Seattle City Light
Office of Environmental Affairs
Seattle, Washington

IMPACTS OF A PROPOSED COPPER CREEK DAM ON BALD EAGLES: SECOND WINTER STUDY

Investigators:

W. Grainger Hunt
Brenda S. Johnson

By:

Biosystems Analysis, Inc.
37 Clementina Street
San Francisco, CA 94105

September, 1981

Recchi

Your Seattle City Light

Memorandum

DATE : October 7, 1981

TO : Mayor Charles Royer
Paul Kraabel, President, Seattle City Council

FROM : Joseph P. Recchi, Superintendent
J. P. Recchi

SUBJECT : Transmittal of Final Bald Eagle Report

The two years of wintering bald eagle studies associated with the Copper Creek Dam environmental assessment have concluded. The final report has been submitted by our consultant, Biosystems Analysis, and copies are attached.

This report deals with a close examination of dynamics of the Skagit River's eagle population, their dependency on salmon as a major food resource, and the fate of a segment of this population if displaced directly and indirectly by the construction of a dam at Copper Creek. In the course of the study, significant new insights were gained on regional eagle movements, habitat interactions and feeding dynamics. Future management of this threatened species will benefit as a result of our support of this research.

If additional copies of the attached report are needed, please call Cheryl Tenney at the Environmental Affairs Office, 625-3151.

SR:sjh

cc: City Council Members

cc: Recchi w/Attachment
Cowan "
Directors "
& Staff
Bishop/Freitas "
Ralph
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Appel 519 K7

January 15, 1981

To Whom It May Concern:

Enclosed is the Final Environmental Impact Statement for the Copper Creek Project. Also enclosed are Appendix D: Comment Letters on the Draft EIS and City Light Responses and Appendix E: Public Hearing Transcripts. We will keep you informed by newsletter of upcoming City Council hearings on this project.

Sincerely,

(Sgd.) L. J. Miller

L. Joe Miller
Acting Superintendent

TC:rps

Enclosures

cc: All Directors
Croll
OEA (3)
File

SPONSOR

Seattle City Light proposes to increase its firm electrical energy resources by 49.3 megawatts and its peaking capability by 110 megawatts with the construction of a hydroelectric dam just below Copper Creek on the Skagit River. Specifically, the action is Seattle City Light's preparation of an application for a Federal Energy Regulatory Commission (FERC) license to construct Copper Creek Dam.

LEAD AGENCY

The lead agency is the proponent, Seattle City Light. The responsible official is Mr. L. J. Miller, Acting Superintendent of Seattle City Light. Comments may be addressed to Ms. Katherine Fletcher, Director, Office of Environmental Affairs, Seattle City Light, 1015 Third Avenue, Seattle, Washington 98104. Phone (206) 625-3105.

AUTHORS AND CONTRIBUTORS, EAGLE ADVISORY GROUP

See list on following pages.

LIST OF PERMITS

The specific action contemplated by this Environmental Impact Statement (EIS), the preparation of a FERC license application, required no licenses or permits. If a decision is made to prepare and file an application for a FERC license, then a number of local, state and federal approvals would be needed before FERC would grant a license for construction. Table 22, which is in the Land Use Section, is a list of those approvals.

LOCATION OF EIS BACKGROUND DATA

The following background data is available at Seattle City Light, Room 926, 1015 Third Avenue, Seattle, WA 98104:

EIS Support Documents:

- Hydrology
- Vegetation
- Fisheries and Aquatic Biology
- Human Environment
- Recreation
- Bald Eagles

Other Reports:

- Copper Creek Environmental Assessment Final Environmental Report and 18 Technical Reports
- "Preliminary, Interim, and Final Reports on Geologic Feasibility Studies for Copper Creek Dam" by Fugro Northwest, Inc.

- "Skagit River Chum Salmon/Carcass Drift Study," Technical Report by Bierly & Associates, Inc.
- "Impacts of a Proposed Copper Creek Dam on Bald Eagles," by Biosystems Analysis, Inc.
- "Copper Creek Hydroelectric Project. Phase I - Project Review and Evaluation," December 1980. By International Engineering Company, Inc.
- "An Alternative to the Copper Creek Dam - Conservation, Decentralized Solar and Peak Load Management," Mathematical Sciences Northwest, Inc./ Shapiro and Associates, Inc.

Much of the more technical detail has been reserved for the above support documents to which the reader is referred.

COST OF EIS

The first 500 copies are available free; thereafter $10.00 each.

DATE OF ISSUE OF FEIS

January 15, 1981

EIS AUTHORS AND CONTRIBUTORS

The following group of City Light, Office of Environmental Affairs employees and consultants helped prepare this Document.

TEAM MEMBER	AREA OF EXPERTISE	CREDENTIALS	RESPONSIBLE FOR
Anthony Basabe	Botany	M.S. Biology, W.W.U.; former botanist, Wash. Natural Heritage Program	Vegetation impacts; rare plant survey
Steve Caicco	Botany	B.S. Biology, W.W.U.; former botanist, Wash. Natural Heritage Program	Vegetation impacts; rare plant survey
Timothy Croll	Geology	M.S. Geology, U.W.	Geology & dam safety; Project Manager beginning 8/4/80
Scott Edson	Fishery Biology	M.S. Biology U.W.; 10 years experience in fisheries, especially salmonids	Fisheries impacts
Elizabeth Gjelten	Writing & Editing	Four years free lance writing & editing experience	Editing of EIS
David Hoopes	Fisheries & Wildlife	Ph.D. Fisheries Biology, Iowa State; B.S. Wildlife Mgmt. Univ of Alaska; 25 years research & consulting experience	Fisheries & wildlife impacts
William Kock	Energy Systems	14 years experience as power system design engineer	Project alternatives
Ted Lane	Socio-economics	Ph.D Economics 15 years experience consulting on social & economic impacts of projects	Consultation on impacts to local communities
Jim Mangi	Ecology	Ph.D. Biological Sciences, State Univ. of N.Y.; 6 years experience as scientist, manager and writer	Project Manager (through 8/4/80

EIS AUTHORS AND CONTRIBUTORS (cont'd)

TEAM MEMBER	AREA OF EXPERTISE	CREDENTIALS	RESPONSIBLE FOR
Suzanne Matchett	Human Ecology	B.S. Environmental Studies, Huxley College; previous experience in socioeconomic impact assessments	Impacts on local communities
Mike McDowell	Fisheries Biology	B.S. Environmental Studies, Huxley College; two years experience with fish hatcheries	Fisheries impacts
Stephen Ralph	Wildlife Biology & Fisheries	M.S. Wildlife Biology, U.W.; six years experience as researcher & consultant on wildlife & fisheries problems	Wildlife impacts
Jeremy Robertson	Eagle Studies	M.S. Environmental Science, WSU; five years in research, policy analysis & consulting on energy and ecology issues	Impacts on Bald Eagles
Mary Savela	Community Planning	Master of Public Affairs, Seattle U., six years experience in community planning and research	Impacts on Local Communities
Mark Siegenthaler	Hydrology; Geology	B.S. Civil Engineering; B.S. Geology; three years consulting experience in runoff, sedimentation & related problems	Impacts on Physical Environment
Lou Taylor	Technical writing & editing	B.S. in Biology; M.S. in science writing; five years writing experience	Editing of EIS
Ron Thompson	Recreation Planning	Twenty years experience as regional planner & consultant, with emphasis on recreation	Recreation and Aesthetics
Gordon Thomson	Urban Energy Planning	Undergraduate & graduate work in planning & social management of technology; two years experience in energy planning	Project alternatives

TEAM MEMBER	AREA OF EXPERTISE	CREDENTIALS	RESPONSIBLE FOR
Judith Wirth	Social Sciences	Master of Public Affairs, U.W.; eight years experience in social and health services	Local communities
Douglas Woodfill	Economics	M.A. Economics, Univ. of Calif., Berkeley; 13 years experience as government economist and as consultant with emphasis on energy & natural resources	Project alternatives & Economics

ORGANIZATIONS:	AREA OF EXPERTISE	RESPONSIBLE FOR
Biosystems Analysis, Inc.	Wildlife Ecology	Wintering Bald Eagle Studies
Montagne-Bierly	Wetland Ecology	Salmon Carcass Drift Study
Fugro Northwest	Geophysical Sciences	Geological Studies
Mathematical Sciences N.W.	Energy Systems	Project Alternatives
Fisheries Research Institute, University of Washington	Fisheries	Impacts on Salmon
International Engineering Co.	Dam Engineering	Preliminary Project Engineering
CH_2M-Hill	Environmental Consulting	Author of Environmental Assessment

GEOLOGICAL ADVISORY BOARD	
Dr. Howard Coombs	University of Washington
Dr. Eric Cheney	University of Washington
Dr. Scott Babcock	Western Washington University

EAGLE ADVISORY GROUP

Rick Anderson
Sierra Club

Alexandra Borrie-Bakewell
Seattle Audubon Society

Lorna Campion
Chairwoman, Conservation Committee
Seattle Audubon Society

John Dobler
U.S. Fish & Wildlife Service

Steve Fransen, Biologist
Skagit System Cooperative

Bob Gerke
Habitat Management
Department of Fisheries

Dr. Pat Goldsworthy
North Cascades Conservation Council

Tony Angell, President
Washington Nature Conservancy

Larry Broder

Eric Cummins
Nongame Program
Washington Department of Game

Jim Fielder
Zig Zag River Runners

Dave Galvin, President
Seattle Audubon Society

Ken Gilbertson
U.S. Forest Service

James Gore
Endangered Species Program
U.S. Fish and Wildlife Service

Jamie Hartley
North Cascades Audubon Society

Verne Huser
Office of Environmental Mediation

Fayette Krause
Northwest Land Steward
Nature Conservancy
Washington Field Office

Russell Orell
Skagit Laboratory
Washington Department of Fisheries

Steve Ralph

Bob Wasem
North Cascades Complex
National Park Service

Rich Howard
Endangered Species Program
U.S. Fish and Wildlife Service

Rick Knight
Nongame Program
Washington Department of Game

Margaret and Joe Miller
North Cascades Conservation Council

Gordon Orians
Institute for Environmental Studies
University of Washington

Susan Skagen, Preserve Steward
Skagit River Bald Eagle Natural Area

Bob Wunderlich
U.S. Fish and Wildlife Service

In addition, many employees of the City Light Engineering and Power Management Divisions and the Office of Environmental Affairs have made major contributions to the Copper Creek EIS Project. Members of the Conservation and Solar Division contributed to the alternative discussion. Members of the Operations Division contributed to the Human Environment sections.

