meet performance criteria developed by the applicant in consultation with the appropriate resource agencies and approved by the Commission.

(4) If the public interest dictates full anadromous fish and ecosystem restoration, irrespective of the foregone hydroelectric potential, removal of both dams would be the preferred alternative. Pursuit of that course, however, would be associated with extremely high costs, technical challenges of a high order, and very substantial adverse impacts during and immediately after removal.

- The total costs (present value in 1996 dollars) of removing both dams is estimated at approximately $245 million. About two-thirds of that cost is the value of energy foregone, which would have to be borne by the region as a whole. The remainder, approximately $81 million, would be the cost of the removal process assuming completion in 1996.

- While a specific plan has been formulated that is deemed representative of the lower impact approaches to dam removal, technical uncertainties

exist which could lead to more disruptive or more costly options. Of particular engineering concern are: (a) the availability of favorable rock conditions in the bottom of the reservoirs for construction of the diversion tunnels, and (b) the stability of the silt component of the reservoir sediments.

- With best efforts at sediment control, removal of the dams would still release large amounts of sediment currently stored in the reservoirs. Much of the silt portion of the sediments currently stored at the bottom of the reservoirs would be released downstream during the 4- to 5-year construction period, and sporadic high levels of suspended silt loads would continue to be experienced over a period of several years after completion of the removal process. High silt loads would reduce production of fish stocks in the middle and lower river reaches and adversely affect municipal, industrial, and fish-rearing channel water supplies. Additional treatment expenditures would be necessary to allow continued use of the Elwha River as a water source during and immediately after the dam removal process. With the return of the natural upstream sediment supply after dam removal, the middle and lower reaches would experience decreased channel stability and increased potential for flood damage.

(5) If the public interest dictates the continued full utilization of the Elwha River's hydroelectric potential, society will need to be willing to accept less than full exploitation of the river's anadromous fish production potential. The applicant's proposal would result in almost the same average annual power generation as is currently produced, but the outlook for restoration would be fair or better for only 4 of 10 stocks with restoration potential (fall chinook and coho salmon, and winter and summer steelhead).

(6) Intermediate alternatives involving removal of only one dam or the other do exist. Elwha dam removal with Glines Canyon modified for fish passage is judged by the staff to better meet the anadromous fish restoration objective, and it would result in continued generation of about 60 percent of the current combined power output of the two projects. It performs poorly, however, in terms of restoring the natural ecosystem of ONP, since the Glines Canyon Project and Lake Mills would remain.

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7.0 LIST OF PREPARERS

FEDERAL ENERGY REGULATORY COMMISSION

S. Ronald McKitrick (B.S., M.S., Ecology)
Twelve years' experience in the field of terrestrial ecology and environmental impact assessment

EBASCO ENVIRONMENTAL

Thomas C. Cannon (B.S., Fisheries Biology; M.A., Biology; M.P.H., Biostatistics)
Eighteen years' experience assessing impacts of water resources developments on aquatic resources.

Douglas M. Davy (B.A., Anthropology; M.A., Ethnology; Ph.D., Archaeology)
Twelve years' experience in archaeology and cultural resources management related to water resources and hydroelectric development.

M. Colleen McShane (B.A., Biology; M.S., Community of Ecology; M.B.A. Project Management)
Fourteen years' experience writing wildlife, terrestrial, endangered species, and mitigation sections of environmental impact assessments and statements.

Kirby W. Gilbert (B.S., Environmental Science; M.S., Resource Geography)
Eight years' experience in recreation, regional and local land use, permitting, and environmental impact analysis.

Bruce A. Stoker (B.S., Geology; M.S., Remote Sensing/Geology, M.S.E., Civil Engineering)
Thirteen years' experience performing sediment transport and geologic investigations and analysis.

Ellen J. Hall (B.A. History/Economics; M.Ag., Agricultural Economics; Ph.D., Resource Economics)
Fifteen years' experience in energy and natural resource planning and permitting, economic analysis, socioeconomic impact assessment, and environmental analysis.

Edward J. Connor (B.S., Biology; M.S., Aquatic Ecology)
Eight years' experience in stream and river ecology, water quality analysis, and impact assessment of water resources projects.

John A. Knutzen (B.A., Biology; M.S., Fisheries)
Thirteen years' experience in aquatic biology, assessing impacts of developments including hydroelectric, nuclear, mining, and oil exploration.

Charles G. "Mike" Prewitt (B.A., Zoology; M.S., Fishery Biology; Ph.D., Aquatic Biology)

Fourteen years' experience in physical habitat simulation modeling and impact assessment of hydroelectric projects and as a project manager of environmental impact statements for major water power projects.

Robert A. Mohn (B.S., Engineering; M.P.A., Project Evaluation and Environmental Policy)

Thirteen years' experience managing development and environmental compliance of water resource and energy project.

8.0 LIST OF RECIPIENTS

Perkins Coie
Priscilla W. Derick

Hosey & Associates
Richard Fleming

James River II, Inc.
Jack Brown

James River II, Inc.
Orville Campbell

James River II, Inc.
Robert Morgan

National Marine Fisheries Service
John Linvog

National Marine Fisheries Service
Brian Winter

National Marine Fisheries Service
Einar Wold

National Marine Fisheries Service
Robert Pearce

National Marine Fisheries Service
Environmental & Technical Services
Dale R. Evans

National Marine Fisheries Service
Department of Commerce
NOAA

National Oceanic & Atmospheric Administration
F. Lorraine Bodi

National Oceanic & Atmospheric Administration
Department of Commerce

Washington Department of Fisheries & Game
Kenneth O. Eikenberry

Washington Department of Fisheries & Game
William C. Frymire

Washington Department of Fisheries
Bob Gerke

Washington Department of Fisheries
Kenneth Bates

State of Washington
Director, Washington Department of Fisheries

Washington State Department of Wildlife
James G. Fenton

Washington Department of Wildlife
Dave Gufler

U.S. Fish and Wildlife Service
Ralph Boomer

U.S. Fish & Wildlife Service
Margaret T. Kolar

U.S. Fish & Wildlife Service
Moses Lake Suboffice

U.S. Fish & Wildlife Service
Dave Stout

U.S. Fish & Wildlife Service
Gwill Ging

Olympic National Park
John Meyer

Olympic National Park
Bob Chandler

Olympic National Park
John Aho

Olympic Parks Associates
Polly Dyer

National Park Service
Regional Director, Pacific Northwest Region

National Park Service
Ron Hyra

U.S. Department of the Interior
Charles S. Polityka

U.S. Department of the Interior
Richard Myshak

U.S. Department of Interior
Susan K. Driver

U.S. Department of the Interior
Office of Policy, Budget & Administration

U.S. Department of the Interior
Bureau of Land Management

Environmental Protection Agency
Marsha Lagerloes

Environmental Protection Agency
Ronald A. Lee
Region 10

U.S. Army Corps of Engineers
North Pacific Division
Glenn R. Meloy

Department of the Army
Corps of Engineers
Richard W. McLaughlin

Department of the Army
Army Corps of Engineers
Office of Chief of Engineers

State of Washington
Washington Department of Agriculture

State of Washington
Department of Ecology
Rodney Sakrison

Washington Department of Ecology
T.L. Elwell

State of Washington
Washington Department of Natural Resources
Division of Land & Management

State of Washington
OR & WA Columbia River Gorge Commission

Habitat Management Division Chief
Washington State Department of Game

WA Office of Archaeology & Historic Preservation
Jacob Thomas

Historic Preservation Officer
Manager

Advisory Council on Historic Preservation
Chairman

Governor of Washington
State Capitol

Attorney General of Washington
James Johnson, Sr., Asst. Attorney General

Department of Agriculture Secretary
Chief, Forest Service

Washington Utilities & Transportation Commission
Chairman

U.S. Department of Transportation
Water Resources Coordinator
Director

Water & Resources Program
Hedia Adelsman

U.S. Geological Survey
A. Condes, Chief

WA Interagency Commission for Outdoor Recreation
Robert Wilder

Ecological Services Program
Manager

Range & Watershed Management Staff
Regional Forester

Public Utility District #1
Phillip K. Jackson, Manager

Bonneville Power Administration
Hydro Site Data Base-RMGB-2
Director

Oregon State Office
Bureau of Land Management
Director

Department of Agriculture
Economic Research Service

Land & Minerals Operations
Oregon State Office
Bureau of Land Management

Planning & Environmental Coordination
Oregon State Office
Bureau of Land Management

Northwest Power Planning Council
Peter Paquet

Point-No-Point Treaty Council
Stephen Ralph

Point-No-Point Treaty Council
Carson J. Boysen

Point-No-Point Treaty Council
Holly Coccoli

Lower Elwha Tribal Fisheries
Marta Nammack

Lower Elwha Tribal Fisheries
Ralph Kopansky

Lower Elwha Tribal Fisheries
Rachael Kowalsky

Lower Elwha Indian Tribe
Russell Busch

Bureau of Indian Affairs
Les McConnell

Bureau of Indian Affairs
Dan Speaks

Oregon Bureau of Indian Affairs
Stanley Speaks

Stillaguamish Tribe
Donald E. Kempf

Nez Perce Tribal Executive Commission
Chairman

Tulalip Tribes of Washington
Mr. Darryl Williams

Muckleshoot Indian Tribe
Mr. Dennis Moore

Makah Tribe
Mark Larivera

Northwest Indian Fisheries Commission
Director

Clallam County
Department of Community Development
James Folk

Olympia Peninsula Agency
Superintendent/Environmental Coordinator

Spokane Agency
Superintendent

Colville Agency
Superintendent

Yakima Agency
Superintendent

Puget Sound Agency
Superintendent

Callam County Economic Development
Frank Ducceschi, President

Jefferson County
Planning & Building Department
Mr. Jim Pearson

Port Angeles Branch
North Olympic Library System

NW Steelhead & Salmon Council
Bill Robinson, President

NW Steelhead & Salmon Council
Loyd Stafford, VP Western WA

NW Steelhead & Salmon Council
George Engledow

NW Steelhead & Salmon Council
Pete Harris

The Steelhead Society of British Columbia
Peter W. Soverel

Friends of the Earth
Dale Jones

Friends of the Earth, NW Rep.
Michael Rossotto

Port of Port Angeles

Association of Western Pulp & Paper Workers
James A. Thompson, General VP

Seattle Audubon Society
Robert Y. Grant, President

Sierra Club
Al Friedman

Sierra Club Legal Defense Fund
Ronald J. Wilson

Wilson & Cotter
Charles E. Magraw

Flower & Andraotti, PS
Patrick Andraotti

Steelhead Trout Club
Ken J. McLeod, President

Olympic Outdoor Sportsmen
Dick Goin

Olympic Rivers Council
Carol Volk

Olympic Rivers Council
Brian Borchers

Hood Canal Environmental Council
Karl Davies

WA Recreational River Runners Association
Mel W. Oleson

The Trumpeter Swan Society
Martha Jordan

American Rivers, Inc.
Matthew Huntington

Puget Sound Flyfishers
F. C. Knipher

Washington Trout
Marc Hurlbert

Washington Wilderness Coalition
Glenn Lawyer

Atlas Trucking Inc.
Richard G. Kott, President

Rich Risks
c/o Peninsula Daily News

Grant Parker
Bank of California Center

University of Idaho
College of Law
Mr. Dale Boeble

Heritage North
Dale A. Stirling

Darrell Peterson

Edwin R. Johnson

B.L. Adamire

Robert Zimmerer

Mrs. John Zahn

Virginia Leinart

Lee Bowen

Walter A. Kuciej

Gordon Thomson

Emily M. Woodson

Graeme Ton

Jeanne Q. Lyon

Mr. & Mrs. William Edwards

Thomas W. Hawksworth

Curtiss E. Howard

James P. Quiring

Michael W. Richer

Robert F. Russell

Mr. & Mrs. Clyde W. Smith

Thomas Baker

Dr. & Mrs. Robert A. Sherry

Maureen Weston

Bob Lyon

Mr. & Mrs. Allan Bentley

Jacqueline Abbott

Mr. & Mrs. Harold A. Deery

Robert V. Walker

Mr. & Mrs. Michael C. Egan

Joseph C. Toynbee

Elisabeth E. Johnson

Randall Rubur

Jerry D. White

Monty McIntyne

Stan Smith

Cal Mogck

Nadine Hamby

Wayne Spires

Christian Leigh Watchie

Diane St. Marie

Gordon D. Boyd

Dan Beck

Mark Johnson

Fritz Jorg

Barbara Guthrie

Robert W. Dalton

Rhys Roth

Randall D. Payne

George Riffero

Leo J. Beer

Harry E. Wilson

Daniel A. Nye

Tony Mauhar

C. Keyes

Bob Barr

A.B. Charles Sr.

Jerry Newlin

Gareth P. Green

Ira Merrill

Susan E. Cox

Mrs. Ruby L. Keller

Eric Broman

Milton E. Griffing

Warren F. Mead

Phillip K. Jackson

Stan A. Hicks

Don Carey

Gary Korb

Edwin R. Johnson

Bill Jensen

W.L. Whittier

City of Port Angeles, City Light
Robert J. Titus, Director

Katherine Baril

Ingrid Hansen

Harry L. Lydiard

Mr. & Mrs. William Reynolds

Max Richardson

Dale E. Sherrow
NW Fisheries Asso.

Stuart Williamson

J. Mike Nelson

Mark Tipperman

Lorna J. Williamson

Mary Pratt Bodman

George Carroll

Douglas J. Vaught

Glenna Gallison

Leonard Barson

APPENDIX A

PROJECT ALTERNATIVES AND COST ESTIMATES

APPENDIX A

PROJECT ALTERNATIVES AND COST ESTIMATES

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PART 1 - APPLICANT'S PROPOSAL FOR FISH PASSAGE

This part of Appendix A describes the applicant's proposal for upstream and downstream fish passage at the Elwha and Glines Canyon projects. The description is based on the applicant's plan as described in the applicant's Final Fish Passage and Restoration Plan, June 5, 1990.

1.1 ELWHA PROJECT

1.1.1 Upstream Passage

Upstream passage would be provided with a fish ladder located on the south shore of the south (right) bank spillway (Figure A-1), along with tailrace racks and an enumeration/adult capture facility near the upstream end of the ladder. This location was selected by the applicant due to the favorable access for construction and future operations and maintenance concerns, and because it allows for the capture of existing leakage through the right bank of the structure to be used for supplemental attraction flow. Upstream passage facilities would include tailrace racks, entrance structures, and the ladder.

1.1.1.1 Tailrace Racks

Water from the Elwha Project turbines falls vertically for approximately 6 feet into a stilling pool. The water then flows out through a large portal into the tailrace pool under atmospheric pressure. Total flow and its apportionment between turbine and spillway flow establishes the elevation of the tailrace pool. The current configuration provides for a gross exit velocity through the portal of 2.5 feet/second. The applicant proposes to rack the powerhouse draft portals to provide an exit flow velocity of 1 foot/second using an inclined plane bar rack. The tailrace rack would decrease the attraction to the tailrace exit portals, thus minimizing the possibility of delaying migrating adults. The rack bars would have a one-inch clear spacing and a baffle system to provide an even flow distribution across the face of the rack. A concrete sill would provide a footing structure, and the rack would be connected to the existing powerhouse structures with a steel frame. A walkway equipped with safety rails would be provided to allow for manual cleaning of the rack system.

The rack would be angled slightly to take advantage of the natural gradient in front of the powerhouse (Figure A-1). This configuration would provide for a natural transverse flow pattern to the powerhouse exit structure to aid in guiding the adult fish past the tailrace into the adjacent ladder entrance.

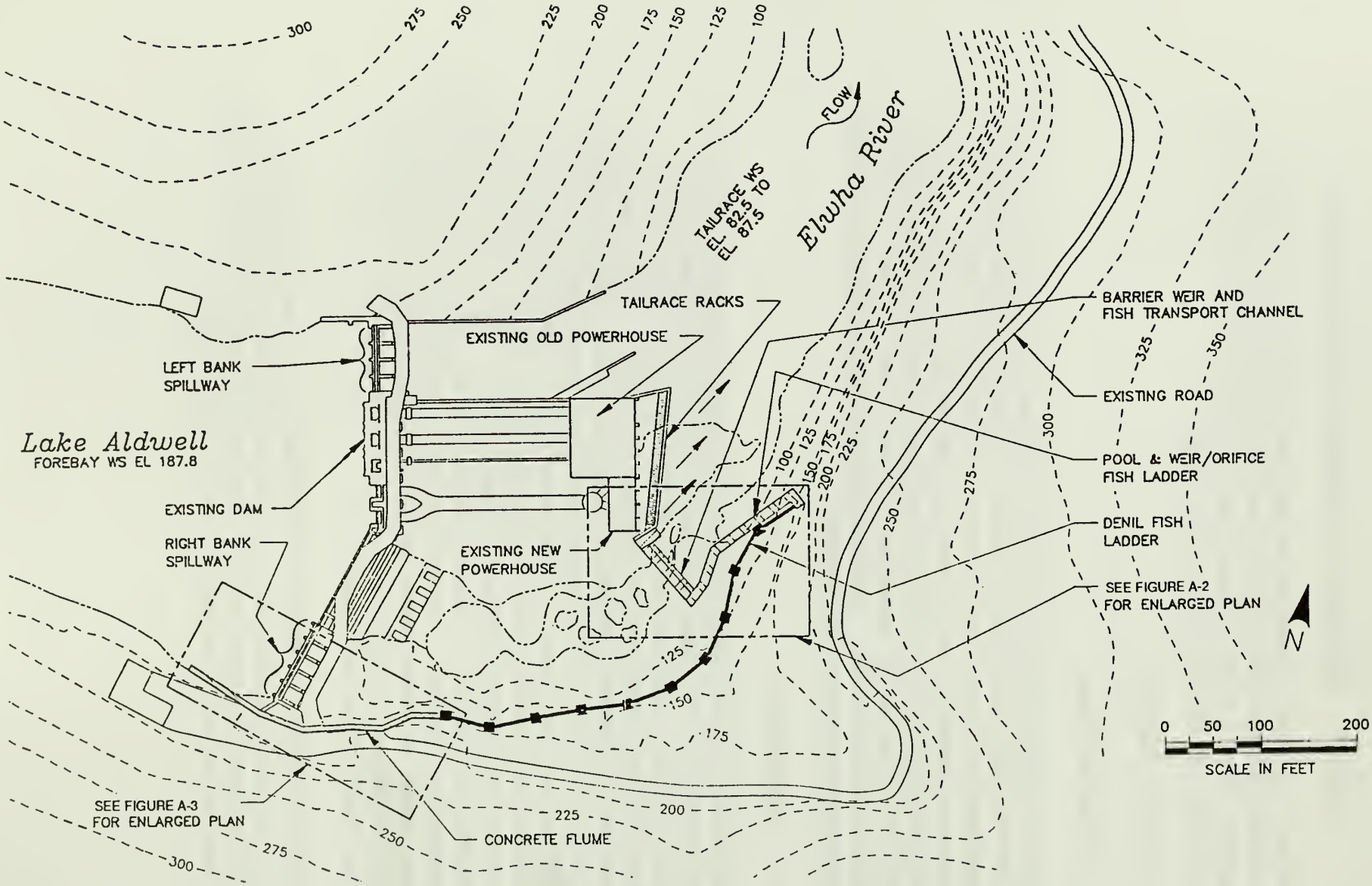


Figure A-1. Applicant's proposal for fish passage, Elwha Project, fish ladder.
(Source: the staff, modified from James River II).

1.1.1.2 Ladder Entrance, Fishway and Barrier Weir

The applicant's ladder entrance would be located directly adjacent to the south end of the powerhouse (Figure A-2). The entrance location would be at the upstream end of an existing flow pattern which passes directly across the front of the powerhouse. A low-level barrier weir would be constructed across the right bank spillway channel to prevent fish from moving upstream past the ladder entrance. The weir would divert the existing 55 cubic feet per second (cfs) of water available in the right bank spillway into the ladder entrance. An additional 25 cfs of transportation flow in the ladder would provide a total of 80-cfs attraction flow.

The low-level weir would also contain a protected open channel to pass fish across the overflow spillway channel to the right stream bank. Since the left bank spillway is capable of passing total flood flows 99 percent of the time on an annual basis, the project would be operated so that the right bank spillway would only be used for major flood events. It is assumed by the applicant that adult fish would not be moving upstream during a flood event of such magnitude that the right bank spillway must be opened. Therefore, in the applicant's view the ladder entrance would be operable at all times when fish are migrating upstream.

1.1.1.3 Fish Ladder

The applicant's proposed ladder would consist of several distinct sections, each selected to accommodate varying field and flow conditions. Flow velocities for each ladder section would be based upon accepted criteria for the target species. Ladder pool sizes would be controlled by hydraulic rather than biological criteria, based upon the estimated run sizes. To prevent poaching, all ladder and pool sections would be covered with steel grating or would be fenced off from public access.

The ladder entrance would be a vertical slot design, passively accommodating the fluctuating tailwater elevation while maintaining an attraction jet of water into the tailrace pool. A maximum head differential of 12 inches at 80 cfs of flow would be maintained through the vertical slots at low tailwater pool elevations. As the tailwater rises, the head differential between pools would decrease. The vertical slot ladder would terminate at a resting pool where the 55 cfs of attraction water would be introduced through a wall diffuser screen. A walkway would be provided to allow for manual cleaning of the diffuser panel.

The remainder of the upstream passage system would provide a transport flow of 25 cfs at varying velocities. An open channel constructed within the barrier weir would be designed to provide 2.5 feet of depth at a velocity of 4 feet/second to transport the fish across the overflow channel into a right bank resting pool. A

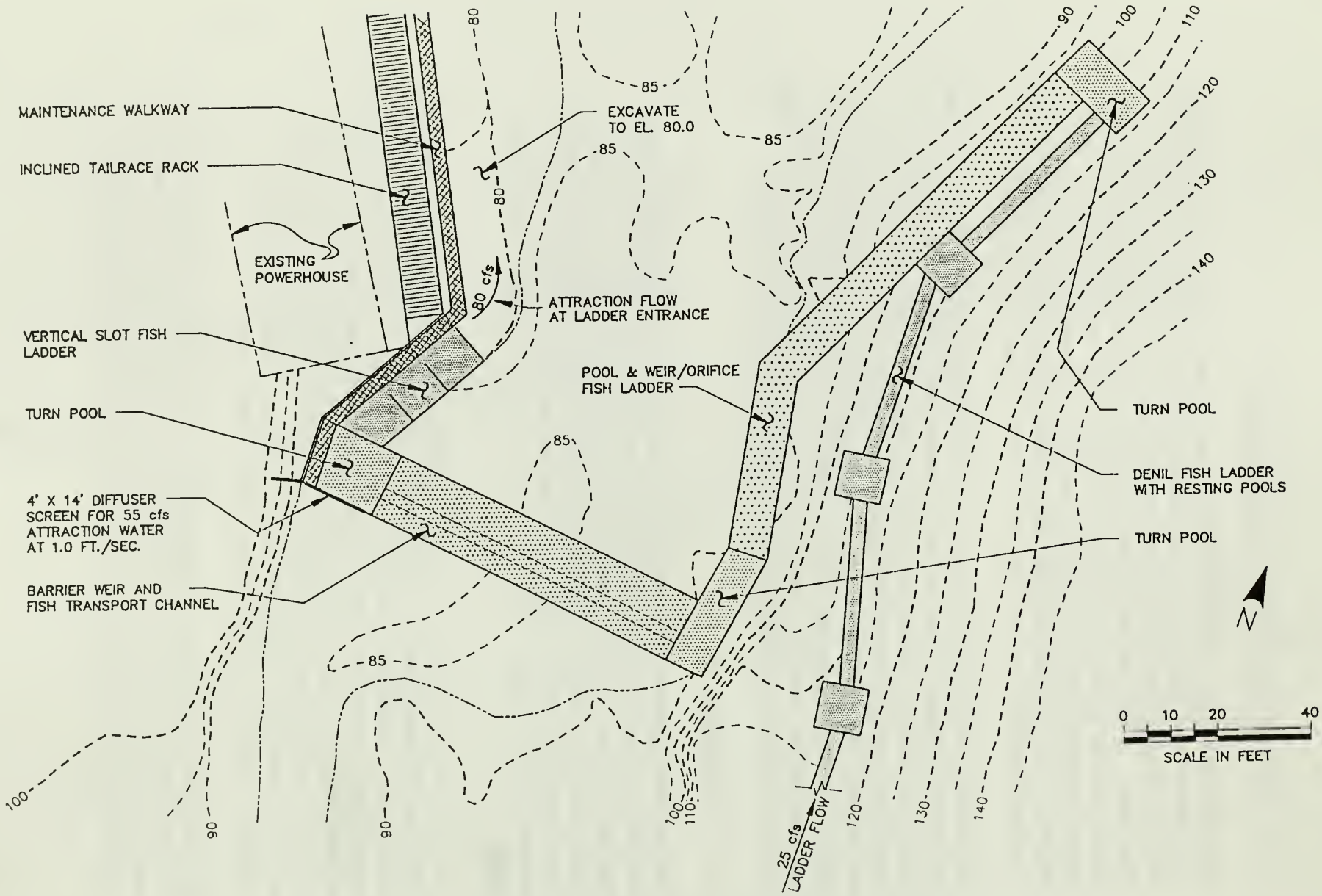


Figure A-2. Applicant's proposal for fish passage, Elwha Project, ladder entrance. (Source: the staff, modified from James River II).

cover would be placed over the open channel for durability during flood flows up to 11,900 cfs. Light ports would be provided in the downstream side of the weir to provide natural lighting into the open channel.

Immediately above the right bank resting pool a concrete pool-and-weir/orifice ladder would be constructed. The ladder would rise on a 10 percent slope along the steep bedrock bank until it is above the high water mark for the probable maximum flood. This reinforced concrete section would be designed to withstand the high velocity of the flood waters. The pool-and-weir/orifice section would provide for a head drop of 12 inches per pool, with a design depth of 12 inches over each weir.

Above the flood water elevation, a Denil fish ladder would ascend the steep hillside at an overall grade of 16 percent. This ladder would consist of 10 prefabricated aluminum roughened channels, spanning a horizontal distance of 40 feet between concrete resting pools keyed into the bedrock slope. Each Denil section would be set on a 20 percent grade, and the concrete resting pools would be 10 foot square with a water depth of 8 feet. The Denil section would provide for a velocity of 4 feet/second through each aluminum channel. The resting pools would be sized to accommodate over 160 adult fish, allowing 5 ft^3 per adult fish.

In order to clear the vertical cliff which is in the path of the right bank spillway discharge, the water surface in the fishway would be brought up to the constant level of the forebay with the Denil sections, then transported the remaining 350 feet through a rectangular open channel. The channel would be designed for a transport velocity of 2-3 feet/second (Figure A-3).

Holding/sorting pools would be constructed parallel to the open channel to provide for adult capture and enumeration. Access to the pools would be controlled by a manual gate system. A mechanical lifting device would be provided to raise the adult fish out of the holding pool and place them into a transport vehicle. Concrete retaining walls would provide bank stabilization adjacent to the access road and would provide for a work area adjacent to the concrete flume. The flume would be constructed on the downhill face of the retaining wall.

The fish ladder exit channel would breach the reinforced concrete dam near the south abutment. Removable precast concrete lid sections would span the channel, maintaining vehicle access to the existing timber bridge structure. The fish ladder exit channel would then parallel the south shoreline of Lake Aldwell for approximately 100 feet, opening to a widely spaced trash rack below the project maintenance shop area.

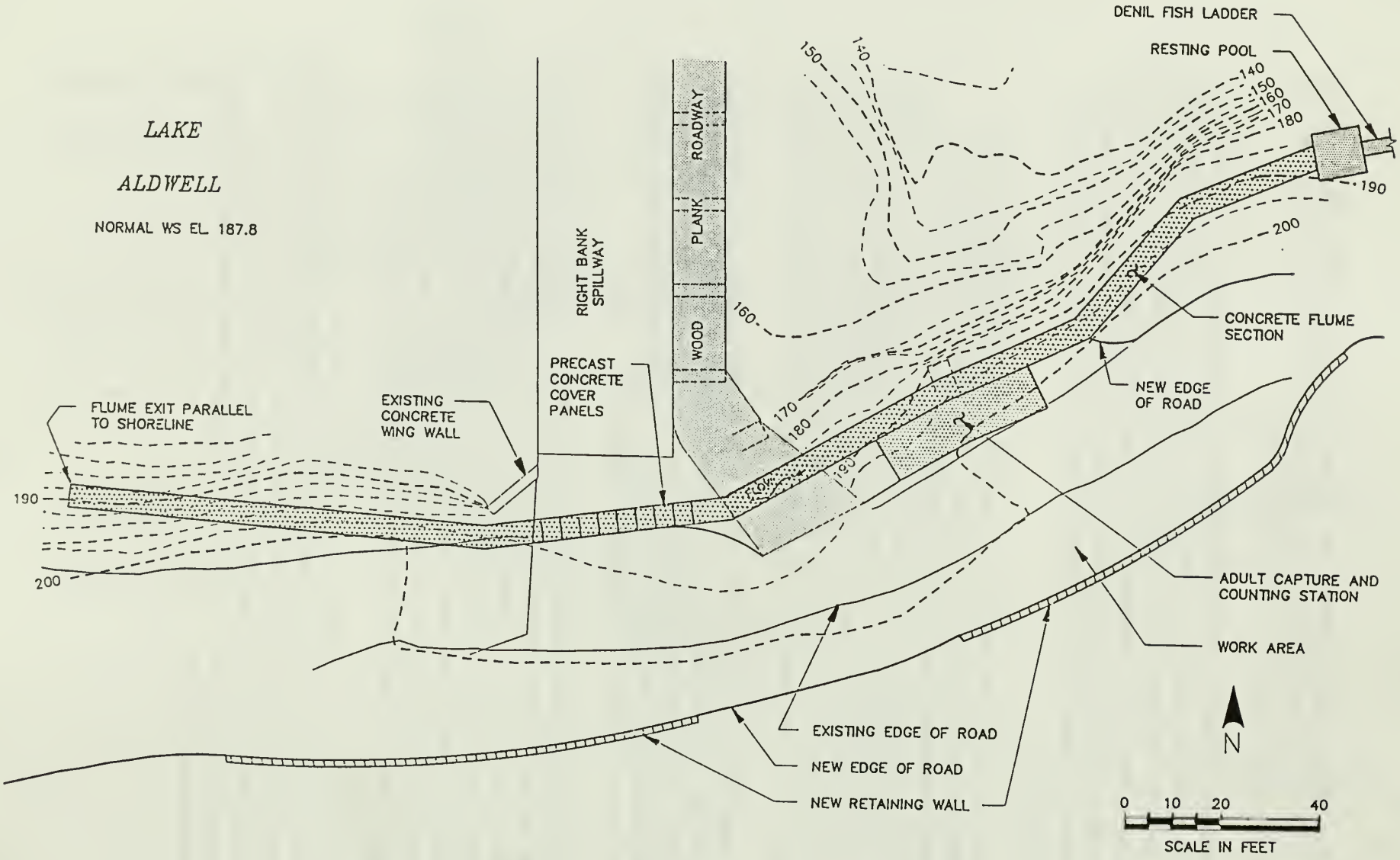


Figure A-3. Applicant's proposal for fish passage, Elwha Project, ladder exit. (Source: the staff, modified from James River II).

1.1.2 Downstream Passage

1.1.2.1 Left Bank Spillway Modifications

The applicant's proposed modifications include the construction of ogee transition sections, concrete-lined spillway chutes, and training walls on gate bay No. 2 and No. 3 of the left bank spillway (Figure A-4). Each spillway bay would handle a flow of up to 2,975 cfs; therefore, even if both powerhouses are shut down, the applicant estimates that the improved spillways would accommodate all flow past Elwha more than 99 percent of the time.

The spillway for gate bay No. 3 was modified in 1989 to improve downstream fish passage. Construction work included an ogee transition section, 30-foot-long training walls and removal of rock from the spillway floor. The applicant's proposed additional modifications would include:

- construction of an ogee transition section in gate bay No. 2 to closely match the spill profile for spills less than 1,000 cfs;
- provision of concrete-lined chute spillways in bay No. 2 and No. 3, down the entire length of the spillway;
- provision of training walls down the entire spillway to maintain depth of spilling water;
- minimization of the bend in the existing spillway, for gate bay No. 2 and No. 3;
- reconstruction of the gate bottom seals in bay No. 2 and No. 3 to minimize spill turbulence in the ogee transition sections; and
- supply and installation of an additional gate hoist so both modified spillways can be operated from the control station without the necessity of shifting the hoisting mechanism from one gate to another.

1.1.2.2 Eicher Screens

One Eicher screen has been installed by the applicant in a 9-foot-diameter penstock at the Elwha Project. The applicant proposes that three additional Eicher screens be installed on the remaining Elwha dam penstocks (Figure A-5). With these modifications, all water used for power production at Elwha would be screened; all other water would be spilled through the modified spillways.

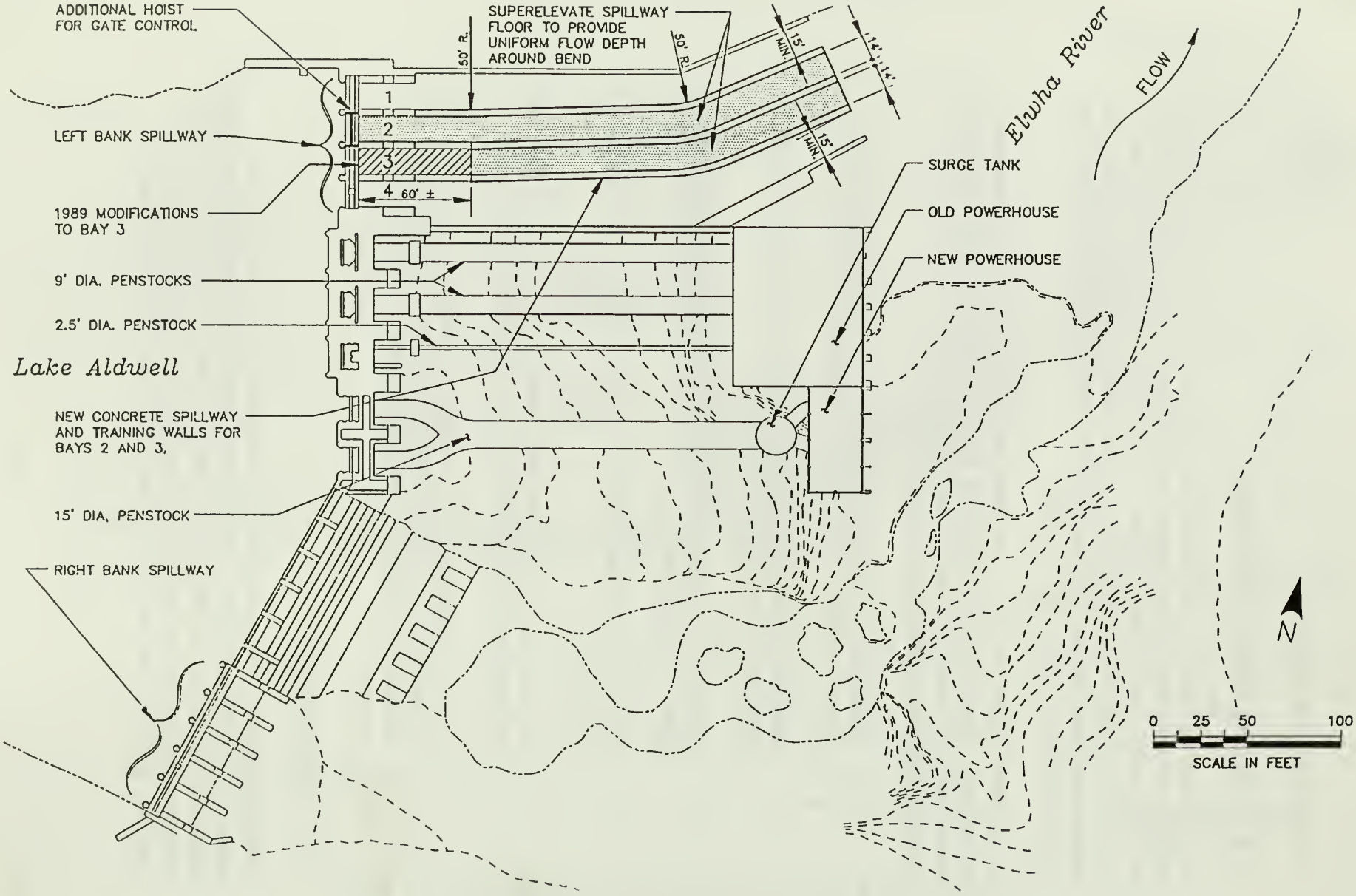


Figure A-4. Applicant's proposal for fish passage, Elwha Project, left bank spillway modifications. (Source: the staff, modified from James River II).

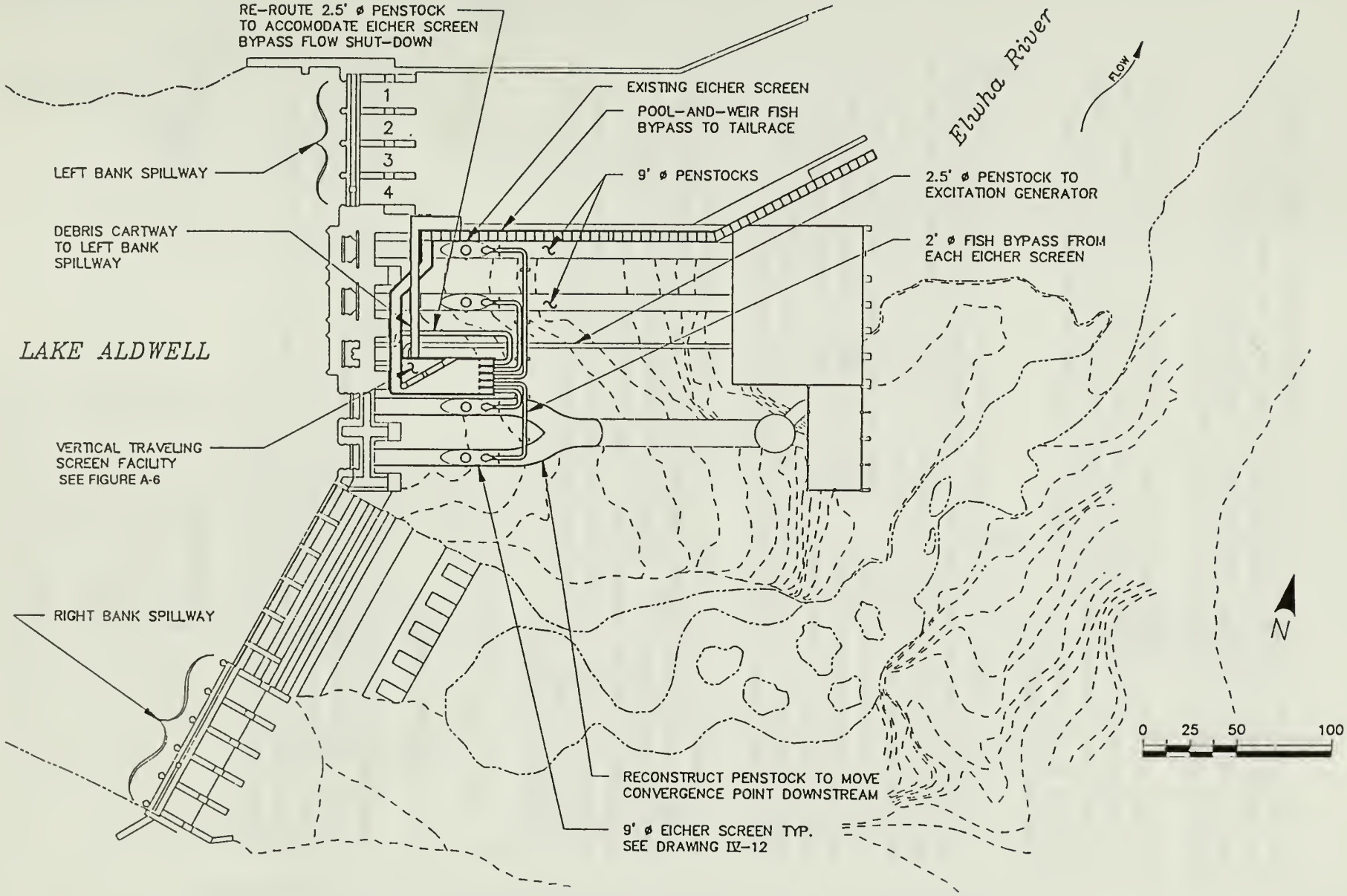


Figure A-5. Applicant's proposal for fish passage, Elwha Project, Eicher screen site plan. (Source: the staff, modified from James River II).

The 15-foot-diameter penstock leading to the "new powerhouse" would be rebuilt by moving the penstock "Y" about 50 feet downstream and extending the length of the 9-foot-diameter penstocks (Figure A-5). This change in penstocks would allow installation of two additional 9-foot-diameter Eicher screens.

Each Eicher screen would divert fish into a 24-inch-diameter bypass pipe leading to a vertical traveling screen facility. Flow in each bypass would be established following the screen evaluations. Downward acting roller gates within the vertical traveling screen facility would independently regulate bypass flows from each Eicher screen (Figure A-6).

Downstream migrating fish diverted past the Eicher screens would be transported through the bypass pipe and into the vertical traveling screen facility; from here, they would be diverted into the fish bypass system and discharged into the tailrace pool near the left bank spillway (Figure A-5). The vertical traveling screens would meet conventional criteria for sweeping and approach velocities, and would also have debris removal systems. Accumulated debris would be carted to the left bank spillway and dumped onto spillway No. 4. Water flowing through the vertical traveling screen would be returned to the 2.5-foot-diameter penstock leading to the excitation generator in the Elwha "old powerhouse."

Fish diverted by the Eicher screens, and about 10 cfs of bypass water, would flow through an open channel flume to a point adjacent to the south side of the left bank spillway (Figure A-5). There, downstream migrating fish and bypass water would enter a concrete pool-and-weir structure that would convey fish to the powerhouse tailrace. The pool-and-weir structure would be built on an overall slope of 25 percent; the preliminary design consists of 45 pools, with a 2-foot drop between each pool.

1.2 GLINES CANYON PROJECT

1.2.1 Upstream Passage

Under the applicant's plan, a trap-and-haul facility would convey migrating adults past the 190-foot-vertical lift of the Glines Canyon Project. The overall site plan of the fish passage system includes a fish barrier weir, the trap-and-haul facility, a tailrace rack, and road improvements up to the release site at the existing boat ramp on the northwest shore of Lake Mills (Figure A-7).