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U.S. Soil Conservation Service

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House Ecology Committee
Huxley College, Western Washington University

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Local

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Burlington Library
Burlington Mayor's Office
Burlington Planning Commission
Concrete City Council
Concrete Planning Commission
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Energy Office, City of Seattle
Governmental Research Assistance Library, City of Seattle
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King County Building and Land Development
King County Energy Planning Project
King County Parks and Recreation
King County Planning and Community Development Dept.
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Lyman City Clerk
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Mayor's Office, City of Seattle
Mount Vernon City Council
Mount Vernon Library
Mount Vernon Planning Commission
Municipality of Metropolitan Seattle (Metro)
Port of Anacortes

Port of Skagit County
Prosecutor's Office, King County
Puget Sound Air Pollution Control Agency
Puget Sound Council of Governments
PUD #1, Mount Vernon
Seattle City Council
Seattle City Light, Office of Community Relations
Seattle Department of Construction and Land Use
Seattle Public Library
Seattle Water Department
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Sedro Woolley City Council
Sedro Woolley Planning Commission
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Skagit County Planning Commission
Skagit County Planning Department
Skagit Valley Hospital
Snohomish Basin Coordinating Council
Whatcom County Building and Codes Department
Whatcom County Commissioner
Whatcom County Parks Department
Whatcom County Planning Commission

American Indian Tribes

Tulalip Tribes of Washington
Sauk-Suiattle Tribal Office
Senate of Swinomish Tribal Community
Skagit System Cooperative
Swinomish Tribal Community
Upper Skagit Tribe

Media

Anacortes American
Argus, Seattle
Arlington Times
Associated Press
Bellingham Herald
Burlington Journal
Cascade Journal
Concrete Herald
Courier Times, Sedro Woolley
Daily Journal of Commerce
Everett Herald
KAGT, KAPS, KARI, KAYO, KBFW, KBRC, KGMI, KING, KIRO, KISM, KISM-FM, KIXI, KJR, KLYN-FM, KOMO, KOQT, KPUG-KERI, KSTW, KVI, KYAC, KZOK, KVOS, KMPS

Lyman Times
Lynden Tribune
META Publication, Marblemount
Mount Vernon Argus
Sedro Woolley Times
Seattle Post Intelligencer
Seattle Sun
Seattle Times
Skagit Valley Herald
United Press International

Organizations

Alpine Club, Sedro Woolley
Alpine Lakes Protection Society
American Canoe Association
Antioch University Seattle, Urban Planning Department
Arcade Building and Realty Company
Arctic Lockers, Sedro Woolley
Audubon Society
Benson's River Trips
Benton Grocery, Concrete
Bierly and Associates
Boeing Company
Canyoneers, Inc., Marblemount
Center for Appropriate Regional Development
Chamber of Commerce: Ballard
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University
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White Center
Chicago Bridge and Iron Co.
Conservation Company, Seattle
Corky's Alpine Grocery

Defenders of Wildlife, Bellevue
Democratic Party, Mount Vernon
Downtown Mount Vernon Business Center
Ducks Unlimited, Mount Vernon
Ecotope Group
Electric League, Bellevue
Energy Conservation Coalition, Seattle
Environment Northwest, Seattle
Envirosphere Company
Evergreen Legal Services, Native American Unit, Seattle
FUND, Denver
Fidalgo Environmental Council
Fidalgo Fly Fishing Club
Friends of the Earth
Gardner Engineers, Inc., Seattle
General Telephone Company
Georgia-Pacific
Greenpeace Seattle
HUB Sports Club, Burlington
Hammond, Collier and Wade Livingstone Associates, Inc.
Historical Preservation Committee, LaConner
Historical Society of Skagit County
Jones Associates
Jones and Jones
Jones and Stokes Associates, Inc.
Kramer, Chin and Mayo, Inc.
Laborers Local #901
Larry Erickson and Associates, Mount Vernon
Lyman Market and Hardware
Madrona Neighborhood Development Association
Mount Vernon Northwest Steelheaders
Mountain Song Restaurant
Mountaineers
Native American Rights Fund, Boulder, Colorado
Nature Conservancy, Seattle
New Careers Office
North Cascades Audubon Society
North Cascades Conservation Council
North Cascades Highway Association
Northwest Air Pollution Authority
Northwest Steelhead and Salmon Council of Trout Unlimited
N.U.S. Corporation
Pacific Northwest Bell
Pacific Northwest Float Trips, Inc., Sedro Woolley
Pacific Northwest Trail Association
Paddle Trails Canoe Club, Seattle
Political Education Now, Sedro Woolley
Polyclinic, Seattle
Quadrant Corporation

R. W. Beck and Associates, Seattle
Rader and Leonard Associates
Recreation Equipment Co-op
Reed, McClure, Moceri and Thonn
Robert E. Meyer Consultants
Roofers and Waterproofers Union
Schroeder, Jackson, Goldmark and Bender
Seattle Canoe Club
Seattle Pacific University
Seattle University, School of Public Service
Sierra Club
Skagit County Historical Society
Skagit Environmental Council
Skagit River Guide Association
Skagit Rock and Gem Club
Skagit Sam's Camping Club
Skagitonians Concerned About Nuclear Power
Skylark, Inc.
Smith, Brucker, Winn and Ehlert, Attorneys at Law
Spencer Products
Steelhead Trout Club of Washington
Teamsters Local #788
Totem Trail Cafe and Motel, Rockport
VTN, Inc.
WASH-PIRG
Washington Environmental Council
Washington Environmental Trade Association
Washington Kayak Club
Washington Natural Heritage Program
Washington Roadside Council
Washington State Sports Council
Washington Society of Professional Engineers
Washington Wilderness Coalition
Wayne Hancock and Associates
Weyerhauser Company
Wildcat Steelhead Club

Introduction

At the conclusion of the pioneering Energy 1990 study in 1976, the Seattle City Council directed the City Light Department to study the development of a hydroelectric dam near Copper Creek on the Skagit River as a possible complement to City Light's energy conservation efforts. This led to the publication of the Copper Creek Environmental Assessment by the consulting firm CH2M-Hill for City Light in December, 1978 and November, 1979. The City moved toward the decision point on the Copper Creek Project by passing Resolutions 26044, 26269, and 26377 calling for the writing of this environmental impact statement on the Copper Creek Project.

The decision-making process for the Copper Creek Project has several steps. The first decision is the one presently before the City: Should an application for a Federal Energy Regulatory Commission (FERC) license be prepared? Based on this final environmental statement (FEIS) and on appended public comments, the Superintendent of City Light will make a recommendation to the Mayor. The Mayor will then present his recommendation to the City Council in early February, 1981. The City Council will be considering the Copper Creek Project over the next three months and will reach a decision on the preparation of a FERC license by April 15, 1981.

If this initial decision is negative, Copper Creek would not be considered in the foreseeable future.

If the initial decision is positive, City Light will prepare a license application. If no new information appears during preparation that casts a serious shadow on the feasibility of the project, this application would be filed by December 31, 1981. FERC would then begin its own evaluation of project impacts and benefits. It would consult affected agencies, hold public hearings, and write a federal environmental impact statement. FERC could request further data from City Light during this license review process. At the end of this process, which could take several years, FERC would either issue or deny a license for the Copper Creek site. Any license issued may have conditions included relating to design, construction, operation and mitigation of environmental impacts. Formal City Council acceptance of this license would be required before construction could proceed.

A third outcome of the City Council's initial decision in the spring of 1981 could be to place Copper Creek in the Contingency Reserve category in the City Light resource planning process. Development of projects in this category is generally limited to steps which cut down the lead time in implementing the project, should it be reactivated. This third choice would be equivalent to putting Copper Creek "on hold".

It is apparent that many decisions would have to be made both in the City and by the federal government before Copper Creek could be built. However, the present consensus within city government is that a positive decision by the City Council in the spring of 1981 would be the significant commitment by the City to the construction of the Copper Creek Project. If this commitment were made, it is assumed that the City would pursue the project, barring unforeseen factors. So the Council's coming decision is perhaps the most important from the City's point of view, and it is toward this decision and the preceding departmental and Mayoral recommendations that this document is focused.

Summary

The City of Seattle faces a decision: Should the City prepare an application for a federal license to build a dam on the Skagit River near Copper Creek?

In compliance with state environmental law, and to help Seattle's City Council and Mayor make their decision, we have prepared this document. It identifies the environmental effects of a dam on the various parts of the environment.

Seattle City Light must take some action in order to ensure that its resources match its customers' demands after 1990. Since the 1950's, energy officials have seen a need for more power for Seattle. Early in 1980, City Light completed its latest study of this problem, and in a report called "Resource Analysis 1980", the utility reviewed specific energy resources available to the City through the year 2000. The study concluded that even with current energy resources from thermal plants and its own hydroelectric dams (including High Ross Dam), plus power that can be purchased from BPA and other utilities, Seattle faces an energy deficit before the end of the century. Copper Creek Dam, discussed in this EIS, would be one way to partially offset this projected deficit.

City Light must provide reliable power resources. Power requirements and resources are conventionally expressed in quantities of energy and/or capacity, and quantified in megawatts. The terms firm energy and firm capacity are generally used to describe that capability of a generating resource that can be produced with high reliability. (Further references to energy and capacity in the EIS are intended to be firm energy and firm capacity.) Peak system loads occur during the cold winter months. The capacity of generating resources is required to meet such peak demands. Energy loads, likewise, vary seasonally with maximum consumption in the cold winter months. The Copper Creek Project would supply both energy and capacity with high reliability.

A look at Seattle's present electrical picture helps put the Copper Creek Project in perspective. This year City Light's customers are using an average of about 990 megawatts of energy (one megawatt is one million watts). In twenty years, the utility could supply about 1,050 megawatts of energy (assuming High Ross or equivalent is on line). During that period, however, average demand will exceed supply, so that the utility may end the century with a deficit of 270 megawatts. Similarly, City

Light foresees a deficit in peaking capability of about 450 megawatts by century's end, even though peaking resources will have increased between 1980 and 2000 by about 20 percent, from 1,600 to 2,000 megawatts.

The Copper Creek Project could make up about one fourth of these deficits: 49.3 megawatts of firm energy and 110 megawatts of peaking capability. (This 49.3 Mw of firm energy added to 12.3 Mw of non-firm energy gives the project an average energy capability of about 62 Mw.) It may also be possible, as we explain later, to use other means to supply some of the needed energy to reduce demand to cut the projected deficits. However, it should be recognized that these other means may be needed in addition to the Copper Creek Project to meet the total projected deficits.

THE PROJECT

From an engineering point of view, there are two sites suitable for building a dam on the Skagit River. The Copper Creek site, at river mile 83.9 in Skagit County about five miles upstream of Marblemount, would allow construction of a dam to one of two possible elevations. An alternative site suitable for construction of a dam is at river mile 86.6 near Damnation Creek. For economic, engineering and energy supply reasons, City Light's preference is the higher dam at Copper Creek.