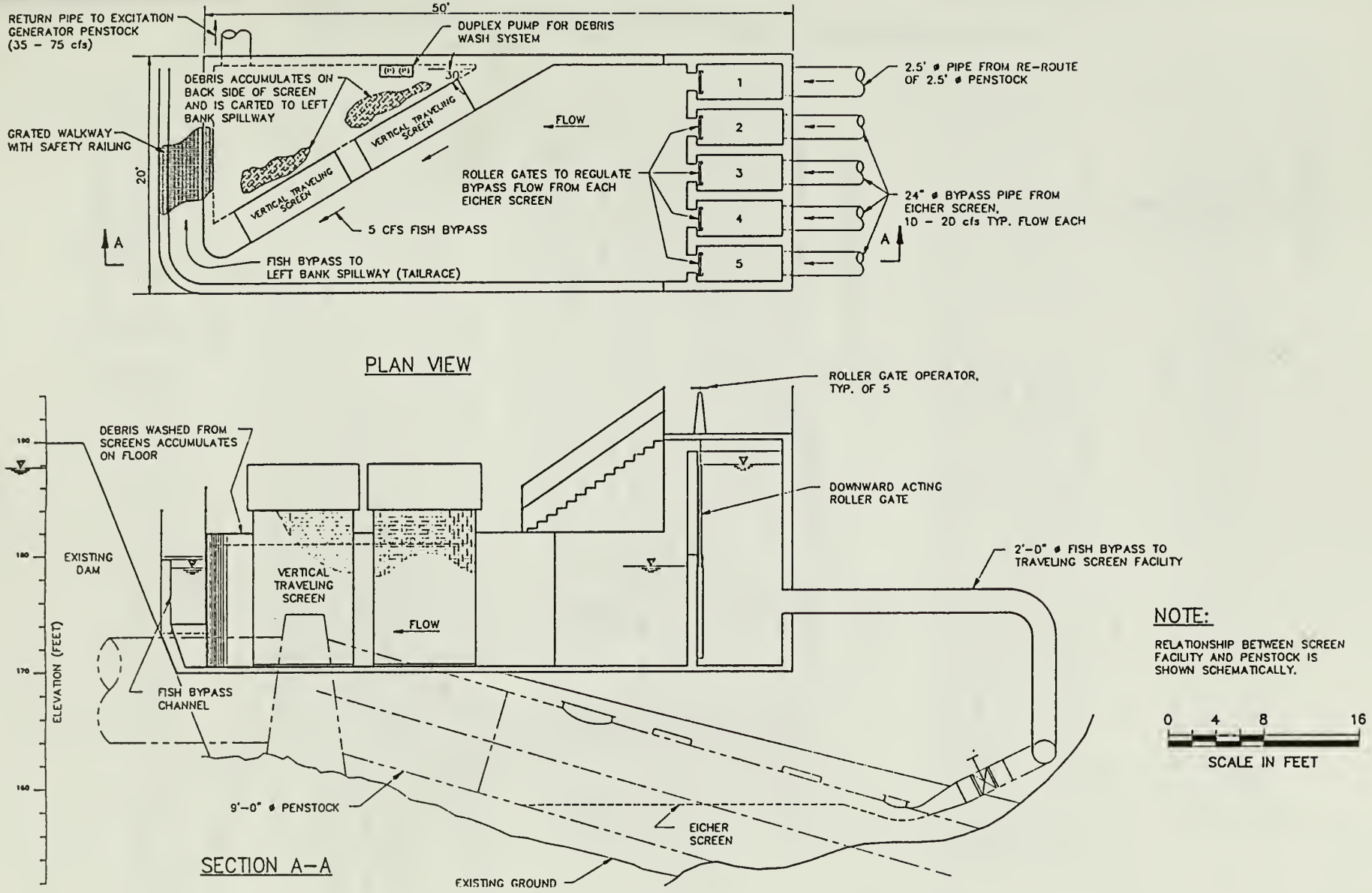


Figure A-6. Applicant's proposal for fish passage, Elwha Project, vertical traveling screen facility. (Source: the staff, modified from James River II).

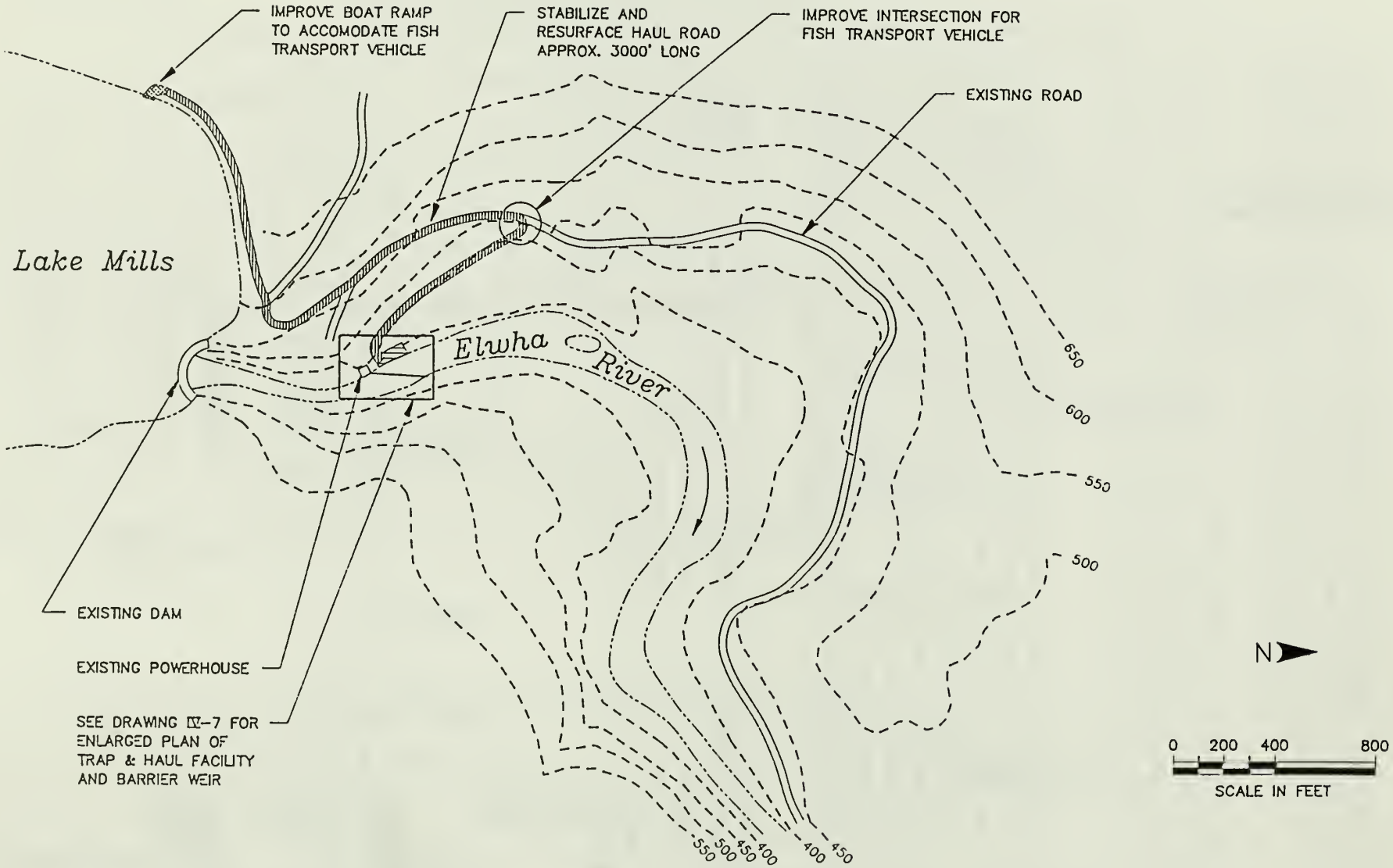


Figure A-7. Applicant's proposal for fish passage, Glines Canyon Project, trap and haul site plan. (Source: the staff, modified from James River II).

1.2.1.1 Barrier Weir

A combination velocity barrier and electric weir would be installed to prevent migrating adults from continuing upstream beyond the trap facility, while allowing outmigrating juveniles to pass downstream (Figure A-8). The profile of the barrier structure would be designed so as not to increase the flow depth of the river.

At low to mid flows, the sloping downstream sill would produce a very shallow sheet flow, which would not provide the adult fish with sufficient depth to swim or jump over the barrier. As flows were to increase to a point where the depth and velocity barrier would no longer be effective, a graduated electric field would be activated across the flat portion of the weir. The gradually increasing electric field would discourage adult fish from attempting to swim upstream across the flat sill.

1.2.1.2 Facility Configuration

The applicant's fish barrier would be designed on a diagonal across the river to allow for greater weir length, and to direct the adult fish upstream towards a ladder entrance near the left bank powerhouse. A tailrace rack would be constructed downstream of the powerhouse to provide for a 1 foot/second exit velocity across the rack structure. Baffles would be provided to achieve a uniform flow across the rack face. A vertical slot fish ladder would be constructed along the powerhouse face, discharging a jet of attraction water near the barrier weir. The attraction water would be provided with a low head pump located inside of the tailrace rack adjacent to the holding and sorting facilities. A low-flow slot would be constructed in the barrier weir adjacent to the ladder entrance to complement the pumped attraction water jet.

Holding, sorting, and transfer pools would be constructed to meet standard design criteria, downstream of the powerhouse on a relatively flat bench of land. This location would provide a level work area and would be graded to a level above the 100-year floodplain. A hoist system would be provided to load the adult fish onto a transport truck. The truck would deliver the fish to the existing boat launch site on Lake Mills. Approximately 3,000 feet of the existing road would be stabilized and resurfaced to accommodate the transport vehicle (Figure A-7). In addition, improvements would be made to the boat launch site for the transport vehicle.

1.2.2 Downstream Passage

The applicant proposes to spill 100 cfs over the existing spillway during the outmigration periods of the target species. No physical changes to the spillway are proposed by the applicant.

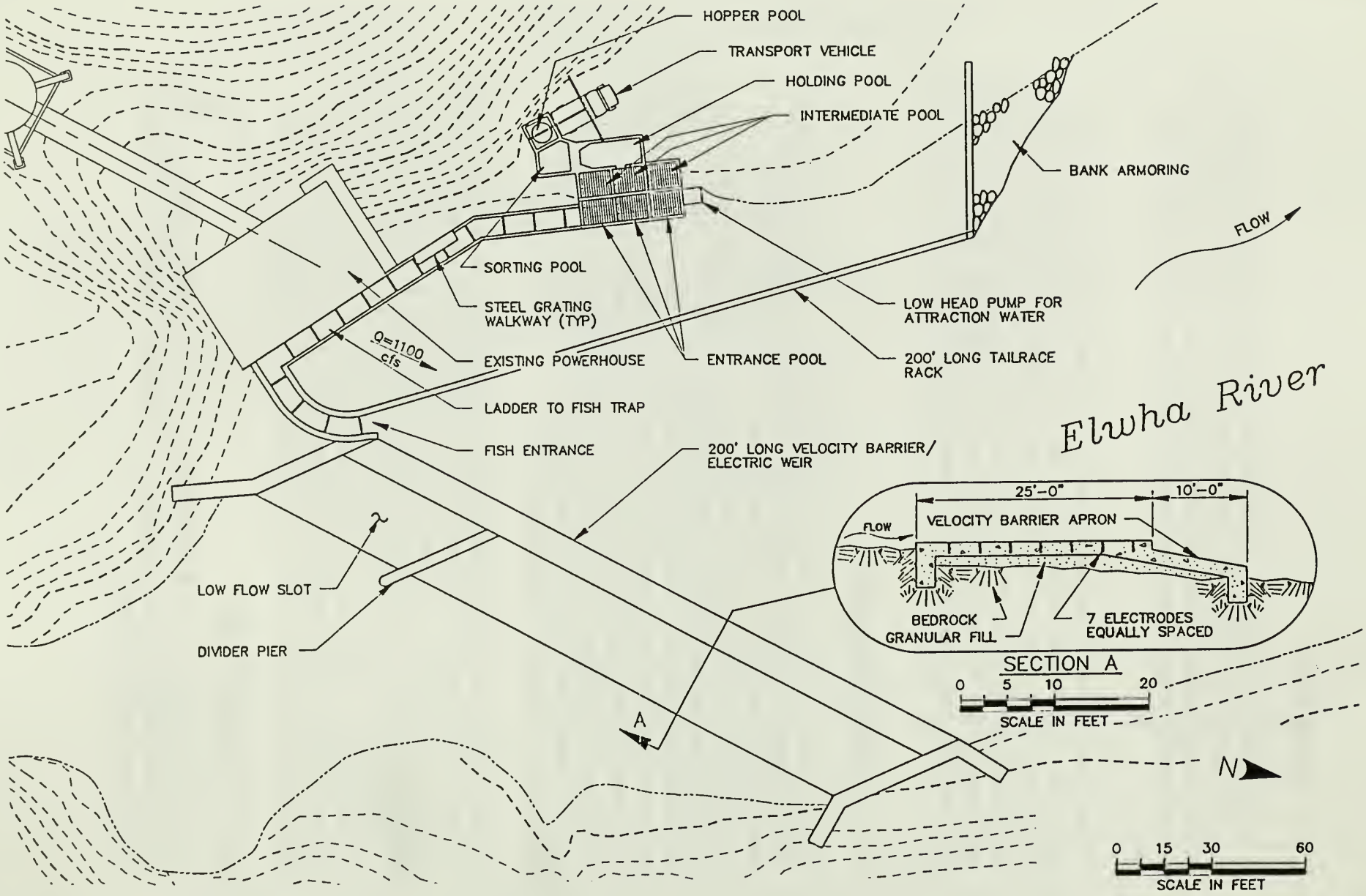


Figure A-8. Applicant's proposal for fish passage, Glines Canyon Project, trap and haul facility plan. (Source: the staff, modified from James River II).

PART 2 - MEASURES CONSIDERED FOR IMPROVING THE APPLICANT'S PROPOSAL

This part of Appendix A describes alternative concepts developed by the staff for upstream and downstream fish passage at the Elwha and Glines Canyon projects.

2.1 ELWHA PROJECT

2.1.1 Upstream Passage

Upstream fish passage would be provided by a fishway (fish ladder) located on the south shore of the south (right descending bank) spillway; see Figure A-9 for the route of the ladder. A tailrace rack would be provided at the existing powerhouses, and an enumeration and adult capture facility near the upstream end of the ladder. The ladder would include an entrance pool and an auxiliary water system.

2.1.1.1 Tailrace Bar Racks

Tailrace bar racks across the draft tube portals of the existing powerhouses would be provided. The rack area would be sufficient to yield an exit velocity of 1 foot per second (fps). Clear spacing of rack bars would be 1 inch, and an upstream low-porosity baffle would be furnished to distribute the flow uniformly over the rack area. A mechanical rake would be provided to clean the low-porosity baffle.

2.1.1.2 Ladder Entrance Pool, Barrier Weir and Auxiliary Water

The ladder entrance pool would be located at the south end of the powerhouse tailrace rack. The entrance pool would include two gated entrances, one adjacent to the south end of the tailrace rack and one at the left end of the spillway channel barrier weir. The first entrance would operate at all times the ladder was in operation, the second only when spill was passing the right spillway. The fish entrance pool would be supplied with attraction water from the auxiliary water system and also from spillway gate leakage. Attraction water would be admitted to the fish entrance pool through wall diffusers which would have sufficient area to limit the velocity entering the pool to 1 fps. Attraction water flow would be controlled by gates to cause 100-cfs flow to issue from each open fish entrance. The openings would be sized to provide an attraction jet velocity of 8 fps. The fish would exit from the entrance pool via the fish transport channel, which would convey the fish ladder discharge flow into the entrance pool. All structures would be provided with locking deck grating panels to prevent poaching and with handrails for safety. Figures A-10 and A-11 show the entrance pool and associated features.

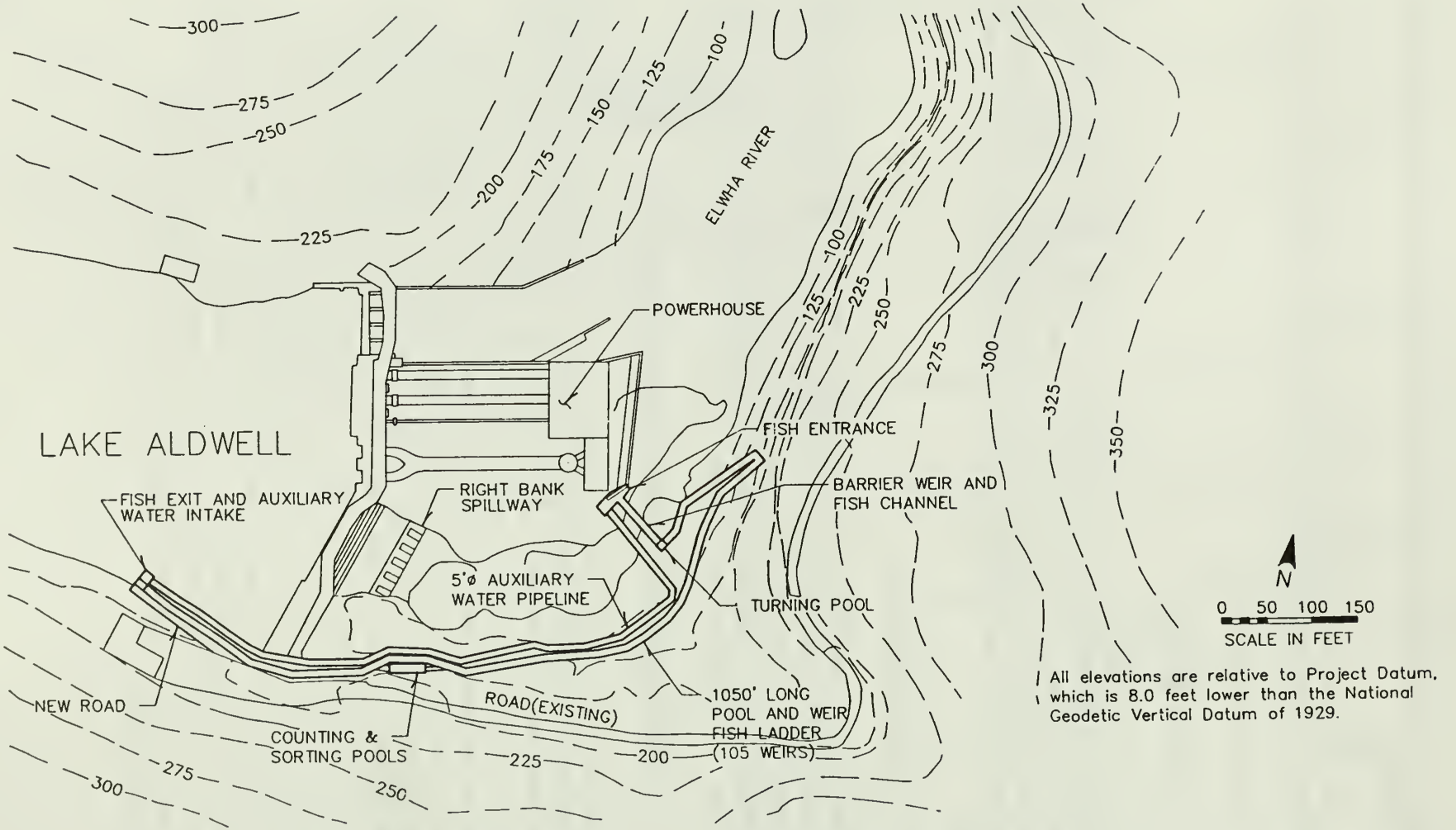


Figure A-9. Elwha fish ladder, general plan. (Source: the staff).

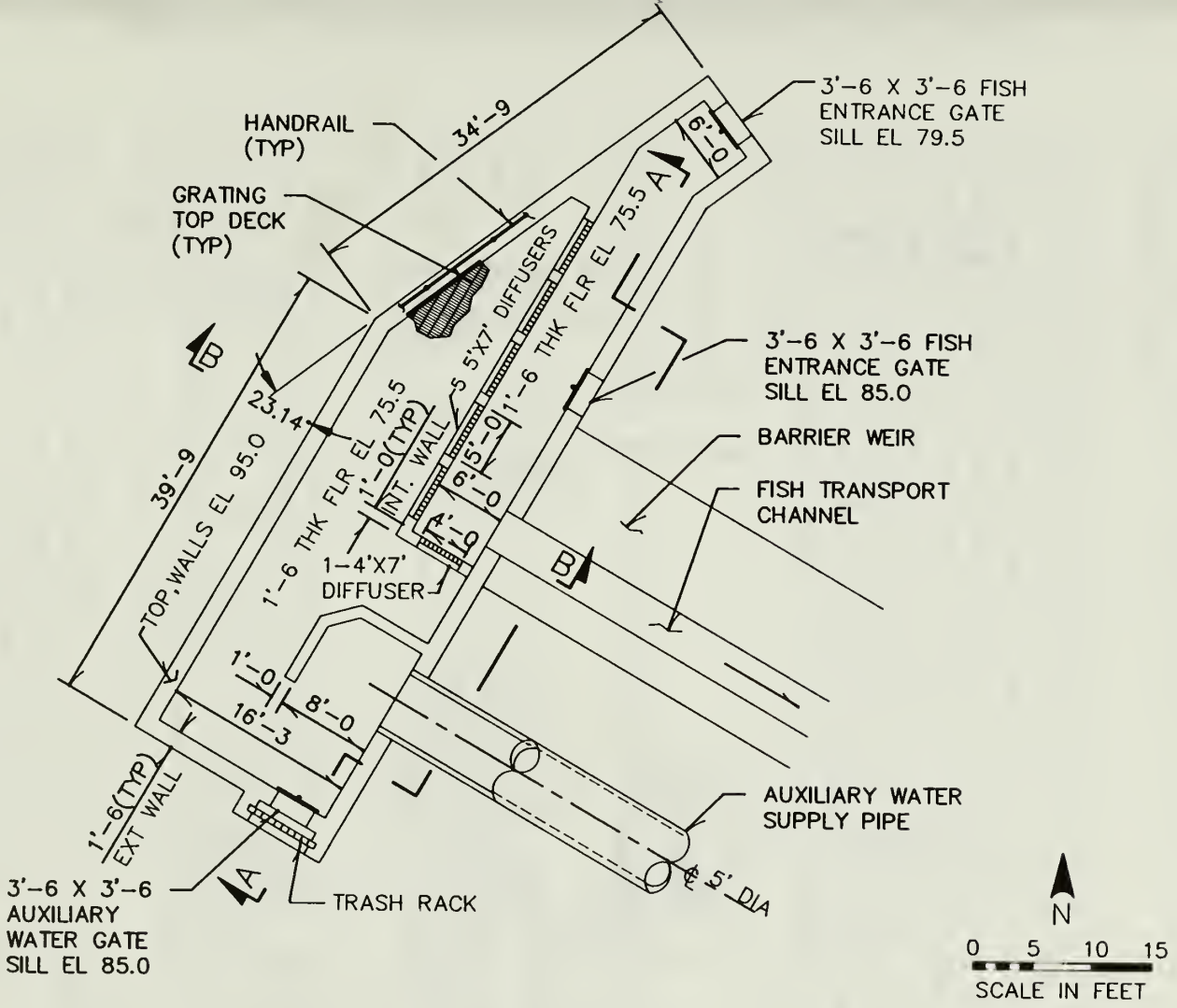


Figure A-10. Elwha fish ladder, entrance pool plan. (Source: the staff).

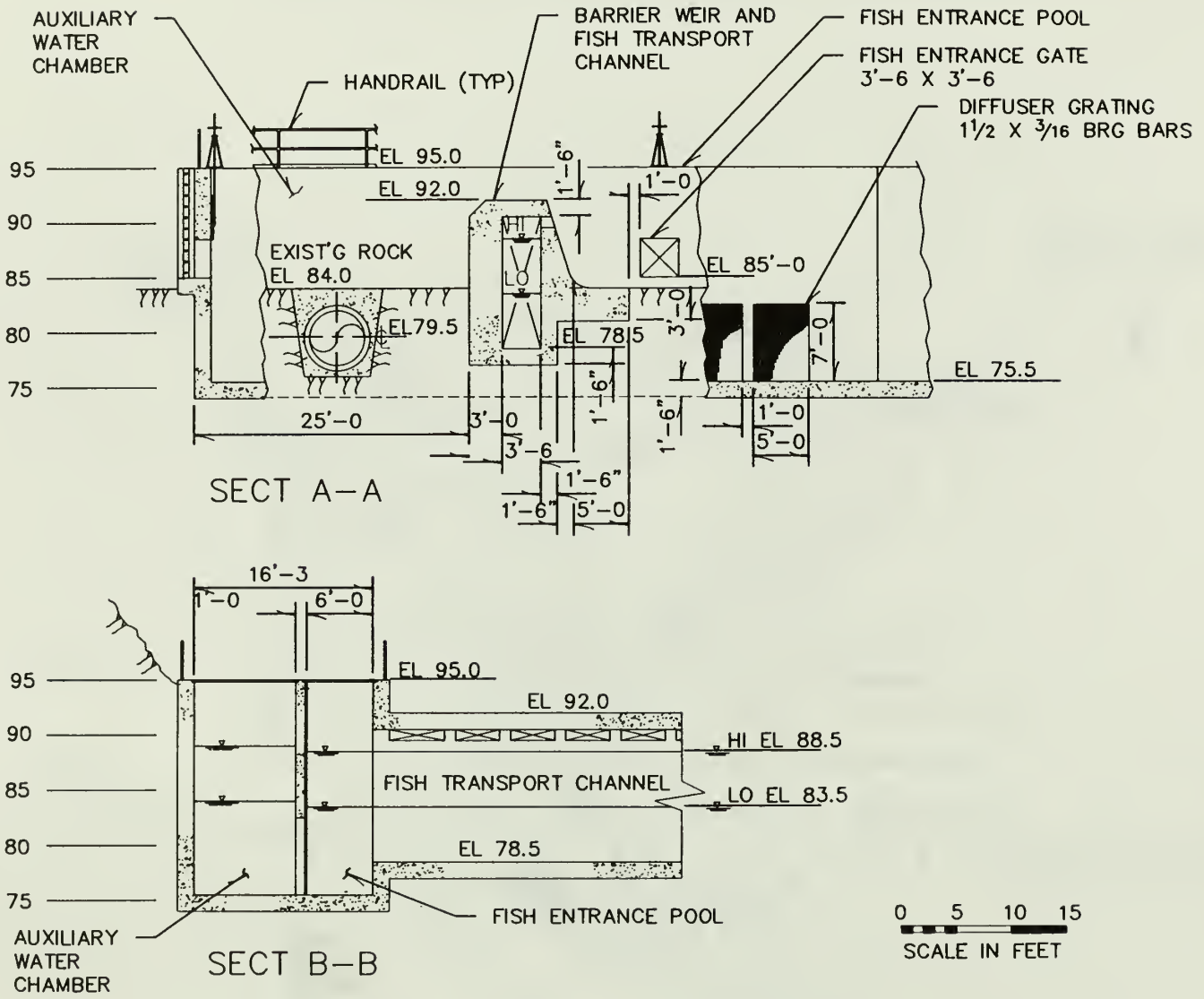


Figure A-11. Elwha fish ladder, entrance pool sections. (Source: the staff).

A concrete gravity dam barrier weir would be constructed across the right bank spillway channel to prevent fish from moving upstream past the entrance pool. The barrier weir would also divert spillway gate leakage into the entrance pool as attraction water, and would contain the fish transport channel for leading the adult fish from the entrance pool to the fish ladder turning pool on the south bank of the spillway channel. Light ports would be provided on the downstream face of the fish transport channel.

The auxiliary water supply to the entrance pool would be provided by two sources: spillway gate leakage and a piped supply from the upper reservoir. The pipeline generally follows the fish ladder route on the downhill or north side, and is supported at grade or notched into the slope, except that where it crosses the spillway channel it would be buried for protection. The hydraulic capacity of the pipeline would be sufficient to provide all auxiliary water required by the fish ladder along its route, including under conditions of no spillway gate leakage. In addition to the entrance pool, the fish ladder would require auxiliary water for the turning pool at the foot of the ladder and for the counting and sorting facility near the top of the ladder.

2.1.1.3 Fish Ladder

The fish ladder would be a pool-and-weir concrete fishway with orifices at floor level in each weir.

The ladder would begin at a turning pool at the right end of the barrier weir across the spillway channel. The first two pools in the ladder would be provided with a gated auxiliary water supply to keep the velocity over the weirs up at high tailwater conditions. This arrangement is shown in Figure A-12. Typical ladder sections are shown in Figure A-13.

The fish exit and auxiliary water intake are represented in Figure A-14. The fish exit would be protected from entrance of large debris by a coarse trash rack with 1-foot clear spaces, through which the fish can exit; the auxiliary water intake would be provided with a fine rack to prevent re-entrainment of adult fish emerging from the fish exit. The layout shown assumes that Lake Aldwell would be maintained at a constant level of 187.8 feet.

The counting and sorting facility is shown in Figure A-15. The facility would operate by diverting fish out of the pool-and-weir fishway by a hinged bar rack into a Denil ladder section which would run alongside the main ladder. Because the Denil ladder has a slope twice that of the main ladder (20 percent vs. 10 percent), fish which pass over a false weir at the high end of the Denil ladder can be returned to the main ladder by gravity flume, re-entering the ladder at a higher elevation than they left it. The flume beyond the end of the Denil ladder would have a series of lift traps and chutes, leading to holding pools or a transport

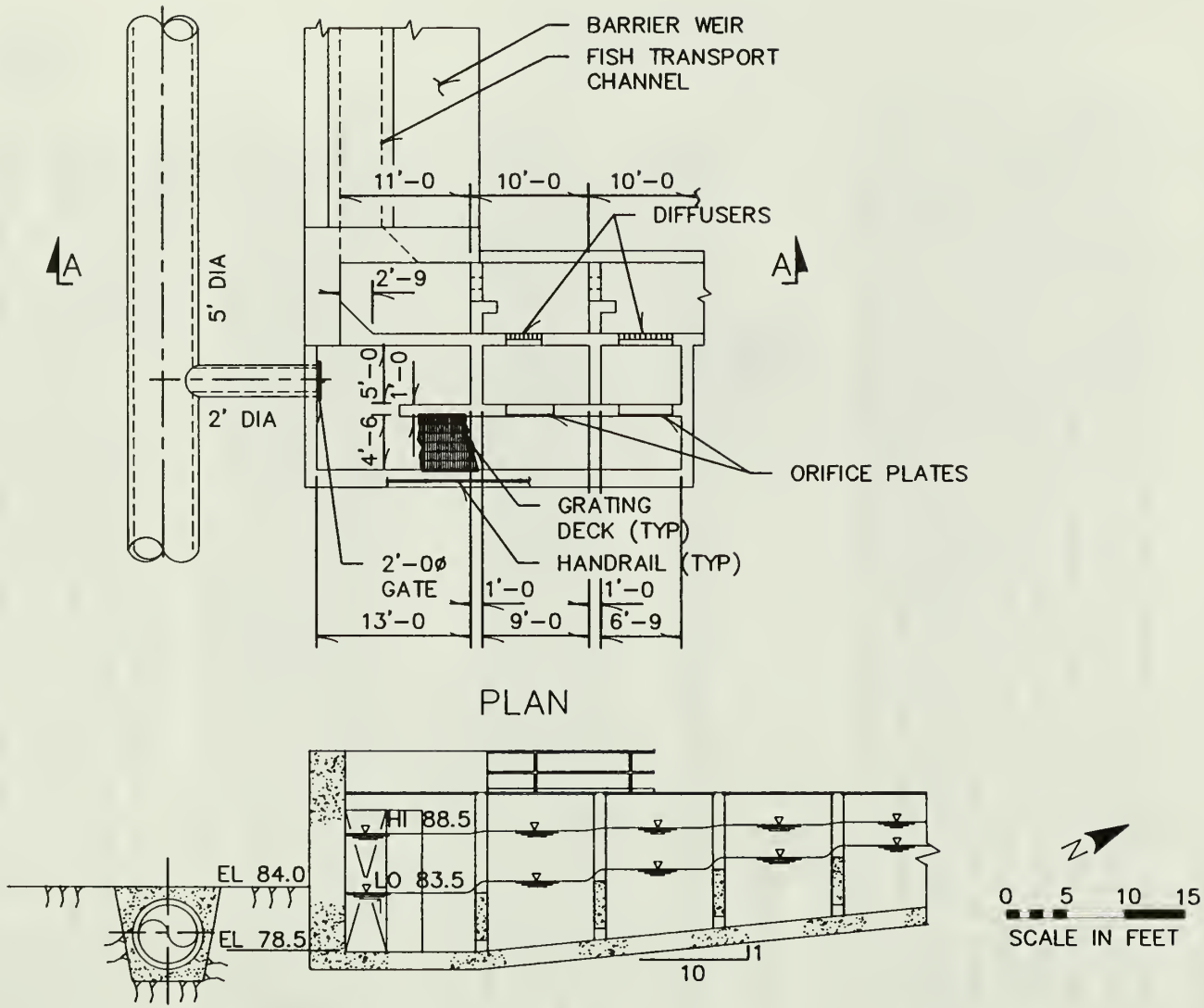


Figure A-12. Elwha fish ladder, turning pool and start of ladder section. (Source: the staff).

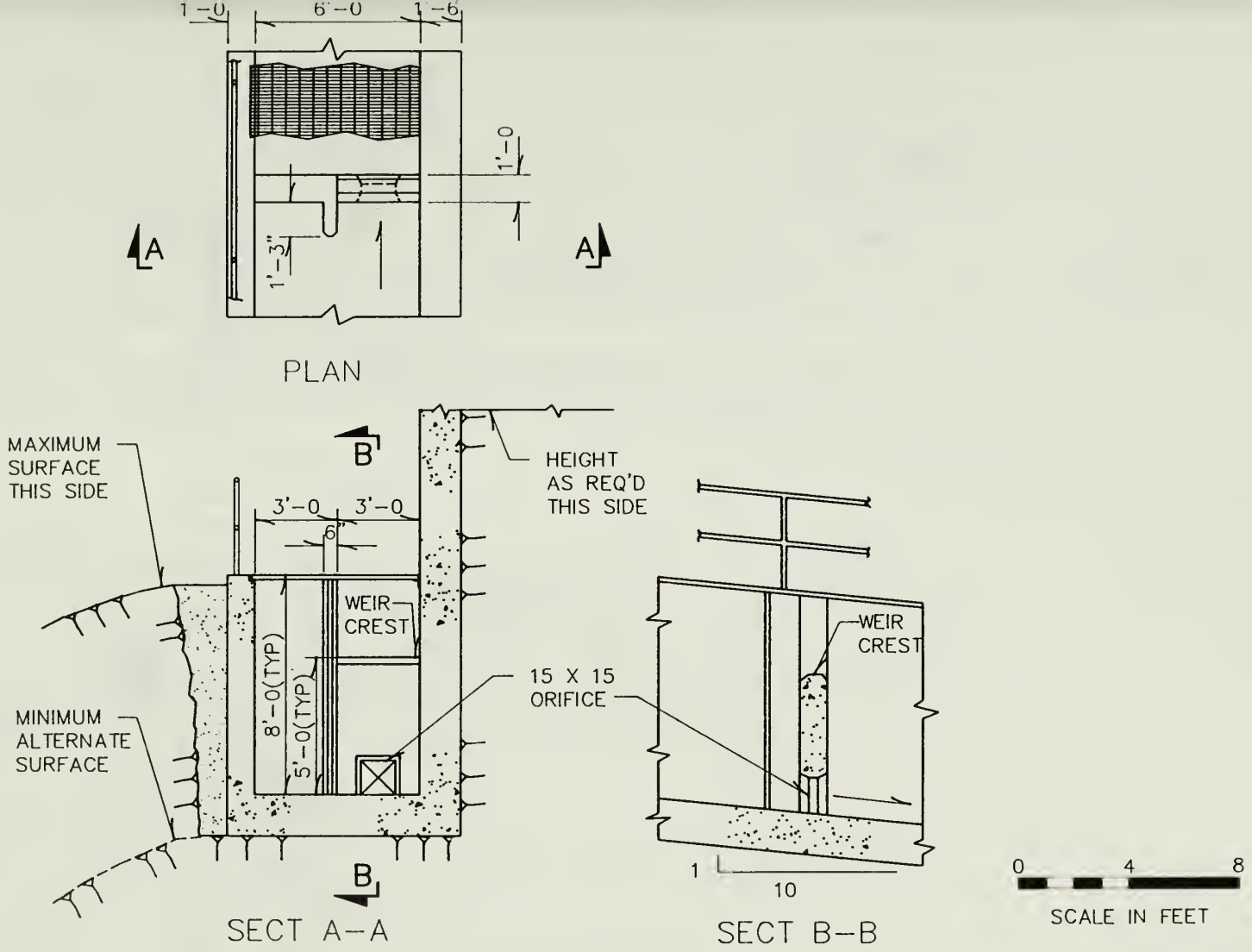


Figure A-13. Elwha fish ladder, typical ladder sections. (Source: the staff).

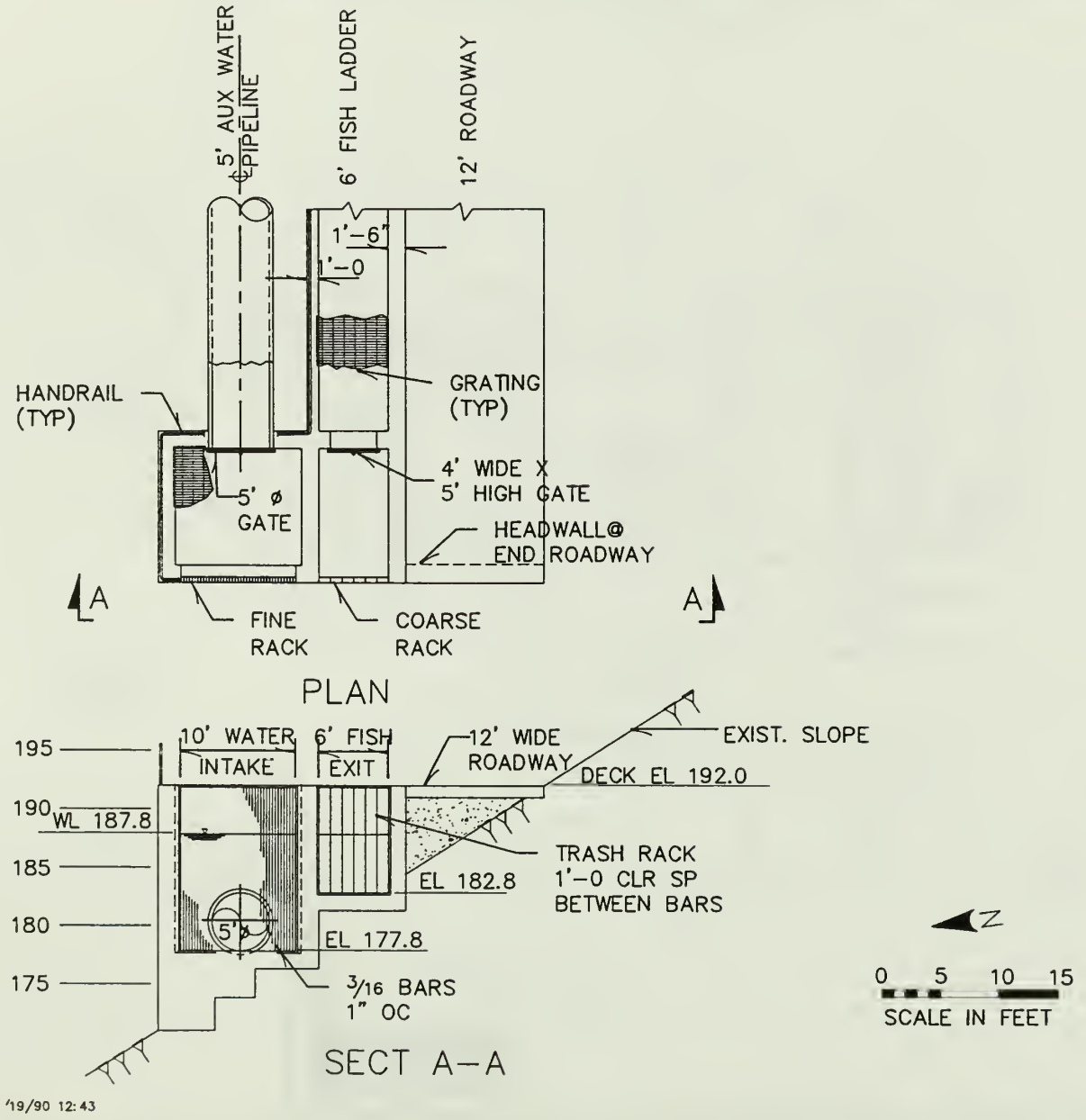


Figure A-14. Elwha fish ladder, intake area (fish exit). (Source: the staff).

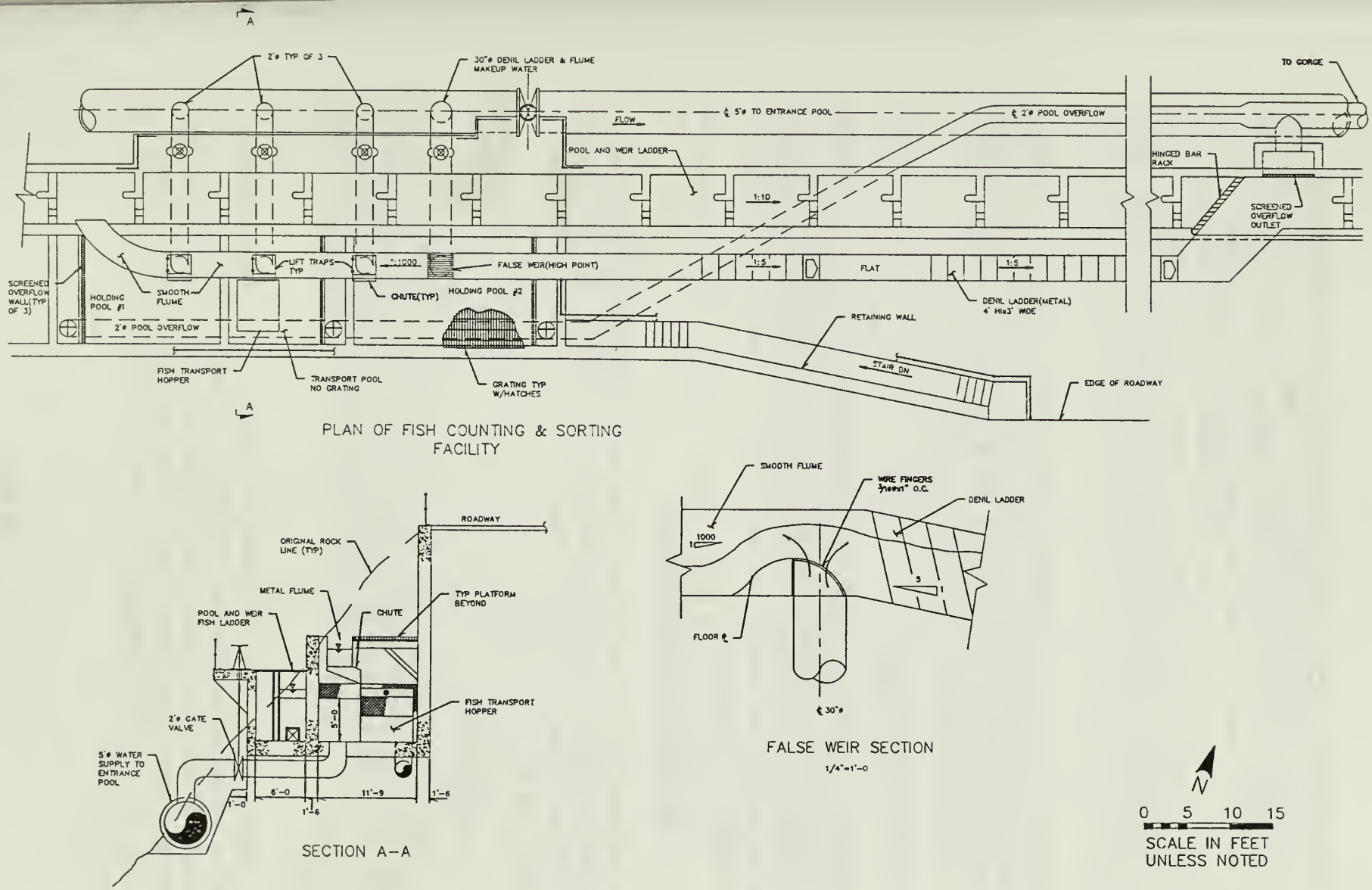


Figure A-15. Elwha fish counting and sorting facility. (Source: the staff).

hopper directly below. This arrangement would result in the minimum bench width on the wall of the gorge for the facility. Water to operate the facility would be drawn from the auxiliary water pipeline. Because the water supply is gravity fed, the facility would be located lower than the level of Lake Aldwell. Water added to the main ladder by operation of the facility would be bled off at screened overflows in order to keep the ladder flow constant. All water required to operate the facility would be drained into the gorge, where it would join with the spillway gate leakage and potentially contribute to the attraction water flow for the entrance pool.

The ladder's ordinary operating flow would be 100 cfs, of which 45 is assumed to be diverted from the turbines resulting in lost generation, the remaining 55 being spillway gate leakage. Maximum ladder flow is 200 cfs, but this would occur only at times of high spill, so no penalty is assumed for that case.

2.1.2 Downstream Passage

Downstream juvenile fish passage would be enhanced by diversion of juvenile fish away from the turbines by use of bypass screens, and by modification of the left bank spillway to improve survival. Since the right bank spillway is infrequently used and modification would be extremely difficult, no modification to the right bank spillway is proposed.

2.1.2.1 Left Bank Spillway Modification

The proposed modifications include the construction of ogee transition sections, concrete-lined spillway chutes, and training walls on gate bay No. 2 and No. 3 of the left bank spillway (Figure A-4). The details are the same as the applicant's proposal (see Section 1.1.2.1).

2.1.2.2 Eicher Screens

The proposed modifications include the installation of four 9-foot Eicher screens in the four penstocks leading to the turbines, with a common fish bypass system. One screen has already been installed for test purposes. For the general layout, see Figure A-5. The details are the same as the applicant's proposal (see Section 1.1.2.2).

The Eicher screens' performance would be studied during the fish restoration program. If passage survival was unsatisfactory to meet the goals of the restoration program, the screens and/or the operation of the turbines would be modified to meet passage survival goals. If the modifications did not meet passage survival goals, a contingency plan would be implemented as described in the section below.

For Eicher screen operation, a bypass flow of 10 cfs would be diverted from the turbines and result in lost generation. The remaining bypass flow would be pumped back to the forebay or injected into the excitation turbine penstock.

2.1.2.3 Contingency Plan for Intake Screens

A forebay screening facility with a fish bypass system would be installed upstream of the power intakes. The concrete screen structure would be equipped with entrance stop logs and trash racks set normal to the flow, leading to two straight rows of screens mounted diagonally to the flow to form a vee with apex downstream. The screens would be vertical traveling screens with 1/8-inch mesh openings and a submerged gross screen basket area sufficient to yield an approach velocity of 0.4 fps. The angle of the vee would be set to result in a sweeping velocity of twice the approach velocity. The bypassed fish would be collected at the apex of the vee in a single pipe flume and returned to the river below the powerhouse tailrace by a fish ladder attached to the spillway (the same ladder used in the Eicher screen system). The base slab of the screening facility would be lower than the present forebay bottom elevation. Since the forebay fill is relied upon to reduce leakage under the dam, the excavated channel through the forebay fill to the sill of the screen structure would be paved. The layout of the facility is shown in Figure A-16.

Lost generation would result from a bypass flow of 10 cfs diverted from the turbines. The remaining bypass flow would be pumped back to the forebay.

2.2 GLINES CANYON PROJECT

2.2.1 Upstream Passage

Upstream fish passage would be provided by a fish ladder located on the east bank (right descending bank) of the river just upstream and across from the powerhouse, and just below a new barrier dam; see Figure A-17 for the route of the ladder. A tailrace rack would be provided at the existing powerhouse and an enumeration and adult capture facility near the upstream end of the ladder. The ladder would include an entrance pool and an auxiliary water system. For a more detailed view of the ladder entrance and exit areas see Figure A-18.

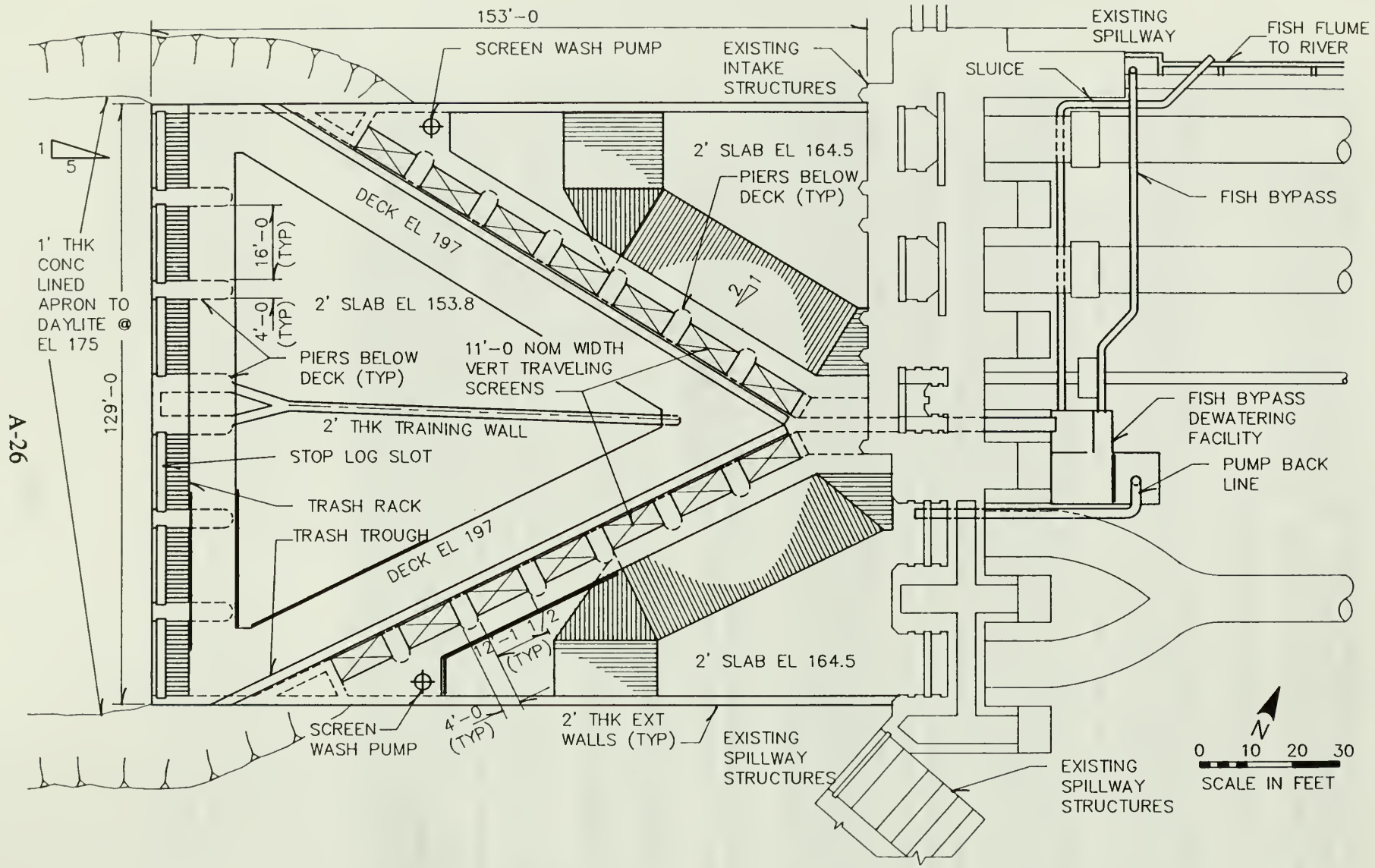


Figure A-16. Elwha conventional screen structure. (Source: the staff).

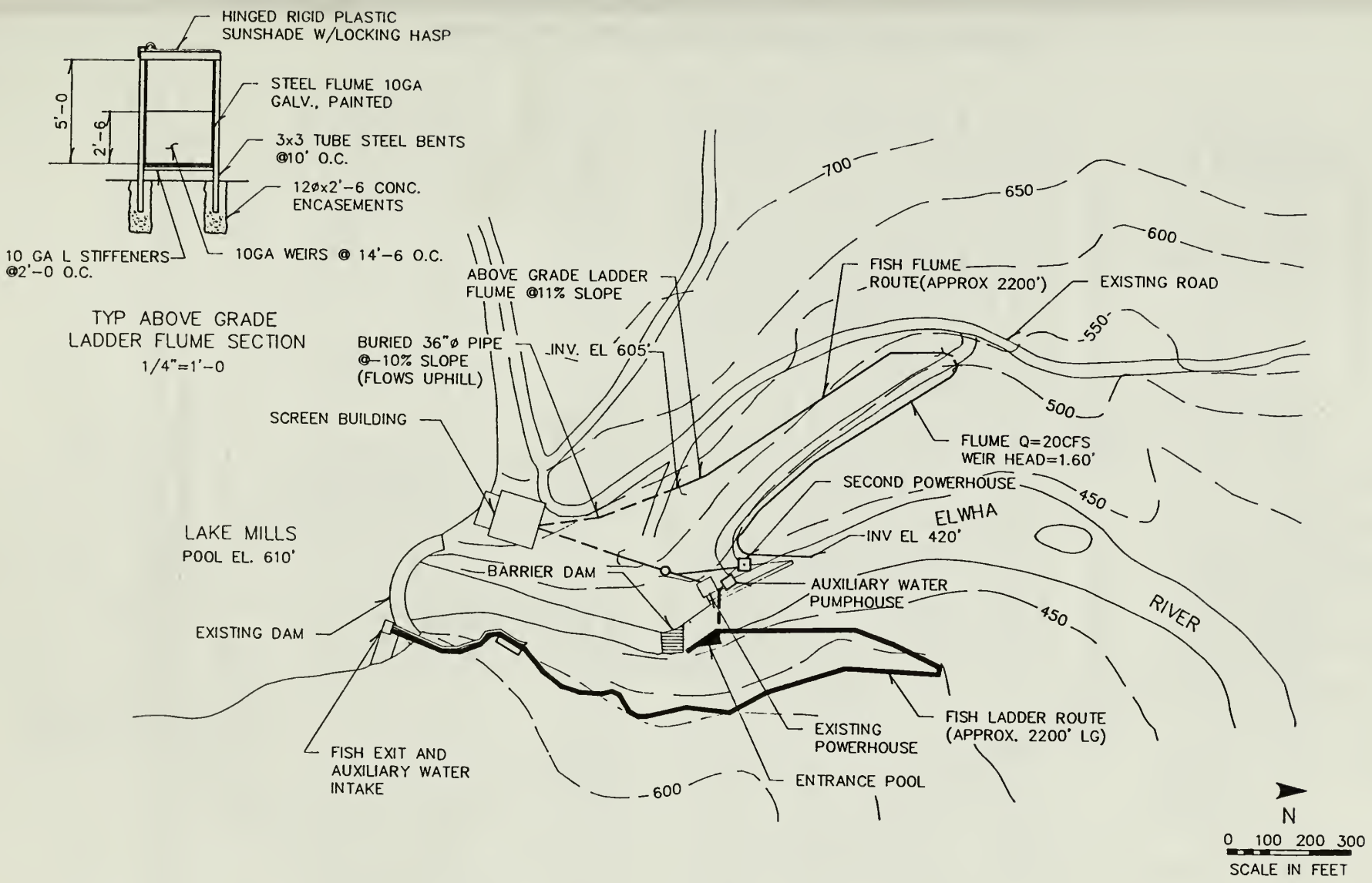


Figure A-17. Glines Canyon fish ladder and fish flume, general plan. (Source: the staff).

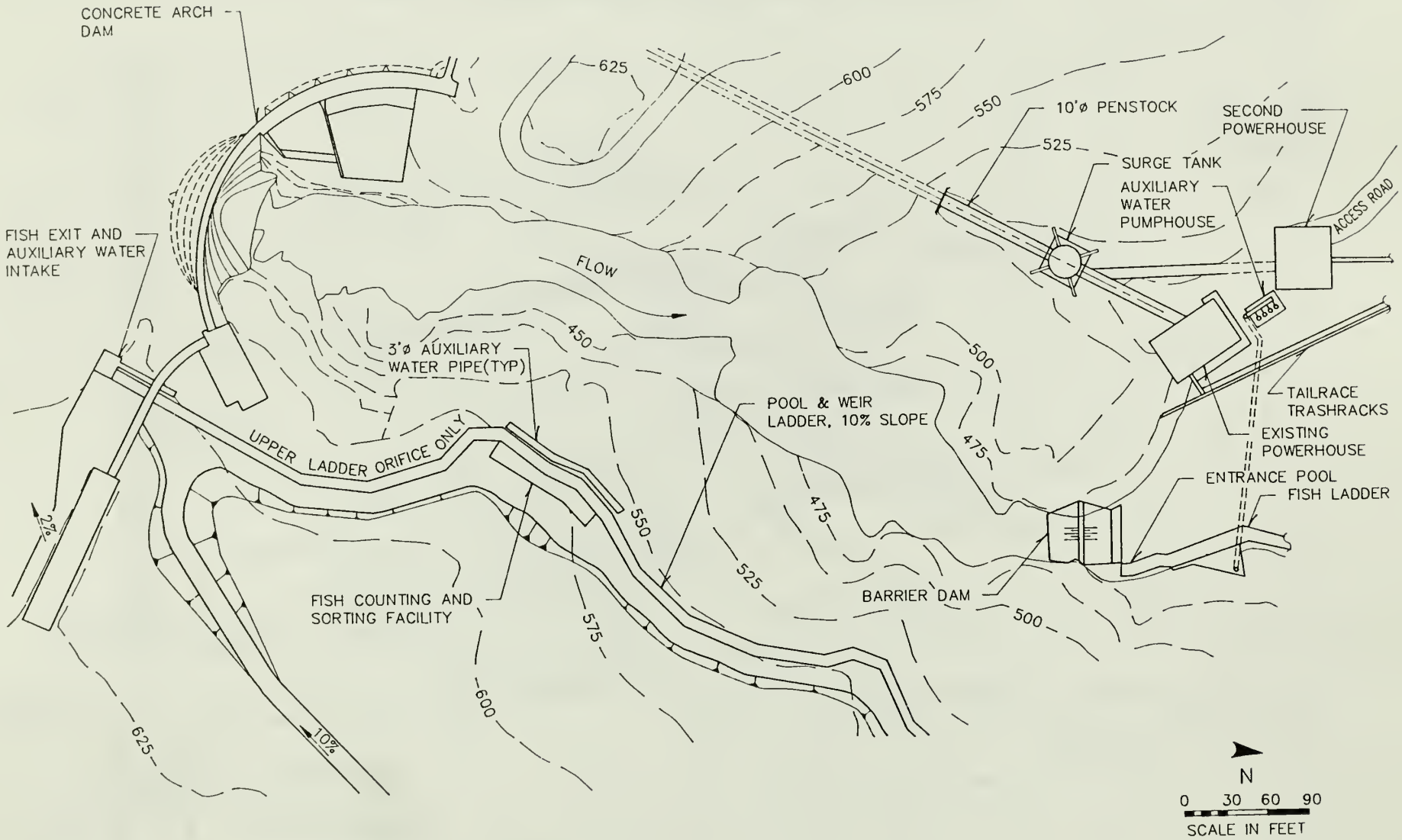


Figure A-18. Glines Canyon Fish ladder. (Source: the staff).

2.2.1.1 Tailrace Bar Racks

Common tailrace bar racks across the draft tube portals of the existing and second powerhouses would be provided. The rack area would be sufficient to yield an exit velocity of 1 fps. Clear spacing of rack bars would be 1 inch, and an upstream low-porosity baffle would be furnished to distribute the flow uniformly over the rack area. A mechanical rake would be provided to clean the low-porosity baffle.

2.2.1.2 Ladder Entrance Pool, Barrier Dam and Auxiliary Water

The ladder entrance pool would be located just downstream of the right abutment of the new barrier dam. The entrance pool would include two gated entrances, one adjacent to the downstream apron of the dam, and one about 25 feet downstream of the first. The first entrance would operate when there was little or no spill over the dam, and the second when high spill conditions existed. The fish entrance pool would be supplied with attraction water from the auxiliary water system. Attraction water would be admitted to the fish entrance pool through wall diffusers which would have sufficient area to limit the velocity entering the pool to 1 fps. Attraction water flow would be controlled by gates to cause 100-cfs flow to issue from each open fish entrance. The openings would be sized to provide an attraction jet velocity of 8 fps. The fish would exit from the entrance pool directly into the fish ladder. All structures would be provided with locking deck grating panels to prevent poaching and with handrails for safety. Figures A-19 and A-20 show the entrance pool and associated features.

A 14-foot-high reinforced rockfill dam with a concrete upstream and downstream shell and concrete aprons would be constructed across the river to prevent fish from moving upstream past the entrance pool. The dam cross-section is shown in Figure A-20.

The auxiliary water supply to the entrance pool would be provided by a pumped supply from a pumphouse located inside the tailrace bar rack (see Figures A-21 and A-22). In addition to the entrance pool, the fish ladder would require auxiliary water for the counting and sorting facility near the top of the ladder. A pipeline from the upper reservoir would supply this water. The pipeline generally would follow the fish ladder route on the downhill or west side, and would be supported at grade or notched into the slope.

2.2.1.3 Fish Ladder

The fish ladder would be a pool-and-weir concrete fishway with orifices at floor level in each weir, hydraulically and dimensionally similar to the new Easton left bank fish ladder.

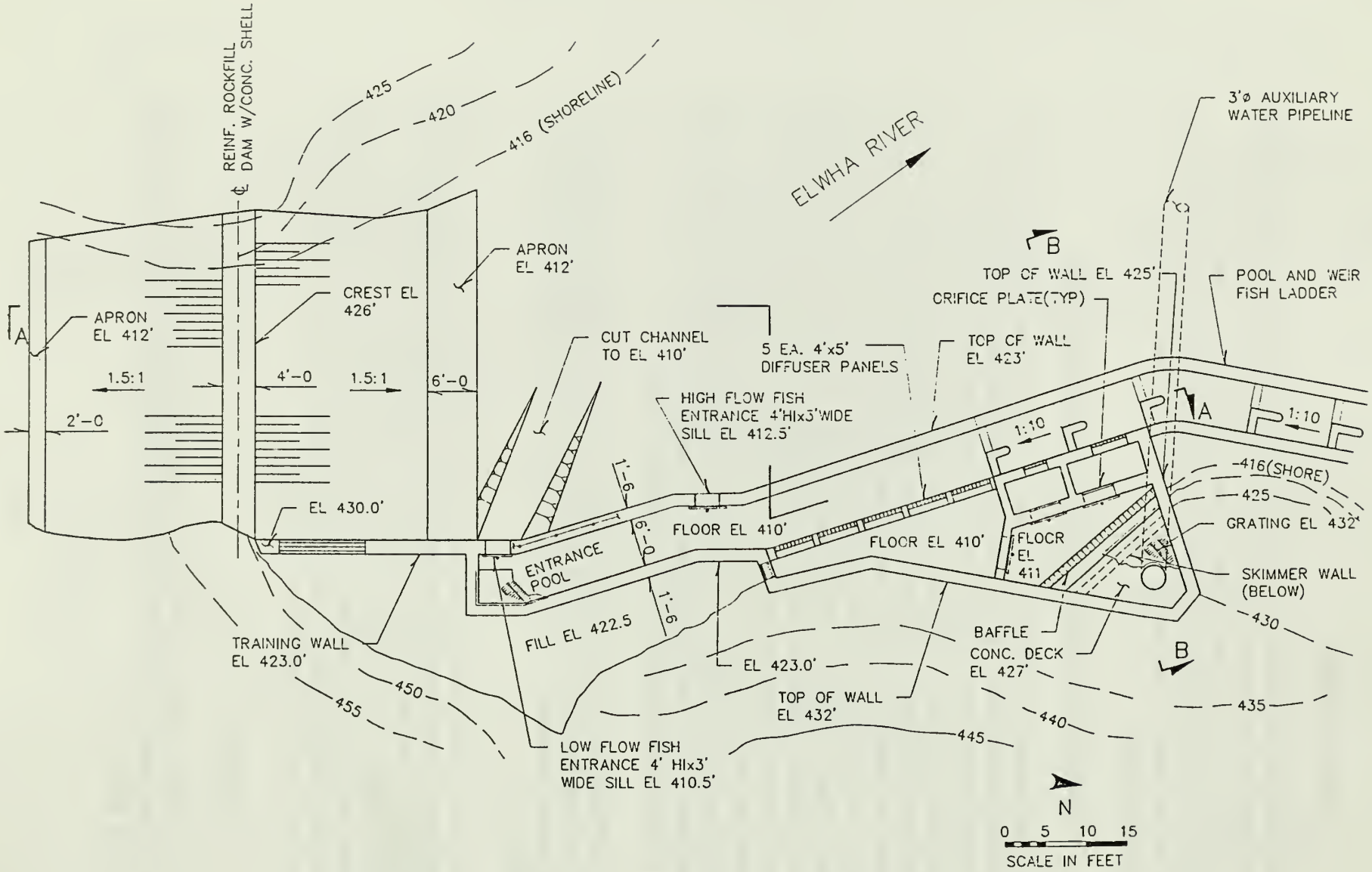


Figure A-19. Glines Canyon fish ladder, barrier dam, and entrance pool plan. (Source: the staff).

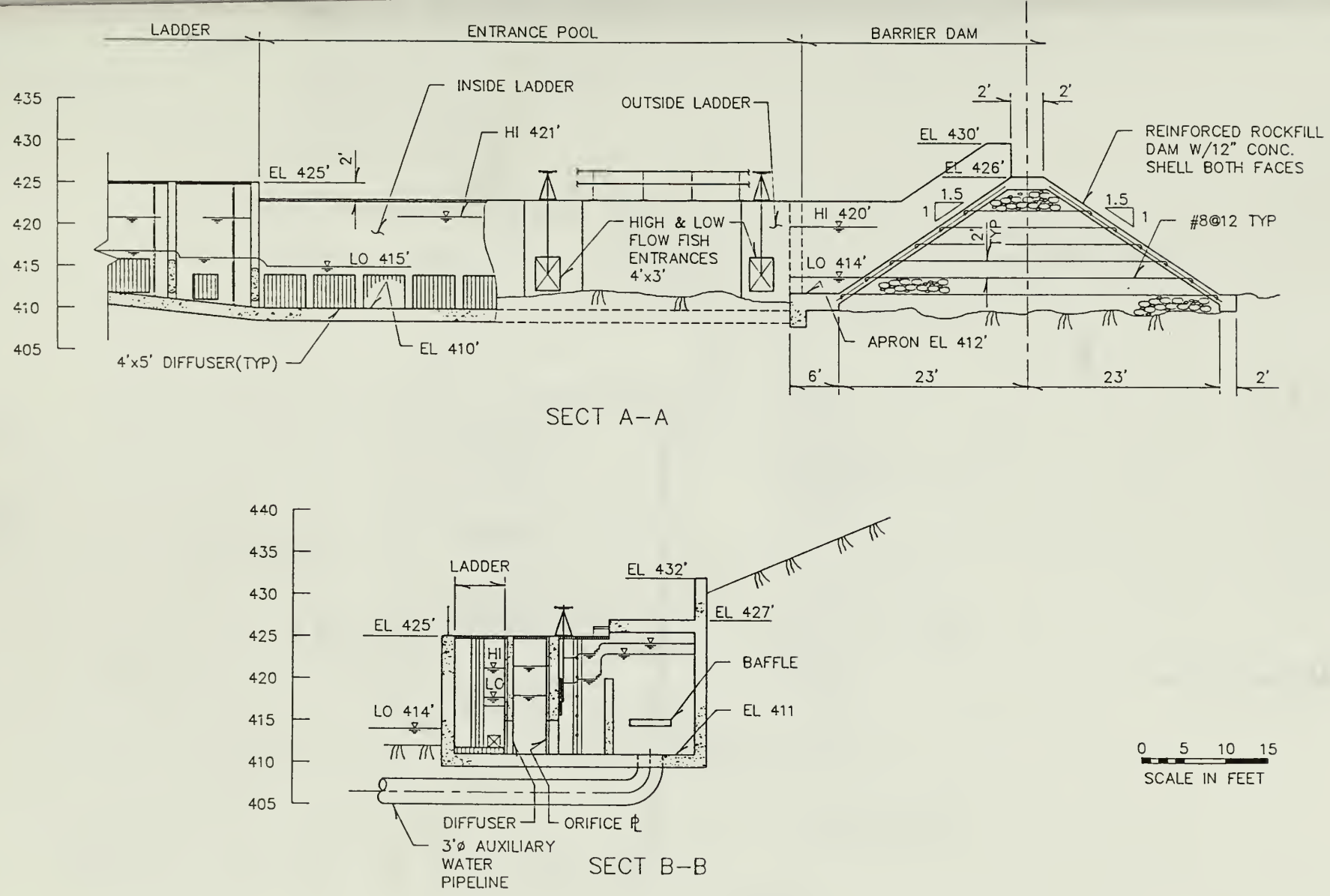
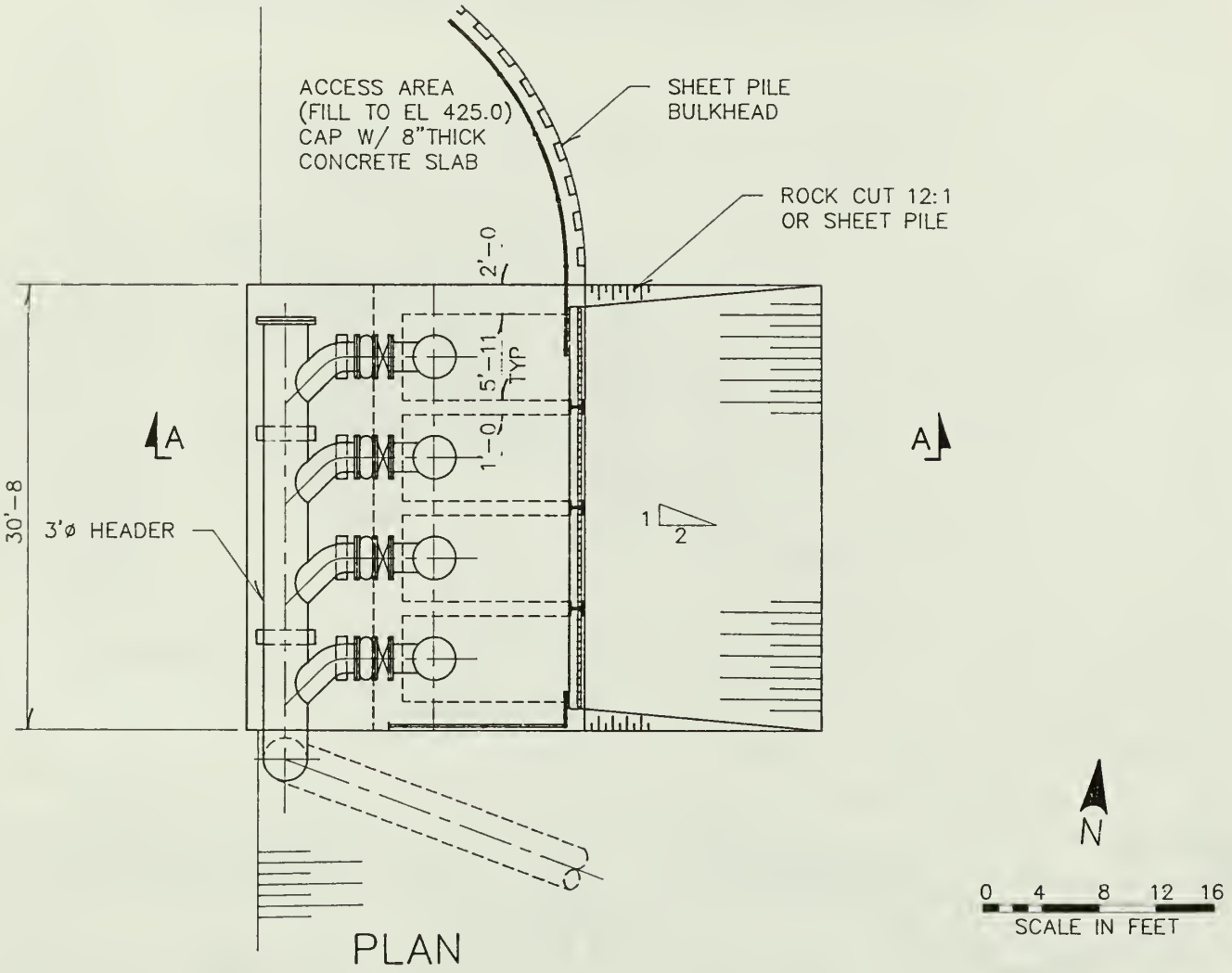


Figure A-20. Glines Canyon fish ladder, sections. (Source: the staff).



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Figure A-21. Glines canyon fish ladder auxiliary water pumping station plan. (Source: the staff).

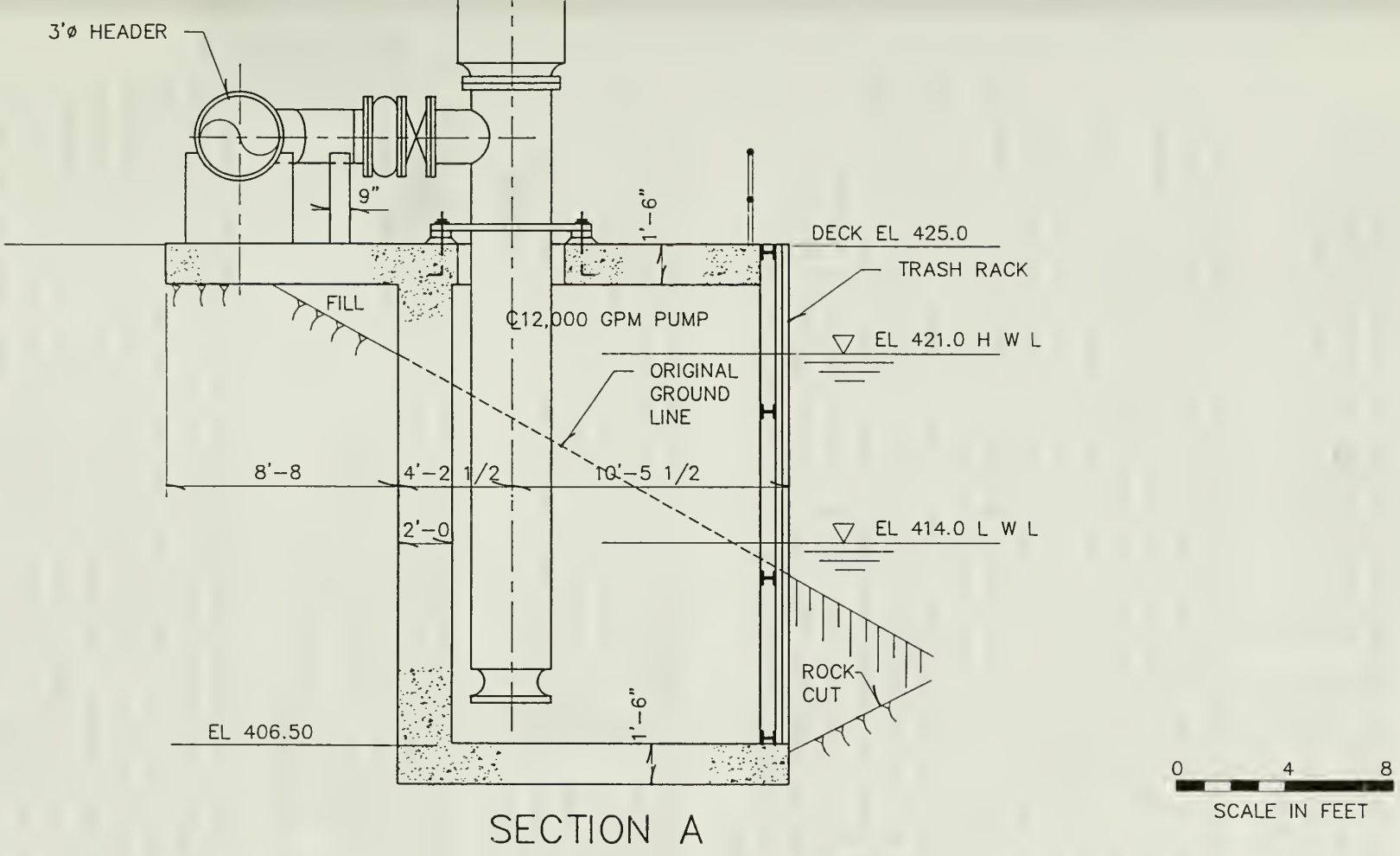


Figure A-22. Glines canyon fish ladder auxiliary water pumping station section. (Source: the staff).

The first two pools in the ladder would be provided with a gated auxiliary water supply to keep the velocity over the weirs up at high tailwater conditions. This arrangement is shown in Figures A-19 and A-20. Typical ladder sections are shown in Figure A-23.

The counting and sorting facility is shown in Figure A-24. The facility would operate by diverting fish out of the pool-and-weir fishway by a hinged bar rack into a Denil ladder section which would run alongside the main ladder. Because the Denil ladder has a slope twice that of the main ladder (20 percent vs 10 percent), fish which pass over a false weir at the high end of the Denil ladder can be returned to the main ladder by gravity flume, re-entering the ladder at a higher elevation than they left it. The flume beyond the end of the Denil ladder would have a series of lift traps and chutes, leading to holding pools or a transport hopper directly below. This arrangement would result in the minimum bench width on the wall of the gorge for the facility. Water to operate the facility would be drawn from the auxiliary water pipeline. Because the water supply is gravity fed, the facility would be located lower than the level of Lake Mills. Water added to the main ladder by operation of the facility would be bled off at screened overflows to keep the ladder flow constant. All water required to operate the facility would be drained into the gorge and would represent an additional loss to power generation.

The fish exit and auxiliary water intake for the counting and sorting facility are represented in Figure A-25. The fish exit would be protected from large debris by a coarse trash rack with 1-foot clear spaces through which the fish can exit; the auxiliary water intake would be provided with a fine rack to prevent re-entrainment of adult fish emerging from the fish exit. The layout shown assumes that Lake Mills will be maintained at a constant level of 610 feet.

Lost generation would result from the ordinary operating flow of 25 cfs. Operation of the fish counting and sorting facility would require an additional 45 cfs, but this is not expected to be more than a sampling operation; accordingly, operation only 10 percent of the time is assumed.

2.2.2 Downstream Passage

A new power intake with forebay screening facilities and a fish bypass system would be installed on the shore of Lake Mills to replace the existing power intake. The concrete screen structure would be equipped with entrance stop logs and trash racks set normal to the flow. To provide for maximum attraction of juvenile fish migrating at different depths in the water column, roller gates would be provided for surface skimming and water withdrawal at 40 feet depth. Sufficient waterway opening would be provided to supply the full flow to the turbines using only the high or only the low gates. Downstream of the roller gates would be two straight

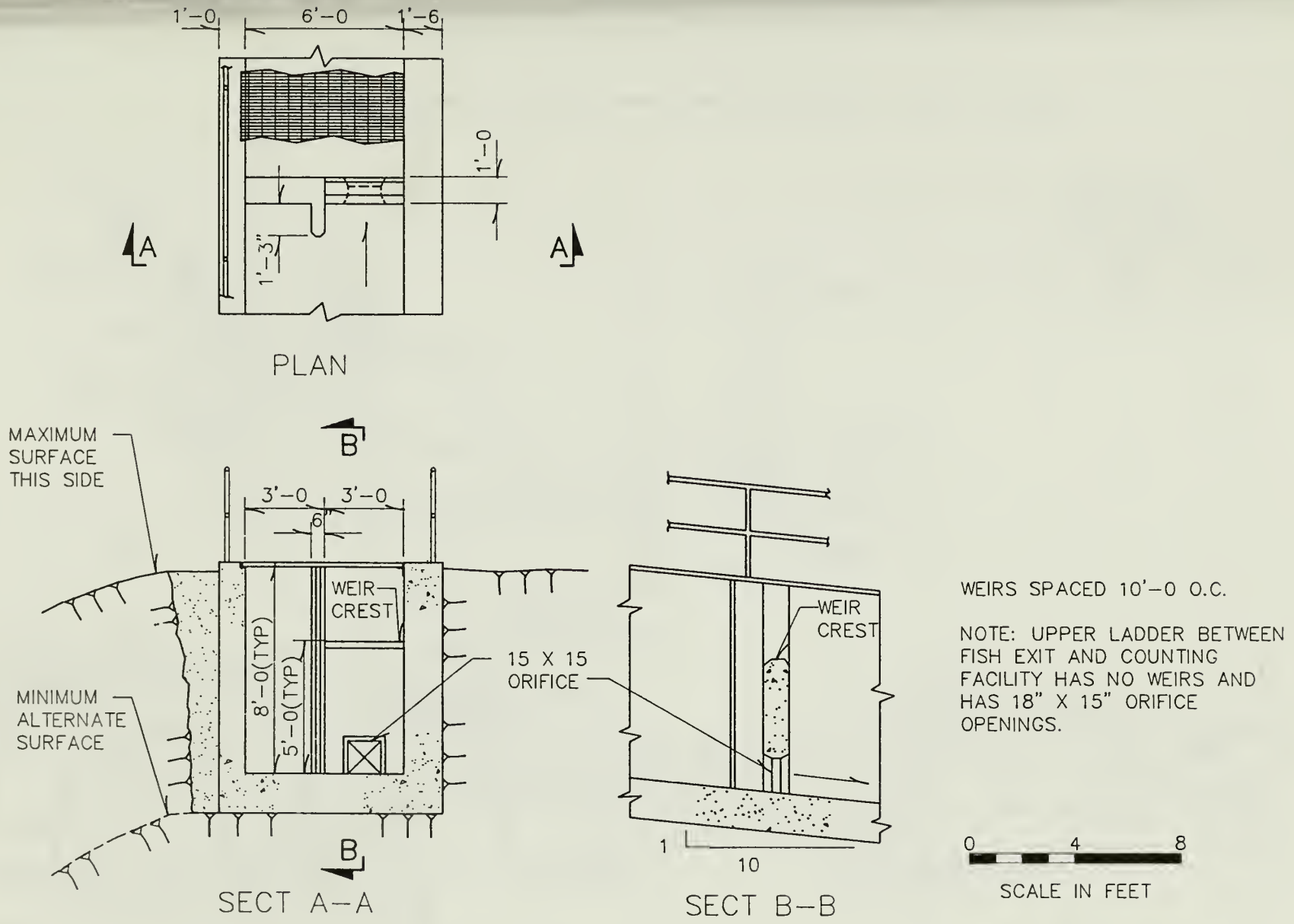


Figure A-23. Glines Canyon typical fish ladder sections. (Source: the staff).

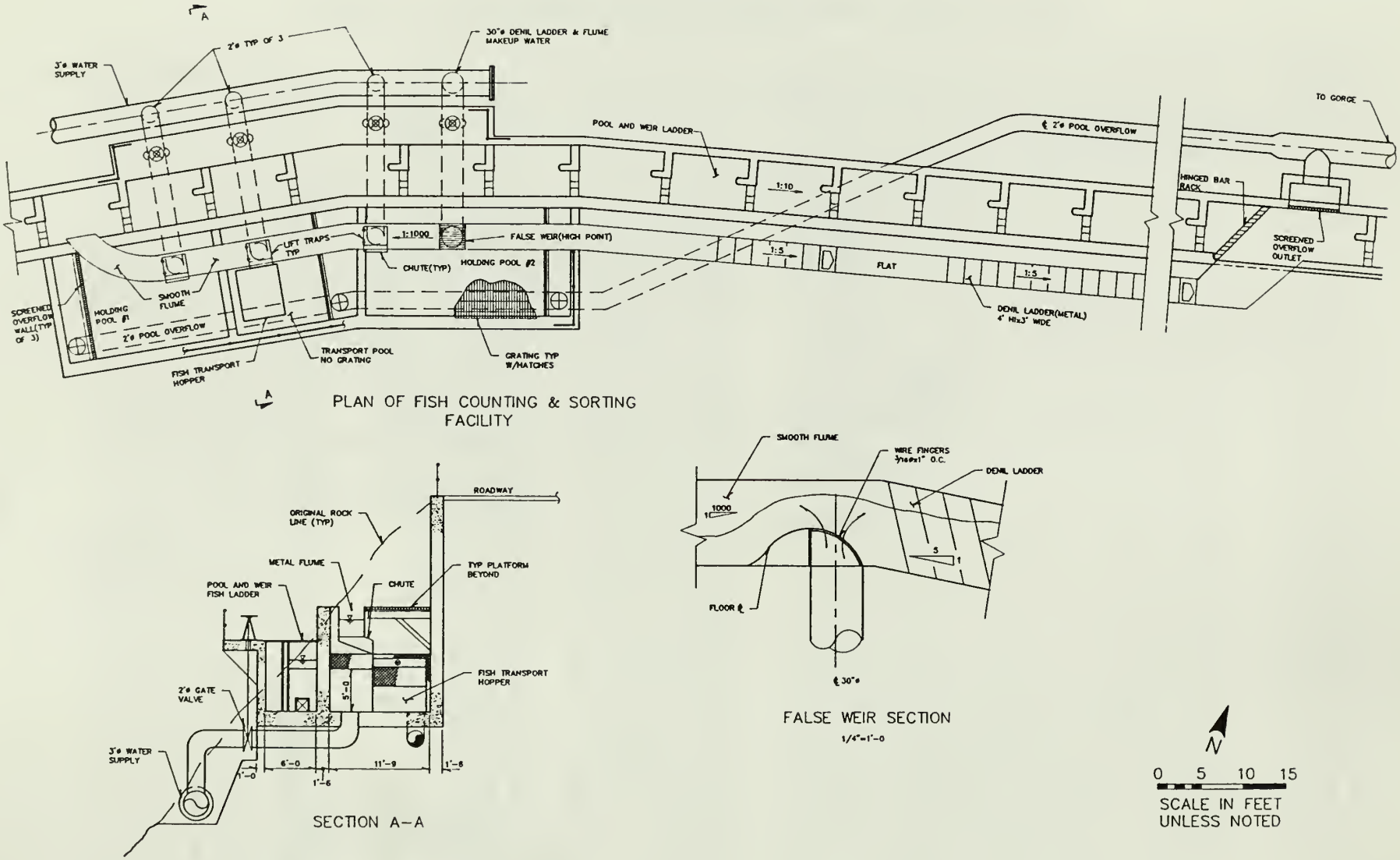


Figure A-24. Glines Canyon Fish counting and sorting facility. (Source: the staff).