City Light's preferred Copper Creek configuration includes a 180-foot high earth-and-rockfill dam about 1,900 feet long at the crest. Elevation at dam crest would be 510 feet. The dam's core would be silt and clay, with gravel and large rocks forming the embankments. To prevent seepage past the dam, a thick cutoff barrier of concrete buried deep in the riverbed would be built. Excavation of 38 acres from a nearby hillside would provide most of the 768,000 cubic yards of fill material. The rest would come from the riverbed.

The dam would flood 10.2 miles of the upper Skagit Valley and create a reservoir covering 2,200 acres (3.4 square miles). Construction would require relocation of SR 20 (the North Cascades Highway) and transmission lines.

The Copper Creek facility would have a powerhouse, spillway, tailrace, intake structure, and switchyard. The powerhouse would contain two or more turbines and generators, which would connect to City Light's powerlines via a transformer. A concrete-lined tunnel would shunt river water to the powerhouse to turn the turbines. Discharge from the turbines would be returned to the river in a channel to be excavated through the north bank floodplain downstream of the dam. The channel would be 1,000 feet long and 100 feet wide at the bottom, with a slight slope toward the river. A spillway on the south abutment of the dam would be designed to pass the maximum expected flood waters likely to occur on the Skagit.

Copper Creek would be operated to produce 49.3 megawatts of firm energy and 110 megawatts of capacity, or peaking capability. There could also be as much as 12.3 megawatts of nonfirm, or secondary, energy available. The facility would also be operated in such a way that the Skagit River flow could be regulated more than it is today. Under present conditions power generation from the three hydroelectric facilities above Copper Creek causes the river level to rise and fall daily. The Copper Creek facility and its reservoir would serve as a buffer to smooth out these differences in flow, thereby providing other downstream benefits. Copper Creek would also provide the option of future expansions at Gorge and Diablo plants.

DAM SAFETY

Geological work to help determine the suitability and safety of building a dam in the Copper Creek area has been performed to identify such factors as soil stability and the level of vibratory ground motion that might come from an earthquake. Based on knowledge of the site's geology, City Light's engineers and consultants have concluded that the Copper Creek area can safely accommodate a dam and that an earth-and-rockfill dam is the most suitable type to build there.

It might be possible to construct a concrete dam at Copper Creek, but a 300-feet thick layer of earth and rock in the riverbed would have to be excavated for conventional concrete dam construction and would thus pose construction difficulties. It might also be possible to build a concrete dam on top of the valley floor sediments. This would require an articulated structure to allow for differential settlement. A "flexible" concrete dam with joints could be built, but it would be a difficult and perhaps unprecedented construction achievement. An earth-and-rockfill dam, however, would have the flexibility and strength to withstand the maximum predicted earth movement.

Not only does the type of earth-and-rockfill dam proposed for the Skagit River have an extremely low probability of failure, but in that unlikely event the dam would be expected to release the water behind it slowly, perhaps over 24 hours, rather than in a large, rapidly moving flood wave. In the worst case, however, the towns of Marblemount, Rockport, Hamilton, Lyman, Concrete and Sedro Woolley would be imperiled by severe flooding. Below Sedro Woolley, impacts of dam failure would be equivalent to severe winter flooding in the area. Future actions, if the dam were constructed, would include emergency plans of action to minimize property damage and threat to downstream residents.

Studies completed in the summer of 1980 by City Light's geological consultant, Fugro Northwest, have shown that faults, or cracks, in the earth's crust near Copper Creek pose no hazards to dam safety. Potential faults that, in preliminary studies, appeared to intercept the dam site are now thought (if the faults exist at all) to point north of the site. In addition, seismic surveys failed to find any faults in the bedrock floor or near the site.

IMPACTS

The Copper Creek Project would have positive and negative effects, which in the EIS are referred to as "impacts." All the impacts are interrelated, but we have separated them to make it easy to analyze each one. We describe impacts on the physical environment, biological environment, and human environment. We then present energy alternatives to Copper Creek Dam, and an economic analysis completes the study.

IMPACTS ON THE PHYSICAL ENVIRONMENT

Geology--the land

Soil and rock materials would be excavated for the dam, but this commitment of natural resources is not considered particularly important. Pumicite, talc, and gravel deposits would be flooded behind the dam. Because none of these are presently worked, their loss probably would not be significant.

Hydrology--water

Human beings and nature control the flow of water in the Skagit River. Seasonally, flooding naturally tends to occur on the Skagit from snowpack runoff (in spring and summer) and after heavy rains (in winter). City Light's three upstream projects control these seasonal variations. Gorge, Diablo and Ross projects release water to generate power according to demands in Seattle. Generally, that means the river level may gradually rise and fall as much as two feet during the daytime, as well as being higher overall during the winter than the rest of the year.

Copper Creek Reservoir could be relatively small and could not significantly alter the present seasonal flow pattern of the river. Copper Creek Project would smooth out most of the discharges from Gorge Powerhouse.

The Copper Creek Project could not change the current flood control capability on the river, and the dam would have a spillway designed to safely pass the river's probable maximum flood (PMF).

During construction, water quality in Bacon Creek (a Skagit River tributary), as well as in the Skagit itself, could be impacted. Excavation of fill material and construction activity at the site would allow the erosion of some soil into the streams, causing muddiness in the water. This water pollution at times could be serious enough to affect the organisms of the river. The use of dikes, levees, diversion channels, and settling ponds could reduce this impact. Even with these measures, some muddiness in Bacon Creek and the Skagit River would occur, although it would be more of a problem in the winter than in summer. With dam construction completed, there would be no long lasting adverse impacts on water quality.

Copper Creek Dam is expected to have some effect on natural processes of erosion and deposition of streambed materials. These processes at the Copper Creek site have already been altered to some extent by the three existing dams upstream. In general, however, those reaches of Skagit now subject to erosion will be eroded more if the dam is built, although no erosion of gravel bars is expected during normal dam operation and discharge. In addition, due to the loss of silt, sand, and gravel from Newhalem and Goodell Creeks, certain areas below the dam site will experience less normal depositional buildup. It is possible that these changes in the nature of the streambed could have effects on the spawning ability of salmon and steelhead in the reaches below the dam site.

Air and Noise Pollution

Construction activities would create some noise and air pollution near the dam site and along the North Cascades Highway. Some impacts, such as machine noise and construction-related dust, would be temporary and could be mitigated by machine maintenance and road watering. Other impacts would be permanent. After filling the reservoir, sounds would travel farther than they do now in the forested valley. The sound of river rapids would be lost. Possible increased highway and powerboat noise could be mitigated by locating the highway away from the shoreline, and by regulation of power boating by the National Park Service, if this is feasible.

Land Use

Certain river shorelines in Whatcom and Skagit Counties, now restricted to limited development, would be flooded by Copper Creek Reservoir. The dam and reservoir, within the Ross Lake National Recreation Area and under National Park Service jurisdiction, could diminish the recreational diversity of the area. The dam could also affect the U.S. Department of Agriculture's management of the downstream Skagit River Wild and Scenic River system. However, if the Federal Energy Regulatory Commission (FERC) grants a license for building the Copper Creek Project, FERC would have ultimate authority over land use within the project boundaries.

IMPACTS ON THE BIOLOGICAL ENVIRONMENT

Vegetation--plant life

Once completed, the Copper Creek Reservoir would flood as many as 2,200 acres of the valley. Vegetation would be lost, but no rare or endangered plants have been found, nor are there forest stands which are unique or of special botanical importance in the area. For these reasons and because such features as a stand of mature trees cannot be replaced once flooded, City Light does not identify any measures to mitigate dam impacts on vegetation.

Wildlife--animals

We have identified approximately two dozen animal species that could be impacted by a dam. It is likely that some deer, bear, beaver, small mammals, birds, reptiles and amphibians would perish. (Bald eagles, because of their unique status, are considered separately later in this discussion.) Wildlife habitat lost to the Copper Creek Project would be difficult to replace with identical habitat located elsewhere. It is probable that many substitute areas are fully used by other wildlife, leaving no room for additional inhabitants.

A solution to this dilemma, and one way to mitigate losses of animal habitat, is to manage adjacent lands to improve their "value" to wildlife. Most lands probably can be made to support more animals this way, but to what degree is questionable and speculative. Moreover, efforts to manage for one species quite possibly can be detrimental to another.

Measures which could be taken to offset losses within the project area include the creation of small, year-round wetland habitats by blocking small streams; management of the rerouted transmission line right-of-way to provide maximum wildlife use; the creation of nesting and feeding habitat for birds by leaving snag trees standing along the reservoir, and the clearing of woodlands adjacent to the reservoir to support a better mix of animals than a mature woodland does.

It is not known how important the loss of wildlife and wildlife habitat in the dam project area would be to the greater ecological systems of the Skagit valley and the North Cascades.

Bald Eagles

Populations of up to 300 bald eagles, a threatened species and the national bird, spend the winter months on the Skagit River. They appear to be drawn there by food. Chum and coho salmon run up the Skagit to spawn. In completing their life cycles they die, and thus provide carcasses on which the eagles feed.

Copper Creek Reservoir would flood spawning grounds, reduce the size of the eagles' feeding grounds, and limit the number of carcasses drifting downstream for eagles to feed on. This could permanently limit the number of eagles supported by the Skagit River, unless these food losses are mitigated.

Since eagles migrate in search of food, dam construction could displace some birds to other river drainages in the region. Until studies are completed in 1982, we cannot estimate how many eagles would be displaced or how well other areas could absorb them.

Eagles have value to humans as an aesthetic and recreational resource. The Skagit River Bald Eagle Natural Area, an eagle refuge downstream of the proposed dam project, provides eagle viewing area, as do other locations in the North Cascades region. Drops in eagle populations could impact the intangible values people place on eagles.

Mitigation of food losses could be achieved by augmenting the eagles' food supply with salmon carcasses from hatcheries or artificial spawning channels. Artificial ponds stocked with salmon might also be an effective solution. The practicality or acceptability of these measures is not known.

A judgment on the potential impacts of the dam on the eagles of Northwest Washington will be formally rendered by the U.S. Fish and Wildlife Service, pursuant to the

Endangered Species Act, if an application to license the project is submitted.

Aquatic Biology--the fish

The Skagit River supports Puget Sound's largest natural salmon spawning runs. All five species of Pacific Salmon, plus steelhead trout, spawn in the river and its tributaries. The Copper Creek Project, while eliminating spawning grounds above the dam site, could improve remaining fish food supplies (and the fishery), depending upon the project's operating regime.