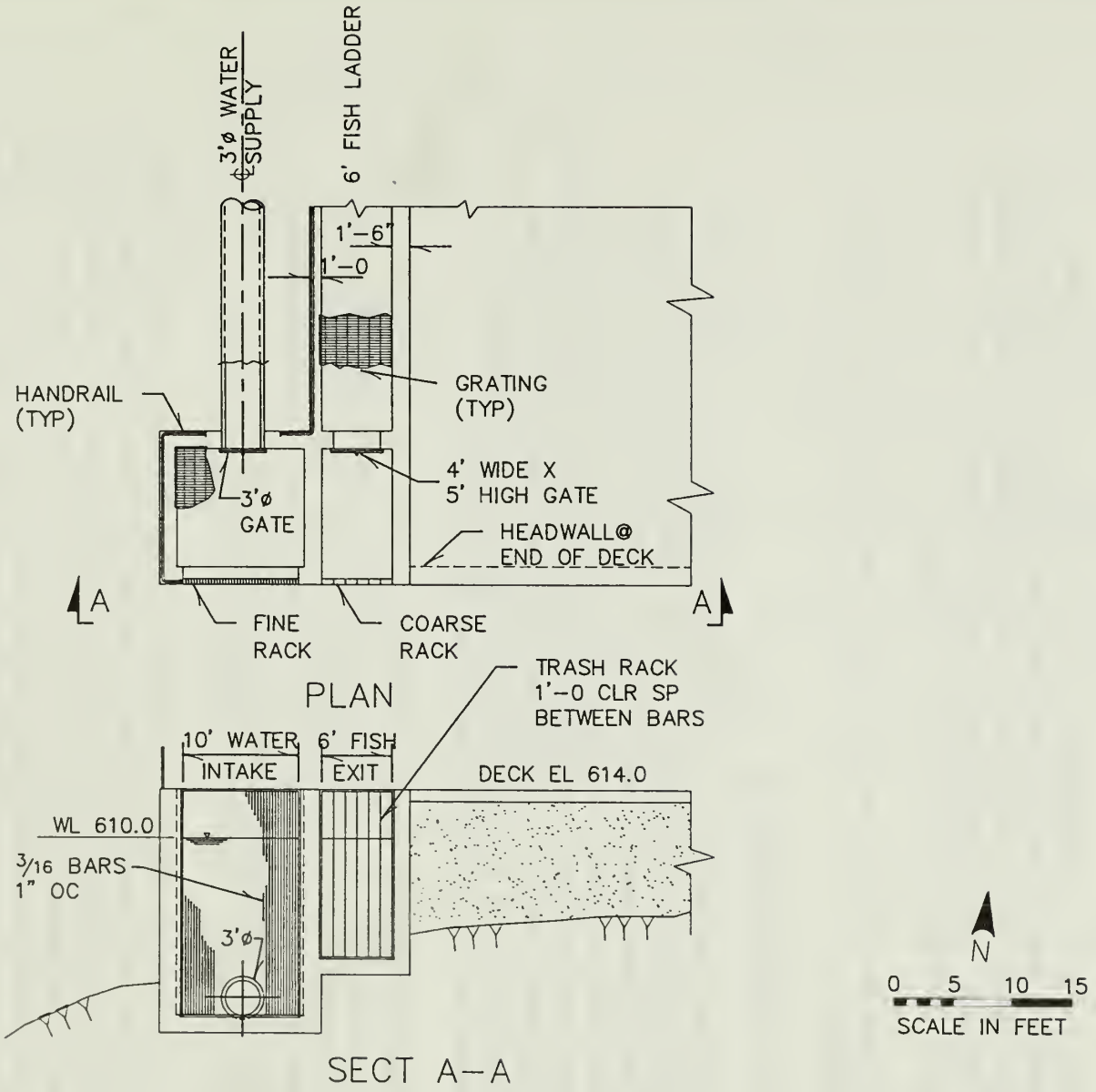


Figure A-25. Glines Canyon fish ladder intake area (fish exit). (Source: the staff).

rows of screens mounted diagonally to the flow to form a vee with apex downstream. The screens would be vertical traveling screens with 1/8-inch mesh openings and a submerged gross screen basket area sufficient to yield an approach velocity of 0.4 fps. The angle of the vee would be set to result in a sweeping velocity of twice the approach velocity. The bypassed fish would be collected at the apex of the vee in a single pipe flume and returned to the river below the powerhouse tailrace by a steel pool-and-weir fish ladder. The flow in the fish bypass would be regulated by a pinch valve located in the pipe flume. The layout of the facility is shown in Figures A-26 and A-27. The route and detail of the fish flume and ladder is shown in Figure A-17.

There would be no scheduled spill from Lake Mills under this proposed alternative, since all migrating juveniles would exit the lake through the bypass screen facility, except when inflow to the lake exceeded the hydraulic capacity of the turbines. Spill, when it occurred, would be regulated to meet the minimum quantity established for safe downstream passage.

A bypass flow of 20 cfs would be diverted from the turbines and result in lost generation.

2.2.3 Powerhouse Expansion

The Glines Canyon Project is presently uneconomically sized with respect to hydraulic capacity of the turbine. The river flow exceeds the Glines Canyon Project hydraulic capacity about 47 percent of the time, indicating that considerable energy is being lost in spill. The staff has examined the technical issues, costs and benefits of expanding project capacity and has concluded that the modification is technically feasible and economically beneficial. It has been viewed by the staff as a reasonable project modification if constructed in conjunction with a relocated power intake (Section 2.2.2).

A second powerhouse would be installed just downstream of the existing powerhouse. The two powerhouses would share a common tailrace bar rack. The plan location of the second powerhouse is shown in Figure A-18 and the cross-section in Figure A-28. The powerhouse would be constructed behind a steel cofferdam arranged to permit continued operation of the existing powerhouse during most of the construction period.

It would contain a single Francis turbine unit with a hydraulic capacity of 600 cfs. This flow would provide a 50 percent increase in project hydraulic capacity, from 1,200 cfs to 1,800 cfs, which would then equal or exceed the mean monthly river flow for all months except June. The percent of the time that river flow exceeds project hydraulic capacity would decrease from 47 percent to 23 percent. Average annual energy production would increase approximately 23 GWh, a 22.5 percent increase over present output.

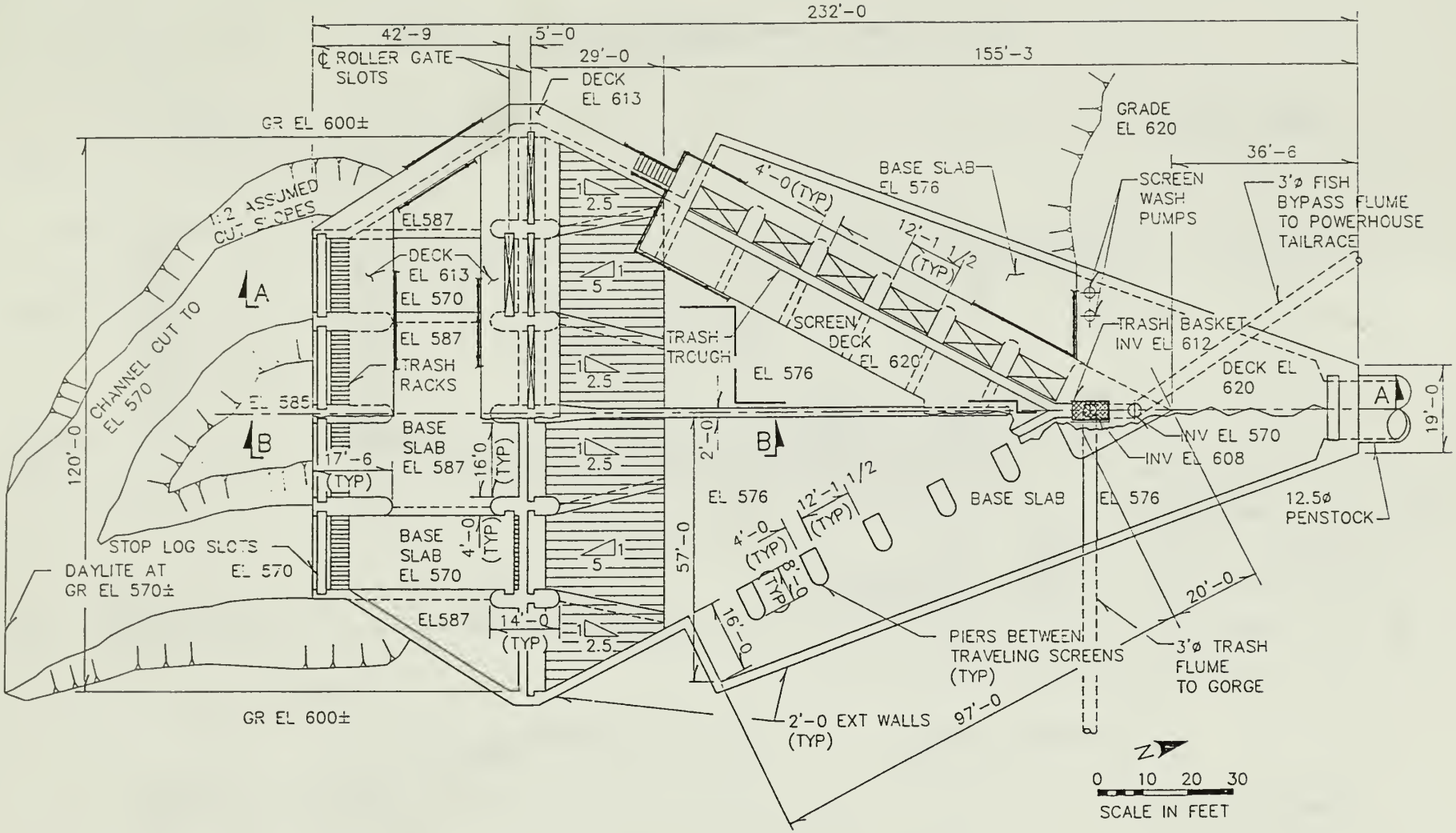


Figure A-26. Glines Canyon screen house plan. (Source: the staff).

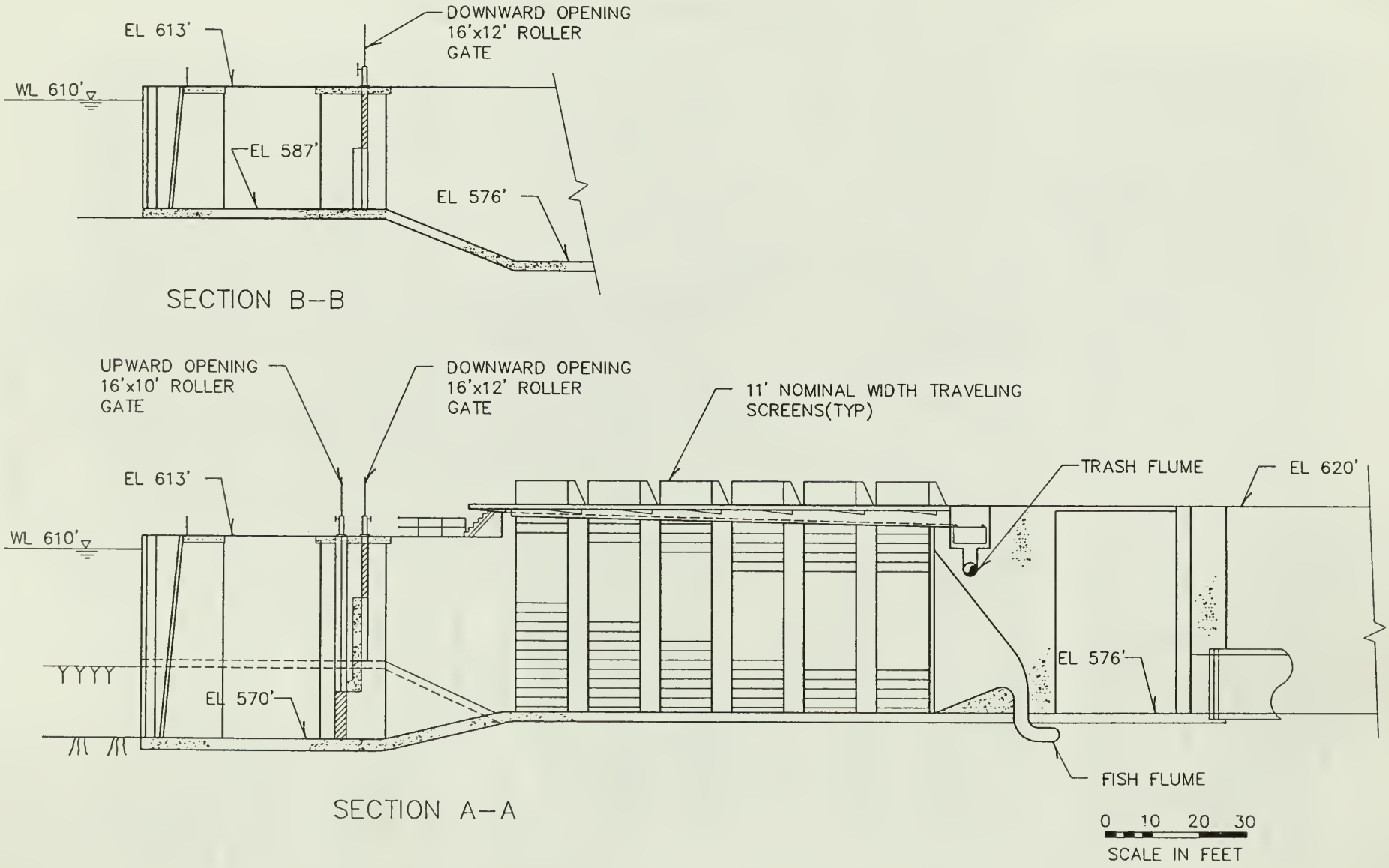


Figure A-27. Glines Canyon screen house. (Source: the staff).

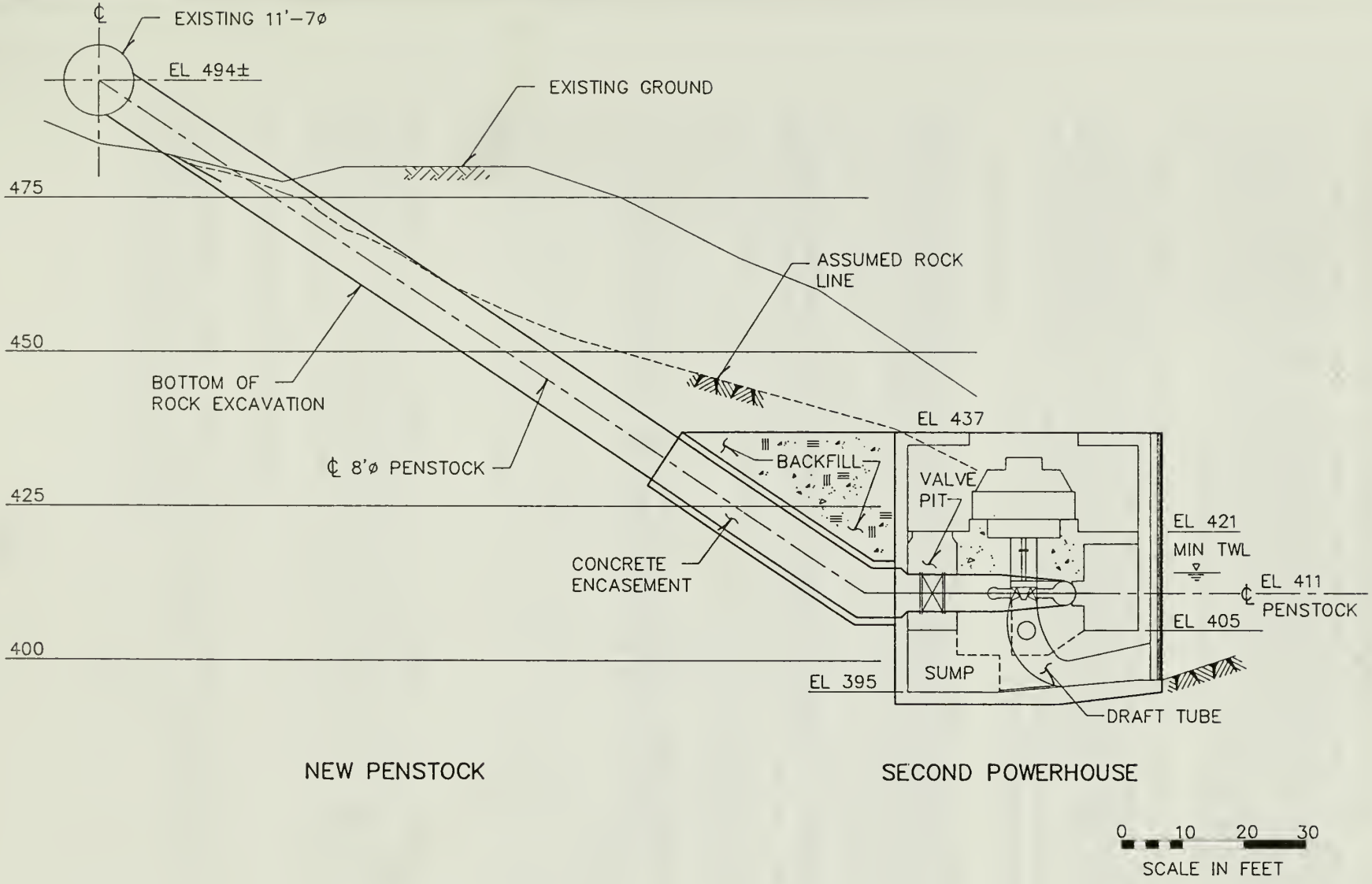


Figure A-28. Glines Canyon Project added capacity scheme, 600-cfs second powerhouse and penstock. (Source: the staff).

Immediately upstream of the turbine and also within the powerhouse would be the shutoff valve for a new 8-foot-diameter steel penstock. The existing 11-foot 7-inch penstock downstream of the surge tank would be bifurcated just downstream of the tank to connect to the new penstock. A new 24-foot-long section of 11-foot 7-inch penstock would be added, incorporating the bifurcation to the 8-foot penstock.

Preliminary transient analysis indicates that continued use of the existing surge tank would be feasible for the higher flows with some modification of the tank. The tank would be increased in overall height by 15 feet, but would be mounted on a new platform 10 feet lower than the existing platform, for a net final elevation of the top of tank 5 feet higher than at present. The existing tower would require modification to support the larger surge tank.

The existing tunnel upstream of the surge tank would be abandoned and replaced with a 12.5-foot-diameter penstock. A reducing section just upstream of the surge tank would be installed to connect the new 12.5-foot penstock to the existing 11-foot 7-inch penstock.

The transmission line would be upgraded to handle the larger generating capacity. The existing overhead transmission line would be replaced by a buried line for the portion of the right-of-way within the boundaries of the Olympic National Park to reduce the visual impact.

The new power intake with bypass screens described in Section 2.2.2 above is sized to accommodate the increased flows associated with an expanded Glines Canyon Project.

PART 3 - DAM REMOVAL PLAN

This portion of Appendix A is a description of the staff-formulated approach to dam removal. During EIS scoping, dam removal was identified as a reasonable alternative. Comparative environmental and economic evaluations necessitated the formulation of a specific dam removal plan. The result is presented first for the Elwha Project (Section 3.1) and second for the Glines Canyon Project (Section 3.2).

As described, the plans are considered by staff as reasonable approximations of actual dam removal programs. Only through additional detailed geotechnical investigations, however, can a final removal plan be formulated.

3.1 ELWHA PROJECT

The recommended plan for removal of the Elwha dam would include three main aspects: (1) the use of a gated tunnel diversion to drain the reservoir and divert river flows during sediment control and dam removal activities; (2) use of in-reservoir sediment management through stabilization of the materials during which the dam would remain in place; and (3) complete removal of the dam and associated structures once in-reservoir stabilization is complete.

Completion of the recommended plan would take approximately four construction seasons (Figure A-29). The first season would consist of constructing the diversion tunnel and associated control works. The following two seasons would involve moving the sediment material away from the original channel and stabilizing the sediment within the existing bounds of the reservoir. The final construction season would involve the physical removal of the dam and spillway structures, redirecting the river through the original channel, decommissioning the diversion works, and regrading the site. Much of the overall activity would be performed during lower flow periods, represented by the midsummer to early fall period.

The estimated work force requirement would range from 15 to 30, not including supervisory and administrative personnel. The estimates are based on single 8-hour shifts. The estimated personnel requirements and monthly payroll, not including supervisory and administrative personnel, are shown in Table A-1.

3.1.1 Diversion During Construction

A diversion tunnel would be employed to drain the reservoir and provide flood protection during the summer construction season (July through September) up to the 1-in-10-year flood during that period.

Table A-1. Personnel requirements and payroll, Elwha dam removal plan (Source: the staff).

	Construction personnel[1/]	Monthly payroll[2/]
Year 1		
April through October	30	$133,000
Year 2		
April through mid-May	30	$133,000
Mid-May through October	18	$79,000
Year 3		
April through mid-November	18	$79,000
Year 4		
April through October	15	$66,000

[1/] Estimated average over period.
[2/] Estimated gross payroll in 1995 dollars and based on 1990 estimates inflated at 5 percent per year.

The diversion would consist of a 13-1/2-foot-diameter concrete-lined tunnel, 980 feet long, located in the rock abutment to the left of the north spillway. The precise alignment of the tunnel would be determined during the final design stage and would be based on geotechnical investigations. A lake tap would be employed whereby tunnel excavation would extend into the lake, with piercing into the lake performed by blasting. This complex method of draining the lake would require competent rock and minimum overburden to succeed. Because of this, underwater investigations in the lake tap area would be conducted during final design to verify acceptable conditions. Surficial geology, such as the rock found in the area of the north spillway suggests acceptable conditions in the area. If acceptable conditions were not found during geotechnical evaluations, alternative methods of diversion would be required. The diversion tunnel would be concrete lined to accommodate high discharge velocities. An 8-foot by 14-foot concrete-lined gate shaft about 90 feet deep would be constructed about 300 feet from the upstream end of the tunnel (Figure A-30). A 14-foot-high by 10-foot-wide wheeled gate would be installed at the bottom of this gate shaft to control the flow in the diversion tunnel. A 2-1/2-foot-diameter air vent would provide air to the diversion tunnel downstream of the wheeled gate when the gate

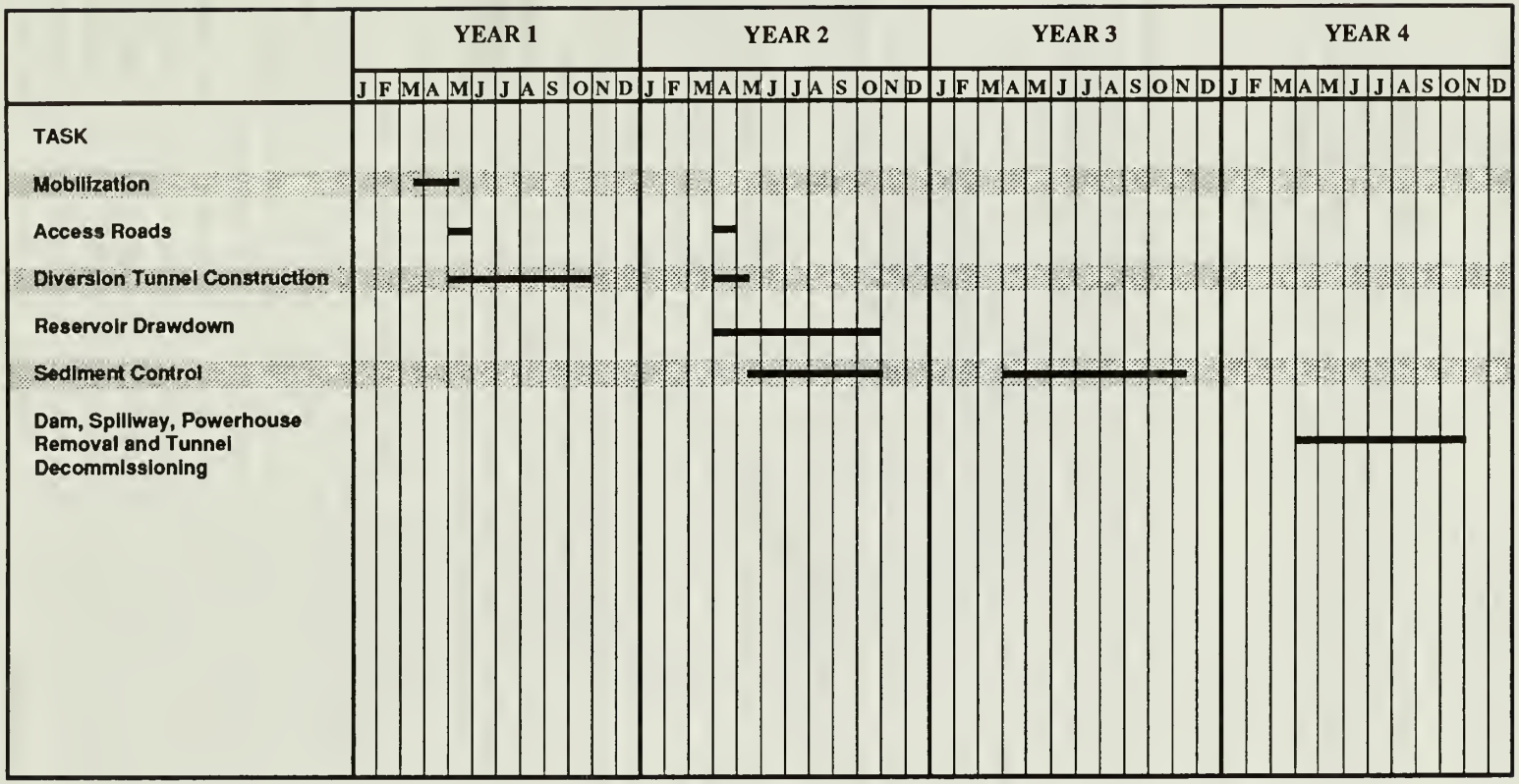


Figure A-29. Construction schedule, dam removal plan, Elwha Project. (Source: the staff).

is operated to control the flow in the tunnel. The diversion tunnel would be sized to discharge 3,500 cfs (the 10-year flood for July, August, and September) with the headwater just covering the crown of the upstream portal of the diversion tunnel, and with the tunnel flowing full.

A new access road approximately 1,200 feet long and 20 feet wide would be required for construction of the diversion tunnel (Figure A-30). A construction staging area approximately one acre in size would also be required and would be located at the head of the new access road, adjacent to the left bank spillway.

3.1.2 Sediment Management

Over the period of project operation, about 4 million cubic yards (cy) of sediment transported downstream through the river system has accumulated in Lake Aldwell. Any dam removal option will eliminate the lake and the associated sedimentation process that occurs in the lake. Subsequent formation of a free-flowing river would revive the sediment transport capability of the system. The major concern with any removal scheme is the subsequent transport of sediment downstream at unusually large rates because of the existing accumulation, and aggradation or accumulation in the downstream river reach. Excessive accumulation would result in elevated streambeds and possibly in water levels increasing above current levels during flood flows.

Most (3.1 million cy) of the sediment deposits in Lake Aldwell are located within a delta in the upstream one-third of the reservoir. Delta sediment materials would be placed in sediment disposal terraces located within the existing reservoir area, away from the future river channel, and stabilized with vegetation (Figure A-31). Following initial drawdown of the reservoir such that the delta surface was exposed, excavation in the delta area would be initiated. This would involve draglines to excavate channel slopes, and bulldozers and loaders to move materials on the delta. A large portion of the delta would be transformed into a sediment storage terrace. Planned drawdowns would be at the rate of approximately 1 to 2 feet per day in order to have time to grade stable slopes along the river channel. Excavation in the Lake Aldwell delta area would involve removing about 0.9 million cy of material. Much of the existing delta would not need dredging because it would remain on the edges of the valley or it would be allowed to wash into the reservoir for later excavation. Excavation of a channel and side slopes along the rest of the lake would involve excavating about 0.8 million cy of material and placing it onto terraces along the edges of the reservoir. This would occur following reservoir drawdown during which a scour channel would develop. Scoured sediments would be eroded and discharged from Lake Aldwell. Natural armor material and large woody debris would be installed along the new channel and tributary banks. This would reduce the time it takes for the channel structure to form, reducing the amount of erosion and slumping from the toe of the new

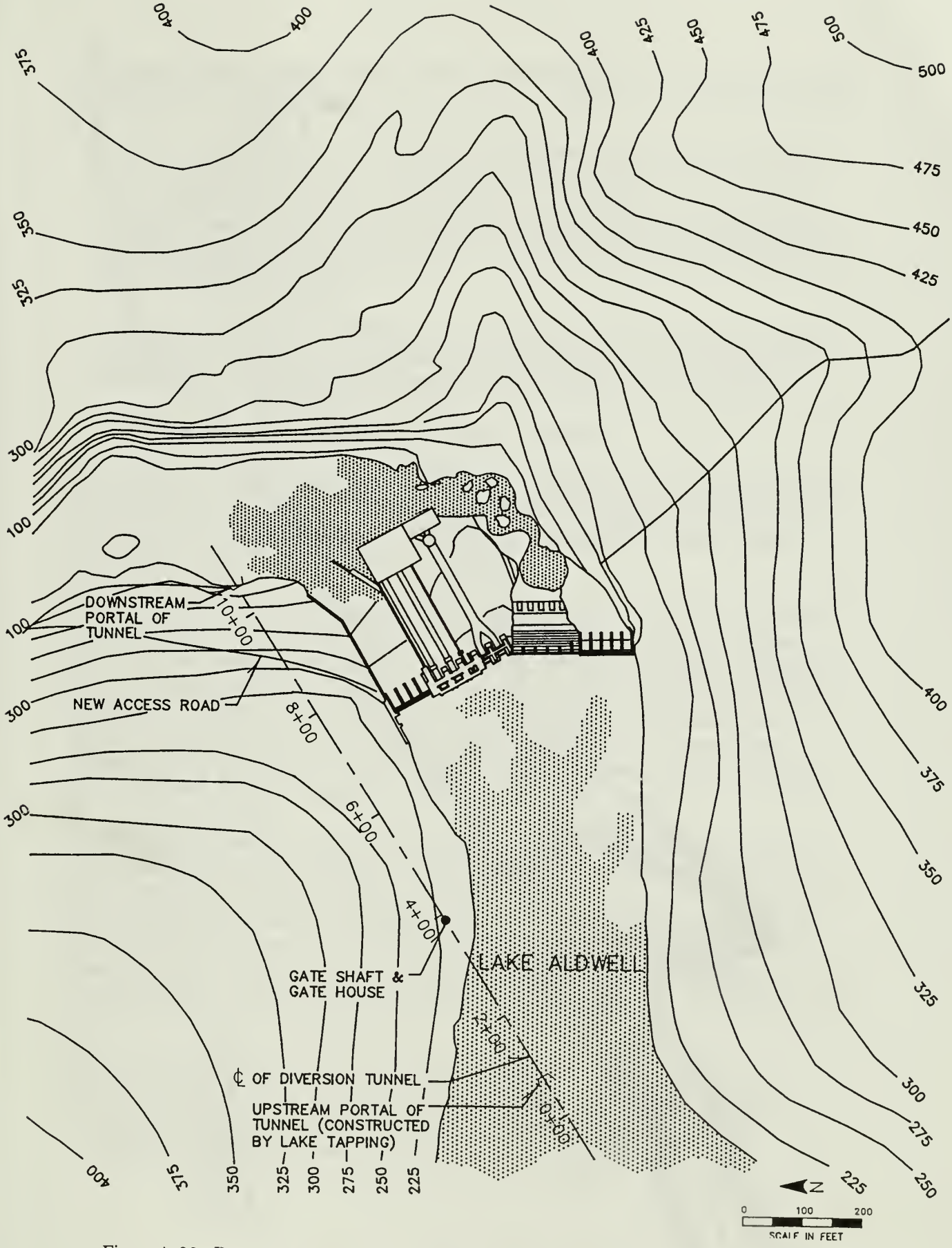


Figure A-30. Dam removal plan, Elwha Project diversion tunnel. (Source: the staff).

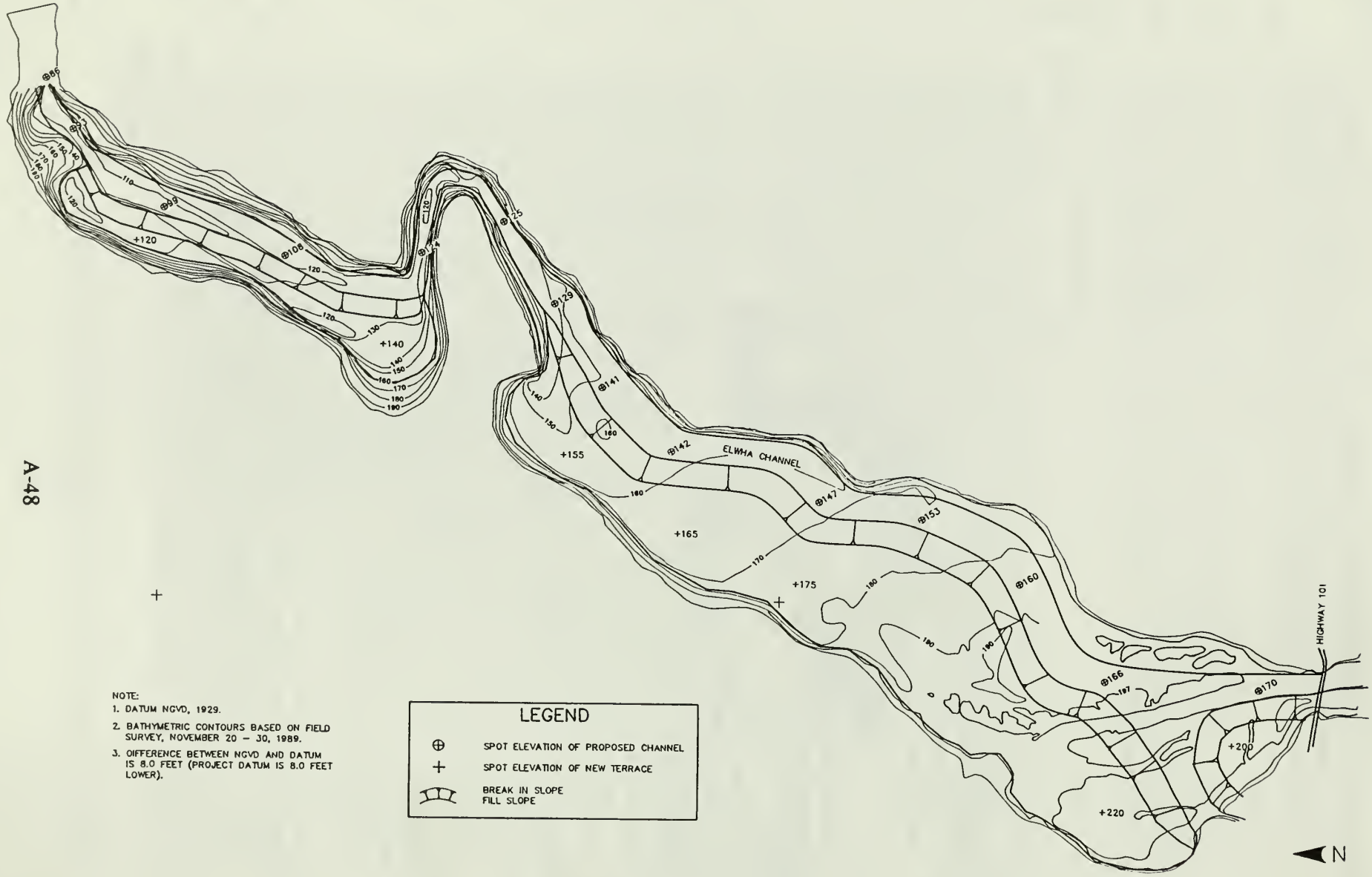


Figure A-31. Sediment stabilization plan, Elwha project. (Source: the staff).

terraces in floods. The addition of armor material would not be needed where the old channel is encountered.

Excavating would be carried out using a conventional dragline while excavators and loaders would be used for exposed sediment after allowing for a drainage period. Trucks would be used for hauling the finer materials to the previously developed upstream sand and gravel terraces. Terraces would be developed with stable and modest slopes to ensure stability. Vegetation of completed terraces would further stabilize the terraces.

Small terraces of silt in the middle and lower reservoir would be protected with a cover of matting material and hydroseeded. No attempt would be made to work these terraces with equipment or to add additional sediment to these terraces.

3.1.3 Sediment Disposal Terrace Restoration/Vegetation

The goal of the vegetation program would be to establish a cover of native species on the disposal terraces as soon possible. The final revegetation plan would be developed in conjunction with the NPS and Soil Conservation Service, but is expected to include four elements.

Terraces would be seeded and mulched in the early fall of the year in which they are constructed. The temperature and natural precipitation at this time of year should allow establishment and growth. Seeding during the summer would result in poor cover without irrigation, which would be prohibitively expensive. Areas affected by winter erosion would be reseeded each spring of the construction period. Areas with poor cover would be reseeded in the fall. The seed mix should contain sterile forms of fast-growing grass and clover species as well as native pioneer species of grasses and forbs.

Terraces would also be planted with seedlings of native trees and shrubs grown from seed or cuttings from plants in the immediate vicinity of each project area. Tree and shrub seedlings would be planted in the fall or late winter when stock is dormant and when natural precipitation would promote establishment before the onset of summer drought. On highly erodible sites, willows should be planted using a process called "wattling." Wattling involves burying all or portions of severed woody stems below the soil surface and is only effective with species, such as willows, that are easily rooted.

A weed control program would also be implemented. This program would involve mainly preventative measures and monitoring. Preventative measures include using seed mixes with no weed seeds, foregoing irrigation and fertilization, and seeding/planting at the appropriate times of year.

A monitoring program would be developed in conjunction with the detailed reclamation plan and would include revegetation goals, procedures, and provisions for dealing with weed invasion and damage by wildlife.

3.1.4 Removal of Project Facilities

Project facilities include a main gravity dam, two spillway sections on opposite sides of the river, an intake dam section, and the powerhouse with penstocks connecting to the intake section (Figure A-30).

Demolition of the dam would employ conventional drill and blast techniques commonly used for rock excavation. Blasting would be controlled so that most of the concrete rubble would be directed to the dewatered upstream side of the dam where it would then be loaded into trucks and removed to the disposal site. Material placed upstream and downstream of the dam for seepage control would be disposed of with the dam rubble.

Other structures to be removed include the north (left) spillway, the south (right) spillway, the intake structures, penstocks, surge tank, and the powerhouse.

3.1.5 Construction Sequence

The level of Lake Aldwell would be lowered from El. 187.8, the normal water surface elevation, to El. 165, which is the invert elevation of the existing penstocks, using the existing right and left spillway gates and the existing powerhouse.

The diversion tunnel excavation would proceed from the downstream portal towards Lake Aldwell following completion of the required access road. The precise alignment of the tunnel would be established during final design and after geotechnical investigations of the proposed route and an underwater assessment of the entrance area to the lake tap. Geotechnical investigations would determine rock suitability along the tunnel alignment. Underwater surveys would be performed to determine if any large materials exist at the lake tap entrance. Large materials that would block the tunnel would require moving or selecting a new alignment. A section of rock shell in Lake Aldwell at the upstream end of the diversion tunnel would stay in place as a plug until the work on the diversion tunnel, the gate shaft, and the wheeled gate is completed. The rock shell at the diversion tunnel entrance would then be blasted to tap the lake, thereby opening the diversion passage. The wheeled gate in the diversion tunnel would then be opened to discharge Lake Aldwell inflows and remaining storage through the 13-1/2-foot-diameter concrete-lined tunnel. A trashrack would be installed around the lip of the lake tap prior to allowing flow through the diversion tunnel. A cofferdam would be constructed just downstream of the lake tap.

Lake Aldwell would be drawn down to El. 120±. The lakebed just upstream of the existing dam is at about El. 176. With the reservoir drained and the river diverted, all existing project structures would be free of flowing and standing water, and the reservoir would be dewatered.

Sediment stabilization activities would be performed during the generally lower flow periods. During periods when flows would tend to be the highest and site work has ceased for the season, the gated tunnel would continue to provide for river diversions. During inflows exceeding the tunnel capacity, the excess would be allowed to accumulate in the reservoir. Major flood events would result in increases in the reservoir level and, under the most severe conditions, use of the existing project structures to discharge inflows. Because of this, project structures would remain in place until sediment stabilization activities were complete.

Stabilization of the sediment would begin concurrently with the reservoir drawdown. Dredging would be used to control the channel alignment through the delta deposits while the drawdown is underway. The dragline would operate from the delta surface while removing material from the desired channel. Additional delta materials would be eroded by the streamflow and carried further into the reservoir. Once substantial surfaces are exposed by the reservoir drawdown, conventional equipment would be used in excavating and moving material to the terrace sites (Figure A-31). This process would continue until drawdown of the reservoir is complete. The estimated time required to complete the excavation, transport, and stabilization of sediments is approximately 13 months carried out over two construction seasons.

The first stage of sediment stabilization would involve dredging material at the head of the existing delta. This would control development of an erosion channel as the lake level is lowered to the 170-foot elevation. Material not eroded into a new delta at the 170-foot elevation would be excavated and placed onto a stable terrace. Sand suspended from erosion and sloughing of banks into the eroding channel would be trapped in the remaining Aldwell Reservoir. Finer materials (silts and clays) would be transported out of the reservoir. Lake levels would incrementally be lowered as dredging, grading, and revegetation is extended down the reservoir to the 140-foot elevation. The reservoir would then be lowered to about 120 feet allowing the natural river flow to wash out the narrow canyon to form a stable channel. Dredged material from the newly formed delta and remaining bottom sediments would be placed along the canyon edges in terraces.

Following the completion of stabilization of reservoir sediments, demolition of the main gravity dam and other structures would begin. The gravity dam would be removed to El. 80±, and the steel piling downstream of the gravity section placed in 1913 would also be removed to this elevation. The right spillway structure, the powerhouse, and penstocks would then be removed.

Demolition of the south spillway and power intake would be completed by first removing and salvaging electrical and mechanical equipment. All the powerhouse parts consisting of steel and the penstocks would be disposed of as scrap steel. Parts that cannot be disposed of as scrap would be hauled away for disposal. Removal of the powerhouse would include removal of electrical and mechanical equipment and demolition of the concrete structure.

After removal of the dam and all structures, the small cofferdam used to direct flows into the tunnel intake and the remainder of the approximately 120-foot-deep hydraulic and earth fill at the dam site would be removed in a controlled manner by standard earth-moving and hauling equipment. Scheduling of the excavation would occur in the lowest reservoir inflow during the summer. Lowering of the reservoir and excavation would continue until removal of the sediment and/or cofferdam is complete.

Decommissioning the diversion tunnel would occur following the removal of all existing project structures and the redirecting of the river through the original river channel. All steel racks and equipment would be removed and salvaged. Visible concrete structures would be demolished with the rubble placed within the tunnel. The tunnel and other exposed shafts would then be closed and grouted. The addition of local material, as necessary, and regrading would restore the tunnel entrance and exit area to approximately the original contours.

The final phase would involve reclamation of the site, including filling and covering the north spillway with rubble, sediment, and other natural material, grading the area, and removing any remaining portions of any cofferdams. Grading the spillway area would blend the area into the left bank to more closely match the original topography. Reclamation of the project area would also include hydroseeding soil slopes with native plant species to restore the site to as close to its preconstruction condition as possible.

3.1.6 Spoils and Rubble Disposal

The spoils resulting from construction of the diversion tunnel, approximately 7,370 cy, would consist of various sizes of rock fragments. The material would be hauled to the upland disposal area, located to the west of the upper reaches of Lake Aldwell. The upland disposal site would require approximately 1,000 feet of temporary road construction. Transport of the material would require approximately 720 truckloads.

Rubble resulting from demolition of the concrete structures would be used as fill material for restoration of the site topography to approximately its preproject condition. Rubble quantities in excess of site restoration needs would be hauled to the upland disposal site. In total, the volume of rubble would approximate 28,000 cy.

3.2 GLINES CANYON PROJECT

The recommended plan for removal of the Glines Canyon Project would include four main elements: (1) the use of a gated tunnel diversion to drain the reservoir and divert river flows during sediment control and dam removal activities; (2) an open channel bypass having a capacity of approximately 1,000 cfs to dilute sediment-laden discharges from the diversion tunnel; (3) use of in-reservoir sediment management through stabilization of the materials during which the dam would remain in place; and (4) complete removal of the dams and associated structures once in-reservoir stabilization is complete.

Completion of the recommended plan would take approximately five construction seasons (Figure A-32). The first season would consist of constructing the diversion tunnel and associated control works. The following three seasons would involve constructing the open channel diversion bypass, reservoir drawdown in three phases, and transporting and stabilizing the sediment material within the existing bounds of the reservoir. The delta of Lake Mills would be drained in year 2 of construction starting in April. During year 3 of construction, the lake level would be lowered to about elevation 460 with the rest of the drawdown occurring in year 4 of construction (Figure A-32). The final construction season would involve the physical removal of the dam and other structures, redirecting the river through the original channel, decommissioning the diversion works, and regrading the site. Much of the overall activity would be performed during low flow periods, represented by the midsummer to early fall period.

The estimated work force requirement is expected to range from 18 to 48 during the construction seasons over a 5-year period, based on single 8-hour shifts. The estimated personnel requirements and monthly payroll, not including supervisory and administrative personnel, are shown in Table A-2.

3.2.1 Diversion During Construction

The existing power tunnel and penstock would be used to drain Lake Mills from water surface El. 610 to El. 521±. A discharge capacity of 6,000 cfs can be accommodated through the existing power conduit if the runner in the turbine were removed and the Lake Mills water surface elevation is at 534.5 or above. To drain Lake Mills from water surface El. 521± to water surface El. 430±, a low-level diversion tunnel would be used. The tunnel would be approximately 12 feet in diameter, would include a 12- by 8-foot vertical gate shaft, and would be controlled using a 12-foot-high by 9-foot-wide control gate. The tunnel would be concrete lined and have a length of approximately 925 feet. It would accommodate a flow rate of 3,500 cfs at a reservoir elevation of 445. This flow corresponds to the 10-year flood during July, August, and September.

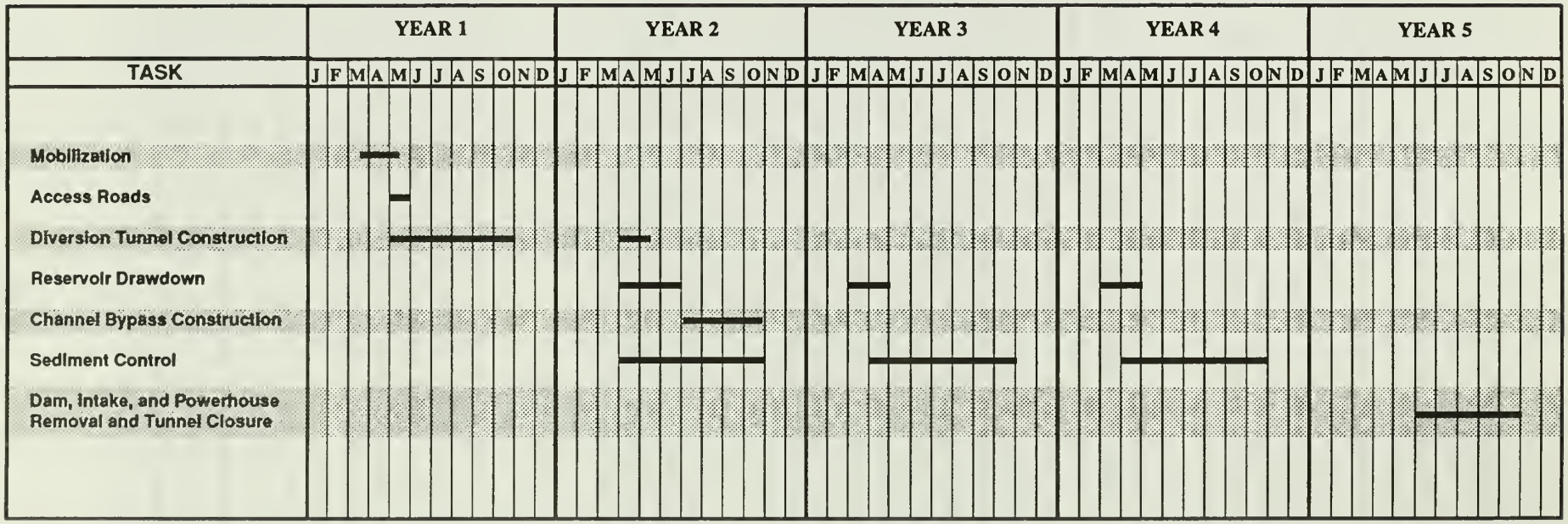


Figure A-32. Construction schedule, removal of Glines Canyon Project . (Source: the staff).

Table A-2. Personnel requirements and payroll, Glines Canyon dam removal plan (Source: the staff).

	Construction personnel[1/]	Monthly payroll[2/]
Year 1		
May through October	20	$88,000
Year 2		
April through mid-May	48	$212,000
Mid-May through June	18	$79,000
July through October	35	$154,000
Year 3		
April through October	18	$79,000
Year 4		
April through October	18	$79,000
Year 5		
June through October	20	$88,000

[1/] Estimated average over period.
[2/] Estimated gross payroll in 1995 dollars and based on 1990 estimates inflated at 5 percent per year.

The alignment of the low-level diversion tunnel would be on the left abutment of the existing Glines Canyon dam (Figure A-33). This alignment would allow the low-level tunnel to be accessed from the existing access road leading to the powerhouse. The outlet portal of the diversion tunnel would be near the northern end of the powerhouse with the upstream end entering the lake through a lake tap. The precise alignment of the tunnel would be established during final design. Because of the complexities involved in a lake tap, extensive geotechnical investigations of the alignment and an underwater assessment of the entrance area to the lake top would be performed. The investigations would determine the suitability of the alignment. Underwater surveys would determine the suitability of the tunnel entrance and lake tap access.

The low-level tunnel would be supplemented by an approximately 1,000-cfs channel bypass extending along the western edge of the lake, from the upstream end of Lake Mills to the existing power intake (Figure A-34). No new access

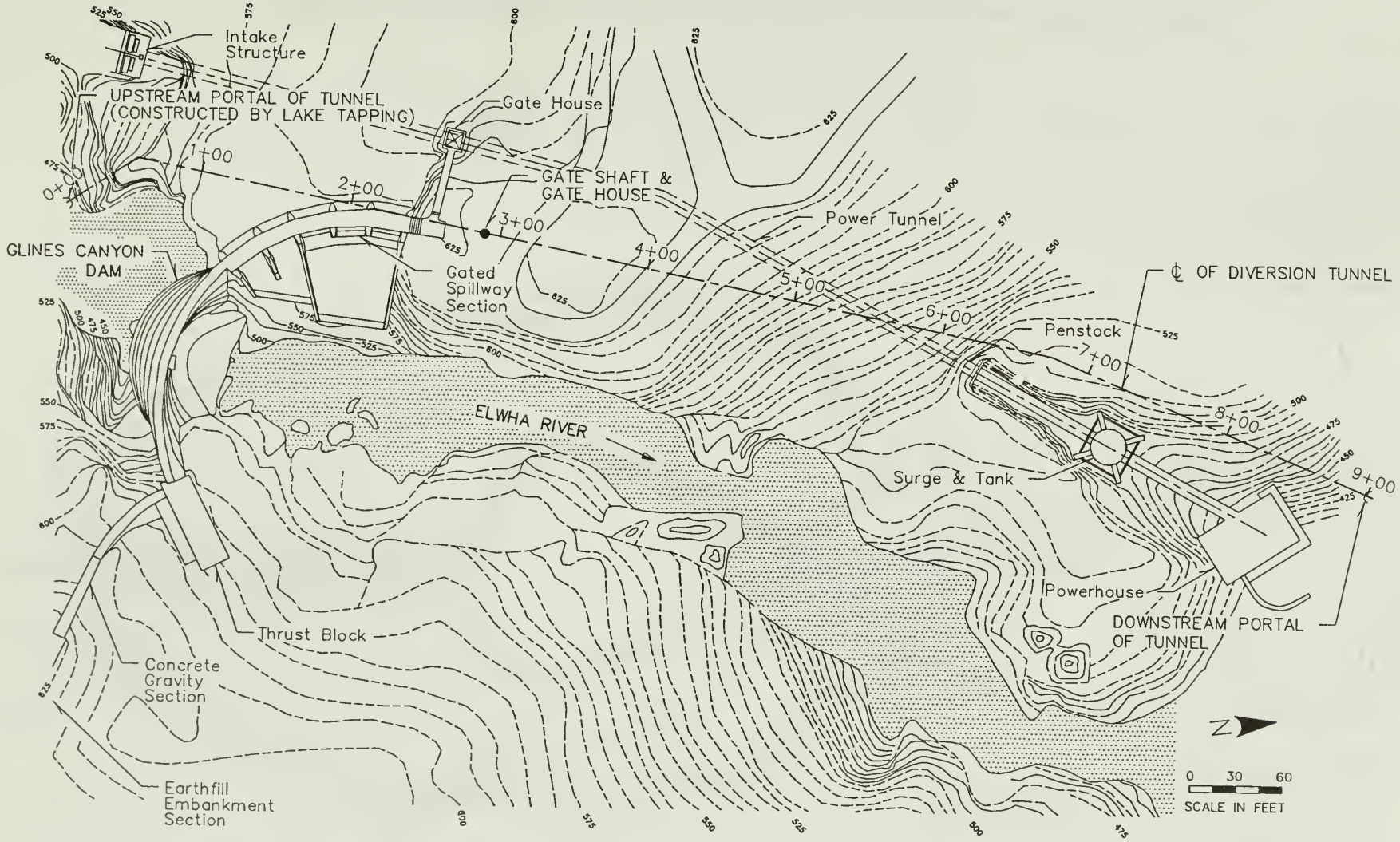
roads would be required to construct the diversion tunnel. A staging area of approximately two acres would be required and would be located north of the existing dam adjacent to the existing access road.

3.2.2 Sediment Management

Approximately 10,900,000 cy of sediment are estimated to be contained within Lake Mills. Materials excavated from the deltas and reservoir areas would be placed within the reservoir area, on top of broad terraces to form gradually sloping terraces, similar to the existing deltas. A river channel would be scoured during drawdown through the lake sediments. Natural armor material and large woody debris would be installed along the new channel and tributary banks. This would reduce the time it takes for the channel structure to form, reducing the amount of erosion and slumping from the toe of the new terraces in floods. The addition of armor material would not be needed where the old channel is encountered. Additional armor material would wash from Rica Canyon in the first winter season following the initial drawdown.

Careful grading and placement of check dams of rock and large woody debris would be used to develop the structure of the tributaries flowing off the valley walls onto the new erosive sediment storage terraces. Because the stored sediment is mostly very permeable sand, water soaks in quickly. Water from small tributaries and swales will soak-in, flowing to the river as groundwater. Small wetlands would be designed into the grading of the new terraces and channels. Side slopes of the channel and the top of the new terraces would be revegetated to assist in stabilization and erosion prevention. During the initial stages of reservoir drawdown, equipment and personnel would likely access the upstream delta by barge. As the lake is further drawn down, access would occur via temporary construction roads (Figure A-35).

Vegetation of the sediment disposal terraces would proceed in a manner similar to that described for Lake Aldwell (Section 3.1.3).



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Figure A-33. Dam removal plan, Glines Canyon, project diversion tunnel. (Source: the staff).

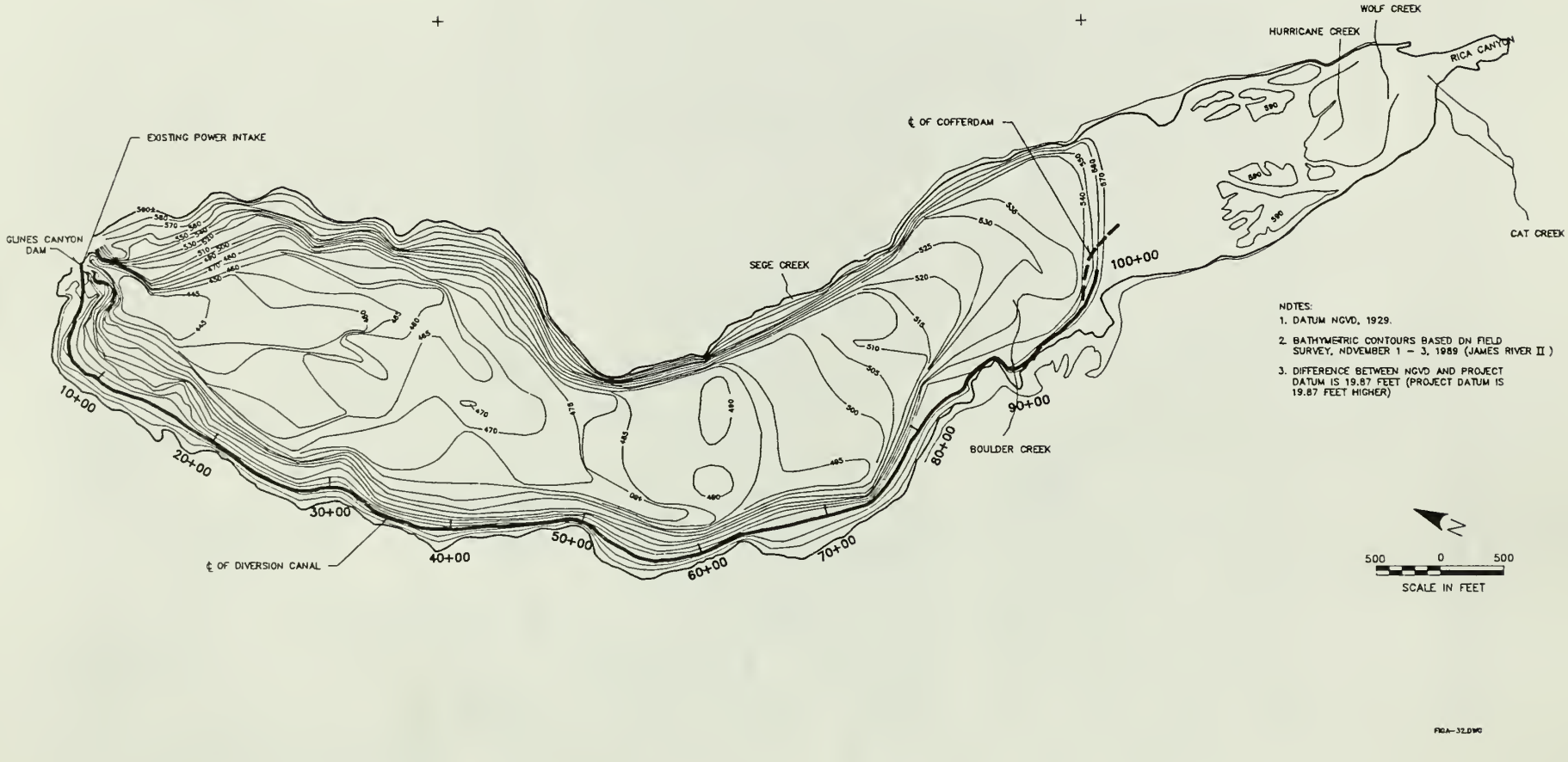


Figure A-34. Dam removal plan, Glines Canyon project, channel bypass. (Source: the staff).

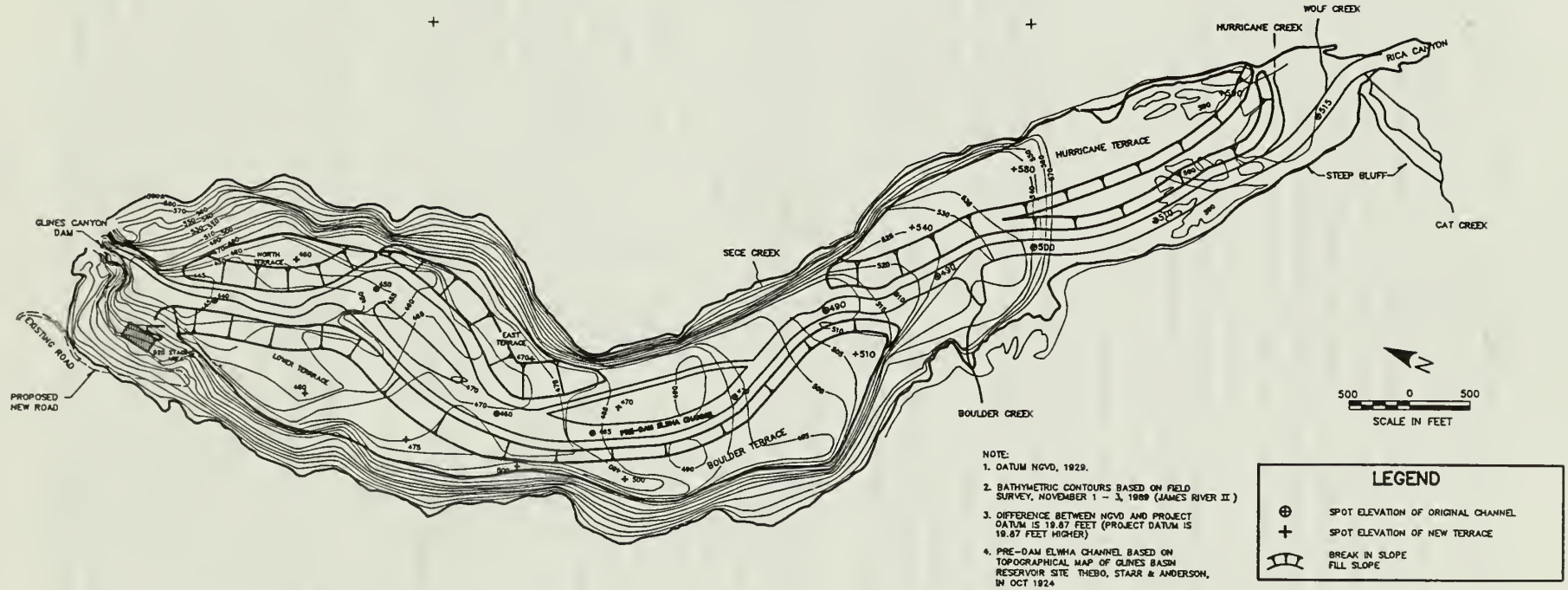


Figure A-35. Sediment stabilization plan, Glines Canyon project. (Source: the staff).

3.2.3 Removal of Project Facilities

The concrete arch dam is the major structure, having a height of approximately 195 feet, a width of approximately 155 feet at the crest and 55 feet at the base, and a total concrete volume of approximately 15,200 cy including the volume for the spillway, abutment block, and small retaining wall on the right abutment. Structures integral with the dam include the gated spillway structure, right abutment thrust block, and the short wall and fill section on the right abutment. Remaining structures associated with the project include the power tunnel intake structure, power tunnel, penstock conveyance system, and the powerhouse. The dam and other concrete structures would be demolished by drilling and blasting.

3.2.4 Construction Sequence

To create a low-level outlet for the diversion tunnel, lake tap construction would be employed. Construction would extend from the downstream outlet and advance toward the reservoir. A rock plug would remain near the entrance of the diversion tunnel until construction of all tunnel components was completed. The plug would then be removed by blasting. Following installation of a trashrack, draining the reservoir through the tunnel would begin.

Using the preferred diversion scheme of a tunnel and control gate, stabilization of the sediment would be initiated concurrently with the reservoir drawdown. A dragline would be used in the upstream delta area to control channel development while the drawdown is underway. Exposed sediment surfaces would be excavated using conventional excavation methods with the silt materials requiring a draining and drying period prior to excavation. Excavated material would be placed in designated terraces within the existing reservoir boundary. Silt material in approximately the middle and lower third portion of the reservoir would remain generally undisturbed. Unstable material would be allowed to sluff into the erosion channel and be carried out through the diversion. The naturally occuring stabilization of the slopes would be followed with revegatation efforts. These silt terraces would be hydroseeded and covered by matting material to reduce erosion before vegetation is established. Following completion of all sediment stabilization activities, dam removal acivities would begin.

Following initial reservoir drawdown, thus exposing the upstream delta, earth-moving equipment would be moved to the delta on barges. Additional lowering of the lake would allow for construction of river training works and for dragline excavation to be initiated. The river would be channeled to the west side of the delta (Figure A-35). Lake Mills would be lowered to the 520-foot elevation with the existing power tunnel inlet or proposed diversion tunnel. As Lake Mills is lowered to the 520-foot level, the delta sediments between El. 520 and El. 590 would rapidly erode. The channel sides would be maintained at modest slopes with bulldozers. A deposition zone between the lower delta and the 520-foot

reservoir surface would likely form a braided-river pattern. Cobbles, gravel, sand, and coarse and medium silt would be deposited as a new delta. Delta sediments that remain as the Hurricane Terrace (about 4 million cy) would be graded as needed to form a wide floodway with stable slopes, seeded, mulched, and planted with trees (Figure A-35). As the lake is lowered, further rapid erosion would occur within the channel through the delta and stabilization work would continue. Exposed areas would be excavated and the material hauled to terrace locations. Completed terraces would then be vegetated.

Use of the diversion tunnel would provide control over reservoir outflow. To prevent large amounts of sediment from being transported downstream during flood flows, the flow could be controlled so that excess flows would accumulate within the reservoir. During periods when the diversion tunnel carries an excessive sediment load, the open channel bypass would provide a means of diverting at least a portion of the flow, thus diluting the sediment-laden flow from the reservoir. Essentially, all sediment stabilization activities would be completed prior to beginning demolition of the dam.

The diversion tunnel structure would remain operational throughout the removal or stabilization of sediments and the removal of the dam. Once the river was redirected into the original alignment, the diversion tunnel would be decommissioned. The tunnel would be plugged with concrete caps and filled as necessary. The control gate and structure would also be removed with any surface openings plugged for safety. The power tunnel would be similarly decommissioned by plugging.

3.2.5 Spoil and Rubble Disposal

Material obtained from tunnel construction would consist of rock and rock fragments. The total volume of material would be approximately 6,300 cy, and would be disposed of by transporting to an off-site land disposal area.

Rubble resulting from demolition of the dam and other concrete structures would also be hauled to the upland disposal site. This material would account for an additional 18,000 cy.

Assuming a placement depth of 6 to 8 feet, the disposal area needed to accommodate the spoil and rubble from removal of both projects would be about 8 acres.

PART 4 - OTHER ALTERNATIVES CONSIDERED AND REASONS FOR REJECTION

This section contains a discussion of various means of fish passage and dam removal at the Elwha and Glines Canyon projects. It summarizes the evaluations of the staff that led to the elimination of certain options from further consideration. These options had been identified by the staff during the scoping process, but after an initial screening-level evaluation, it was determined that they did not offer any distinct advantages over the options that were selected for incorporation into the principal alternatives described in Section 2.0.

4.1 DAM RETENTION

Multiple approaches were considered for each of the two aspects of dam retention with anadromous fish restoration: (1) upstream passage and (2) downstream passage. In each case one of the approaches consisted of the applicant's proposal, with additional approaches considered as appropriate.

4.1.1 Approaches to Upstream Passage

The two dams are impassable barriers to upstream migrating fish. At present, there are no provisions for upstream passage by upstream migrating fish at either dam. Restoration of anadromous fish to the river above the dams therefore requires installation of upstream fish passage facilities of some type. The two main types considered are fishways (fish ladders) and trap-and-haul facilities. Within each main type there can be considerable design variation which can substantially affect successful fish passage.

4.1.1.1 Elwha Project

Four approaches to upstream passage at the Elwha Project were considered: a trap-and-haul facility; the applicant's proposed right bank fish ladder; an alternative right bank fish ladder design developed by the staff; and a left bank fish ladder for use in conjunction with a right bank ladder. The left bank fish ladder for use in conjunction with the right bank ladder was eliminated from detailed evaluation, since the likelihood of needing both a left and right bank ladder is not high.

Trap-and-haul facilities at Elwha have been proposed by various parties in the past, both for permanent fish passage and for interim mitigation. A fish trap is placed in proximity to a barrier to further upstream fish passage. The trap consists of a short fish ladder with its entrance at or near the barrier, leading to fish holding pools. Upstream migrating fish are stopped by the barrier and enter the fish ladder. Species separation may be performed as desired by diverting individual fish with flap gates into the proper pool as they travel along a flume

upstream of the short ladder. Fish are subsequently crowded from the holding pools into a portable container and then either transferred to a tank truck or carried in the container to the release point or points upstream. The fish trap could be located either upstream or downstream of the Elwha powerhouses. If it were located upstream of the powerhouses the barrier would be much less costly because there would be little normal flow and the channel is very narrow; however, the powerhouse draft tube portals would then need to be screened to divert fish away from them and to the ladder entrance.

The applicant's proposed fish ladder would be located upstream of the Elwha powerhouses and would climb the south (right descending) bank of the gorge. A low-level barrier weir would be constructed across the right bank spillway channel, and the powerhouse draft tube portals would be screened. The ladder entrance would be a short section of vertical slot fishway, with flow augmented by collection of the spillway gate leakage into the ladder to provide better attraction to the first vertical slot. Upstream of the vertical slot fishway, the fish would pass through a transport channel within the barrier weir to the right bank; upstream of the transport channel in the barrier weir would be a short section of concrete pool-and-weir/orifice fishway, followed by a metal Denil fish ladder with enlarged resting pools every 40 feet, rising at an overall slope of 16 percent until forebay water level was reached. Once the forebay water level was reached, a flat flume would lead the fish to a trash-racked exit on the south shore of Lake Aldwell about 100 feet beyond the dam. A fish capture and enumeration facility consisting of holding and sorting pools constructed parallel to the flat flume would also be provided.

The alternate fish ladder would occupy the same route, and have nearly the same end points, as the applicant's proposed ladder; the powerhouse draft tube portals would also be screened and the barrier weir would be located in the same place. The alternate fish ladder would be provided with an entrance pool equipped with gated fish entrances both at the upstream end of the powerhouse draft tube screen and adjacent to the barrier weir. An attraction flow of 100 cfs would be provided at each fish entrance, augmenting the ladder flow by means of an auxiliary water system carrying water from the forebay (Lake Aldwell) as well as utilizing spillway gate leakage. The ladder would be a concrete pool-and-weir/orifice ladder ascending the right bank of the gorge. The ladder would end at the fish exit on the south shore of Lake Aldwell, which would have a coarse trash rack; the adjacent auxiliary water entrance would have a fine bar rack. A fish counting and sorting facility would be provided, reached by a short Denil ladder section into which fish would be shunted off the main ladder. The makeup water for the fish counting and sorting facility would be provided under pressure from the auxiliary water pipeline, which would run parallel to the fish ladder for most of its route.

Of the alternatives evaluated, a ladder is preferred to a trap-and-haul because it involves no handling of fish and no confinement stress, and the potential for delay is less because the fish can move when they want. Of the choices for ladders, the alternate ladder would offer better performance than the applicant's proposal because it has more positive fish attraction and it avoids potential problems associated with resting pools and trash accumulation which are recognized weaknesses in the applicant's proposed Denil ladder.

4.1.1.2 Glines Canyon Project

Three approaches to upstream passage at the Glines Canyon Project were considered: a trap-and-haul facility as proposed by the applicant; an alternative right bank fish ladder design developed by the staff; and a left bank ladder. The left bank fish ladder was eliminated from further consideration because other proposed facilities would occupy the necessary space on the left bank and conflict with the ladder.

The applicant's proposed fish trap would be placed in proximity to a barrier located just upstream of the powerhouse. The trap would consist of a short fish ladder with its entrance between the left end of the barrier and the upstream end of the tailrace bar rack, with the ladder leading across the draft tube portals to fish holding pools on the riverbank just downstream of the powerhouse. Low head pumps located in the tailrace would supply water to operate the fish ladder. The barrier weir would consist of a low concrete sill equipped with electric shock devices to discourage fish passage. A notch in the barrier weir would be provided at the left end next to the fish ladder entrance to provide more flow for fish attraction on that side of the weir.

The fish ladder option formulated by the staff would be located upstream of the existing Glines Canyon powerhouse and would climb the east (right descending) bank of the river outside the gorge. A reinforced rockfill barrier dam would be constructed across the river in the narrows upstream of the powerhouse, and the powerhouse draft tube portals would be screened. The high and low level fish entrances would be located downstream of the right abutment of the barrier dam and would lead into an entrance pool. They would be gated and would be supplied with 100 cfs each by an auxiliary water system taking its supply from Lake Mills. The ladder would be a concrete pool-and-weir/orifice ladder with auxiliary water provided as required for the lower two pools to keep overflow velocities up during high tailwater. The auxiliary water pipe would end at a sleeve valve to dissipate excess head. The ladder would end at a fish exit on the shore of Lake Mills adjacent to the right abutment of the arch dam, which would have a coarse trash rack; the adjacent auxiliary water entrance would have a fine bar rack. A fish counting and sorting facility would be provided, reached by a short Denil ladder section into which fish would be shunted off the main ladder. The makeup water for the fish counting and sorting facility would be provided

under pressure from the auxiliary water pipeline, which would run parallel to the fish ladder for most of its route.

Of the alternatives evaluated, a ladder is preferred to a trap-and-haul because it involves no handling of fish and no confinement stress, and the potential for delay is less because the fish can move when they want. The ladder entrance through a gated opening into an entrance pool is preferred to an entrance directly into a ladder pool because it allows the fish to become adjusted to the ladder interior before having to move further upstream. In addition, the reinforced rockfill dam is preferred over the low sill barrier weir proposed by the applicant for diverting fish into a ladder entrance because it is a more positive barrier than the low sill and does not rely on experimental technology such as the electric shock devices.

4.1.2 Approaches to Downstream Passage

There are three basic methods of downstream passage for juvenile anadromous fish migrating past hydroelectric projects: passage in spill; passage through the turbines; and passage in a bypass system, usually associated with fish screens, although various other devices have been used to divert fish away from turbine intakes and into bypass systems.

4.1.2.1 Elwha Project

Three alternatives were evaluated for downstream passage at the Elwha Project: spillway improvements; penstock screens; and forebay screens. The applicant proposes to improve spill facilities at Elwha to improve downstream passage survival. This is necessary but not sufficient, since the applicant does not propose to spill water at Elwha most of the time, and studies have shown that turbine passage survival at Elwha is not sufficient to meet the goals of the restoration program. Two alternative bypass systems were evaluated: the Eicher screen system proposed by the applicant (and concurred with by the staff as a prime alternative) and a forebay screen alternative developed by the staff for application in the event that the prime alternative proves unsatisfactory.

The applicant's proposed Eicher screen system consists of four 9-foot nominal size tilting-type penstock screens with Hendrick bar screen media, bypassing 10 to 20 cfs of flow each to a common bay. The individual screen bypass entrances into the common bay are each provided with a downward acting roller gate for individual flow control. The common bay provides for return of most of the bypass flow to the forebay or to the excitation turbine penstock by means of vertical traveling screens and low-head pump-back pumps. A small amount of flow containing the bypassed fish is sent on to the tailrace by means of a small metal fish ladder attached to the right wall of the left bank spillway.

The staff's alternative proposal, for implementation in the event that the applicant's Eicher screen system proves unsatisfactory, consists of a forebay screen upstream of the turbine intakes. The vertical traveling screens would be arranged in a "vee" with the apex downstream; water admitted to the screen house through inclined, mechanically raked trash racks would be guided by training walls past the traveling screen basket faces at a sweeping velocity of twice the approach velocity. Bypassed flow would be collected in a small screen bay to reduce the water transported with the fish, which would be sent on to the tailrace by means of the same fish ladder used with the Eicher screens. The excess water separated from the fish would be pumped back to the forebay to minimize energy loss, or could be used to supply the excitation turbine.

Of the screening alternatives evaluated, the applicant's proposal is deemed potentially preferable based on very early performance test results. In the staff's view, however, the Eicher screen option needs to be back-stopped by the option of subsequent installation of forebay screens if the Eicher system proved unable to meet the passage survival goals of the restoration program. The applicant's proposed spillway improvements are considered adequate and no alternatives were considered.

4.1.2.2 Glines Canyon Project

Two alternatives were evaluated for downstream passage at Glines Canyon. The applicant has proposed to spill water from Gate No. 5. The staff has developed an alternative proposal consisting of a new screened turbine intake with fish bypass, which could be operated without spill.

The applicant's proposal calls for a small quantity of nighttime spill during the months of downstream migration for target fish species. No changes would be made to the unscreened turbine intake.

Because of the configuration and location of the existing intake, screening of the existing intake is not deemed practical.

The alternative screened turbine intake proposed by the staff would be located beyond the left abutment of the existing dam. It would include a fish bypass system and could be used to replace fish passage spill altogether. It would feature vertical traveling screens arranged in a "vee" with the apex downstream; water admitted to the screen house through inclined, mechanically raked trash racks would be guided by training walls past the traveling screen basket faces at a sweeping velocity of twice the approach velocity. Roller gates would be provided at two levels to draw water from the surface and also at depth, to improve fish capture and allow temperature control. Bypassed flow would be collected in a fish transportation conduit, which would pass under the structure and emerge at the ground surface nearby. From the conduit the fish would be transferred into a

small metal fish ladder for a descent generally paralleling the existing access road to the tailrace of the powerhouse.

Spill alone will not capture all the downstream migrants, especially the chinook or any other species which are not exclusively near-surface migrants. Unacceptably high losses have been observed in chinook which passed through the Glines Canyon turbine. A new turbine intake is an expensive alternative, and therefore it is conceived to be part of a capacity enhancement project for Glines Canyon. When river flow exceeds project hydraulic capacity and spill occurs, the minimum quantity of spill should be that demonstrated adequate for successful fish passage.

4.2 DAM REMOVAL

Multiple approaches were considered for each of the three aspects of any dam removal plan: (1) river diversion during project removal; (2) reservoir sediment disposition; and (3) project structures removal.

4.2.1 Approaches to River Diversion

A significant aspect of any dam removal scheme is the diversion of the river during the removal process. Successful diversion is required for work to be conducted in dewatered conditions, thereby resulting in safe and more efficient conditions for the performance of work. In considering potential removal schedules, site work sensitive to flows would be focused in the July-through-September period when average flows are lowest. A flood flow for this 3-month period having a 10-year recurrence interval was estimated by the staff at 3,500 cfs and was used as a basis for sizing diversion features. Because of the multi-year duration of the decommissioning activities, the 10-year flood flow was judged to be more appropriate than a 3- to 5-year diversion design flood more typical of in-river construction.

4.2.1.1 Elwha Project

For removal of the Elwha Project, three general approaches were identified for diverting river flows during dam removal activities: (1) controlled demolition; (2) an in-channel diversion scheme; and (3) a low-level diversion tunnel.

The controlled demolition option would involve sequential demolition of the dam, starting from the crest, as a means of simultaneously draining the reservoir and removing the dam. Demolition would proceed with a series of notches which would allow for reservoir drainage and river flow after each successive section of the dam is removed. Dredging of a stable channel through the earth and rockfill adjacent to the Elwha dam would also be required. This dredging operation would necessarily penetrate the impervious lining above the earth and rockfill upstream and below the concrete gravity dam. Because of the pervious nature of

this fill material, the controlled demolition approach could potentially result in a rapid evacuation of Lake Aldwell once the impervious layer was breached.

The in-channel diversion option for the Elwha Project would consist of a diversion channel leading to the left bank spillway, with a cofferdam downstream of the channel to isolate river flow from the remaining portions of the dam structure. The cofferdam would be an embankment 6 to 8 feet high, with a crest elevation of 180 feet, a crest width of 15 feet, and a length of about 480 feet. The diversion channel constructed upstream of the cofferdam would divert flows through the existing left bank spillway, after the spillway's gates, concrete piers and superstructure had been removed and the spillway crest had been lowered approximately 5 feet.

The low-level diversion would consist of a 13.5-foot-diameter, 980-foot-long concrete-lined tunnel bypassing the dam and located in the left abutment. The tunnel would be gated to control the release of flows and include a trashrack at its upstream end. The tunnel would accommodate between 3,500 cfs and 9,950 cfs depending upon reservoir water surface elevation. The diversion tunnel option would result in complete reservoir drainage and the complete bypass of existing structures during the removal activities.

The principal consideration in assessing diversion options at the Elwha Project is downstream safety during the sediment control and dam removal activities. A major concern is the potential instability of the fill materials placed to cut off seepage under the dam during its early history. Both the controlled demolition and in-channel diversion options would require eventual breaching of the potentially unstable materials, with no alternative path for the remaining reservoir water and the normal river flow. This final step would present an exposure to uncontrolled breaching and associated sediment transport. With the major focus on safety, the gated low-level tunnel, with its ability to afford positive control of flows and reservoir levels without affecting dam integrity, represents the superior approach to diversion at the Elwha Project. The diversion tunnel provides maximum safeguard against uncontrolled release of water and sediment along with maximum flexibility to control reservoir levels and safely pass high flows. For these reasons, the controlled demolition and in-channel diversion options were eliminated from further consideration, and the low-level diversion tunnel was adopted as the preferred approach for river diversion during Elwha Project decommissioning.

4.2.1.2 Glines Canyon Project

Three approaches were identified for diverting flows during Glines Canyon dam removal activities: (1) in-channel diversion; (2) a channel bypass; and (3) a low-level diversion tunnel.

The in-channel diversion option would consist of an outlet constructed through the concrete arch dam. The outlet would be 7.5 feet in diameter and consist of a steel-lined dam adit and a steel pipe extension. On the downstream end, a 6-foot-diameter valve gate would control the outflow and discharge at riverbed level.

The channel bypass approach would entail the use of the existing power intake and conduit system. River flows would be diverted at the upper end of the reservoir by means of a low fill diversion embankment that would transition into a trapezoidal open channel running for about 8,000 feet along the western edge of the reservoir. The channel, with a 23-foot width at the base and 1-to-1 side slopes, would have a capacity of 3,500 cfs. Riverflow would be conveyed via the channel to the existing intake structure. The powerhouse would be modified to allow for free discharge from the tunnel and penstock system. Following completion of the diversion, the reservoir would be dewatered by means of incremental lowering of the arch dam by blasting and mechanical means.

The low-level diversion tunnel would involve construction of a 12-foot-diameter, 925-foot-long concrete-lined tunnel in the left abutment. The tunnel would include a vertical gate shaft and control gate, and the outlet portal would be in the vicinity of the Glines Canyon powerhouse.

Of the options evaluated, the diversion tunnel approach is preferred because of the positive control it affords of river flows and reservoir levels, without the drawbacks associated with the alternatives. The in-channel diversion scheme with discharge facilities constructed in the dam would present an exposure to potential overstressed conditions in the dam due to the presence of the void. While detailed stress analysis would be necessary to determine the potential for such a condition to arise, the safety hazard associated with potential dam failure arising from overstressing precludes the adoption of this approach without the additional engineering analyses. The channel bypass option would provide the benefit of conveying relatively sediment-free flow to the downstream river reaches since water would be diverted at the headwater of the reservoir. The major drawbacks, however, are: the continuous exposure to diversion embankment overtopping and associated rebuilding; the complete loss of downstream flow if the diversion or channel were to be breached; the necessity for channel construction purposes to remove the upper portion of the dam (to 20 feet below the spillway crest) prior to constructing the channel; and the need to remove the dam in order to drain the reservoir.

While the staff recommends a diversion tunnel as the principal means of flow control during Glines Canyon Project decommissioning, it is also recommended that the diversion tunnel option be supplemented at Glines Canyon with a scaled-down version of the channel bypass. The modified channel would follow the same alignment as described above, but would be substantially smaller and

have a reduced capacity (1,000 cfs). The modified channel bypass would be used to divert sediment-free river water from the head of Lake Mills and thereby provide the capability to dilute sediment-laden diversion tunnel discharges and reduce suspended sediment concentrations downstream.

4.2.2 Approaches to Disposing of Reservoir Sediments

Over the period of project operation, a large quantity of sediment transported downstream through the river system has accumulated in Lake Mills and Lake Aldwell. Any dam removal option would eliminate the lake and the associated sedimentation process that occurs in the lake. Subsequent formation of a free-flowing river would revive the sediment transport capability of the system. The major concern with any removal scheme is the subsequent transport of sediment downstream at unusually large rates because of the existing accumulation, and aggradation or accumulation in the downstream river reach. Excessive accumulation would result in elevated streambeds and possibly in water levels increasing above current levels during flood flows. Three alternatives have been considered for control of these sediments: (1) natural flushing; (2) complete removal; and (3) in-reservoir stabilization. The three options apply to both the Elwha and Glines Canyon projects.