One current influence on the size of the fish runs is the operation of City Light's three Skagit River dams, which cause daily changes in downstream flow and water level. River plants, and insects that eat them, are sensitive to these changes in flow; they dry out and die of flow drops, or they are scoured free from the river bottom and drift away if flows become too high. The Copper Creek Project might have a beneficial influence on the river's food web downstream of the dam, but the net effect on the fish population of this potential improvement, coupled with the loss of spawning area, is unknown.

Copper Creek Reservoir would remove more than 10.2 miles of mainstem river and eliminate 8.8 miles of tributary streams containing existing salmon spawning grounds. If it is assumed that the river keeps producing fish at the rate it does today, loss of these spawning grounds could cut commercial fishing revenues by at least $100,000 a year.* If, in the next few years, fish production is enhanced to the levels planned by the Washington Department of Fisheries, commercial salmon losses could be much larger, on the order of $600,000 per year*, after completion of the dam.

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* These figures would be decreased an uncertain amount by reregulation benefits, more intensive use of downstream spawning ground, and failure to reach escapement goals. The sport fishery figures could be further reduced if the loss of fishing days was not proportional to the loss of sport fish. These figures, however, could be increased by two factors. The first is by the effects of armoring, the erosion of sand and fine gravel from the streambed, which could hamper spawning. The second is due to the fact that fish loss estimates in the EIS cannot account for the number of Skagit-bound fish that are intercepted and harvested elsewhere. This number of fish is not known.

The dam could also result in losses to the sport fishery. Losses in the chinook and coho fishery could range between $10,000 and $16,000 a year* and between $10,000 and $30,000 per year* in the steelhead fishery. If steelhead production levels were brought back to their potential demonstrated in 1963-64, losses might total between $70,000 and $100,000 annually*.

American Indians, who have fished the Skagit for unrecorded generations, would be impacted by the dam. Economically, the tribes who fish the river (and account for 70 percent of the commercial catch in the Skagit area) could lose that portion or $70,000 a year* at current production levels. Should tribal or government management improve the runs in the next few years, Indian fisheries could experience yearly losses totalling about $400,000*. Culturally, dam-related changes in the Skagit would adversely affect ceremonial and religious values that tribal members associate with the fish.

Various court actions, including the recent Boldt II decision (U.S. v. Washington, Phase II) have affirmed Indians' rights to fish in their traditional areas and have prescribed treaty rights relative to fishery habitat protection and water rights. It is not known if the Copper Creek Project would be compatible with these treaty rights.

The loss of ten miles of river containing spawning grounds could be mitigated in several ways. For instance, spawning channels could be built adjacent to the reservoir that mimic natural spawning grounds, or fish lost could be replaced by artificial propagation in hatcheries. This latter method, however, would create an additional impact. There is a concern that the genetic variability of "wild" runs of fish would be reduced by the addition of hatchery fish to the natural run. Hatchery fish are developed from eggs selected by hatchery personnel. Human selection may favor some qualities (such as size and color or meat) at the expense of others (such as the innate timing of spawning). Since a wide range of genetic variability enables fish populations to survive harsh environmental changes, its loss or reduction could be a significant impact. The State currently operates a hatchery at Marblemount which likely already affects the gene pool to some extent.

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* See footnote previous page.

The proposed Copper Creek Reservoir area presently supports populations of resident fish (Dolly Varden, rainbow trout, mountain whitefish, and longnose dace).

The foregoing impacts on eagles and aquatic biology may be reduced by the reregulation capability of the Copper Creek Project, which should improve the fish habitat. The net effect is not certain.

IMPACTS ON THE HUMAN ENVIRONMENT

Construction of a dam at Copper Creek or Damnation Creek could have an effect on the people in the surrounding region, on their economy and unemployment rates, housing, public services and transportation--the "human environment."

Eight communities in Skagit County (from Mount Vernon to Marblemount), and Newhalem and Diablo in Whatcom County, would be affected by the project. Up to 900 American Indians in the area could be affected as well. The area is primarily rural and depends largely on natural resources. The largest population and employment center is Mount Vernon.

If a dam were built, a construction force peaking at approximately 450 workers could be needed during a five-year period. (The peak would persist for roughly one year, while the five-year period would average around 200 workers. However, the impacts are determined by the peak level.) Many of these workers could come from Skagit County. The most likely scenario is that very few would need to move into the area from elsewhere. If the local work force were used, then the major effect on the river valley communities could be increased traffic from commuting construction workers. This potential impact could be decreased by the use of car pools, van pools and crew buses.

If, however, in the worst case (which we consider unlikely) the maximum number of workers with dependents had to move into the area from other counties or states, they could increase the population by as much as 1,000, and there would be effects on communities such as Concrete or Sedro Woolley. Financial (tax) support from relatively transient residents is usually less than that of locals, so the towns' networks of community and governmental services, schools, police and fire protection could be stretched.

The temporary influx of workers could also affect the communities' quality of life and increase crime and domestic disturbances.

In general, mitigation efforts could include planning for increased demand on utilities, providing for additional housing, securing supplementary funding for local schools and public services, and constructing a temporary work camp to accommodate the majority of nonlocal workers. All efforts could be coordinated with local government officials.

The small communities might have to adjust to temporary growth followed by decline, but few long-term impacts would remain. With proper mitigation planning measures, the net changes could be permanent improvements to services and facilities.

The dam itself would directly impact the Upper Skagit, Swinomish and Sauk-Suiattle Tribes. As explained earlier, spawning grounds of salmon on which the tribes depend would be lost. This loss could be partially mitigated by artificial propagation and/or river reregulation.

Cultural Resources

Several archaeological features in the Skagit Valley--Indian living, fishing and activity sites--would be affected by a dam. Artifacts which may have significance have been found at some of these sites. More "modern" historic sites from the early twentieth century, including cabins, a small ranch, a river landing and a mine, would be impacted by the dam as well.

Some of these areas could be protected from flooding. Others could not, and might have to be fully investigated prior to filling the reservoir. The significance of these cultural sites is not known, so the impact of their loss is uncertain.

Recreational and Aesthetic Resources

The proposed Copper Creek Dam would impact an area that is referred to as the "Gateway to the American Alps." The upper Skagit Valley lies within the boundaries of the Ross Lake National Recreation Area. This area was created by an act of the U.S. Congress which recognized hydroelectric development including the proposed Copper Creek Project. Visitors find numerous recreational and aesthetic amenities in the area, many of which are associated with or use the river. Replacement of this portion of river with a reservoir would have significant long-term effects.

Up to ten miles of the Skagit containing its last stretch of whitewater rapids would be flooded. This could result in some losses to recreation-oriented enterprises, such as whitewater rafting, that would probably not be offset by lake-oriented recreation.

Fishing, camping and wildlife observation points on the river bank would be lost. Observation of fish spawning in the stream would be lost. These losses could be partially offset by improved boating opportunities, construction of camp sites elsewhere, and better access to hiking on the valley slopes.

By flooding up to ten miles of valley floor, lowland valley characteristics and scenic diversity would be lost. The sight and sound of moving water would be replaced by a lake. During some periods, an unvegetated strip of land would be exposed along the shoreline. This strip would be narrow along most of the reservoir and considerably wider near Newhalem.

The North Cascades Highway and power transmission lines would have to be relocated. Highway relocation would create scarring roadcuts and change the traveller's relationship to the river. Like those that exist now, powerlines placed along the valley slopes would be highly visible and detract from the forested landscape.

Finally, dam construction would change the natural character of a portion of the Skagit Valley in the vicinity of the Copper Creek Project. Man-made elements which are a part of the construction project would intrude on the landscape.

ALTERNATIVES

The Copper Creek Project has been proposed as a way to partly meet Seattle's future power needs. There are a number of alternatives which also meet the primary objective of adding or displacing 49.3 megawatts energy and 110 megawatts peaking capability. In order to determine the best alternatives, we started with a list of many promising energy resource technologies. These were reduced to a smaller number, largely on the basis of technical, economic, and environmental considerations. The remaining alternatives are all feasible but vary in cost, some operational characteristics, and environmental impacts.

From this analysis, the best choices appeared to be the following:

- Copper Creek Project
- Centralized wind systems and small hydro

- Decentralized solar, conservation and load management
- Municipal solid waste and on-site cogeneration
- Coal

Although we have selected combinations of complementary technologies in order to match the power requirements of Copper Creek, these resources can be considered singly or in other combinations.

A number of large wind stations could be built adjacent to existing transmission corridors to capture winds. These are feasible but would require siting and development studies. Small hydro facilities, such as existing irrigation facilities, are also feasible. These options exploit renewable resources and may have fewer environmental impacts depending on site specific characteristics.

Decentralized solar and conservation are currently being developed as alternatives by the utility; load management (control of peak customer demand) is a desirable supplementary option for meeting power requirements. Unlike adding new generation, these are demand-reduction options. As such, there may be some additional costs of inconvenience and regulation. The costs of this option may be reasonably low but depend entirely on the types of programs developed.

We ranked municipal solid waste energy and cogeneration (capturing industrial waste heat) as another promising alternative. The City of Seattle and King County are jointly investigating solid waste opportunities, and City Light is considering cogeneration possibilities.

A share of a coal plant is another alternative to Copper Creek. Our preliminary generic analysis shows coal to be more expensive, with environmental impacts perhaps as severe as those of Copper Creek. City Light is at present investigating purchasing a share in the Creston Project in Eastern Washington. This investigation will allow a site-specific analysis of the coal option.

ECONOMIC EVALUATION

This EIS, a document designed to aid the decision-making process, describes the environmental consequences of the proposed project, potential mitigation measures, and energy alternatives that have been considered to be feasible, either as alternatives or in addition to the Copper Creek Project. This EIS also contains an economic analysis of the costs and benefits of the projects in which environmental impacts, as much as practicable, share an equal status with cost and value considerations. We attempt to process the value of qualitative environmental elements in a systematic way.

Benefits

The primary benefit of the Copper Creek Project would be to provide 49.3 megawatts for meeting firm energy needs and 110 megawatts of peaking capability. Secondary benefits include:

- increase of operational flexibility of upstream projects,
- greater regulation of downstream flow on the Skagit River, as a benefit to fisheries, and
- a capability for increasing generation capacity at Gorge and Diablo by as much as 334 megawatts.

Costs

The dam would cost approximately $245 million to build, $1 million annually to operate, and $1.6 million per year to transmit and distribute the power derived (1981, Energy Resources Report and Data Base).

The social and environmental impacts would impinge on:

- fisheries
- bald eagles as a biological and human resource
- whitewater and other recreation
- local communities and their economies
- local rural life-styles
- dam safety
- transfer of benefits out of the project area

Mitigation for some of these impacts could add to costs of the project. Other impacts among these may be unavoidable and may not be subject to direct mitigation.