With the natural flushing option, sediment management activities would be limited to controlling reservoir drawdown and seeding of exposed and barren surfaces. During reservoir drawdown, a cut would naturally develop in the sediment delta in the upper end of the reservoir. Material eroded from the cutting action would be carried further into the reservoir, and erosion and sediment transport would continue until equilibrium conditions were achieved. The extent of sediment transport at any particular time would be proportional to flow. Normal flows would erode and transport modest amounts of material, while quantities transported would be greatly increased during flood flows. Downstream sedimentation would fill pools, expand river bars and cause channel shifting in the lower reach of the Elwha River. Although natural river processes would eventually remove much of this sediment from the river system without dredging, it could take decades to remove the accumulated sediment and to establish an equilibrium condition with respect to sediment transport throughout the downstream reaches.

A second option identified is complete removal. The objective of this approach would be to avoid sedimentation impacts by removing a substantial portion, or all, of the trapped sediment prior to or concurrent with dam removal. Complete removal would involve dredging, possible dewatering of the dredged sediment, and transport of the sediment by truck or slurry pipeline to an off-site disposal location. Disposal would occur at either an upland disposal site in the general vicinity of the projects or in the open water of the Strait of Juan de Fuca. The

latter disposal option would require a longer haul and probable construction of a barge loading facility.

In-reservoir sediment management, the third identified approach would involve the creation of a stable channel through the drained reservoirs, with dredged sediment placed away from the channel in sediment disposal terraces located within the confines of the existing reservoir. The terraces would be revegetated.

In the staff's view, stabilization of the majority of reservoir sediments within the existing confines of the reservoir is the preferred approach. When compared to the natural flushing option, in-reservoir stabilization is preferred, because massive downstream sediment transport would be avoided, along with the associated channel aggradation. In comparison to complete sediment removal, in-reservoir stabilization would provide comparable fish passage and habitat benefits at a substantially lower cost, particularly in the case of Glines Canyon (Table A-3). In-reservoir sediment management would result in greater long-term suspended sediment concentrations than with complete sediment removal, as periodic flood flows gradually scoured the terraced deposits. On the other hand, the disturbance impacts of decommissioning activities would be limited to the immediate project vicinity, and off-site environmental degradation would be largely avoided.

Table A-3. Estimated construction costs for sediment management approaches (Source: the staff).

Approach	Construction cost (in thousands of 1990 dollars) Elwha Project	Glines Canyon Project
In-Reservoir Management	$14,700	$25,000
Complete Removal	$19,100	$82,800

4.2.3 Approaches to Removal of the Dam Structures

In addition to river diversion and sediment management, project decommissioning would also require the actual destruction of the dams and disposal of the rubble. The Elwha dam is comprised of a main gravity section, two spillway sections and an intake section. The Glines Canyon dam consists of the concrete arch, a spillway structure, a thrust block and short wall and fill sections on the right abutment. Two approaches to dam removal were identified during EIS scoping: (1) complete removal; and (2) partial removal.

Complete removal would involve demolition of the dam structures using conventional drill and blast techniques used for rock excavation. The dam sections would be taken down to a level commensurate with the elevations of the adjacent river channel (e.g., El. 80 for the Elwha gravity section and El. 410 for the Glines Canyon arch section). Blasting would be controlled so that most of the concrete rubble would be directed to the dewatered upstream side of the dam where it would then be loaded into trucks and hauled to the disposal site.

With the partial removal option, the lower portion of the dam would be retained in place to serve as a sediment retention weir, and the concrete rubble would be disposed of in the river channel. At Elwha, the crest of the remaining stub would be at approximately El. 125, and the stub height would be about 45 feet. The corresponding elevation for the Glines Canyon dam would be El. 460, with a stub height of about 50 feet. During demolition of the structure's upper portions, concrete debris would be placed in the river channel immediately downstream. Debris would be spread along the streambed to a final elevation, at the upstream end, equaling the crest of the remaining dam stub. From that point, the debris deposit would slope downstream at a grade of approximately 4 percent in the case of the Elwha Project and 5 percent at Glines Canyon. Concurrent with debris deposition, sand and gravel obtained from the dewatered reservoir would be placed to eliminate voids within the debris mass. A layer of larger natural materials would provide a cap to the debris layer.

At the Glines Canyon Project, retaining a 50-foot-stub of the arch dam would permanently increase the upstream streambed elevation for an estimated 5,000 feet. This reach, elevated by sands, gravels, and cobbles immobilized by the remaining portion of the dam, would taper in elevation from roughly 50 feet above the original streambed (at the dam) to the elevation of the natural streambed at the point where the existing and newly formed streambed converge. By retaining the sediment "wedge" behind the dam, approximately 1,000,000 cy of sands and gravels would be permanently immobilized. With the area upstream of the dam stub filled with sediment, natural river processes would begin to carry material over the stub of the dam and gradually deposit sands and gravels in the downstream riverbed. By engineering the sloped portion of the riverbed to contain the concrete rubble and filling the interstices with sands and gravels, the flow conveyed through the debris mass could be confined to approximately 2 cfs (based on an estimated permeability of 1 cm/sec).

Retaining a portion of the dam at either Elwha or Glines Canyon and developing the streambed immediately downstream would result in unassisted fish passage in the upstream and downstream directions. It also would retain and immobilize a portion of the fill material and accumulated sediment upstream of the dam stub. Immobilizing this accumulated sediment would reduce the total amount of sediment that would otherwise need to be moved and/or stabilized. A less desirable result of retaining a portion of the dam would be the tendency of the

river at the dam stub and immediately upstream, to be wider than the original channel. A wider streambed would result in a corresponding increase in the width of flow, along with reduced depths and velocities. In general, the elevated river channel would not be as suitable for fish passage and habitat as a channel following the natural contour.

In the staff's view, the preferred option is the complete removal of the dam. Complete removal offers fewer uncertainties than the partial removal option and preferable channel characteristics, while cost differences are not substantial (Table A-4).

Table A-4. Estimated construction costs for dam structure removal options (Source: the staff).

Approach	Construction cost (in thousands of 1990 dollars)	
	Elwha Project	Glines Canyon Project
Complete Removal	$1,800	$1,160
Partial Removal	$1,340	$1,260

PART 5 - OPERATION, MAINTENANCE AND REPAIR COSTS FOR DAM RETENTION

This part of Appendix A identifies routine operation and maintenance costs and nonroutine repair and replacement activities that can be reasonably anticipated over the next 50 years at the Glines Canyon and Elwha projects, assuming dam retention. It also presents estimates of recurring energy losses due to fish facility releases and removal of dams.

5.1 ROUTINE OPERATION AND MAINTENANCE OF THE HYDROELECTRIC FACILITIES

This category of costs includes all routine ongoing operation and maintenance activities associated with the hydroelectric facilities. It excludes the operation and maintenance of any new fish passage facilities or any addition to powerplant capacity; these are addressed separately.

The period 1982 through 1989 represented a transition from a lower level of project performance and maintenance to a distinctly higher level (personal communication, Orville Campbell, James River II, July 27, 1990). Increased attention was directed at project safety and at safeguards against plant outage. As a result, the costs of operation and maintenance rose at a high rate (Table A-5).

Table A-5. Routine operation and maintenance costs (Source: letter from Priscilla Derick, attorney for James River II to Lois Cashell, secretary, FERC, dated August 7, 1990).

	Annual Cost		
Year	Elwha Project	Glines Canyon Project	Total
1982	$389,925	$309,001	$ 698,926
1983	477,759	292,118	769,877
1984	426,330	454,082	880,412
1985	465,162	277,266	742,428
1986	571,019	335,056	906,075
1987	518,243	319,666	837,909
1988	686,775	372,024	1,058,799
1989	913,056	538,945	1,452,001

Having reached a higher level of project upkeep, future cost increases are anticipated by the staff to reflect the general trend in the underlying inflation rate, which is projected for this analysis at 5 percent.

5.2 ESTIMATED ENERGY USE AND LOSS

The operation of the fish passage facilities would require water flow of varying quantities. Except during times of spill when flow exceeds the hydraulic capacity of the power facilities, the fish facility flows result in reduced power generation. Additionally, certain fish facilities require energy for pumping water. Finally, dam removal alternatives would be associated with the complete loss of energy generation.

Energy use and loss for each alternative is summarized in Table A-6.

5.3 LONG-TERM REPAIR AND REPLACEMENT

Forecasts of repairs and replacement were made by the staff for five decade-long periods, based on dam safety reports, technical periodicals and engineering judgment. These activities are in addition to routine operation and maintenance functions. Approximate costs (January 1, 1990 dollars) are shown for each period and for each project (Table A-7 and A-8). The estimated costs shown are meant to be representative of the timing and magnitude of nonroutine expenditures, not a precise forecast of future repair and replacement requirements.

Table A-6. Estimated energy use and loss associated with fish facility operations and dam removal (Source: the staff).

Item	Basis	Energy (kWh) annually)
APPLICANT'S PROPOSAL		
Elwha Ladder	25 cfs year-round [1/]	1,184,000
Elwha Screen		
Bypass Flow	10 cfs year-round [1/]	474,000
Pump Back	70 cfs at 10' head year-round [1/]	519,000
Glines Canyon Trap and Haul	25 cfs at 10' head year-round (continuous)	228,000
Glines Canyon Spill	100 cfs for 8 hrs/day from Mid-April to Mid-November[1/]	1,507,000
Total (Energy Use/Loss)		3,912,000
STAFF-DEVELOPED MEASURES		
Elwha Ladder	49.5 cfs year-round [1/]	2,351,000
Elwha Screen (Conventional)		
Bypass Flow	10 cfs year-round [1/]	474,000
Pump Back	70 cfs at 10' head year-round [1/]	519,000
Wash Pumps	10 cfs at 60 psi (140' head)	1,296,000
Glines Canyon Ladder		
Ladder Flow	29.5 cfs year-round [1/]	2,007,000
Pumped Attraction Flow	75 cfs at 10' head year-round [1/]	420,000
Glines Canyon Screen		
Bypass Flow	20 cfs year-round [1/]	1,430,000
Wash Pumps	10 cfs at 60 psi (140' head) continuous	1,296,000
Spill	Spill at least 450 cfs when occurring	3,757,000
REMOVAL OF BOTH DAMS		
Elwha	Full loss of project output	70,000,000
Glines Canyon	Full loss of project output	102,000,000
Total (Energy Use/Loss)		172,000,000
GLINES CANYON REMOVAL AND RETENTION OF ELWHA		
Elwha Ladder	25 cfs year-round [1/]	1,184,000
Elwha Screen		
Bypass Flow	10 cfs year-round [1/]	474,000
Pump Back	70 cfs at 10' head year-round[1/]	519,000
Glines Canyon Removal	Full loss of project output	102,000,000
Total (Energy Use/Loss)		104,177,000

[1/] Does not include any energy use/loss when water availability in excess of requirement.

Table A-6. (Continued).

Item	Basis	Energy (kWh annually)
ELWHA REMOVAL AND RETENTION OF GLINES CANYON		
Elwha Removal	Full loss of project output	70,000,000
Glines Canyon		
Trap And Haul	25 cfs at 10' head year-round	228,000
Glines Canyon Spill	100 cfs for 8 hrs/day from Mid-April to Mid-November[1/]	1,507,000
Total (Energy Use/Loss)		71,735,000

[1/] Does not include any energy use/loss when water availability in excess of requirement.

Table A-7. Forecast of repairs or replacement reasonably foreseen over the next 50 years (1990-2040), Elwha Project. (Source: the staff).

Feature	Repair or replacement item	Ten-Year Periods				
		1990-1999	2000-2009	2010-2019	2020-2029	2030-2040
Elwha Project						
General	Part 12 Safety Inspection	40,000	40,000	40,000	40,000	40,000
Spillway/Intake Section	Test and install anchors			70,000		
	Repair spalled concrete	10,000	10,000		10,000	
	Nondestructive testing of dam concrete		20,000		20,000	
	Overhaul north spillway gates		20,000		20,000	
	Overhaul south spillway gates		25,000		25,000	
	Inspect trashracks and intakes	10,000	10,000		10,000	
	Repair intake gates and gate seals	25,000		25,000		
	Repair trashracks	15,000		15,000		
Penstocks and Surge Tanks	Painting		50,000		50,000	
	Measure pipe thickness	5,000	5,000		5,000	
	Repair penstocks and surge tank	50,000		50,000		
Powerhouse	Repair turbines					
	(1) horizontal Francis	500,000			500,000	
	(2) vertical Francis	500,000			500,000	
	Rewind generators (4 each)	1,000,000			1,000,000	
	Miscellaneous		10,000		10,000	
Transmission Lines	Conductors		400,000			
	Poles and insulators	130,000	130,000	130,000	130,000	130,000
Substation	Transformer (s)		120,000			
	Switchgear	100,000		100,000		
Access Roads	Periodic repair	10,000	10,000	10,000	10,000	10,000
Totals		2,395,000	850,000	440,000	2,330,000	180,000

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Table A-8. Forecast of repairs or replacement reasonably foreseen over the next 50 years (1990-2040),Glines Canyon Project. (Source: the staff).

Feature	Repair or replacement item	Ten-Year Periods				
		1990-1999	2000-2009	2010-2019	2020-2029	2030-2040
Glines Canyon Project						
General	Part 12 Safety Inspection	40,000	40,000	40,000	40,000	40,000
Dam	Test and install anchors			10,000		
	Repair earthfill embankment section		10,000		10,000	
	Nondestructive testing of dam concrete		20,000		20,000	
Spillway	Overhaul radial gates		25,000		25,000	
	Repair spillway concrete			10,000		
	Inspect trashracks and intakes	10,000				
	Repair intake gates and gate seals	15,000		15,000		
	Repair trashracks and future intake bulkheads	10,000		10,000		
Tunnel Upstream of Gate Shaft	Repair gunite lining	100,000		100,000		
Tunnel Downstream of Gate Shaft	Repair gunite lining	50,000		50,000		
Gate Shaft	Repair concrete transition	50,000			50,000	
Penstock and Surge Tank	Painting		40,000		40,000	
	Measure pipe thickness		4,000		4,000	
	Repair penstocks and surge tank	40,000		40,000		
Powerhouse	Repair turbine			400,000		
	Rewind generator				400,000	
	Miscellaneous		10,000		10,000	
	Bank erosion downstream	5,000	5,000	5,000	5,000	5,000

Table A-8. (Continued).

Feature	Repair or replacement item	Ten-Year Periods				
		1990-1999	2000-2009	2010-2019	2020-2029	2030-2040
Glines Canyon Project						
Transmission Lines	Conductors		200,000			
	Poles and insulators	65,000	65,000	65,000	65,000	65,000
Substation	Transformer		150,000			
	Switchgear	100,000		100,000		
Access Roads	Periodic repair	10,000	10,000	10,000	10,000	10,000
	TOTALS	495,000	579,000	545,000	1,079,000	120,000

PART 6 - CAPITAL COST ESTIMATES

This portion of Appendix A contains the basis for capital cost estimates presented in other parts of the EIS. Unless otherwise indicated, all costs are presented in 1990 dollars and exclude interest during construction. The estimates include contractor's overhead and profit, owner's costs, sales tax, and a contingency appropriate to the type of feature being estimated.

The estimates are grouped into three subsections: (1) the applicant's fish passage plan (Table A-9); (2) the modified fish passage proposal (Tables A-9 through A-15); and (3) dam removal (Tables A-16 through A-22).

Table A-9. Summary of applicant's fish passage plan costs. (Source: the staff, modified from Hosey & Associates, Response to February 1, 1989 Request for Additional Information Item 1, Fish Passage and Restoration Plan, June 5, 1990).

Feature	Capital Cost (1990$)	Plant Outage Costs (1994$)[1/]
ELWHA PROJECT		
Upstream Passage	$3,217,521	$ 187,440
Downstream Passage	3,729,974	170,400
GLINES CANYON PROJECT		
Upstream Passage	2,404,384	880,400
Downstream Passage	N/A	N/A
FISH PRODUCTION FACILITIES	3,070,000	
Total	$12,421,879	$1,238,240

[1/] Forecasted 1994 cost of purchased power (28.4 mills/kWh) applied to applicant's energy loss estimates.

A-10 Cost Estimate Summary - Elwha Fish Ladder
A-11 Cost Estimate Summary - Elwha Conventional Screen Structure
A-12 Cost Estimate Summary - Elwha Left Bank Spillway Modifications
A-13 Cost Estimate Summary - Glines Canyon Fish Ladder
A-14 Cost Estimate Summary - Glines Canyon Intake Screen House
A-15 Cost Estimate Summary - Glines Canyon Additional Powerhouse

Table A-10. Cost estimate summary, Elwha fish ladder. (Source: the staff).

FERC Acct. No.	Description	Quantity	Units	Unit Price	Amount (1990 $)
332	Reservoirs, Dams, and Waterways				
332.5	Waterways				
332.59	Fish Facilities				
332.591	Diversion/Control of Water		LS		18,500
332.592	Structural Excavation	7,223	CY	18.50	133,626
332.593	Concrete Structures	3,060	CY	445.00	1,361,840
332.594	Auxiliary Water Pipeline				
332.5941	Excavation	2,331	CY	15.50	36,131
332.5942	Pipe, 5' Dia.	700	LF	163.00	114,100
332.5943	Support Saddles 50 ea.	52	CY	390.00	20,280
332.5944	Encasement	245	CY	62.00	15,190
332.5945	3' Dia. Piping and Appurtenances	20,000	LB	2.90	58,000
332.5946	2' Dia. Piping and Appurtenances	5,000	LB	3.20	16,000
332.595	Metalwork				
332.5951	Denil Ladder and Flume	16,520	LB	4.81	79,461
332.5952	Handrail	1,500	LF	17.40	26,100
332.5953	Walkway Grating	8,600	SF	12.15	104,490
332.5954	Diffusers	231	SF	10.00	2,310
332.5955	Trashracks	57	SF	32.50	1,861
332.5956	Orifice Plates	28	SF	10.00	280
332.596	Gates and Valves				
332.5961	Auxiliary Water Gate (3'-6 x 3'-6)		LS		4,100
332.5962	Fish Entrance Gates (3'-6 x 3'-6)	2	EA	4,100	8,200
332.5963	Intake Gate (Ladder - 4' x 5')		LS		4,900
332.5964	Aux. Water Supply Bulkhead (5' x 5')		LS		4,900
332.5965	Turning Pool (2' Dia.)		LS		2,300
332.5966	Gate Valve (30" Dia.)		LS		3,450
332.5967	Gate Valves (2' Dia.)	3	EA	2,800	8,400
332.5968	Butterfly Valve (5' Dia.)		LS		22,500
	Subtotal Direct Construction				$2,047,000
	Contractor's Overhead and Profit				396,000
	Subtotal Direct and Indirect				$2,443,000
	Overhead Construction:				
	Owner's Costs (30%)				733,000
	Washington State Sales Tax (8%)				195,000
	Subtotal for Contingency				$3,371,000
	Contingency (25%)				843,000
	TOTAL PROJECT COST				$4,214,000

Table A-11. Cost estimate summary, Elwha conventional screen structure (Source: the staff).

FERC Acct. No.	Description	Quantity	Units	Unit Price	Amount (1990 $)
	PRODUCTION PLANT				
332	Reservoirs, Dams, and Waterways				
332.42	Intake Structure				
332.421	Cofferdam				
332.4211	Inst. and Rem. Dike Fill	17,675	CY	17.40	307,545
332.4212	Pumping and Dewatering		LS		53,000
332.4213	Temporary Access		LS		37,500
332.422	Excavation				
332.4221	Common	20,278	CY	5.00	101,390
332.4222	Rock	17,756	CY	19.00	337,364
332.4223	Backfill	5,739	CY	15.00	86,085
332.423	Intake Structure Concrete				
332.4231	Structural Concrete	3,650	CY	334.00	1,219,100
332.4232	Reinforcing Steel	365,000	LB	0.55	200,750
332.424	Outlet Gates and Hoists				
332.4241	Trashracks (4,200 SF)	151,200	LB	2.30	347,760
332.4242	Traveling Screens	14	EA	75,500	1,057,000
332.4243	Bulkheads - 6 slots, 3 bulkheads	183,000	LB	2.30	420,900
332.425	Handrail	800	LF	17.40	13,920
332.426	Grating	1,500	SF	12.15	18,225
332.427	Level Monitoring		LS		25,000
332.428	Screen Wash Pumps	2	EA	34,500	69,000
332.429	Dewatering Facility		LS		8,800
332.43	Piping		LS		36,000
	Subtotal, Intake Structure				$4,339,339
332.6	Fish Flume	2,200	LF		
332.61	Auger Holes	440	EA	111.00	48,840
	Support Bents	220	EA	135.00	29,700
	Trough and Weirs	2,200	LF	70.00	154,000
332.62	Plastic Sun Shade	2,200	LF	110.00	242,000
	Subtotal Fish Flume	2,200	LF	215.70	474,540
	Subtotal, Reservoirs, Dams, and Waterways				$4,813,879
	Subtotal Direct Construction				$4,814,000
	Contractor's Overhead and Profit				596,000
	Subtotal Direct and Indirect				$5,410,000
	Overhead Construction:				
	Owner's Costs (30%)				1,623,000
	Washington State Sales Tax (8%)				433,000
	Subtotal for Contingency				$7,466,000
	Contingency (25%)				1,867,000
	TOTAL PROJECT COST				$9,333,000

Table A-12. Cost estimate summary, Elwha left bank spillway modifications (Source: the staff).

FERC Acct. No.	Description	Quantity	Units	Unit Price	Amount (1990 $)
	PRODUCTION PLANT				
332	Reservoirs, Dams, and Waterways				
332.41	Spillway				
332.412	Excavation				
332.4121	Rock	200	CY	115.00	23,000
332.4122	Demolition of Existing Concrete	30	CY	85.00	2,550
332.413	Concrete				
332.4131	Ogee	124	CY	319.00	39,556
332.4132	Chute	425	CY	379.00	161,075
332.4133	Training Walls	159	CY	439.00	69,801
332.4134	Reinforcing Steel	50,000	LB	0.55	27,500
332.4135	Rock Anchors	180	EA	115.00	20,700
332.414	Tainter Gates and Hoists				
332.4141	Diversion and Water Control		LS		23,400
332.4142	Reconstruct Existing Gate Seals		LS		8,150
332.4143	Additional Gate Hoist		LS		17,400
	Subtotal, Spillway				$393,132
	Subtotal Direct Construction				$393,000
	Contractor's Overhead and Profit				75,000
	Subtotal Direct and Indirect				$468,000
	Overhead Construction:				
	Owner's Costs (30%)				140,000
	Washington State Sales Tax (8%)				37,000
	Subtotal for Contingency				$645,000
	Contingency (25%)				161,000
	TOTAL PROJECT COST				$806,000

Table A-13. Cost estimate summary, Glines Canyon fish ladder (Source: the staff).

FERC Acct. No.	Description	Quantity	Units	Unit Price	Amount (1990 $)
332	Reservoirs, Dams, and Waterways				
332.5	Waterways				
332.59	Fish Facilities				
332.591	Diversion/Control of Water		LS		18,500
332.592	Structural Excavation	5,443	CY	18.50	100,696
332.593	Concrete Structures	3,810	CY	445.00	1,553,939
332.594	Auxiliary Water Pipeline				
332.5941	Excavation	1,166	CY	15.50	18,065
332.5942	Pipe, 3' Dia.	350	LF	102.90	36,014
332.5943	Support Saddles 18 ea.	20	CY	390.00	7,800
332.5945	3' Dia. Piping and Appurtenances	20,000	LB	2.90	58,000
332.5946	2' Dia. Piping and Appurtenances	5,000	LB	3.20	16,000
332.595	Metalwork				
332.5951	Denil Ladder and Flume	16,520	LB	4.81	79,461
332.5952	Handrail	3,180	LF	17.40	55,332
332.5953	Walkway Grating	9,680	SF	12.15	117,612
332.5954	Diffusers	129	SF	10.00	1,290
332.5955	Trashracks	1,068	SF	32.50	34,710
332.5956	Orifice Plates	16	SF	10.00	160
332.596	Gates and Valves				
332.5961	Auxiliary Water Gate (3'-6 x 3'-6)		LS		1,650
332.5962	Fish Entrances (3'-6 x 3'-6)	2	EA	1,650	3,300
332.5963	Intake (Ladder - 4' x 5')		LS		3,000
332.5964	Intake (Aux. Water 3' Dia.)		LS		2,650
332.5966	Gate Valve (30" Dia.)		LS		12,000
332.5967	Gate Valves (2' Dia.)	3	EA	9,600	28,800
332.597	Pumped Auxiliary Water				
332.5971	12,000 gpm Vertical Turbine Pumps	4	EA	23,200	92,800
332.5972	Gate Valves (2' Dia.)	4	EA	9,600	38,400
332.5973	Electrical	4	EA	2,300	9,200
332.5974	Header/Manifold	5,000	LB	3.20	16,000
332.5975	Pipe, 3' Dia.	150	LF	102.90	15,434
332.5976	Excavation (Under Riverbed)	500	CY	27.00	13,500
332.5977	Encasement (Under Riverbed)	66	CY	62.00	4,092
336	Excavation for Roadway	11,000	CY	9.50	104,500
	Subtotal Direct Construction				$2,584,000
	Contractor's Overhead and Profit				499,000
	Subtotal Direct and Indirect				$3,083,000

Table A-13. (Continued).

FERC Acct. No.	Description	Quantity	Units	Unit Price	Amount (1990 $)
	Overhead Construction:				
	Owner's Costs (30%)				925,000
	Washington State Sales Tax (8%)				247,000
	Subtotal for Contingency				$4,255,000
	Contingency (25%)				1,064,000
	TOTAL PROJECT COST				$5,319,000

Table A-14. Cost estimate summary, Glines Canyon intake screen house (Source: the staff).

FERC Acct. No.	Description	Quantity	Units	Unit Price	Amount (1990 $)
	PRODUCTION PLANT				
332	Reservoirs, Dams, and Waterways				
332.42	Intake Structure				
332.421	Cofferdam				
332.4211	Inst. and Rem. Sheet Pile	204	TON	630.00	128,520
332.4212	Inst. and Rem. Cell Fill	2,858	CY	17.40	49,729
332.4213	Pumping and Dewatering		LS		53,000
332.4214	Temporary Access		LS		37,500
332.422	Excavation				
332.4221	Common	20,278	CY	5.00	101,390
332.4222	Rock	17,756	CY	19.00	337,364
332.4223	Backfill	5,739	CY	15.00	86,085
332.423	Intake Structure Concrete				
332.4231	Structural Concrete	5,161	CY	334.00	1,723,774
332.4232	Reinforcing Steel	516,100	LB	0.55	283,855
332.424	Outlet Gates and Hoists				
332.4241	Trashracks (2,400 SF)	86,400	LB	2.30	198,720
332.4242	Traveling Screens	12	EA	75,500	906,000
332.4243	Bulkheads - 4 ea. 16' wide x 12' high	64,334	LB	2.30	147,968
332.4244	Gates, Upward Opening, 2 ea.	46,862	LB	4.10	192,134
332.4245	Gates, Downward Opening, 5 ea.	36,645	LB	4.10	150,245
332.425	Handrail	600	LF	17.40	10,440
332.426	Grating	1,500	SF	12.15	18,225
332.427	Level Monitoring		LS		25,000
332.428	Trash Flume		LS		26,000
332.429	Screen Wash Pumps	2	EA	34,500	69,000
	Subtotal, Intake Structure				$4,544,949
332.53	Abandon Existing Facilities				
332.531	Preparatory Work		LS		4,200
332.532	Decommission Intake Structure		LS		3,660
332.533	Decommission Gate Structure		LS		3,660
332.534	Decommission Tunnel		LS		3,660
332.535	Cut Penstock		LS		3,660
332.536	Tunnel Concrete Plug	400	CY	330.00	132,000
	Subtotal, Modifications to Tunnel				$150,840

Table A-14. (Continued).

FERC Acct. No.	Description	Quantity	Units	Unit Price	Amount (1990 $)
332.6	Fish Flume	2,200	LF		
332.61	Auger Holes	440	EA	16.00	7,040
332.61	Support Bents	220	EA	135.00	29,700
332.61	Trough and Weirs	2,200	LF	70.00	154,000
332.62	Plastic Sun Shade	2,200	LF	40.00	88,000
332.63	3' Dia. Pipe to Fish Flume		LS		26,000
	Subtotal, Fish Flume	2,200	LF	138.52	$304,740
332.8	Penstock				
332.81	Upper				
332.811	Excavation				
332.8111	Common	12,400	CY	5.00	62,000
332.8112	Rock	344	CY	19.00	6,536
332.8113	Bedding	300	CY	18.00	5,400
332.8114	Backfill	4,000	CY	5.00	20,000
332.812	Steel Penstock	300	LF		
332.8121	Purchase 12.5' Dia. Penstock	157	TON	1,200.00	188,400
332.8122	Install and Connect to Existing	157	TON	1,440.00	226,080
	Subtotal, New Penstock				$508,416
	Subtotal, Reservoirs, Dams, and Waterways				$ 659,256
	Subtotal Direct Construction				$5,509,000
	Contractor's Overhead and Profit				787,000
	Subtotal Direct and Indirect				$6,296,000
	Overhead Construction:				
	Owner's Costs (30%)				1,889,000
	Washington State Sales Tax (8%)				504,000
	Subtotal for Contingency				$8,689,000
	Contingency (25%)				2,172,000
	TOTAL PROJECT COST				$10,861,000

Table A-15. Cost estimate summary, Glines Canyon additional powerhouse (Source: the staff).

FERC Acct. No.	Description	Quantity	Units	Unit Price	Amount (1990 $)
	PRODUCTION PLANT				
331	Power Plant Structures				
331.1	Powerhouse				
331.11	Cofferdam				
331.111	Inst. and Rem. Sheet Piling	310	TON	630.00	195,300
331.112	Inst. and Rem. Cell Fill	6,250	CY	17.40	108,750
331.12	Excavation				
331.121	Common Excavation	4,852	CY	5.50	26,686
331.1211	Rock Exc. - Conventional	1,672	CY	19.00	31,768
331.1212	Rock Exc. - Tail Channel	890	CY	19.00	16,910
331.13	Powerhouse Substructure				
331.131	Concrete	1,107	CY	259.00	286,713
331.132	Reinforcing Steel	166,050	CY	0.45	74,889
331.133	Compacted Backfill	1,500	CY	5.00	7,500
331.16	Powerhouse Superstructure				
331.161	Misc. Architectural		LS		95,020
331.162	HVAC		LS		28,700
331.163	Lighting	2,500	SF	6.00	15,000
331.164	Miscellaneous Metal	40,000	LB	1.65	66,000
331.17	Draft Tube Bulkheads and Guides	8,900	LB	3.03	26,988
331.2	Miscellaneous Buildings and Structures				
331.21	Station Yard				
331.211	Excavation				
331.2111	Common	5,000	CY	5.50	27,500
331.2112	Rock	1,000	CY	19.00	19,000
331.212	Grading and Paving	200	SY	42.50	8,500
331.213	Fence	180	LF	15.00	2,700
	Subtotal, Power Plant Structures				$1,037,924
332	Reservoirs, Dams and Waterways				
332.7	Modifications to Surge Tank				
332.71	Remove Tank and Platform		LS		15,300
332.72	Shorten Legs and Riser Pipe		LS		8,900
332.73	Modify Existing Legs		LS		9,900
332.74	Reinstall Platform				6,900
332.75	Install New Tank Section		LS		51,300
332.76	Reinstall Old Tank Section		LS		24,300
	Subtotal, Modification to Surge Tank				$116,600

Table A-15. (Continued).

FERC Acct. No.	Description	Quantity	Units	Unit Price	Amount (1990 $)
332.8	Penstock				
332.86	Lower				
332.861	Excavate Trench				
332.8611	Common	500	CY	8.00	4,000
332.8612	Rock	200	CY	19.00	3,800
332.862	Bifurcation				
332.8621	Purchase Bifurcation	16	TON	2,000.00	32,000
332.8622	Crotch Welding	80	LF	50.00	4,000
332.863	Purchase 8' Dia. Penstock	26	TON	1,200.00	52,000
332.864	8' Flex Couplings	1	EA	5,200.00	5,200
332.865	11.5' Flex Couplings	2	EA	7,700.00	15,400
332.866	Cut and Remove Exist.		LS		2,750
332.867	Install Bifurcation		LS		5,150
332.868	Install Penstock		LS		31,100
332.869	8' Dia. Butterfly Valve	1	EA	168,600.00	168,600
332.870	Concrete Encase	200	CY	190.00	38,000
	Subtotal, New Penstock				$362,000
	Subtotal, Reservoirs, Dams and Waterways				$1,516,524
333	Waterwheels, Turbines, and Generators				
333.1	Turbine and Governor		LS		850,000
333.2	Generator and Exciter		LS		1,135,000
	Subtotal, Waterwheels, Turbines and Generators				$1,985,000
334	Accessory Electrical Equipment				
334.1	Connections, Supports, and Structures				
334.12	Conductors and Insulators				
334.121	Trays, Racks, Wireways < 12"	1,500	FT	15.00	22,500
334.122	Trays, Racks, Wireways > 12"	500	FT	20.00	10,000
334.123	Power Cable	6,000	FT	10.00	60,000
334.124	Power Cable Terminations	200	EA	15.00	3,000
334.125	Grounding System				
334.1251	2/O and 250 MCM Cu. Cond.	3,000	FT	5.00	15,000
334.1252	15' Ground Rods	20	EA	200.00	4,000
334.1253	Cadweld Connections	40	EA	50.00	2,000
334.1254	Controller Grounding	200	FT	5.00	1,000
334.126	Control Cable	15,000	FT	2.00	30,000
334.127	Control Cable Termination	3,000	EA	5.00	15,000
334.13	Conduits				
334.131	Rigid Cond. 1/2" to 1-1/2"	1,500	FT	7.00	10,500

Table A-15. (Continued).

FERC Acct. No.	Description	Quantity	Units	Unit Price	Amount (1990 $)
334.132	Rigid Galv. Cond. >2"	500	FT	20.00	10,000
334.2	Switchgear and Control Equipment				
334.21	6.6 kV Switchgear with Relays	1	EA	0	178,580
334.22	Station Service Transformer	1	EA	34,290	34,290
334.23	Low Voltage Switchgear	1	EA	108,580	108,580
334.24	Control Equipment	1	EA	88,580	88,580
334.3	Battery System		LS		29,290
334.4	UPS System		LS		11,714
334.5	Instrumentation and Controls				
334.51	Forebay Level Monitoring	2	EA	5,857	11,714
334.52	Conduits and Wires for Above		LS		5,000
334.53	Flow Measurement		LS		100,000
334.6	Miscellaneous Electrical		LS		50,000
	Subtotal, Accessory Electrical Equipment				$800,748
335	Miscellaneous Power Plant Equipment				
335.1	Fire Protection		LS		33,000
335.2	Miscellaneous Mechanical		LS		80,000
335.3	Communication System		LS		34,290
	Subtotal, Miscellaneous Power Plant Equipment				$147,290
336	Roads and Bridges				
336.1	Permanent Access Road to Powerhouse				
336.11	Additional Excavation, Rock	1,000	CY	13.00	13,000
336.12	Surfacing, 6" Crushed Rock	100	CY	25.00	2,500
	Subtotal, Roads and Bridges				$15,500
	TRANSMISSION PLANT				
353	Substation and Switching Station Equipment				
353.2	Switchgear and Control Equipment				
353.21	Main Power Transformer		LS		217,130
356	Overhead Conductors and Devices				
356.1	Remove Existing				
356.11	Poles and Structures		LS		19,000
356.12	Conductor	16,000	LF	0.94	15,040

Table A-15. (Continued).

FERC Acct. No.	Description	Quantity	Units	Unit Price	Amount (1990 $)
358	Underground Conductors and Devices				
358.2	69 kV Underground Cable	57,000	LF	19.51	1,112,070
358.3	Trenching and Installation	19,000	LF	8.00	152,000
358.4	Elwha River Bridge Crossing		LS		20,000
358.5	Cable Splices and Terminations		LS		0
358.6	69 kV Line Switches	1	EA	10,000	10,000
	Subtotal, Transmission Plant				$1,545,240
	Subtotal Direct Construction				$5,995,000
	Contractor's Overhead and Profit				580,000
	Subtotal Direct and Indirect				$6,575,000
	Overhead Construction:				
	Owner's Costs (30%)				1,973,000
	Washington State Sales Tax (8%)				526,000
	Subtotal for Contingency				$9,074,000
	Contingency (25%)				2,269,000
	TOTAL PROJECT COST				$11,343,000

A-16 Cost Estimate Summary - Elwha Tunnel Diversion
A-17 Cost Estimate Summary - Elwha Reservoir Sediment Management
A-18 Cost Estimate Summary - Elwha Dam Complete Removal
A-19 Cost Estimate Summary - Glines Canyon Diversion Tunnel
A-20 Cost Estimate Summary - Glines Canyon Diversion Canal
A-21 Cost Estimate Summary - Glines Canyon Reservoir Sediment Management
A-22 Cost Estimate Summary - Glines Canyon Dam Complete Removal

Table A-16. Cost estimate summary, Elwha tunnel diversion (Source: the staff).

FERC Acct. No.	Description	Quantity	Units	Unit Price	Amount (1990 $)
332	Reservoirs, Dams, and Waterways				
.5000	Waterways				
.5001	Cofferdam Fill	8,000	CY	5.00	40,000
.5002	Cofferdam Removal	8,000	CY	1.60	12,800
.5311	Excavation, Rock	6,814	CY	70.00	476,980
.5312	Excavation, Lake Tap	14	CY	7,262.86	101,680
.5313	Excavation, Rock Trap	21	CY	130.00	2,730
.5314	Disposal Site	7,370	CY	2.30	16,951
.5315	Excavation, Gate Shaft and Vent	521	CY	115.00	59,915
.5321	Tunnel Lining	2,566	CY	415.00	1,064,890
.5322	Shaft Lining	250	CY	483.00	120,750
.5330	Decommissioning				
.5331	Concrete Plugs	64	CY	295.00	18,880
.5332	Misc. Removals	1	LS		7,000
.6111	Gate (14'h. x 10'w.)	32,000	LB	9.70	310,400
.6112	Gatehouse	1	LS		3,075
.6120	Trashrack	17,500	LB	2.40	42,000
336	Access Road	1,500	LF	84.00	126,000
	Subtotal Direct, Diversion Tunnel				$2,404,000
	Contractor's Overhead and Profit				485,000
	Subtotal Direct and Indirect				$2,889,000
	Overhead Construction:				
	Owner's Costs (30%)				867,000
	Washington State Sales Tax (8%)				231,000
	Subtotal for Contingency				$3,987,000
	Contingency (25%)				997,000
	TOTAL PROJECT COST				$4,984,000

Table A-17. Cost estimate summary, Elwha reservoir sediment management (Source: the staff).

FERC Acct. No.	Description	Quantity	Units	Unit Price	Amount (1990 $)
332	Reservoirs, Dams, and Waterways				
.1000	Reservoir				
.1001	Delta Dredging	340,000	CY	2.09	710,600
.1002	Delta Sediment Grading and Placement	900,000	CY	2.83	2,547,000
.1003	D/S Dredging and Placement, Silt	810,000	CY	3.77	3,053,700
.1004	Revegetation	267	AC	1,000.00	267,000
	Subtotal Direct Construction				$6,578,000
	Contractor's Overhead and Profit				1,894,000
	Subtotal Direct and Indirect				$8,472,000
	Overhead Construction:				
	Owner's Costs (30%)				2,542,000
	Washington State Sales Tax (8%)				678,000
	Subtotal for Contingency				$11,692,000
	Contingency (25%)				2,923,000
	TOTAL PROJECT COST				$14,615,000

Table A-18. Cost estimate summary, Elwha dam complete removal (Source: the staff).

FERC Acct. No.	Description	Quantity	Units	Unit Price	Amount (1990 $)
331	Structures and Improvements				
.1000	Demolish Powerhouse and Appurtenances	3,900	CY	18.00	70,200
.2000	Restoration and Grading	3.50	AC	2,300.00	8,050
332	Reservoirs, Dams, and Waterways				
.2000	Dams				
.2301	Concrete Removal, North Spillway	1,600	CY	18.00	28,800
.2302	Concrete Removal, Intake Structure	1,800	CY	18.00	32,400
.2303	Concrete Removal, Gravity Section	19,430	CY	18.00	349,740
.2304	Concrete Removal, South Channel Spillway	1,375	CY	18.00	24,750
.2305	Miscellaneous Removals	1	LS		100,000
.2306	Concrete Disposal	28,105	CY	7.30	205,167
336	Access Road	1,000	LF	84.00	84,000
	Subtotal Direct Construction				$903,000
	Contractor's Overhead and Profit				143,000
	Subtotal Direct and Indirect				$1,046,000
	Overhead Construction:				
	Owner's Costs (30%)				314,000
	Washington State Sales Tax (8%)				84,000
	Subtotal for Contingency				$1,444,000
	Contingency (25%)				361,000
	TOTAL PROJECT COST				$1,805,000

Table A-19. Cost estimate summary, Glines Canyon diversion tunnel (Source: the staff).

FERC Acct. No.	Description	Quantity	Units	Unit Price	Amount (1990 $)
332	Reservoirs, Dams, and Waterways				
.5000	Waterways				
.5001	Cofferdam Fill	3,325	CY	5.00	16,625
.5002	Cofferdam Removal	3,325	CY	1.60	5,320
.5003	Care of Water	1	LS		42,000
.5311	Excavation, Rock	5,245	CY	70.00	367,150
.5312	Excavation, Lake Tap	29	CY	3,568.28	103,480
.5313	Excavation, Rock Trap	44	CY	130.00	5,720
.5314	Excavation, Gate Shaft	1,011	CY	115.00	116,265
.5315	Excavation, Air Vent	35	CY	115.00	4,025
.5316	Disposal	6,364	CY	8.30	52,821
.5320	Concrete Lining	1,710	CY	415.00	709,650
.5331	Decommissioning				
.5332	Concrete Plugs	64	CY	295.00	18,880
.5333	Misc. Removals	1	LS		7,000
.6111	Gate (14'h. x 10'w.)	32,000	LB	5.01	160,400
.6112	Gatehouse	625	SF	50.00	31,250
.6120	Trashrack	17,500	LB	2.40	42,000
336	Access Road	500	LF	84.00	42,000
	Subtotal Direct Construction				$1,725,000
	Contractor's Overhead and Profit				345,000
	Subtotal Direct and Indirect				$2,070,000
	Overhead Construction:				
	Owner's Costs (30%)				621,000
	Washington State Sales Tax (8%)				166,000
	Subtotal for Contingency				$2,857,000
	Contingency (25%)				714,000
	TOTAL PROJECT COST				$3,571,000

Table A-20. Cost estimate summary, Glines Canyon diversion canal (Source: the staff).

FERC Acct. No.	Description	Quantity	Units	Unit Price	Amount (1990 $)
332	Reservoirs, Dams, and Waterways				
.5000	Waterways				
.5001	Cofferdam Fill	34,000	CY	4.00	136,000
.5002	Cofferdam Removal	34,000	CY	1.60	54,400
.5003	Care of Water	1	LS		34,500
.5411	Excavation, Rock	40,000	CY	15.00	600,000
.5412	Excavation, Common	360,000	CY	2.60	936,000
	Subtotal Direct Construction				$1,761,000
	Contractor's Overhead and Profit				408,000
	Subtotal Direct and Indirect				$2,169,000
	Overhead Construction:				
	Owner's Costs (30%)				651,000
	Washington State Sales Tax (8%)				174,000
	Subtotal for Contingency				$2,994,000
	Contingency (25%)				749,000
	TOTAL PROJECT COST				$3,743,000

Table A-21. Cost estimate summary, Glines Canyon reservoir sediment management (Source: the staff).

FERC Acct. No.	Description	Quantity	Units	Unit Price	Amount (1990 $)
332	Reservoirs, Dams, and Waterways				
.1000	Reservoir				
.1001	Delta Dredging	220,000	CY	2.09	459,800
.1002	Delta Sediment Grading and Placement	760,000	CY	2.83	2,150,800
.1003	Reservoir Sediment Dredging and Placement, Sand and Gravel	1,080,000	CY	3.73	4,028,400
.1004	Reservoir Sediment Dredging and Placement, Silt	1,050,000	CY	3.96	4,158,000
.1005	Revegetation	415	AC	1,000.00	415,000
	Subtotal Direct Construction				$11,212,000
	Contractor's Overhead and Profit				3,240,000
	Subtotal Direct and Indirect				$14,452,000
	Overhead Construction:				
	Owner's Costs (30%)				4,336,000
	Washington State Sales Tax (8%)				1,156,000
	Subtotal for Contingency				$19,944,000
	Contingency (25%)				4,986,000
	TOTAL PROJECT COST				$24,930,000

Table A-22. Cost estimate summary, Glines Canyon dam complete removal (Source: the staff).

FERC Acct. No.	Description	Quantity	Units	Unit Price	Amount (1990 $)
331	Structures and Improvements				
.1001	Demolish Powerhouse and Appurtenances	2,700	CY	5.50	14,850
.1002	Miscellaneous Removals	1	LS		75,000
.2000	Restoration and Grading	2	AC	2,300.00	4,600
332	Reservoirs, Dams, and Waterways				
.2000	Dams				
.2301	Concrete Removal, Arch Dam	10,880	CY	18.00	195,840
.2302	Concrete Removal, Spillway	2,260	CY	18.00	40,680
.2303	Concrete Removal, Abutment Block	1,800	CY	18.00	32,400
.2304	Concrete Removal, Gravity Section	200	CY	18.00	3,600
.2305	Concrete Removal, Intake Tower and Miscellaneous	140	CY	18.00	2,520
.2306	Concrete Haul and Dispose	17,980	CY	7.30	131,254
336	Access Road	1,000	LF	84.00	84,000
	Subtotal Direct Construction				$585,000
	Contractor's Overhead and Profit				87,000
	Subtotal Direct and Indirect				$672,000
	Overhead Construction:				
	Owner's Costs (30%)				202,000
	Washington State Sales Tax (8%)				54,000
	Subtotal for Contingency				$928,000
	Contingency (25%)				232,000
	TOTAL PROJECT COST				$1,160,000

PART 7 - COST SUMMARIES FOR THE ALTERNATIVES (SOURCE: THE STAFF)

This section of Appendix A presents tabular summaries of the various cost elements of the prinicipal alternatives (Tables A-23 through A-26).

Table A-23. Cost summary for the applicant's proposal. [1]

Item	Capital Costs: Construction Cost	Capital Costs: Plant Outage Cost [2]	Recurring Annual Expenses: Operation and Maintenance	Recurring Annual Expenses: Foregone Power Production (kWh) [3]
Elwha Project				
Upstream Fish Passage	$ 3,218,000	$ 188,000	$100,000	1,184,000
Downstream Fish Passage	3,730,000	170,000	48,000	993,000
Spillway Improvements	806,000			
Project Automation	475,000			
Stream Gage	60,000		10,000	
Recreation Facilities	47,000		7,000	
Terrestrial Habitat Protection	430,000		10,000	
Historical Resources Protection	5,000			
Glines Canyon Project				
Upstream Fish Passage	2,404,000	880,000	100,000	228,000
Downstream Fish Passage	0	0	0	1,507,000
Project Automation	400,000			
Recreation Facilities	20,000		3,000	
Historical Resources Protection	5,000			
Fish Production				
Facilities	3,070,000			
Initial Outplanting			240,000 [4]	
Long-Term Repair and Replacement				
Elwha	6,195,000 [3]			
Glines Canyon	2,818,000 [3]			
Operation & Maintenance				
Elwha Hydroelectric			959,000 [3]	
Glines Canyon Hydroelectric			566,000 [3]	

[1] James River II, Response to Request for Additional Information of May 28, 1987,Volume 1 of 4, May 27, 1988 and James River II, Final Response to Feb. 1, 1989 Request for Additional Information Item 1, Fish Passage and Restoration Plan, June 5, 1990, except as otherwise noted.

[2] Based on forecasted cost of purchased power in 1994 (1994$); all other costs are in 1990$.

[3] Staff estimate.

[4] First 10 years, only; after 10 years cost of $150,000 for rearing channel.

Table A-24. Cost summary for removal of both dams (Source: the staff).

Item	Capital Costs		Recurring Annual Expenses	
	Construction Cost	Plant Outage Cost (prior to 1996)[1]	Operation and Maintenance	Foregone Power Production (kWh)
Elwha Project				
Diversion Tunnel	$ 4,984,000	$ 3,472,000		70,000,000
Sediment Stabilization	14,615,000			
Structures Removal	1,805,000			
Revegetation	2,444,000		$ 30,000	
Power Factor Correction	79,000			
Glines Canyon Project				
Diversion Tunnel	3,571,000	7,589,000		102,000,000
Bypass Channel	3,743,000			
Sediment Stabilization	24,930,000			
Structures Removal	1,160,000			
Revegetation	3,743,000		45,000	
Power Factor Correction	101,000			
Fish Restoration				
Facilities	3,070,000			
Initial Outplanting			240,000[2]	

[1] Based on forecasted cost of purchased power in 1994 (1994$).
[2] First 10 years only.

Table A-25. Cost summary for Glines Canyon removal with retention of Elwha. (Source: the staff).

Item	Capital Costs		Recurring Annual Expenses	
	Construction Cost	Plant Outage Cost [1]	Operation and Maintenance	Foregone Power Production (kWh)
Elwha Project				
Upstream Fish Passage	$ 3,218,000	$ 188,000	$100,000	1,184,000
Downstream Fish Passage	3,730,000	170,000	48,000	993,000
Spillway Improvements	806,000			
Project Automation	475,000			
Stream Gage	60,000		10,000	
Recreation Facilities	47,000		7,000	
Terrestrial Habitat Protection	430,000		10,000	
Historical Resources Protection	5,000			
Glines Canyon Project				
Diversion Tunnel	3,571,000	7,589,000		102,000,000
Bypass Channel	3,743,000			
Sediment Stabilization	24,930,000			
Structures Removal	1,160,000			
Revegetation	3,743,000		45,000	
Power Factor Correction	150,000			
Fish Production				
Facilities	3,070,000			
Initial Outplanting			240,000 [2]	
Long-Term Repair and Replacement				
Elwha	6,195,000			
Operation & Maintenance				
Elwha Hydroelectric			959,000	

[1] Based on forecasted cost of purchased power in 1994 (1994$); all other costs are in 1990$.

[2] First 10 years, only; after 10 years cost of $150,000 for rearing channel.

Table A-26. Cost summary for Elwha project removal with retention of Glines Canyon. (Source: the staff).

Item	Capital Costs		Recurring Annual Expenses	
	Construction Cost	Plant Outage Cost[1]	Operation and Maintenance	Foregone Power Production (kWh)
Elwha Project				
Diversion Tunnel	$ 4, 984,000	$ 3,472,000		70,000,000
Sediment Stabilization	14,615,000			
Structures Removal	1,805,000			
Stream Gage	60,000		$10,000	
Revegetation	2,444,000		30,000	
Power Factor Correction	135,000			
Terrestrial Habitat Protection	430,000			
Glines Canyon Project				
Upstream Fish Passage	2,404,000	880,000	100,000	228,000
Downstream Fish Passage	0			1,507,000
Project Automation	400,000			
Recreation Facilities	20,000			
Historical Resources Protection	5,000		3,000	
Fish Production				
Facilities	3,070,000			
Initial Outplanting			240,000[2]	
Long-Term Repair and Replacement				
Glines Canyon	2,818,000			
Operation & Maintenance				
Glines Canyon Hydroelectric			566,000	

[1] Based on forcasted cost of purchased power in 1994 (1994$); all other costs are in 1990$.

[2] First 10 years, only; after 10 years cost of $ 150,000 for rearing channel.

PART 8 - RESOURCES AVAILABLE TO REPLACE THE ELWHA AND GLINES CANYON PROJECTS

This portion of Appendix A contains a description of the resources that are available to replace the power foregone by reduced output from the Elwha and Glines Canyon Projects. Each of the conservation and generating resources indentified by the Council as cost-effective is described in the paragraphs that follow.

This discussion is adapted from the Council's 1989 Supplement to the 1986 Northwest Conservations and Electric Power Plan (Northwest Power Planning Council, 1989b), augmented by Council staff-issued papers updating resource information (Northwest Power Planning Council, 1990).

8.1 Conservation Resources

The Council has identified conservation as a key resource for meeting the Northwest's future electrical energy needs, with as much as 2,400 average MW of achievable, cost-effective conservation available. The Council acknowledges significant uncertainty in estimates of cost-effective conservation, especially in the commercial and industrial sectors.

In the Council's definition, conservation resources are measures that enable residential and commercial buildings, appliances, and industrial and irrigation processes to use energy efficiently. Conservation also includes measures to reduce electrical losses in the region's generation, transmission, and distribution system. The Council sees conservation as a uniquely flexible resource that tends to automatically match growth in electrical demand and can be developed more quickly than generation resources.

In the residential sector, the Council has identified about 1,030 average MW of achievable conservation. About 60 percent of this resource is available from reducing the energy required to heat homes, both existing and new. In existing residences, savings from space heating can be achieved by improving the insulation level, adding storm windows, and reducing air leakage. For new homes, conservation estimates are based on implementation of the Council's model conservation standards. Washington and Oregon have taken significant action to improve building codes for new residential construction, and at least 36 jurisdictions in Washington, Idaho, and Montana have adopted local codes that meet the level of the model conservation standards. The Council believes that energy codes based on governmental regulatory authority are the best means for achieving savings in new buildings, but it also emphasizes utility marketing and incentive programs.

The energy used to heat water is the second largest residential sector end-use, and conservation savings can be achieved through better-insulated water heaters, pipe wraps, and more efficient hot water-using appliances (i.e., clothes washers and dishwashers).

The final residential sector conservation target identified by the Council is electricity consumed to operate other residential appliances, including refrigerators, freezers, stoves, and lights. The Council bases its estimated savings in this area on cost-effective efficiency improvements at levels defined by California's 1992 standards, which exceed the 1990 federal standards.

The Council reports that the commercial sector consumed approximately 22 percent of the region's total firm energy sales in 1987, or about 3,479 average MW. Office buildings and retail stores consume about 50 percent of the electricity used in the commercial sector, and space heating, space cooling, and lighting are the dominant end-uses. The Council estimates, in its high demand forecast, 530 average MW of achievable cost-effective conservation potential associated with existing commercial buildings and 470 average MW from new commercial buildings.

In the industrial sector, the Council assumes 280 average MW of achievable cost-effective conservation potential. This represents electrical energy savings identified by industrial plant managers associated with motors, motor controls, lighting, and other plant equipment.

Of particular interest for this analysis is the potential industrial conservation resource within the Daishowa America mill, along with the cost of realizing that potential. Since March 1989, Daishowa America reports the implementation of rebuild and upgrade measures that, together, account for a 26.6 GWh energy saving per year (letter from Yutaka Mochizciki and Stan Hicks, Daishowa America, March 29, 1990). (As a point of reference, the total output of the Elwha and Glines Canyon projects is about 172 GWh, and the mill's total annual energy requirement is about 400 GWh.) The savings have resulted from three individual projects having a combined capital cost of $71 million. Daishowa America reports that "further cost effective conservation opportunities are relatively limited" (letter from Yutaka Mochizciki and Stan Hicks, Daishowa America, March 29, 1990); no independent audit of remaining conservation potential has been undertaken.

The irrigation sector is a relatively small consumer of energy, representing about 620 average MW consumption, or less than 4 percent of the region's total. The Council has identified 75 average MW of conservation potential in this sector from the use of more efficient water application systems and irrigation scheduling improvements for new and existing acreage.

Table 8-1 presents a summary by sector of forecasted demand and planned conservation projected by the Council in its high-growth forecast. Conservation resources in the Council's plan reduce the projected overall demand for electricity by 8 percent from the demand levels associated with existing electrical energy use efficiencies.

Table 8-1. Summary of projected demand and conservation in the high forecast in 2010[1/] (average MW[2/]).

Sector	Demand in 2010			Conservation included in Council's plan
	With current efficiencies	With plan's conservation	Percent savings	
Residential	10,380	9,350	10	1,030
Commercial	7,880	6,890	13	990
Industrial	10,750	10,470	3	280
Agricultural	625	550	12	75
TOTAL [3/]	29,635	27,260	8	2,375

[1/] Source: Northwest Power Planning Council, 1989b.
[2/] Does not include line losses.
[3/] Excludes the category termed "other," which is a demand of 219 average MW.

8.2 Transmission and Distribution Efficiency Improvements

According to the Council, regional transmission and distribution system losses comprise about 7.5 to 9.0 percent of regional load. BPA and the Council have identified opportunities to reduce these losses. Identified measures include upgrading primary distribution feeder voltage, replacing standard transformers with higher efficiency designs, and reconductoring transmission lines and primary distribution feeders. The Council estimates that improvements to the efficiency of the region's transmission and distribution systems offer opportunities for securing at least 200 average MW of energy savings.

8.3 Conservation Voltage Regulation

The Council defines conservation voltage regulation as the process of reducing distribution feeder voltage drop and improving feeder voltage regulation so that the optimal voltage range for appliance operation is achieved at all points along the distribution circuit. Improved regulation generally improves appliance efficiency and thereby reduces energy consumption. Improved voltage regulation

is normally implemented in two steps. First, a loss reduction program is undertaken to reduce voltage drop along the feeder. Second, voltage regulation is adjusted to control the minimum standard voltage at the end of the distribution feeder. This may require improved voltage regulation equipment. The Council estimates a potential of about 200 average MW associated with cost-effective improvements. Pending further assessment, however, the Council has refrained from including this resource in its resource portfolio.

8.4 Existing Hydropower System Efficiency Improvements

The Council estimates 110 average MW of efficiency improvements from retrofit measures on the region's existing system of hydroelectric projects. According to the Council, it is possible to retrofit many of the older projects using advanced designs, materials, and equipment. The measures include improved designs for turbine blades, governors, and generator cooling systems; generator rewinding; use of solid state exciters, and high-efficiency transformers; reduced station service loads; improved project operating procedures; and reduced friction losses in hydraulic structures. The Council finds these measures attractive because of their low cost, short lead time, and flexibility.

8.5 Better Use of the Existing Hydropower System's Nonfirm Energy

In a typical water year, the region's hydropower system produces substantially more energy than during the critical (i.e., low) water period. In the Council's view, this large amount of nonfirm energy available in most years represents a resource that can be put to better use. The Council attributes significant regional benefits through strategies to make nonfirm energy more reliable so it can be used to dependably serve new and existing firm energy loads.

Methods to back up the region's nonfirm energy include the use of new powerplants, improved international cooperation on operating the Columbia River system, the purchase of energy from existing powerplants, and load management techniques such as increased interruptible loads. In its current plan supplement, the Council adopts new combustion turbine and combined-cycle powerplants as a representative vehicle for backing up the nonfirm component of the regional hydropower system, and it estimates that such a strategy represents an estimated 3,000 average MW resource. The Council's analysis indicates that simple-cycle combustion turbines would be cost-effective for about the first 1,000 MW of nonfirm hydropower. Each added increment of combustion turbine capacity must operate more often than the previous increment, since less nonfirm energy is available to displace combustion turbine operation. Therefore, each added increment of energy firmed up is more expensive than the preceding increment. Beyond 1,000 MW, more efficient combined-cycle plants become cost-effective because of the decreased availability of nonfirm hydropower.

Gas-fired combustion turbines have the advantage of short lead times, small module sizes, and relatively low capital costs. The Council's estimates of simple-cycle combustion turbine cost and performance are based on a new generation, high-temperature, heavy-duty design in the 135-150 MW range.

The Council's combined-cycle reference plant uses two combustion turbines, one heat recovery steam generator, and one steam turbine generator. The Council's generic combined-cycle plant consists of twin units installed near Hermiston, Oregon. The plant includes site improvements, a gas pipeline spur, weather enclosure, water supply facilities, cooling towers, a switchyard, and a transmission line linking the plant with the regional grid.

8.6 New Hydroelectric Development

The Council estimates that about 410 average MW of firm energy may be available from new hydropower development that is cost-effective and not precluded by stream reach protection designations. This potential includes retrofits at irrigation, flood control, and other nonpower water projects; additional generating equipment at existing hydroelectric projects; and construction of new projects at undeveloped sites. The Council's 410 average MW planning assumption represents about 500 individual projects.

With respect to exclusionary hydropower development options specific to the affected Elwha River reach, discussion of alternative projects is presented in Sections 2.3 through 2.6.

8.7 Cogeneration

Cogeneration is a well-established technology involving the sequential production of electricity and thermal energy. Approximately 900 MW of cogeneration capacity exists in the region, principally in the wood and paper industries. The thermal energy produced in cogeneration may be used for industrial process heating, space heating, hot water heating, and absorption chiller loads. Since the thermal energy offers value that can offset part of the cost of fuel and equipment, the electrical energy produced can be generated at less cost than electricity produced alone using comparable equipment and fuel.

The Council has identified nearly 2,200 average MW of new cogeneration but includes between 190 and 320 average MW in its current plan pending further evaluation.

Potentially, cogeneration is a resource option for the Daishowa America mill. Because of the size of the wood-waste fuel boiler and the availability of wood-waste fuel, cogeneration potential would be limited to about 15 MW (Washington State Department of Ecology, Draft Environmental Impact Statement, Expansion of Daishowa America Port Angeles Papermill, December 1989).

8.8 Coal-Fired Powerplants

Coal-fired units provide the region with 3,957 MW of capacity and 3,154 average MW of energy generation capability. While little coal is mined in the region, proven reserves of low sulfur coal are available near the region that far exceed the amount required to meet electricity needs for the foreseeable future. Although the Council intends to reassess the limits to coal use for the region because of increasing environmental concerns, the costs and performance characteristics of new coal-fired powerplants continue to be used by the Council to represent the region's long-term marginal resource because of the abundance of coal reserves and the proven nature of coal-fired generation technology. The Council's resource portfolio includes 4,800 average MW from new coal-fired powerplants.

The Council has identified three commercially available means of producing electricity from coal at a scale appropriate for regional consideration: pulverized coal-fired powerplants, atmospheric fluidized-bed powerplants, and coal gasification/combined-cycle powerplants. Pending further evaluation, the Council is using a twin unit pulverized coal-fired powerplant as the generic reference plant. Each unit is designed for a net capacity of 603 MW, typical of the larger plants constructed in recent years. The plant includes facilities for coal receiving, storage, handling, and preparation; a pulverized coal-fired boiler; a steam turbine generator; wet limestone scrubbers and electrostatic precipitators for emissions control; and a mechanical draft heat rejection system. The project also would include site improvements, water supply development, switchyards, and transmission facilities to link it with the regional grid. In keeping with the Council's assumptions, the reference plant would be located at a site such as Hermiston, Oregon. Coal would be delivered by unit train from outside the region.

8.9 Geothermal Resources

Recent Council estimates indicate that 3,600 to 4,600 MW of energy might be obtained from the region's geothermal resources at costs less than or comparable to the cost of new coal plants. If the resource proves out, the Council indicates that pilot plants could be operating by 1994, and commercial plants could be in service by 1997. While environmental effects of geothermal development are largely mitigable, promising geothermal resource areas are often remote, and located near environmentally sensitive natural areas. Geothermal plants produce high quality firm power, but dispatchability may be constrained. While proven

technology is available, the region's geothermal potential is largely unconfirmed; the Council has indicated an intent to include 350 average MW in its resource portfolio.

8.10 Wind Power

The region has favorable wind resources, but development of wind power in the Pacific Northwest has been very limited. The Council has found that the technical and economic potential for wind-generated electric energy in the region is substantial, but numerous constraints will limit the extent to which this resource potential can be developed. The Council has indicated an intent to include 400 average MW of wind-generated power in its resource portfolio.

8.11 Biomass

Biomass fuels generally include forest residues, wood product mill residues, agricultural field residues, waste products from animals and food processing, and municipal solid wastes. While the quantity of biomass produced in the region is large, there are competing uses and the cost of gathering the biomass can be excessively costly. While finding that biomass resources could technically and economically provide up to 1,600 average MW of stand-alone power (excluding cogeneration), the Council has tentatively included 120 average MW in its resource portfolio.

8.12 Other Resources

The Council's Power Plan also considers various other generating resources and identifies several as "promising." For various reasons, however, the Council has excluded them from its current portfolio of cost-effective resources.

APPENDIX B

FISH PASSAGE AND POPULATION PARAMETERS

B.0 FISH PASSAGE AND POPULATION PARAMETERS

Two major areas affecting the assessment of impacts on fish resources from the Elwha and Glines Canyon projects are presented in this appendix. The first is a description of the process undertaken by the staff to estimate passage survival of anadromous fish. The second is a description of the process of estimating salmon and steelhead optimum exploitation rate.

B.1 PASSAGE SURVIVAL MODEL WITH COMPONENTS BY SPECIES AND RACE

The passage survival estimates were developed for determining the restoration potential for anadromous fish in the Elwha River system. Passage survival was one of four criteria used by the staff in evaluating the restoration potential of each anadromous fish stock (Section 4.1.3.2).

Of the ten possible anadromous species and races potentially represented in the Elwha River, estimates of passage survival were made for chinook salmon (fall and spring), coho salmon, and steelhead trout (winter and summer). These species and races were chosen because they represent the major runs, and studies have been conducted on their survival during passage at project facilities.

Estimates of passage survival consist of 10 survival components (Table B-1). The ten components are broken down into two major groups: downstream juvenile survival and upstream adult survival. The components are sequential beginning with the survival of juveniles past the first obstacle, Lake Mills, and continuing until adults pass upstream past Glines Canyon dam.

Survival estimates for each component are relative to "natural mortality," also defined as the unimpounded river. For example, if natural juvenile survival through a river system was 95 percent and the measured survival in the Elwha system for the same region is 92 percent, then the value used in the model for survival was 97 percent (92/95); that is, survival is 3 percent lower than natural. If the natural mortality of a species was not known, a natural mortality factor was assumed or, where available, based on literature.

Given the final survival number from the model is relative to the value for anadromous fish in an unimpounded system, a survival value of 80 percent implies 20 percent additional mortality over that which would occur in the absence of the two dams.

Depending on the species, survival component estimates ranged from zero percent natural mortality (e.g., survival over a length of river equivalent to the width of a

Table B-1. Passage model survival components (Source: the staff).

Downstream Juvenile Components	
1.	Lake Mills passage survival
2.	Glines Canyon dam spill survival
3.	Glines Canyon dam turbine or screen survival
4.	Lake Aldwell passage survival
5.	Elwha dam spillway survival
6.	Elwha dam screen (Eicher or conventional) survival
7.	Cumulative passage survival (Fish originating above Glines Canyon dam)
8.	Delayed survival (all fish)
Upstream Adult Components	
9.	Adult survival at Elwha dam ladder
10.	Adult survival at Glines Canyon dam (trap-and-haul)

dam) to much higher (e.g., natural mortality of chinook fingerlings originating above Glines Canyon dam).

The following discussion presents the parameter estimates for each species and race and summarizes the rationale for choosing these values.

B.1.1 Chinook Salmon

B.1.1.1 Lake Mills Juvenile Chinook Passage Survival

Passage survival of juvenile fall and spring chinook through Lake Mills was estimated to be 79 percent.

This estimate is based on information obtained from releases of hatchery juvenile chinook in and above Lake Mills in which measured survival from release to enumeration of the fish at the dam was 50 percent and 28 percent in 1987 and 1989-90, respectively (Wunderlich and Dilley, 1988; letter from E. Eric Knudsen, Fish and Wildlife Service, United States Department of the Interior, Olympia, Washington, March 22, 1990).

These estimates were corrected for natural mortality from the period of release to enumeration at the dam. Natural mortality of small chinook and other salmonids can be high. Bilby and Bisson (1987) found summer to fall survival of coho underyearlings in a small northwest Washington stream was about 25 percent. Bjornn (1978) found survival from 22 to 26 percent for spring chinook (stocks of 50 to 60 mm) from June through August in an Idaho stream. Based on Bjornn's data, estimated daily mortality rate of underyearling chinook is about 1.68 percent per day. This mortality rate (1.68 percent/day) was used to account for the portion of chinook salmon loss from natural mortality in the two Lake Mills survival studies. Mortality that occurred prior to the onset of major migration was assumed to be natural and not a function of reservoir passage.

In 1989-90, chinook were stocked in the upper watershed on April 3 and 4. Most chinook, based on the observed migration period and lower levels of ATPase measured, appeared to be rearing until nearly the end of June (87 days) prior to the onset of migration. Based on the above mortality rate by the time major migration began, only 23 percent of the juvenile chinook stocked would be predicted to have still been alive in the reservoir at the beginning of the migration period. Considering that an estimated 28 percent left the reservoir (most after June 30), additional reservoir-induced passage mortality would be near 0 percent (100 percent survival).

The 1987 test results were adjusted in a similar fashion. Three groups of chinook underyearlings were released into Lake Mills on May 5, May 22 and June 15, respectively. Most fish from these groups did not begin migration until about mid-June based on the acoustic data results. It was assumed that natural mortality occurred during the reservoir growing period prior to the beginning of the migration. Based on the observed beginning of major migration past the dam, the three groups reared for 41, 24 and 0 days, respectively, prior to mid-June. Based on the estimated number leaving the reservoir after June 1 and the estimated number alive (adjusted for natural mortality) prior to June 15, approximately 71 percent of those left alive at the start of migration left the reservoir.

The results of these tests were used as the basis for estimated passage survival. The average of these two tests (100 percent and 71 percent) was 85 percent survival of juvenile chinook relative to predicted natural survival.

Further adjustments were made in this estimate to account for the expected future natural chinook migration periods and the applicant's proposed spill schedule. The applicant proposes to spill from April 16 through November 15 from 9 P.M. to 5 A.M. (James River II, 1990). Based on studies at other Northwest sites, juvenile chinook migrate downstream or redistribute within the system nearly every month of the year. The staff assumed that about 20 percent of the chinook would be migrating during periods when spills would not be guaranteed. During those periods, natural spills in excess of turbine capacity occurred about 50

percent of the time. The staff assumed that lack of spill could result in about one-half month delay in migration. Applying the daily mortality rate for a 15-day delay would account for an additional 4 percent loss of chinook. Also, Wunderlich and Dilley (1988) found that 70 percent of the chinook migration occurred during the daytime hours at Glines Canyon dam. The staff assumed that fish passing during periods when natural flows in excess of turbine capacity were not available would have an additional one-day delay from lack of daytime spill inducing another 2 percent mortality.

Adjusting the 85 percent survival value for a total additional mortality of 6 percent provides a final survival value of 79 percent under the applicant's proposal. The final survival value is lower than an estimate of passage survival derived from application of the Northwest Power Planning Council (1989) System Planning Group's model to estimate production of salmon and steelhead from the Columbia River System. With this model, the estimated reservoir passage mortality rate for fall chinook underyearlings ranged from 0.4 percent to 4 percent per reservoir mile for high and low flow, respectively. Therefore, total survival in Lake Mills would be expected to be between 99 percent (high flow) and 90 percent (low flow). The higher passage survival estimate using the Columbia River model is justifiable given the Columbia River reservoir flushing rates that are much higher per stream mile than Lake Mills, which helps move fish past predators and reduces residualism. Considering these factors, the 85 and 79 percent survival values appear reasonable.

Spring chinook would have the same survival because most are expected to outmigrate as underyearlings like fall chinook.

B.1.1.2 Glines Canyon Dam Juvenile Chinook Passage Survival

Passage survival through Glines Canyon dam was estimated as a function of three parameters:

(1) survival of fish passing in the spill;
(2) survival of fish passing through the turbine; and
(3) an estimate of the proportion of fish passing through each.

The total Glines Canyon juvenile chinook dam passage survival was estimated by multiplying the survival value from each of the two exits by the proportions of fish passing that exit, and then adding these two results.

Glines Canyon Dam Juvenile Chinook Spill Survival

Passage survival for juvenile chinook (fall and spring) through Glines Canyon dam spill was estimated to be 98 percent based on the result of WDF tests (Wunderlich et al., 1988). The average of 7 tests with high bypass flow (greater than 693 cfs)

during or following spill was 98 percent survival. Wunderlich et al. stated "species related size difference are not expected to be a significant factor in juvenile survival in the 200-foot spill fall at Glines Canyon dam." Based on this statement, the staff assumed the spillway survival test results for all three species tested (coho, steelhead, and chinook) could be combined in assessing survival.

Spill passage survival was much reduced during tests under low spill flow (100 cfs). However, upon evaluation, the cause of the lower survival at lower spills appears to be the result of the configuration of spill pool exit and not directly due to the quantity of spill during fish fall into the pool. Subsequent to the survival tests, the plunge pool exit was improved by blasting rock blocking the exit.

Survival problems from spill passage appear to have been solved and the survival at 100 cfs (the applicant's proposed spill) should be comparable to that at higher flow spills. Future testing is required to confirm this conclusion.

Glines Canyon Dam Juvenile Chinook Turbine Survival

Passage survival of juvenile chinook (fall and spring) through Glines Canyon dam turbine was estimated to be 32 percent. Wunderlich and Dilley (1988) found the average survival at full turbine capacity (1,100 cfs) was 32 percent for chinook fingerlings. It is expected that during most fish passage the turbine would usually be operating at full capacity. The same value was used for fall and spring chinook because fish size would not be greatly different.

Proportion of Juvenile Chinook through Spill and Turbine

The proportion of juvenile chinook (fall and spring) passing through the Glines Canyon dam spill and turbine was estimated to be 92 percent and 8 percent, respectively. During 1989-90 studies through February, 89.7 percent of all chinook used the spill and the remainder used the turbine for outmigration (letter from E. Eric Knudsen, Biologist, U.S. Fish and Wildlife Service, Olympia, Washington, March 22, 1990). During periods when spill occurred, 93.4 percent of fingerlings passed via the spill. Because a small portion of the total run of outmigrating fish would migrate during periods when spill is not occurring under the applicant's proposal, the staff assumed the average of these two rates (92 percent) were using the spillway.

Lake Aldwell Juvenile Chinook Passage Survival

Passage survival of juvenile chinook (fall and spring) through Lake Aldwell was estimated to be 96.3 percent based upon results of studies at Lake Mills, described in Section 2.1. Because no direct Lake Aldwell survival studies were available, survival was assumed to be a function of the survival estimated for Lake Mills and the relative flushing rate of the lakes. The average annual flushing rate of Lake

the relative flushing rate of the lakes. The average annual flushing rate of Lake Aldwell is about four times higher than that of Lake Mills for a reservoir of about the same length. The higher flushing rate is expected to help move fish through the reservoir, reducing mortality in proportion. This four-fold increase in the water movement rate was assumed to result in a reservoir mortality rate of 25 percent of rate for Lake Mills (15 percent). The resulting survival rate, 96.3 percent, was used for fall and spring chinook. No adjustments were made to this rate.

B.1.1.4 Elwha Dam Juvenile Chinook Passage Survival

The same methods used to estimate Glines Canyon dam juvenile passage survival were used for Elwha dam.

Elwha Dam Juvenile Chinook Spill Survival

Passage survival of juvenile chinook (fall and spring) through Elwha dam spill was estimated to be 98 percent. Because the spillway would be greatly modified, past test results at the site are not valid. It is expected that with the improvements, survival would be comparable to good spillways at other dams. Spillway survival for juvenile salmonids at Columbia River dams has been reported to range from 93 to 99 percent (NPPC, 1989). The NPPC (1989) used a value of 98 percent for all salmonid species on the Columbia River and 98 percent was adopted as a reasonable value for all salmonids.

Elwha Dam Juvenile Chinook Eicher Screen Survival

Passage survival of juvenile chinook (fall and spring) through the applicant's proposed Eicher screens was estimated to be 90 percent. Although the proposed Eicher screens have not been tested with chinook salmon, the screens were tested for coho in 1990 with very favorable results (see coho model section). The applicant (James River II, 1988) suggested a value of 90 percent survival for juvenile chinook, which the staff has adopted. Further tests are necessary for both fall and spring chinook to determine chinook survival.

Proportion of Juvenile Chinook through Spill and Screen

The proportion of juvenile chinook (both fall and spring run) passing through the Elwha dam screens and spill was estimated at 95 percent and 5 percent, respectively, based on hydroacoustic tests conducted in 1985 with coho and steelhead at Elwha dam (Wunderlich and Dilley, 1986). Test results indicated 95 percent of all fish migrating during the spring and early summer months enter the turbine intake and 5 percent through the spill gate.

B.1.1.5 Cumulative Juvenile Chinook Passage Survival (Fish Originating Above Glines Canyon Dam)

Cumulative passage survival of juvenile chinook (fall and spring) passing Glines Canyon dam and Elwha dam was estimated to be 99 percent. This value was only applied to fish originating above Glines Canyon dam. Those fish originating below Glines Canyon dam were assumed to have a cumulative survival of 100 percent.

Cumulative mortality (survival) is a function of additional mortality caused by accumulated injury from passing the two dams. Scale loss is a major factor that can cause additional delay in cumulative mortality to fish. Bouck and Smith (1979) noted that even small amounts of scale (10 percent) loss causes high mortality (50 percent) of coho when they were placed into salt water. These effects are greatly moderated if fish can spend even one day in fresh water after scale loss before entering marine water. Wunderlich and Dilley (1988) found increased scale loss from chinook and steelhead passing over the Glines Canyon spillway. Also, increased scale loss was associated with turbine passage. Wunderlich and Dilley (1985) noted that scale loss of coho captured below Elwha dam was higher in fish releases above Glines Canyon dam than for fish released between the dams. This either implies passage at Glines Canyon dam causes more scale loss or that increased scale loss occurred from passing both dams.

Two factors suggest that cumulative and delayed mortality will be minor factors for the applicant's proposal. Long- and short-term mortality studies were conducted for coho to assess effects of delayed or cumulative mortality on survival (Wunderlich, 1988; Wunderlich and Dilley, 1985). They found no difference in short- and long-term survival for fish released upstream of Glines Canyon dam, even though scale loss was apparent on many of the juvenile coho after passing both dams. This suggests that even with some scale loss independent of direct mortality, long-term survival was not affected. Many of the project features that caused scale loss would be eliminated with future improvements (e.g., rock removed below Glines Canyon dam, increased spill frequency, improved spillway, screens at Elwha dam and more regulated flow at Elwha dam).

B.1.1.6 Delayed Juvenile Chinook Passage Survival (All Fish)

Delayed passage survival of juvenile chinook (fall and spring) passing Elwha dam was estimated to be 99 percent. Delayed mortality (survival) is similar to cumulative survival. The mortality is the result of injuries that do not cause significant harm immediately, but later when the fish enter salt water. Delayed survival in this case is applied to fish passing Elwha dam. It is only applied to Elwha dam fish because of the short distance juvenile fish travel before entering salt water. For the same reasons discussed for cumulative mortality, it is expected

to be minor, and was assumed to be equal to 1 percent mortality for both fall and spring chinook.

B.1.1.7 Adult Chinook Passage Survival at Elwha Dam Ladder

Passage survival through the Elwha dam ladder for adult fall and spring chinook was estimated to be 92.5 percent and 90 percent, respectively, based on tests from another system. Gibson et al. (1979) conducted a comprehensive study of survival of spring chinook salmon passing four lower Columbia River dams. Total adjusted mortality ranged from 20 to 33 percent, or an average 5 to 8 percent adult loss per dam and reservoir.

In their model, the NPPC (1989) considered the lower four dams on the Columbia to have mortality of 10 percent per dam, and the upper mainstem river dams (Snake and Columbia) 5 percent per dam for all anadromous species.

The proposed ladder at the Elwha dam has several problems that may reduce adult fish survival: no entry pool, insufficient attraction flow (80 cfs instead of the recommended 100 cfs), a Denil ladder that could collect debris, one fish entrance, and unsecured water supply (it relies on water leakage from the dam).

Because of these problems, the staff assumed survival values at the lower end of the above range (90 and 92.5 percent) for the two chinook races. Because spring chinook stay longer in the river before spawning, through the warmer periods of the year, it was assumed any additional injury or delay from passage would add to its mortality.

B.1.1.8 Adult Chinook Passage Survival at Glines Canyon Dam (Trap-and-Haul)

Passage survival through the Glines Canyon trap-and-haul facility for adult fall and spring chinook were estimated to be 92.5 percent and 90 percent, respectively.

Trap-and-haul facilities are currently being operated with runs of salmon and steelhead in many Northwest streams, (e.g., White River, Wynoochee River, Clackamas River, Baker Lake, Santiam River systems, and Skykomish River). Some of the salmon and steelhead runs in these systems are in a depressed state, but their reduction could be caused by other factors such as reservoir passage of juveniles.

Typically, trap-and-haul facilities have been used where dams are high, making ladder facilities more costly. In these situations, reservoirs are often large, deep, and have long flushing rates. All of these factors typically result in poor juvenile passage either from predation, residualism or poor dam passage. One facility that has had good success with salmon passage is that of the Skykomish River which

passes coho and chinook over a natural falls. Besides being operated by agency personnel, it has one advantage over other trap-and-haul facilities. There is no reservoir above the release point so downstream migration is not impeded for juveniles. But independent of reservoir problems, trap-and-haul facilities have other problems that could reduce their effectiveness. The primary negative factor is increased fish handling, which increases injury compared to a ladder. Fish would be further delayed because movement of fish is dependent on operators to collect and move fish. The Glines Canyon dam trap-and-haul facility also has some specific problems that could increase mortality of fish including an experimental electric weir that has not been used at other major facilities, poor entrance design, and less than optimum (100 cfs) attraction flow.

Because of the potential risks involved for fish survival, the staff assumed that passage success would be similar to the low end of values found on the Columbia River ladders. Values are expected to be worse for spring than fall chinook for the reasons discussed above.

B.1.2 Coho Salmon

B.1.2.1 Lake Mills Juvenile Coho Passage Survival

Passage survival of juvenile coho through Lake Mills was estimated to be 95 percent.

No site-specific studies were done for coho survival through Lake Mills so steelhead smolt study results were used. The survival of stocked steelhead smolts through the reservoir was estimated to be 93.2 percent with some residualism (Dilley and Wunderlich, 1987). Because these were hatchery fish, some residualism is more likely than a native stock. Also, some natural mortality would be expected for any stocks. The staff assumed these factors would improve future wild fish passage survival to 95 percent.

B.1.2.2 Glines Canyon Dam Juvenile Coho Passage Survival

The same methods used for chinook were used for coho.

Glines Canyon Dam Juvenile Coho Spill Survival

Passage survival of juvenile coho through Glines Canyon spill was estimated to be 98 percent. This is the same value used for the same reasons as chinook.

Glines Canyon Dam Juvenile Coho Turbine Survival

Passage survival of juvenile coho through Glines Canyon turbine was estimated to be 32 percent.

The same value used for chinook was used for coho. No recent tests were conducted for coho spill survival so this value was considered appropriate because it was run at maximum turbine capacity. The higher spill survival value (70 percent) estimated by Schoeneman and Junge (1954) was not used because of lack of information on turbine flow, which can have significant effects on survival. They also had some problems with marking of fish for test, which could have influenced these test results.

Proportion of Juvenile Coho through Spill and Turbine

The estimated proportion of juvenile coho passing through the Glines Canyon dam spill and turbine was 91.2 percent and 8.8 percent, respectively.

The 1988 study of coho and steelhead passage at Glines Canyon dam found that 91.2 percent of the fish passed over the spill (Wunderlich et al., 1989). During these studies the fish were mostly coho (93 percent) so this value is assumed to be representative of coho passage.

B.1.2.3 Lake Aldwell Juvenile Coho Passage Survival

Passage survival of juvenile coho through Lake Aldwell was estimated to be 98.8 percent.

Again, no direct studies on survival through Lake Aldwell have been conducted for coho. We used the same method described for chinook (i.e., 25 percent of estimated Lake Mills juvenile coho survival). Wunderlich and Dilley (1986) suggest that passage survival should be high through Lake Aldwell. They found less than 0.5 percent recapture of coho in a lake trap after re-release, suggesting no residualism.

B.1.2.4 Elwha Dam Juvenile Coho Passage Survival

The same methods used for chinook were used for coho.

Elwha Dam Juvenile Coho Spill Survival

Passage survival of juvenile coho through Elwha dam spill was estimated to be 98 percent. Values used and rationale are the same as discussed for chinook.

Elwha Dam Juvenile Coho Eicher Screen Survival

Passage survival of juvenile coho through the Eicher screens was estimated to be 98 percent.

Recent test results with the Elwha dam Eicher screen for coho in 1990 indicates excellent survival. No significant direct mortality (0.3 percent maximum mortality) occurred from the screen tests. An increase in scale loss above control occurred at maximum turbine flow level (3.5 percent of treatment fish vs. 0 percent for control fish).

These Eicher screen results indicate no significant direct mortality, but some delayed mortality could occur for fish with scale loss. Only 3.5 percent had significant scale loss at maximum operation level, and less than 10 percent of these fish died within 3 to 10 days.

The staff therefore assumed 98 percent survival as a reasonable number including long-term delayed mortality.

By comparing other passage systems currently operating, the NPPC (1989) noted that mortality in the bypass collectors on the Columbia River dams was 0.7 to 2.1 percent. From these results, they assumed 98 percent survival at each dam for each species.