Economic Analysis

Economic analysis of the Copper Creek Project shows that, in the long term, it is a feasible investment and will provide net benefits totalling $190 million over the 50-year lifespan of the project. The rate of return on the investment is high; each dollar invested would pay back $1.78. The levelized cost of the project (annualized costs divided by average energy output) is 23.2 mills/kwh (one mill = 1/10¢). This puts Copper Creek close to the cheapest of the alternatives. The levelized cost of the solar/conservation/load management alternative, in comparison, is 15-20 mills/kwh. (This estimate is based on a calculation of 15 mills by Mathematical Sciences Northwest in a consulting study for Seattle City Light. We have added 5 mills for possible unexpected administrative costs.) The Copper Creek Project has many other costs and benefits which are not easily measured in dollars, as noted above.

City policy-makers will be weighing the environmental, economic, and technical advantages and disadvantages of Copper Creek and the alternatives in their coming decision. Public comments and opinions on this document will prove to be valuable in this decision.

CHAPTER I. THE PROBLEM

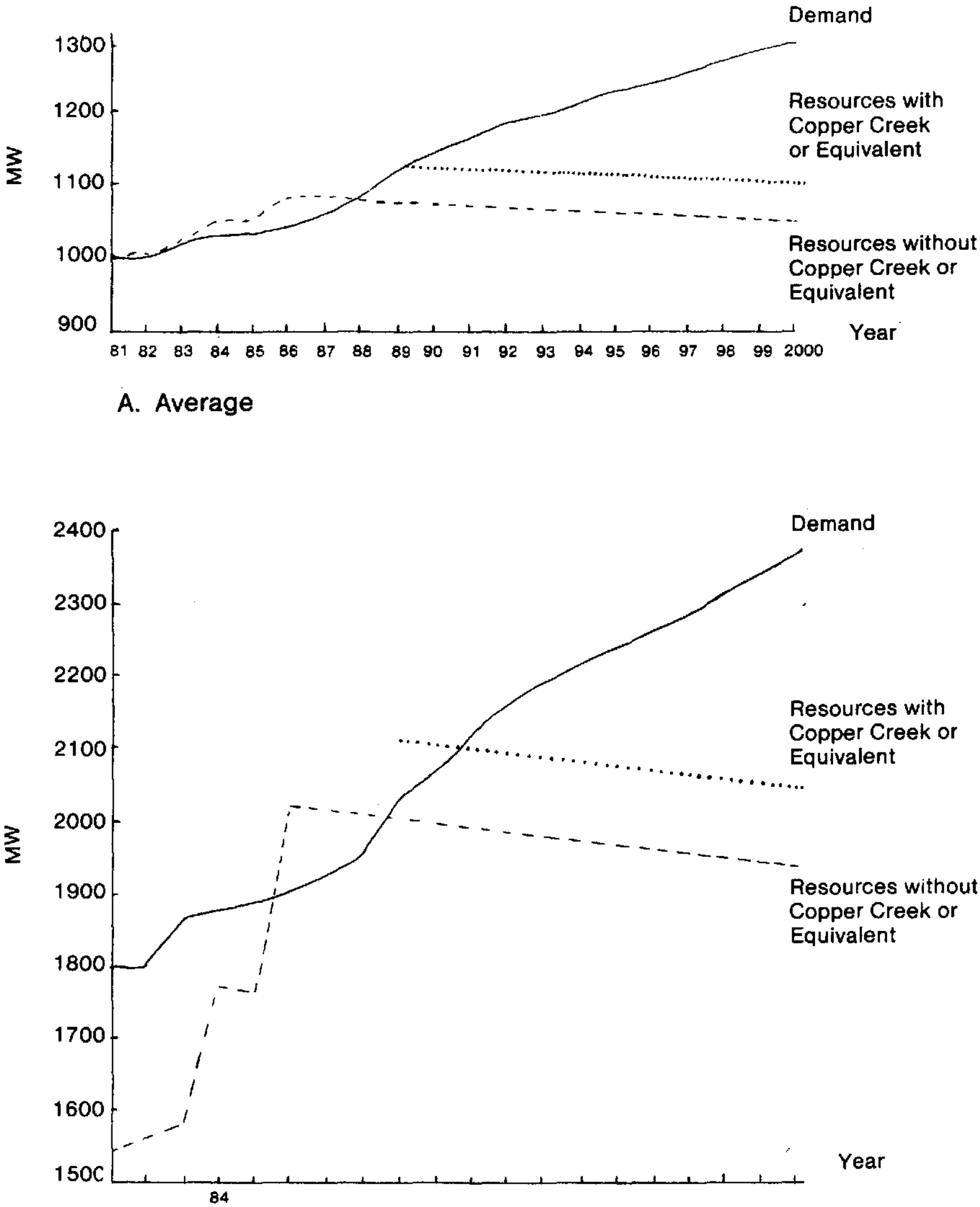
THE PROBLEM

Present estimates show Seattle's demand for average energy exceeding the supply City Light provides beginning in 1987-88. The forecasted peak already exceeds City Light's current resource capability; this shortfall is currently covered by purchased capacity from other utilities at an expensive rate. Such capacity purchase cannot be assured to be available each year. Interruption of industrial customers cannot be relied upon as a firm capacity resource of any magnitude under current rate structure.

Figure 1a shows future average energy demand and resources for Seattle City Light. The demand was calculated in Forecast 1979/80 (endorsed by Council Resolution 26438 and released in September 1980). This growth includes the effects of several conservation programs (see Table 29, Chapter IV). In fact, the forecasted conservation level in 1990 equals 208 Mw. Resources are catalogued in the City Light report Resource Analysis 1980. Future resources listed include existing resources, as well as Seattle's share of the Centralia Steam Plant and High Ross or equivalent; the South Fork Tolt and Columbia irrigation canal projects and other proposed resources have not been included. Figure 1b shows the same information for the peak load (highest hourly demand of a year).

High Ross Dam (or its equivalent from British Columbia) is expected to temporarily remove this deficit of peak generating capacity. But peak demand is predicted to again exceed supply by 1988-89. Details of future resource and demand forecasting are provided in Chapter V, Section 1.

The need to start bridging the gaps in Figure 1 is the reason for consideration of the Copper Creek Project.



B. Peak

Figure 1. Projected Electrical Supply and Demand, Seattle City Light, 1981-2000

CHAPTER II. THE COPPER CREEK PROJECT

HISTORY

Copper Creek has been actively considered as a possible dam site by City Light since the mid-1900's. Since that time, a variety of methods have been proposed to make use of the hydroelectric energy potential of this reach of the Skagit River. Geologic studies in the 1950's revealed that the area is geologically suitable for dam construction, and City Light has continued with feasibility studies and aerial photography and mapping in the vicinity of this part of the Skagit River.

Work by the International Engineering Company (IECO) in the early 1970's indicated that adding a fourth dam to City Light's existing hydroelectric system at the Copper Creek site was structurally feasible and should be considered. A new hydroelectric dam on the Skagit River appears at this time to be one of the most economically feasible means of increasing the electrical generation capacity for the City of Seattle. The dam proposal preferred at this stage of the planning process is described below.

FACILITIES

The dam, powerhouse, and tailrace would be located in Skagit County, Washington, in the southeast quarter section of Section 21, Township 36 North, Range 11 East, Willamette Meridian. The dam site would be at river mile 83.9, which is downstream from City Light's three existing hydroelectric projects (Gorge, Diablo, Ross). The site is about 10.4 miles above the confluence of Bacon Creek with the Skagit (Figure 2). The urban development closest to the dam site is the community of Marblemount, approximately five miles southwest. The community of Newhalem in Whatcom County would be adjacent to the reservoir headwaters.

The project, if constructed, will require approximately 3,000 acres of land, including land for the dam, powerhouse, and tailrace, a 2,000-acre reservoir, relocated roads and transmission lines, and a borrow area for dam core materials (Figures 3, 4, 5 and 6).

The primary purpose of the 120,000-acre-foot reservoir is to produce power and energy; in addition, it could regulate downstream flow to reduce fluctuations now caused by the existing upstream dams. The project could produce 49.3 Mw of firm energy and 12.3 Mw of nonfirm energy for a total of about 62 Mw of average energy. The project would also have approximately 110 megawatts of peaking capacity. One megawatt (Mw) equals one million watts.