Proportion of Juvenile Coho through Spill and Screens

The proportion of juvenile coho estimated to be passing through the Elwha dam screens and spill was 95 percent and 5 percent, respectively. The values used were for the same reasons discussed for chinook.

B.1.2.5 Cumulative Juvenile Coho Passage Survival (Fish Originating above Glines Canyon Dam)

Cumulative passage survival of juvenile coho through Glines Canyon and Elwha dams was estimated to be 100 percent. This value was only applied to fish originating above Glines Canyon dam.

The long-term mortality tests for coho, even without improvement in passage, suggest that cumulative and delayed mortality did not occur for coho (Wunderlich, 1988). With the improvements in passage facilities, mortality should be negligible.

B.1.2.6 Delayed Juvenile Coho Passage Survival (All Fish)

Delayed passage survival of juvenile coho through Elwha dam was estimated to be 100 percent. See cumulative survival for reasons.

B.1.2.7 Adult Coho Passage Survival at Elwha Dam Ladder

Adult coho passage survival was estimated to be 92.5 percent.

The same reasons discussed for chinook apply to coho. Because these fish spend short periods in the river during cool times of the year prior to spawning, the staff assumed survival would be similar to fall chinook.

B.1.2.8 Adult Coho Passage Survival at Glines Canyon Dam (Trap-and-Haul)

Adult coho passage survival was estimated to be 92.5 percent. The rationale for values used are the same as for fall chinook.

B.1.3 Steelhead Trout

B.1.3.1 Lake Mills Juvenile Steelhead Passage Survival

Passage survival of juvenile steelhead (winter and summer) through Lake Mills was estimated to be 95 percent.

Survival of steelhead smolts from Lake Mills arriving at Glines Canyon dam was 93.2 percent with some residualism (Dilley and Wunderlich, 1987). Assuming that some loss is natural, and hatchery fish outmigration is less reliable than wild fish, the staff assumed the relative survival would be 95 percent for wild winter and summer steelhead.

B.1.3.2 Glines Canyon Dam Juvenile Steelhead Passage Survival

The same methods used for chinook were used for steelhead.

Glines Canyon Dam Juvenile Steelhead Spill Survival

Passage survival of juvenile steelhead (winter and summer) through Glines Canyon spill was estimated to be 98 percent. The same values and reason used for chinook were used for steelhead.

Glines Canyon Dam Juvenile Steelhead Survival through Turbine

Passage survival of juvenile steelhead (winter and summer) through the Glines Canyon turbines was estimated to be 32 percent.

The same value used for chinook was used for steelhead because it is the most accurate estimate of smolt survival through the Glines Canyon turbines in full operation.

Proportion of Juvenile Steelhead through Spill and Turbine

The estimated proportion of juvenile steelhead (winter and summer) passing through the Glines Canyon dam spill and turbines was 97.6 percent and 2.4 percent, respectively. Dilley and Wunderlich (1987) found that 97.6 percent of all steelhead smolts left through the spillway, although spill did not occur for several days during the study. This test was considered representative of future distribution because it was conducted during the spring when peak migration would be expected and no other species were present to affect the acoustic fish counts.

B.1.3.3 Lake Aldwell Juvenile Steelhead Passage Survival

Passage survival of juvenile steelhead (winter and summer) through Lake Aldwell was estimated to be 98.8 percent.

A value of 25 percent of Lake Mills mortality was used for Lake Aldwell passage for the same reasons discussed for chinook.

Wunderlich et al. (1988) examined long-term relative survival of steelhead smolt planted into Lake Mills. They considered dam passage to be the major source of mortality and that residualism was "inconsequential."

B.1.3.4 Elwha Dam Juvenile Steelhead Passage Survival

The same methods used for chinook were used for steelhead.

Elwha Dam Juvenile Steelhead Spill Survival

Passage survival of juvenile steelhead (winter and summer) through Elwha dam spill was estimated to be 98 percent. The same reasons presented for chinook apply for steelhead.

Elwha Dam Juvenile Steelhead Eicher Screen Survival

Passage survival of juvenile steelhead (winter and summer) through Eicher screens was estimated to be 90 percent. No test results are available for steelhead with the Eicher screen. The same reasons and values discussed for chinook apply for steelhead.

Proportion of Juvenile Steelhead through Spill and Screens

The proportion of juvenile steelhead (winter and summer) passing through the Elwha dam screens and spill was 95 percent and 5 percent, respectively. The same reasons presented for chinook apply for steelhead.

B.1.3.5 Cumulative Juvenile Steelhead Passage Survival (Fish Originating above Glines Canyon Dam)

Cumulative passage survival of juvenile steelhead (winter and summer) through Glines Canyon dam and Elwha dam was estimated to be 99 percent. This value was only applied to fish originating above Glines Canyon dam. The same reasons and values presented for chinook apply for steelhead.

B.1.3.6 Delayed Juvenile Steelhead Passage Survival (All Fish)

Delayed passage survival of juvenile steelhead (winter and summer) through Elwha dam was estimated to be 99 percent. The same reasons and values for chinook apply to steelhead.

B.1.3.7 Adult Steelhead Passage Survival at Elwha Dam Ladder

Passage survival of adult winter and summer steelhead through the Elwha dam ladder was estimated to be 92.5 percent and 90 percent, respectively.

The same reasons presented for chinook apply for steelhead with the following difference. Summer steelhead were given the lowest survival value because extra delay and injuries occurring from passage could result in a higher chance of mortality. Because these fish stay a long time in the system prior to spawning, mortality could occur from secondary disease as a result of injuries or deterioration from delays.

B.1.3.8 Adult Steelhead Passage Survival at Glines Canyon Dam (Trap-and-Haul)

Passage survival of adult winter and summer steelhead through the Glines Canyon dam trap-and-haul facility was estimated to be 92.5 and 90 percent, respectively.

The same reasons presented for chinook survival apply to steelhead. A lower value was applied to summer steelhead because of their longer residence in freshwater prior to spawning, thereby increasing the effects of delay or injury.

B.1.4 Model Calculations Summary

The calculations of total relative survival using the 10 survival components (Table B-1) for fall chinook, spring chinook, coho, winter steelhead, and summer steelhead are shown in Tables B-2 through B-6.

Results are shown for each of the three dam retention alternatives: (1) applicant's proposal; (2) Glines Canyon dam removal alternative; and (3) Elwha dam removal alternative.

Table B-2. Relative passage survival (percent) calculated for fall chinook (Source: the staff).

Input variable	Applicant's Proposal: Survival factors	Applicant's Proposal: Relative number above Glines Canyon	Applicant's Proposal: Relative number between Elwha & Glines Canyon
Upper reach Input number (percent)		100	
Lake Mills passage survival	0.790	79.00	
Glines Canyon spillway (proportion)	0.920	72.68	
Glines Canyon spillway survival	0.980	71.23	
Glines Canyon turbine (proportion)	0.080	6.32	
Glines Canyon turbine/screen survival	0.320	2.02	
Middle reach Input number (percent)		73.25	100
Lake Aldwell passage survival	0.963	70.54	96.30
Elwha spillway (proportion)	0.050	3.53	4.82
Elwha spillway survival	0.980	3.46	4.72
Elwha turbine (proportion)	0.950	67.01	91.49
Elwha screen survival	0.900	60.31	82.34
Cumulative passage survival	0.990	63.77 63.13	87.06
Delayed survival	0.990	62.50	86.18
Upstream passage survival at Elwha dam ladder	0.925	57.81	79.72
Upstream passage survival at Glines Canyon dam ladder/trap and haul	0.925	53.47	
Total survival above Glines Canyon		53.47	
Total survival between Elwha and Glines Canyon			79.72
Survival with Glines Canyon Removal Alternative (all fish) 1/			79.72
Survival with Elwha Removal Alternative (above Glines Canyon) 2/		67.08	

1/
All fish originating above Elwha dam

2/
Fish originating below Glines Canyon dam have survival of 100%

Table B-3. Relative passage survival (percent) calculations for spring chinook (Source: the staff).

Input variable	Applicant's Proposal		
	Survival factors	Relative number above Glines Canyon	Relative number between Elwha & Glines Canyon
Upper reach input number (percent)		100	
Lake Mills passage survival	0.790	79.00	
Glines Canyon spillway (proportion)	0.920	72.68	
Glines spillway survival	0.980	71.23	
Glines Canyon turbine (proportion)	0.080	6.32	
Glines Canyon turbine/screen survival	0.320	2.02	
Middle reach input number (percent)		73.25	100
Lake Aldwell passage survival	0.963	70.54	96.30
Elwha spillway (proportion)	0.050	3.53	4.82
Elwha spillway survival	0.980	3.46	4.72
Elwha turbine (proportion)	0.950	67.01	91.49
Elwha screen survival	0.900	60.31	82.34
Cumulative passage survival	0.990	63.77 63.13	87.06
Delayed survival	0.990	62.50	86.18
Upstream passage survival at Elwha dam ladder	0.900	56.25	77.57
Upstream passage survival at Glines Canyon dam ladder/trap and haul	0.900	50.62	
Total survival above Glines Canyon		50.62	
Total survival between Elwha and Glines Canyon			77.57
Survival with Glines Canyon Removal Alternative (all fish) [1/]			77.57
Survival with Elwha Removal Alternative (above Glines Canyon) [2/]		65.26	

1/ All fish originating above Elwha dam

2/ Fish originating below Glines Canyon dam have survival of 100%

Table B-4. Relative passage survival (percent) calculations for coho (Source: the staff).

Input variable	Applicant's Proposal		
	Survival factors	Relative number above Glines Canyon	Relative number between Elwha & Glines Canyon
Upper reach input number (percent)		100	
Lake Mills passage survival	0.950	95.00	
Glines Canyon spillway (proportion)	0.912	86.64	
Glines spillway survival	0.980	84.91	
Glines Canyon turbine (proportion)	0.088	8.36	
Glines Canyon turbine/screen survival	0.320	2.68	
Middle reach input number (percent)		87.58	100
Lake Aldwell passage survival	0.988	86.53	98.80
Elwha spillway (proportion)	0.050	4.33	4.94
Elwha spillway survival	0.980	4.24	4.84
Elwha turbine (proportion)	0.950	82.20	93.86
Elwha screen survival	0.980	80.56	91.98
Cumulative passage survival	1.000	84.80	96.82
Delayed survival	1.000	84.80	96.82
Upstream passage survival at Elwha dam ladder	0.925	78.44	89.56
Upstream passage survival at Glines Canyon dam ladder/trap and haul	0.925	72.56	
Total survival above Glines Canyon		72.56	
Total survival between Elwha and Glines Canyon			89.56
Survival with Glines Canyon Removal Alternative (all fish) [1/]			89.56
Survival with Elwha Removal Alternative (above Glines Canyon) [2/]		81.01	

1/ All fish originating above Elwha dam

2/ Fish originating below Glines Canyon dam have survival of 100%

Table B-5. Relative passage survival (percent) calculated for winter steelhead (Source: the staff).

Input variable	Applicant's Proposal		
	Survival factors	Relative number above Glines Canyon	Relative number between Elwha & Glines Canyon
Upper reach input number (percent)		100	
Lake Mills passage survival	0.950	95.00	
Glines Canyon spillway (proportion)	0.976	92.72	
Glines Canyon spillway survival	0.980	90.87	
Glines Canyon turbine (proportion)	0.024	2.28	
Glines Canyon turbine/screen survival	0.320	0.73	
Middle reach input number (percent)		91.60	100
Lake Aldwell passage survival	0.988	90.50	98.80
Elwha spillway (proportion)	0.050	4.52	4.94
Elwha spillway survival	0.980	4.43	4.84
Elwha turbine (proportion)	0.950	85.97	93.86
Elwha screen survival	0.900	77.37	84.47
Cumulative passage survival	0.990	81.81 80.99	89.32
Delayed survival	0.990	80.18	88.42
Upstream passage survival at Elwha dam ladder	0.925	74.17	81.79
Upstream passage survival at Glines Canyon dam ladder/trap and haul	0.925	68.60	
Total survival above Glines Canyon		68.60	
Total survival between Elwha and Glines Canyon			81.79
Survival with Glines Canyon Removal Alternative (all fish) [1/]			81.79
Survival with Elwha Removal Alternative (above Glines Canyon) [2/]		83.88	

1/ All fish originating above Elwha Dam

2/ Fish originating below Glines Canyon Dam have survival of 100%

Table B-6. Relative passage survival (percent) calculations for summer steelhead (Source: the staff).

Input variable	Applicant's Proposal		
	Survival factors	Relative number above Glines Canyon	Relative number between Elwha & Glines Canyon
Upper reach initial input number (percent)		100	
Lake Mills passage survival	0.950	95.00	
Glines Canyon spillway (proportion)	0.976	92.72	
Glines Canyon spillway survival	0.980	90.87	
Glines Canyon turbine (proportion)	0.024	2.28	
Glines Canyon turbine/screen survival	0.320	0.73	
Middle reach input number (percent)		91.60	100
Lake Aldwell passage survival	0.988	90.50	98.80
Elwha spillway (proportion)	0.050	4.52	4.94
Elwha spillway survival	0.980	4.43	4.84
Elwha turbine (proportion)	0.950	85.97	93.86
Elwha screen survival	0.900	77.37	84.47
Cumulative passage survival	0.990	81.81 80.99	89.32
Delayed survival	0.990	80.18	88.42
Upstream passage survival at Elwha dam ladder	0.900	72.16	79.58
Upstream passage survival at Glines Canyon dam ladder/trap and haul	0.900	64.95	
Total survival above Glines Canyon		64.95	
Total survival between Elwha and Glines Canyon			79.58
Survival with Glines Canyon Removal Alternative (all fish) [1/]			79.58
Survival with Elwha Removal Alternative (above Glines) [2/]		81.61	

1/ All fish originating above Elwha dam

2/ Fish originating below Glines Canyon dam have survival of 100%

The methods of calculation used in the model are as follows.

The river was divided into two sections relative to the dams: (1) above Glines Canyon dam (upper reach), and (2) the region between Glines Canyon dam and Elwha dam (middle reach). Relative survival was determined by starting with an initial number of 100 for each of these two regions. This number in each region was then multiplied by the appropriate relative survival factor (and proportion through passage facilities) to obtain a final relative survival value separately for fish originating in each reach (upper and middle). The final values include relative mortality incurred by juveniles and adults during passage.

Only the results of the Glines Canyon dam removal and Elwha dam removal are shown because survival values for these alternatives are calculated from appropriate proportions of the applicant's dam retention alternative.

For the Glines Canyon removal, only the survival factor used in the middle reach apply to all fish. For the Elwha dam removal alternative, the upper reach juvenile survival value, plus delayed mortality and Glines Canyon adult passage survival values, apply to fish destined above Glines Canyon dam. In this alternative, fish originating below Glines Canyon dam would have 100 percent relative survival.

B.2 OPTIMUM SUSTAINED YIELD ESTIMATES

It is generally recognized that sustained exploitation of salmon or steelhead populations depends upon maintaining a balance between spawner escapement and harvest. Although several models have been developed to predict the relationship between spawner escapement and recruits, the most common and widely accepted model appropriate for salmon stocks is the Ricker Function (Morishima, 1981). Another model that has been employed for salmon and steelhead is the Beaverton-Holt model (NPPC, 1989; Gibbons et al., 1985; Ricker, 1975). Both models have similar parameters and can be used to estimate the relationship between the number of spawning fish and adult fish produced by those spawners.

One of the most important parameters from these models is the ability to estimate maximum sustainable yield (MSY). This is the value where the maximum number of fish is available for harvest above what is needed for spawning to maintain the run size at this level in the future.

The harvest rate to maintain MSY is the proportion of total run that can be harvested while maintaining the same run size. This is referred to as the Optimum Exploitation Rate (OER). Generally, if the exploitation rate of a stock exceeds the OER, future run sizes and available harvest will decrease.

The following section summarizes the OER used for discussing harvest effects on stocks of chinook, coho, and steelhead.

B.2.1 Chinook

The OER was based on estimates for wild fall chinook stocks from the Puget Sound area and Washington coast. OER for spring chinook was from the Nooksack River spring chinook stocks. The parameters needed to estimate these values were obtained from Gary Morishima (personal communication, Pacific Salmon Commission, June 27, 1990).

These stocks were chosen because they were the closest regional stocks for which stock-recruitment parameters have been determined. The calculations used to determine the OER for fall and spring chinook are summarized below.

The formula used for the calculations OER is as follows:

$$B = \frac{\text{Optimum Escapement}}{0.5 - 0.07 \times a}$$

$$\text{Recruits at MSY} = e^{a(1-S/B)}$$

Where S = number of spawners at OER
a = Ricker "a" (Ricker, 1975)

Values obtained from Gary Morishima were:

	Optimum Exploitation Rate Escapement	Ricker a
Fall Chinook - Puget Sound	16,966	2.238
Fall Chinook - Washington coast	21,300	2.34
Spring Chinook - Nooksack River	4,000	1.489

Fall Chinook - Puget Sound Stocks

1.	Optimum spawner escapement for MSY		= 16,966
2.	Recruits/Spawner at MSY		= 4.3475
3.	Total run at MSY	= 4.3425 x 16,966	= 73,760
4.	Optimum Exploitation Rate	= (73,760-16,966)/73,760	= 0.77

Fall Chinook - Washington Coast Stocks

1.	Optimum spawner escapement at MSY		= 21,300
2.	Recruits/Spawner at MSY		= 4.727
3.	Total run at MSY	= 4.727 x 21,300	= 100,685
4.	Optimum Exploitation Rate	= (100,685-21,300)/100,685	= 0.79

Average Optimum Exploitation Rate

Average OER = (0.77 + 0.79)/2 = 0.78

Spring Chinook - Nooksack River Stock

1.	Optimum Escapement	=	4,000
2.	Recruits per spawner at MSY	=	2.4589
3.	Total run at MSY	=	9,835
4.	Optimum Exploitation Rate	=	(9,835-4,000)/9,835 = 0.59

The above OER of 0.78 for fall chinook and 0.59 for spring chinook were used for the text discussion of suitable harvest rate needed to maintain the stock at MSY.

B.2.2 Coho

No recently calculated MSY or OER is available from local stocks. Chapman (1986) indicated available OER rate for Canadian west coast stock was 0.77. But Gary Morishima (personal communication, Pacific Salmon Commission, July 27, 1990) indicated that the above estimate is too high. He states OER for coho in Georgia Strait on the Washington coast should be less than 60 percent. Current

harvest rate on Georgia Strait stock has been reduced to the mid 60s. Oregon coho harvest had been about 75 percent which was also too high for OER. He thought Puget Sound stock may be able to handle higher harvest rates than Washington coastal stocks.

Based on this discussion, the staff used an expected OER of 60-65 percent to be representative of future wild stock of the Elwha River.

B.2.3 Steelhead

The MSY escapement estimate for Washington's Puget Sound and coastal steelhead stocks was used to establish the OER for the Elwha River wild steelhead. Gibbons et al. (1985) used Ricker and Beaverton-Holt models to estimate MSY escapement goals for all major rivers. This report used estimates of Potential Parr Production (PPP) to modify the form of the Ricker and Beaverton-Holt curves. Because the true forms of the population spawner-recruit relationships could not be accurately determined with the available data, they used five different error structures for each model type to estimate the population parameters.

Of these, they presented final MSY escapement estimates for the Ricker and Beaverton-Holt models. Based on the data in Gibbons et al. (1985), the OER rate for each model was determined.

The formulas used to calculate the OER for steelhead are as follows:

Beaverton-Holt models

$$R = S/[(a * S)/PPP + B)]$$

where R = Recruits (Adults)
a = Beaverton-Holt slope parameter
S = Number of spawners
PPP = Potential Parr Production
(specific to Gibbons et al., 1989)
B = Beaverton-Holt B parameter

Ricker Models

$$R = (a)(s)e^{(-BS/PPP)}$$

where R = Recruits (adults)
a = Ricker a parameter
S = Number of spawners
PPP = Potential Parr Production
(specific to Gibbons et al., 1985)
B = Ricker B parameter

The results of the calculations for each model are presented below.

Model Type and Number		Optimum Exploitation Rate
Beaverton-Holt		
Model 1	=	0.38
Model 4	=	0.47
Model 5	=	0.42
Ricker		
Model 1	=	0.40
Model 4	=	0.48
Model 5	=	0.44
Average	=	0.43

The average OER rate (0.43) was used in the text analysis of suitable harvest rates to maintain wild stock of steelhead in the Elwha River at maximum sustainable yield.

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APPENDIX C

ELWHA RIVER SEDIMENT STUDY METHODS

PART 1 - INTRODUCTION

Potential impacts to the Elwha River channel morphology and sediment transport resulting from the dam retention and dam removal options influences fisheries and terrestrial habitat, water quality, and river flood conditions. Dam retention alternatives will continue to trap the natural upstream sediment supply which alters channel substrate, channel stability, flood stages, coastal zone sediment supply and maintains present water quality conditions. Removal of the dams releases, in the near-term, significant amounts of sediment stored in the reservoirs and in the long-term returns the natural upstream sediment supply which would alter channel substrate, channel stability, flood stages, coastal zone sediment supply and changes present water quality conditions.

The staff investigation of the range of potential changes to sediment transport in the Elwha River was based on: (1) a review of present river conditions in the project area and upstream of the project area, (2) analysis of quantities and grain size distribution of reservoir and river channel substrate, (3) field visits along the full length of the river from RM 19 to the river mouth, (4) comparison to other rivers in the region, and (5) modeling of sediment transport and sediment routing using the HEC-2 and HEC-6 models (HEC,1990).

Field visits along the river from RM 19 to the coastal zone and Ediz Hook along with analysis of the stereo aerial photographs (Walker, 1989, 1990) provided the overall picture of present river and coastal zone conditions and provided a check on and additions to field surveyed river cross sections.

Present river conditions in the project areas and coastal zone indicate the expected impacts of the dam-retention options. Present river conditions upstream of the project areas (especially above RM 17 to RM 20) provide information on the range of river conditions prior to the projects and on the conditions to which the project and coastal zone areas would return with the dam removal alternatives. Reservoir and river channel substrate were extensively sampled (James River II, 1989, 1990). The reservoir sediment quantities, grain size distribution and areal distribution in the reservoirs along with the reservoir areas and volumes allowed the bedload and suspended sediment yields of the watershed to be assessed and allowed various in-reservoir sediment stabilization methods to be evaluated (see Appendix A).

Comparison of the present Elwha River conditions to other rivers in the region provided basic data on the range of sediment yields and channel conditions that are typical to the maritime mountain rivers of northwest Washington (Collins, 1986, 1987; Fahnestock, 1963; Feely et al, 1979; Glancy, 1971; Nelson, 1971). A 17 foot drawdown test of the Lake Mills reservoir was conducted to investigate the response of the delta sediment to rapid erosion (James River II, 1990). The test indicated heavy machinery could work on the delta and showed the pattern and rate of erosion and downstream impacts.

A sediment transport model using HEC-6 (October, 1990 PC Beta test version, Scour and Deposition in Rivers and Reservoirs) was prepared to assess the range of potential changes during erosion of the reservoir sediments in the dam removal alternatives and to estimate the amount of potential aggradation that would be expected from return of the natural upstream sediment supply.

PART 2 - ELWHA RIVER HEC-6 MODEL

Geometric data for the HEC-6 model was derived from three sources. The Army Corps of Engineers (ACOE) design study for the Lower Elwha set-back levee (ACOE, 1986, 1987). The ACOE model using the Seattle District Backwater Curve-Method II w/Floodway Analysis program was converted to HEC-2 data format for the Elwha River from RM 0.0 to RM 2.5. The FEMA floodplain study for the Lower Elwha (FEMA, 1980) using the USGS Program J635 was converted to HEC-2 format for RM 2.5 to RM 5.0 at the Elwha Dam. Some corrections to the FEMA cross sections were made based on the stereo aerial photographs (Walker, 1989).

Cross sections prepared by the applicant (James River II, 1989, 1990) were used for the middle Elwha River from RM 8.5 to 13.52. Additional cross sections were added for the middle reach, because of the high gradient, based on the stereo aerial photographs, ground level photographs, USGS topographic maps and nearby surveyed cross sections.

The original channel profile as shown on the Lake Mills pre-reservoir map (Thebo et al, 1924) and the 1989 bathymetric survey (James River II, 1990) were used in developing the Mills reservoir geometric data. The reservoir isopach and bathymetric maps (James River II, 1990) were used to estimate the geometric data for the Aldwell reservoir. A standard canyon cross section was used for the Rica Canyon portion of the Lake Mills delta using elevations from the USGS topographic map.

2.1 Model Calibration

Each section of the model was tested separately in the HEC-2 format and then combined and converted to the HEC-6 format. Observed water surface elevations were available at 1568 cfs and 3481 cfs for the lower Elwha ACOE cross sections. For the middle reach cross sections, observed water surface elevations were measured at 248 cfs, 1200 cfs and 12000 cfs and were available at the USGS stream gage site.

Calibration in the lower reach was a compromise between matching the observed low flow water surface elevations and duplicating the ACOE calculations for flood flows along the levee section. Because the model was mostly intended to model sediment transport and flood levels, calibration was for the higher discharge rates. Model calibration in the lower Elwha River at cross sections up-river of tidal influence were within 0.5 feet of observed elevations for both flows at 4 cross sections, within 1 foot at one flows at one cross section and within 2 feet of observed at one flow at two cross sections. In the middle reach the model was not stable. The middle reach consists of a sequence of high gradient riffles and lower gradient pools that would have required far more surveyed cross sections then were practical to obtain. Calibration at most of the cross sections in the middle reach was within 0.5 to 2 feet. At several cross sections the calibration was poor, but considered adequate for routing sediment delivered from upstream, which was the main purpose of the model.

Flood levels in the area of the ACOE set-back levee were analyzed by first comparing the ACOE water surface elevations for the 200 year recurrence interval flood (Q200 = 56,000 cfs, ACOE, 1986) with the HEC-2 and HEC-6 models (Table C-1) . The water surface elevations for the specific sediment yield of 785 $t/yr/mi^2$ after running the model for 20 years indicates levee freeboard of 1.5 feet at cross section RM 1.02 with adequate freeboard along the rest of the levee. Using a specific sediment yield of 1100 $t/yr/mi^2$ results indicate the upstream section of the levee between Rm 1.02 and RM 1.5 would need to be raised 4 to 5 feet.

2.2 Sediment Data

The natural upstream sediment supply to the Elwha river was estimated for use in the HEC-6 model. The volume and grain size distribution of Lake Mills sediment that has accumulated in the 63 year life of the reservoir were used in conjunction with estimates of lake trap efficiency (Brune, 1953; Churchill, 1947; and HEC-6 model) to estimate the total sediment load into Lake Mills.
Sediment densities, which affect the estimated volume of deposits, were measured for one lake bottom sample from the center lower end of Lake Mills (MP-1, Table A.1, James River II, 1990) and estimated after the methods of Miller (1953), Colby (1963) and Hembree et al, all presented in Vanoni (1977).

Table C-1 Water surface elevations for a 56,000 cfs flood at the Lower Elwha River set-back levee.

RM	COE CROSS SECTION NUMBER	COE Q_{200}[1] WSEL(ft)	HEC-6[2] ELWHA MODEL Q_{200} INITIAL CONDITION	HEC-6[2] ELWHA MODEL[3] (after 20 yrs) WSEL Q_{200}	CHANGE WSEL (ft)	HEC-6[2] ELWHA MODEL[4] (after 20 yrs) WSEL Q_{200}	CHANGE WSEL (ft)
.1	1+00	8.8	7.3 tide	7.58	+0.04	7.74	+0.44
.5	2+00	14.0	14.62	14.76	+0.14	15.09	+0.47
.78	4+00	21.3	22.17	22.12	-0.05	22.53	+0.36
1.02	5+00	28.9	28.75	30.15	+1.4	32.62	+3.87
1.22	6+00	32.2	31.87	33.17	+1.3	35.74	+3.87
1.42	7+00	36.1	35.49	35.66	+.17	41.11	+5.62

1. Q_{200} = 56,000 cfs, starting water surface elevation = 6.8 ft.

2. 1969 to 1988 water years.

3. Specific sediment yield = 780 tons/yr/mi^2.

4. Specific sediment yield = 1100 ton/yr/mi^2.

The shape of the sediment rating curve from the Soleduck River (Nelson, 1982) just west of the Elwha was used with the Elwha River USGS stream gage data (adjusted by area ratio to River Mile 13.52) to converge on a reasonable range for the Elwha River sediment rating curve. The sediment weighted histogram generator was used to aid in integrating the sediment load curve with the 63 years of daily flows and to generate a HEC-6 hydrologic deck that would run more efficiently than the full set of daily flows. The estimated sediment load curve was then used in the HEC-6 program for Lake Mills (1927 geometry) to build (with the model) the delta and lake bottom sediments. Initial calculations using reservoir trap efficiencies from the literature (Brune,1953; Churchill, 1947) indicated an Elwha River specific sediment yield of 700 to 800 t/yr/mi^2. This sediment yield is in the lower range of other rivers in the region (Olympic Mountains 500-2000 t/yr/mi^2; Puget Lowland and Western Cascades 100 to 700 t/yr/mi^2) (Nelson, 1971; Collins, 1987). With this range of sediment yield the accumulation of lake bottom sediment in the Lake Mills HEC-6 model; for a range of sediment densities, critical shear stresses for deposition, compaction rates, and trap efficiencies; were 1 to 5 feet less than observed and the delta front was 800 feet short of the measured location indicating sediment yield from the Elwha basin could be higher than the estimated 700 to 800 t/yr/mi^2 range.

The Elwha Model adequately matches the observed lake sediments using a load curve that develops a specific sediment yield of 1000-1200 t/sq mi/yr (Figure C-1) which is in the upper range for rivers of the Olympic Mountains, indicating the estimates are reasonable (Table C-2 and Figure C-2). One area of significant discrepancy to the model built delta occurs between RM 15 to RM 14.5. A discrepancy between the 1990 Lake Mills isopach map (James River II, 1990) and the 1927 pre-reservoir topographic map is apparent in the delta area between RM 15 to RM 14.5. A sediment thickness of 10 to 12 feet on the isopach map (Figure 3.3, James River II, 1990) differs from a thickness of about 30 feet based on the 1924 pre-reservoir topographic map with the 1990 bathymetric data. The 1924 map shows a steeper channel gradient in this area which is related to the Elwha flowing past the Boulder Creek alluvial fan. Potential slumps from the steep delta face combined with erosion from the delta during drawdown in the decades prior to run-of-river operation, and because of the presence of the Boulder Creek alluvial fan and present day Boulder Creek delta indicate that the sediment would be thicker (17 to 30 feet) in this reservoir zone. The processes of delta drawdown erosion, slumping and Boulder Creek delta deposition were not included in the model thus potentially explaining the poor fit in this area (Figure C-1).

The Elwha River has a steep gradient and constrained narrow valley in close proximity to steep terrain that could deliver a large sediment supply when compared to the Soleduck, on which the starting sediment rating curve was based (Figure C-3) (Nelson, 1971). The presence of abundant glacial and Old Lake Elwha sediments could further explain the apparent high estimated specific sediment yield of the Elwha basin.

Table C-2 Specific sediment yields for Northwest Washington Rivers.

River	Source	Watershed Area	Annual Volume	Specific Volume	Annual Discharge	Specific Yield
		sq mi	cu yds/yr	cu yds/yr/sq mi	tons/yr	tons/yr/sq mi
Elwha	1	245	64,290	262	90,100	368
Elwha	2	246	208,000	846	260,000	1,057
Soleduck	3	226	96,000	425	120,000	531
Bogachiel	3	111	200,000	1,802	250,000	2,252
Calawah	3	129	96,000	744	120,000	930
Bogachiel	3	287	319,000	1,111	400,000	1,394
Dickey	3	86	48,000	556	60,000	695
Dickey	3	108	60,000	556	75,000	694
Quillayute	3	629	482,000	766	606,000	963
Dungeness	4	167	80,000	479	108,000	647
Chehalis	5	113	15,600	138		
Newaukum	5	155	9,629	62		
Chehalis	5	895	43,000	48		
Chehalis	5	1,294	52,000	40		
Satsop	5	299	88,888	297		
Wynoochee	5	155	57,000	368		
NF Newaukum	5	32	1,406	45		
SF Newaukum	5	42	2,300	54		
Cloquallum	5	65	3,108	48		
Fraser	6	79,923	14,700,000	184		
Skagit	6	3,104	955,500	308		
Notes						
1. James River II, 1989, Table 1, Appendix 5						
2. FERC Staff, 1990						
3. Nelson, 1971						
4. Clallam County Dept. of Public Works, 1987						
5. Feely and Lamb, 1979						

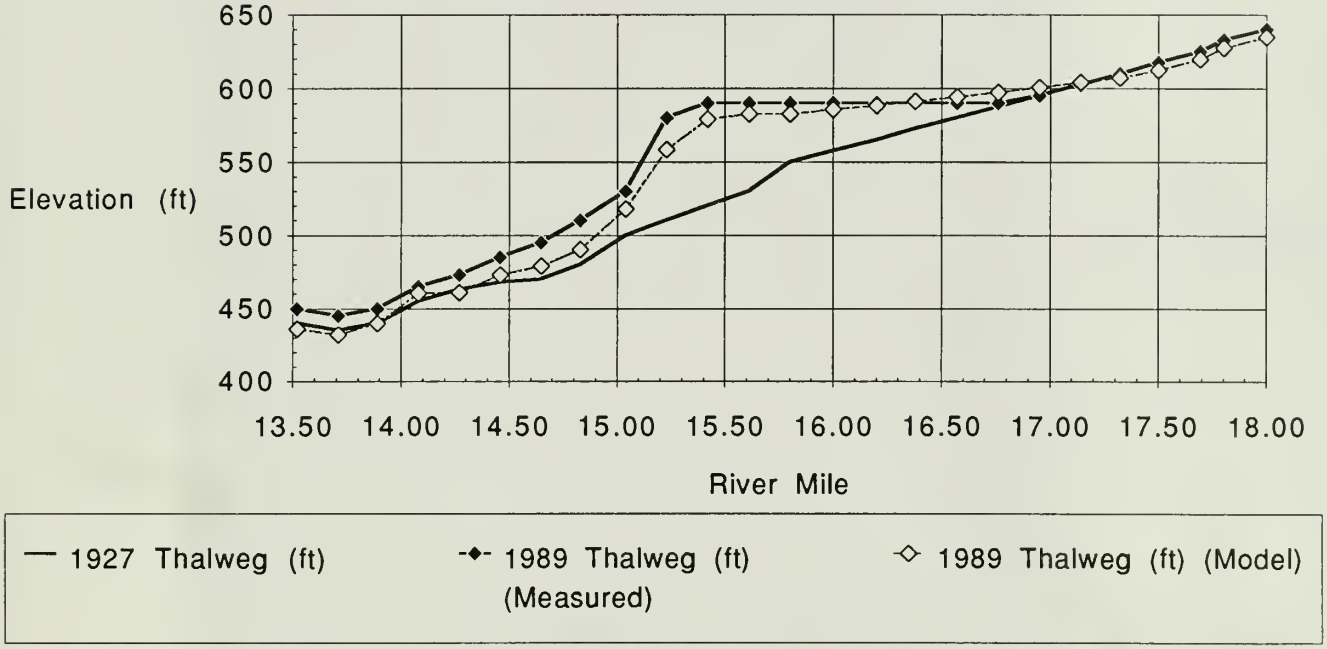


Figure C-1 Lake Mills Profiles for pre-reservoir conditions, 1989 profile and HEC-6 1989 model profile.

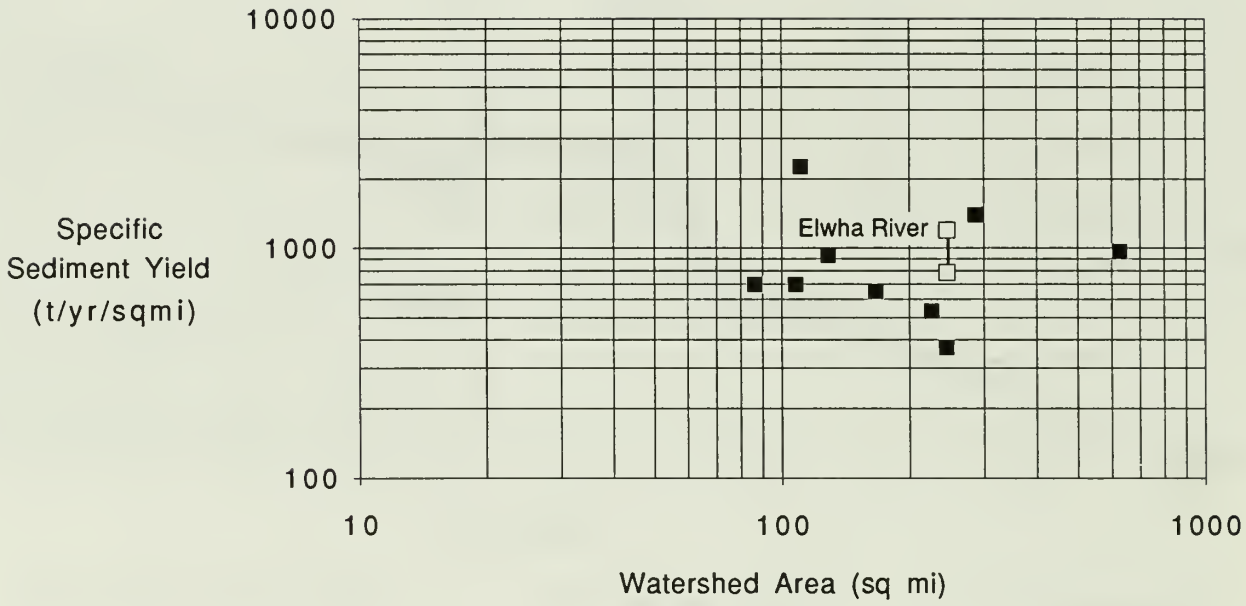


Figure C-2 Specific sediment yields for Northwest Washington Rivers.

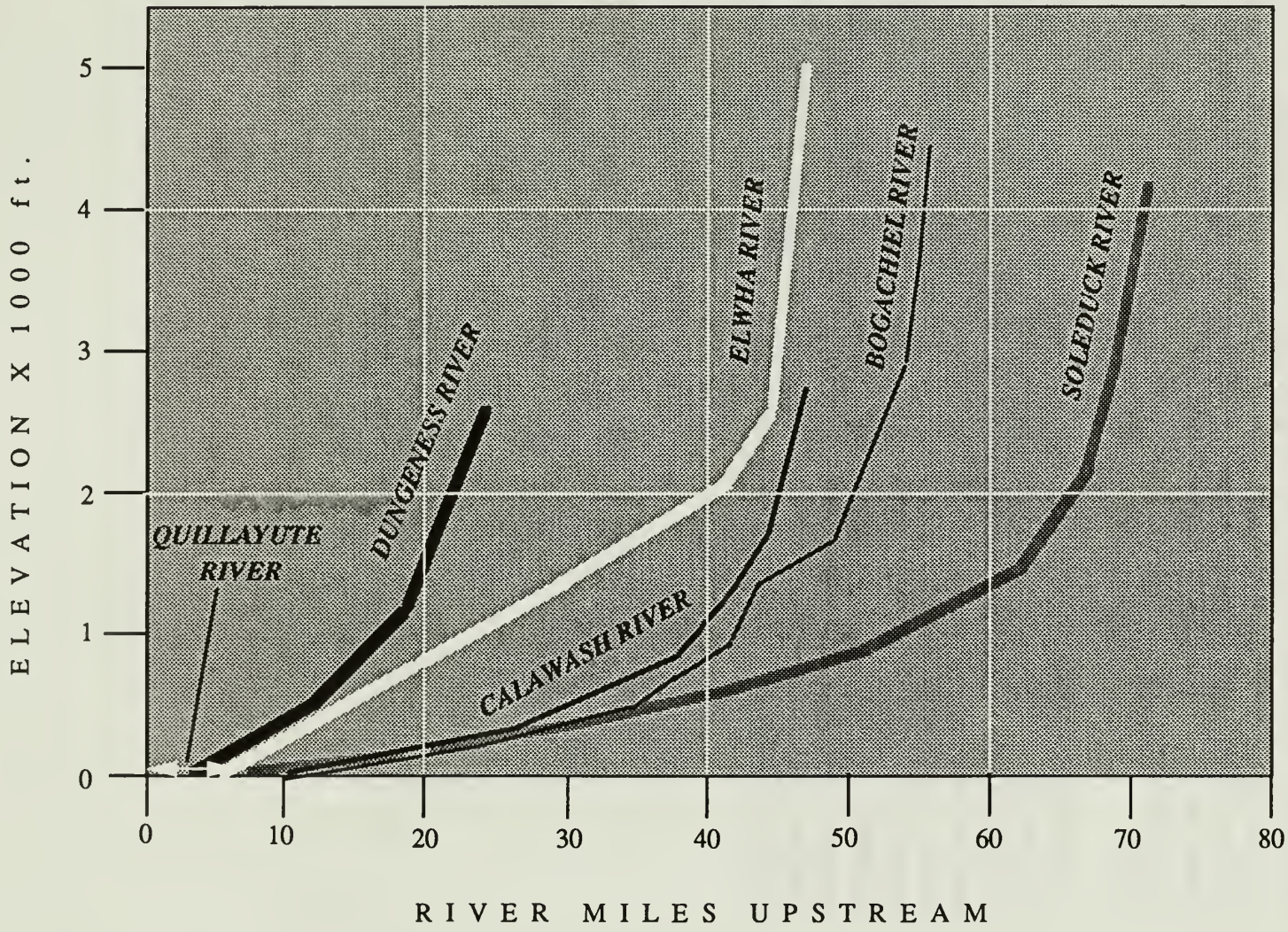


Figure C-3 River profiles for streams on the Olympic Peninsula.

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River channel pavement and sub-pavement substrate samples for the Elwha River (James River II, 1990) were used in the HEC-6 model. Runs using both the sub-pavement for analysis of potential degradation effects from the dams and the pavement samples for analysis of present armored channel condition were used in the study.

Critical shear stress for the clay and silt fractions were estimated based on values in the literature and adjusted to help duplicate the estimated trap efficiencies and observed lake bottom sediment thicknesses. The critical shear stress threshold of deposition for silt and clay of between 0.005 and 0.04 lb/sq ft were used with little effect on the results relative to the strong influence of the upstream sediment supply.

The Meyer-Peter and Muller (1948) sediment transport function was used for transport of sand through coarse gravel size material. The Elwha River at present is armored with cobbles and boulders which the model sediment transport function does not include. The main point of the model is to assess what the effects of releasing large quantities of clay to gravel size material during dam removal and to assess the return of the natural upstream sediment supply, both of which lead to deposition over the top of the armored bed and stream lateral migration which was assessed by comparison to other rivers. Therefore, the lack of a transport function that includes cobble and boulder size material was not considered a serious drawback to this application of the model.

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