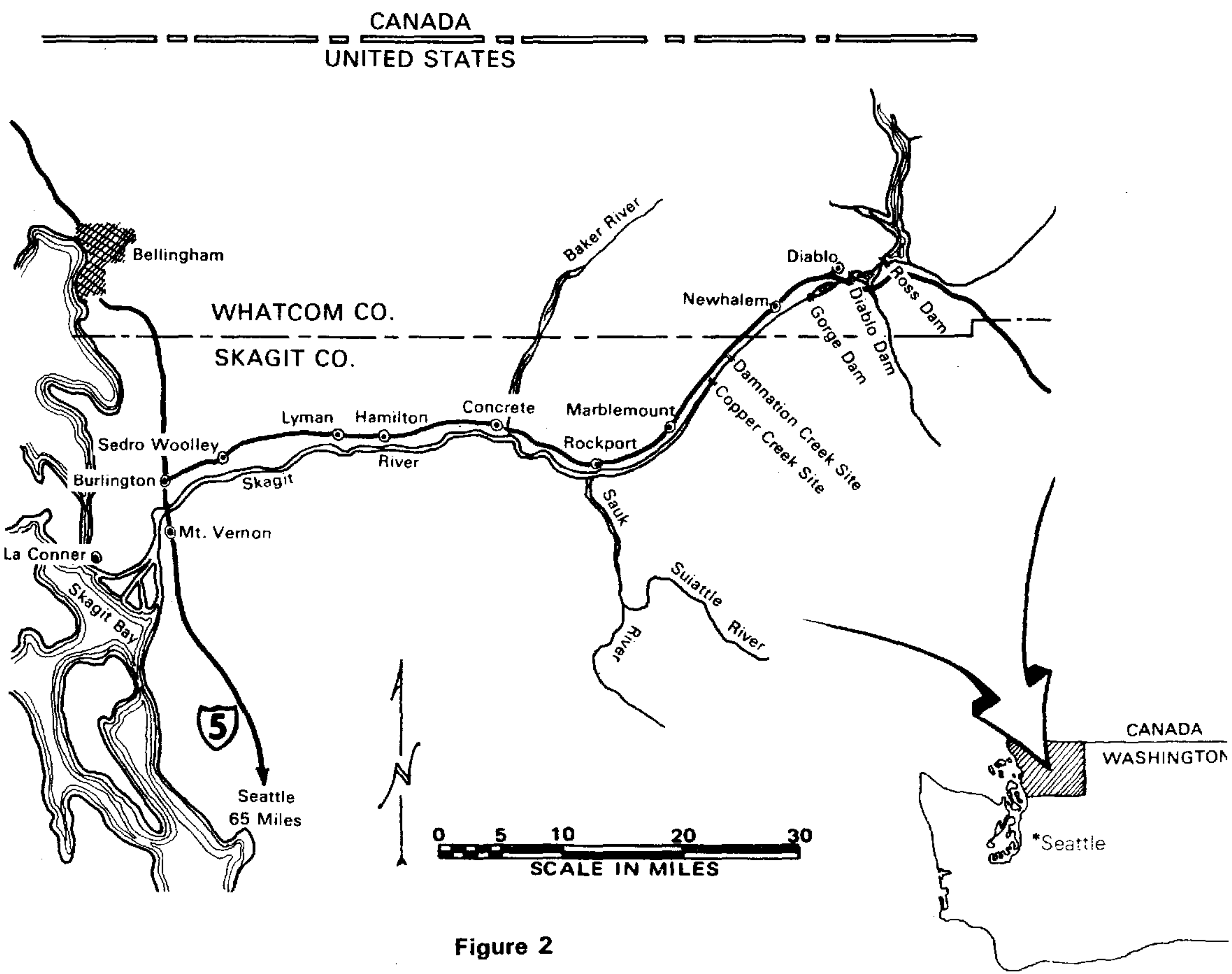


Figure 2

Project Location Map

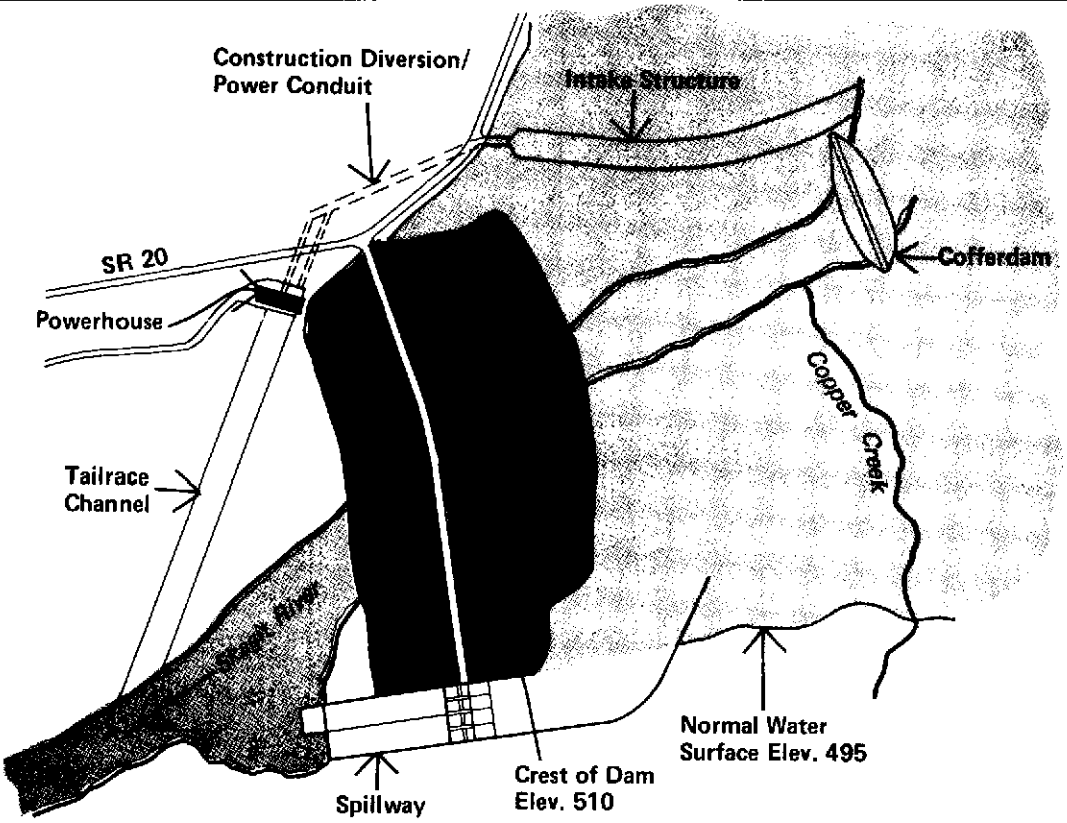


Figure 3. Schematic of Preferred Dam

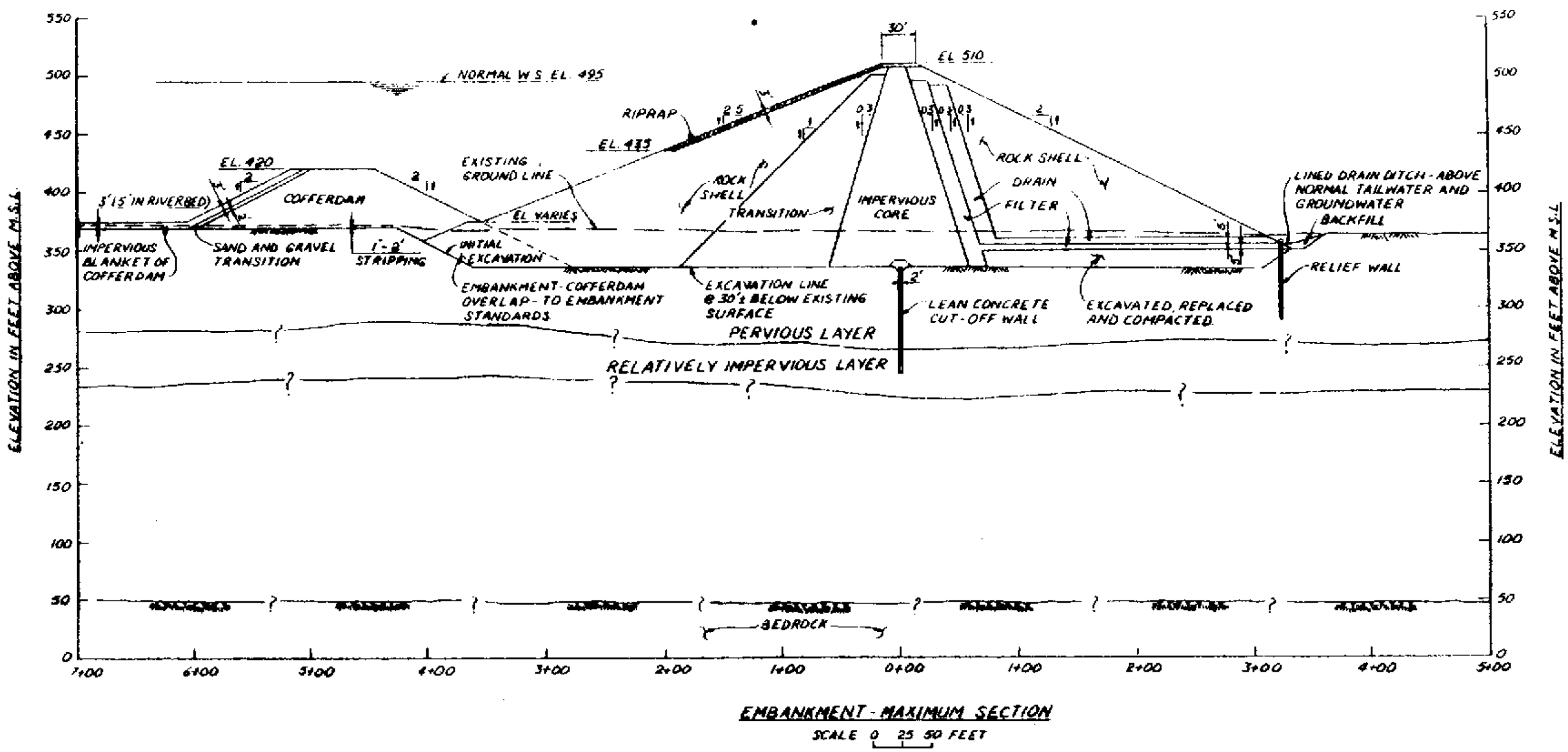


Figure 4 Cross Section of Copper Creek Dam

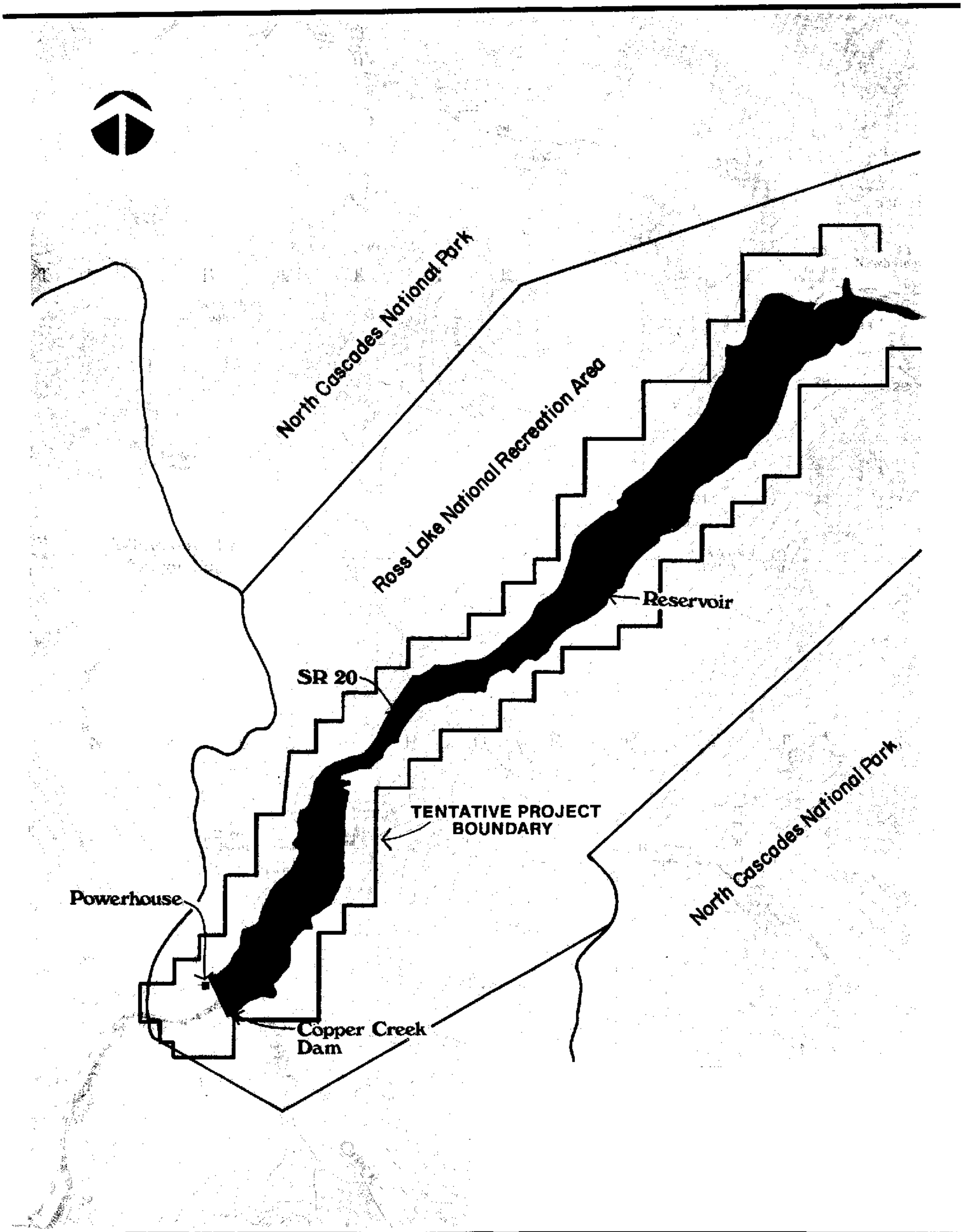
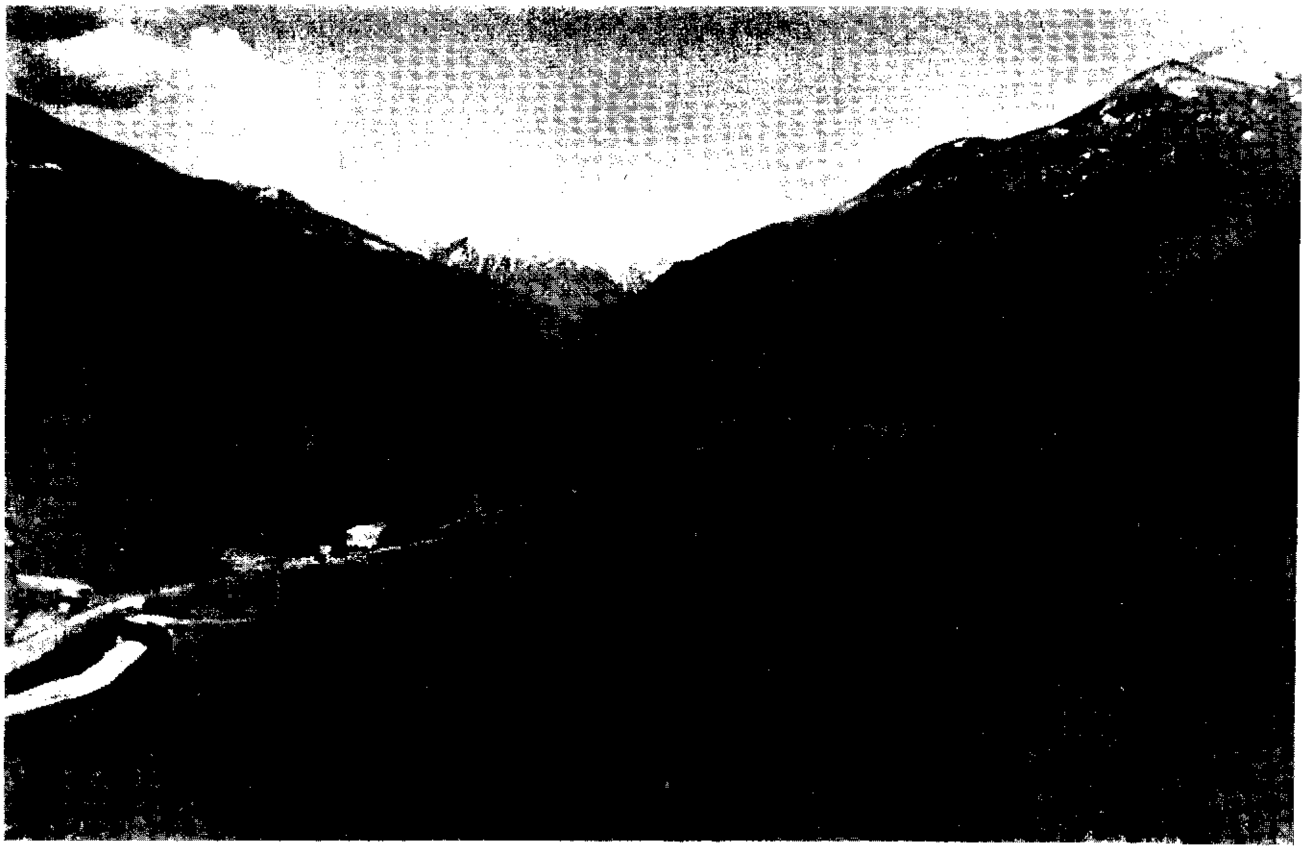


Figure 5. Copper Creek Dam and Reservoir

Existing



After construction of high dam, low road, and high transmission lines

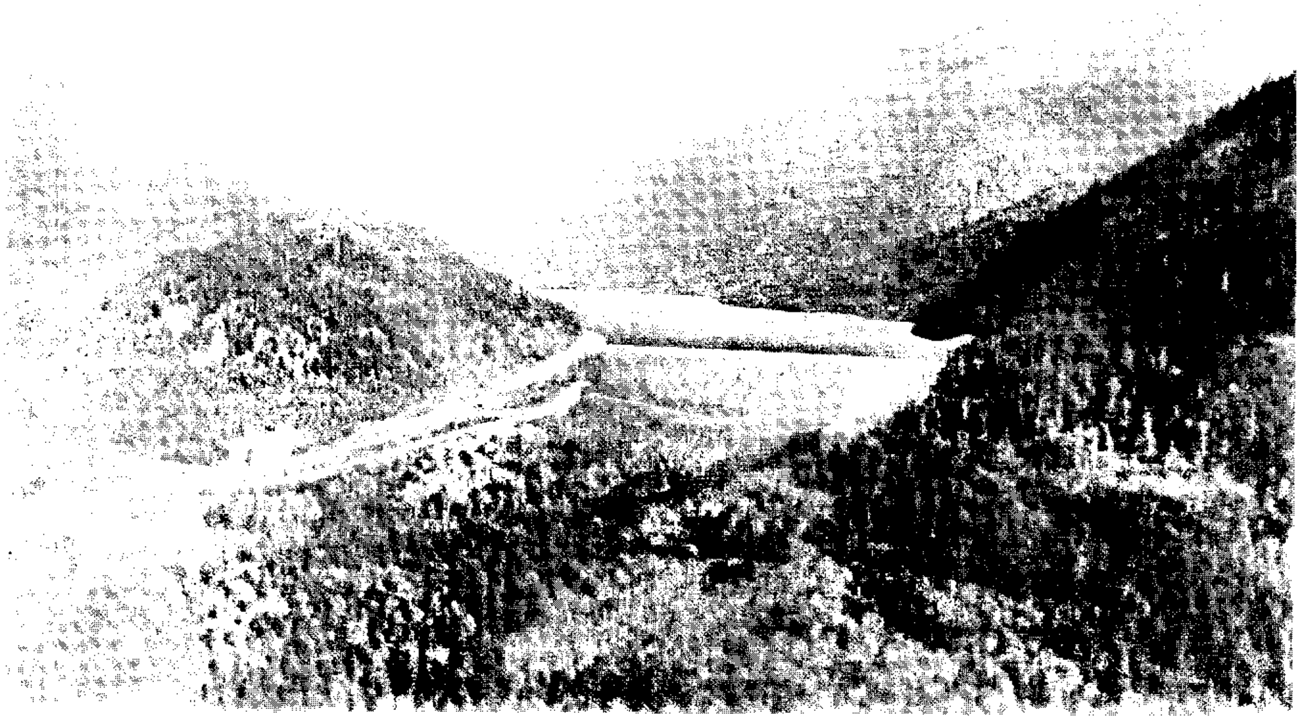


Figure 6. Two Views Upstream from Copper Creek Dam Site

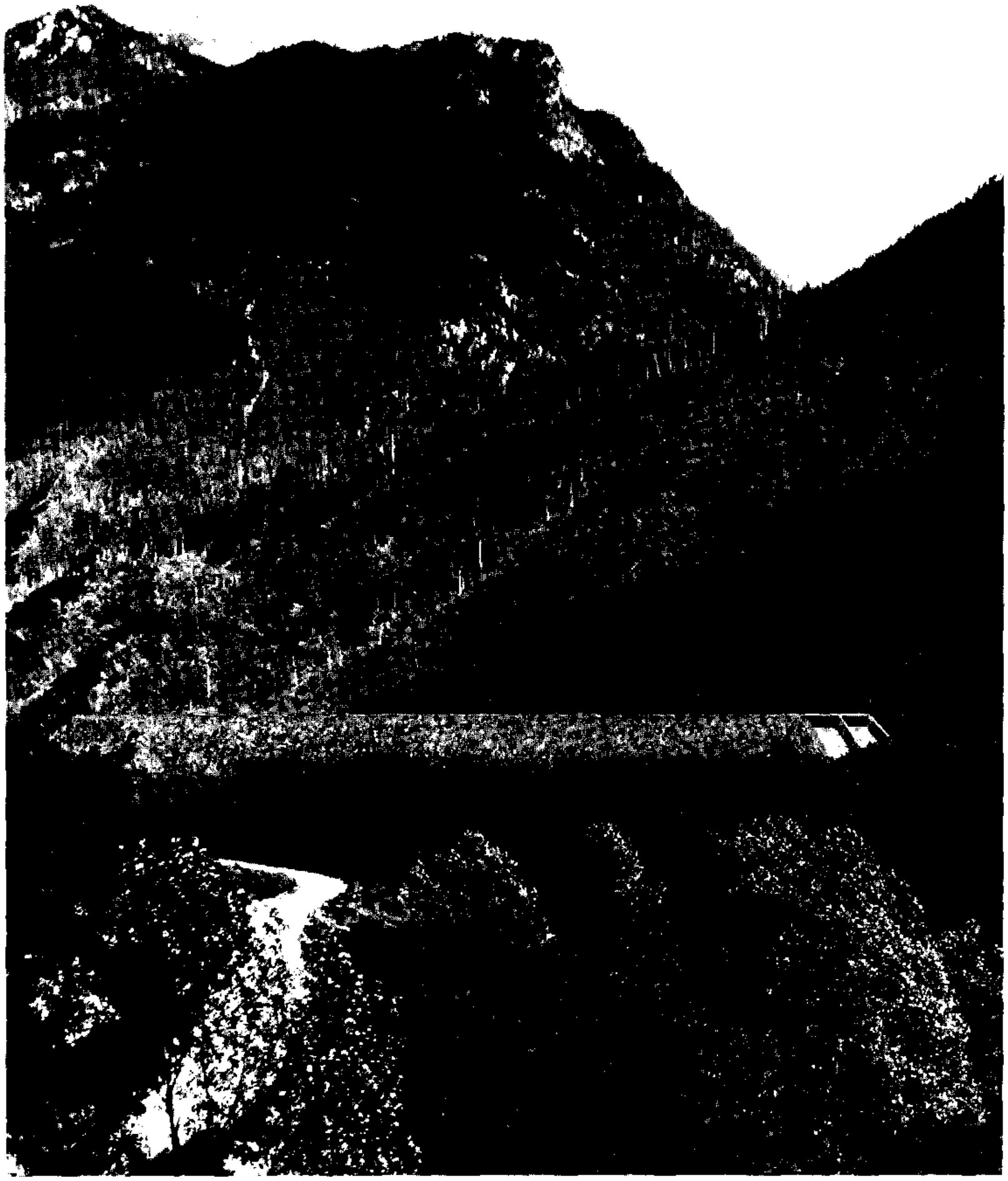


Figure 7. View of Dam from Ground Level

The major elements of the preferred dam proposal are:

- A 180-foot-high rockfill dam and a powerhouse housing two or more turbines and generators;
- A spillway and four radial gates on the left abutment;
- A reservoir approximately ten miles long, covering 2,200 acres and capable of storing 120,000 acre-feet of water;
- Relocation of an 11-mile segment of State Route 20 along the length of the reservoir and up to 11 miles of City Light's two, 2-circuit, 230 kilovolt (kv) transmission lines; and
- Borrow areas in the Bacon Creek-Oakes Creek drainage area or in areas within a short distance of the dam site.

The preferred dam proposal would be an earth-and-rockfill design consisting of silt, clay, gravel and rocks arranged in distinct zones. As shown in Figure 4, the core of an earth and rockfill dam would consist of impervious (water stopping) compacted silt and clay soil. The filter zone, made of fine gravel and sand and adjacent to the core, prevents the washing out of the core. The layers of selected river deposits (gravel) protect the inner layers. The rockfill (rocks up to five feet in diameter) supports the structure against the pressure of the water and possible earthquake shaking.

Since the proposed earth-and-rockfill dam would be built on top of river deposits through which water can pass, the design includes a cutoff barrier. This is a curtain of concrete running across the river channel and down to sufficient depth to hold seepage under the dam to insignificant amounts.

The maximum reservoir pool elevation would be 495 feet. The reservoir surface area at this elevation will be about 2,200 acres and the total volume about 120,000 acre-feet. The reservoir would extend up the Skagit River valley to the existing Gorge powerplant at Newhalem, a distance of about ten miles. At Newhalem, the reservoir would be confined to the river channel. Because the reservoir would extend all the way to the Gorge powerplant, the dam would make use of the entire amount of potential head at the dam site.

The amount of impervious core material for the dam would be 768,000 cubic yards. Because the soil needed for the dam is not available at the reservoir site, this material would need to be excavated elsewhere in the vicinity. Studies for City Light have concluded that approximately 950,000 cubic yards of impervious soil are available near Bacon Creek-Oakes Creek located in the south half of Section 8 and the north half of Section 17, Township 36 North, Range 11 East. This amount would be enough for the dam core.

Rock would be obtained from the spillway excavation on the south abutment. Gravels for the transition zones would be borrowed from the valley bottom upstream of the site.

State Route (SR) 20 and City Light transmission line relocations would be required. The preferred dam proposal is not yet developed in sufficient detail to select specific routes for these relocations; consequently, several alignments have been studied and are shown in Figure 8. These alignments include locations close to the reservoir level and farther up the hillside. If the decision is made to proceed with the project, a specific route or routes will be selected prior to submitting the Federal Energy Regulatory Commission (FERC) license application required for hydroelectric dams.

OPERATION

The Copper Creek Powerhouse is proposed to have an estimated design maximum hydraulic capacity of 10,000 cfs (cubic feet per second) which is approximately 2,800 cfs greater than the hydraulic capacity of the Gorge Powerhouse. Copper Creek Project, under normal operation, will reregulate the Gorge Powerhouse variable discharges such that the discharges below the Copper Creek Project are made uniform over daily periods and the fluctuations from day-to-day are minimal. Current estimates indicate that the daily fluctuations may be as large as 2,000 or 3,000 cfs at most (one to two feet change in river elevation measured at the USGS gage above Bacon Creek on the Skagit). The maximum fluctuation occurring over a week's period may be 4,000 or 6,000 cfs (two to three and one-half feet change in river elevation). This will result in a substantial improvement over current Gorge operations which during winter season can vary from 2,000 cfs to 7,200 cfs on a daily basis (three feet change daily). Every effort will be made to produce uniform flows from the project at all times of the year. This is made possible by the relatively larger size of the Copper Creek Reservoir compared to that of the Gorge Reservoir, which, because of its small size, cannot reregulate to make the river flow uniform.

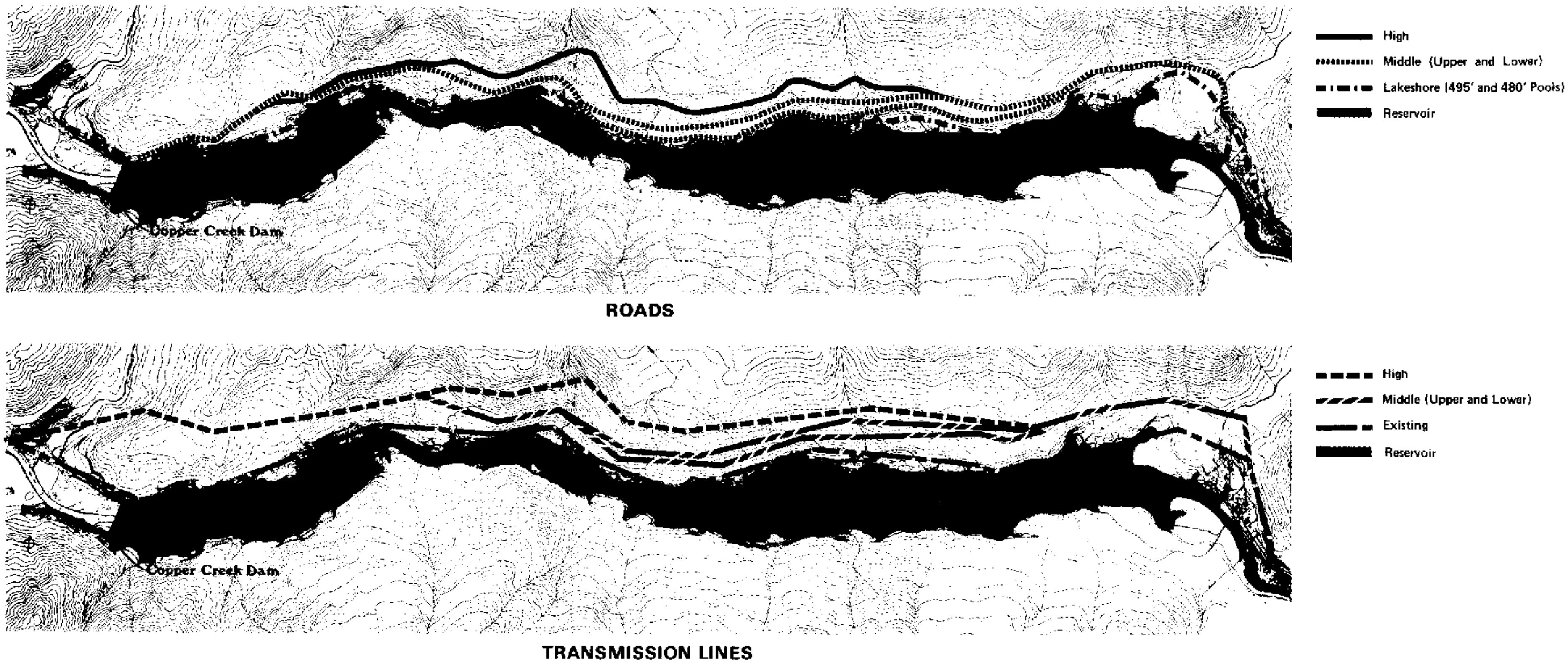


Figure 8. Road and Transmission Line Realignment Options

An appropriate ramping rate for Copper Creek releases to the Skagit River must be determined in order to incorporate operational criteria in a FERC license application. Studies presently in progress, part of the Skagit Interim Flow Agreement, examine the relationship between, among other things, flow fluctuation and salmon production by controlling the ramp rate of Gorge generation. (The Skagit Interim Flow Agreement is a tentative two year operating schedule for Gorge powerhouse which is presently being negotiated with City Light, U.S. Forest Service, Washington Department of Fisheries and Game, Skagit System Co-op, U.S. Fish and Wildlife Service and National Marine Fisheries Service. Approval of this Agreement is expected soon.)

The Skagit Interim Flow Agreement ramp rate limits tailwater fluctuations downstream from Gorge Powerhouse to between 0.65 and 0.75 ft. per hour for river flows below 5,000 cfs. While not a precedent for Copper Creek project operation, a 0.7 foot per hour tailwater restriction to Copper Creek results in a virtually identical ramp rate curve. The fish studies based on this flow fluctuation regime are intended to lead to long-term resolution of the issue of flow fluctuation impacts on the anadromous fish resource, and may well lead to a different regime for control of river flow fluctuations.

Minimum Releases

Minimum water releases from Gorge Project were developed under the Skagit Interim Flow Agreement to study impacts of flow levels on the anadromous fish resource. While not a precedent for Copper Creek, these required Gorge water releases were adjusted to the Copper Creek site using estimated sidestream inflow data. Gorge, Copper Creek, and Marblemount flows are shown in Table 1.

Seasonal Operation

The volume of water stored in the proposed Copper Creek reservoir is too small to provide seasonal storage. For time periods of a day and longer, project discharge will approximately equal inflow, with some forebay fluctuation to reregulate river flows. Because of this, seasonal operation of Copper Creek can be derived from monthly records of river flow. Graphs of monthly river flow and power production for wet, dry and median water years, based on 45 years of water records, are shown in Figure 9.

TABLE 1. Skagit Interim Flow Agreement Miminum Water Releases

Period	Required Gorge Release(cfs)	Estimated Copper Creek Release(cfs)	Estimated Marblemount Flow(cfs)
March	2300	2856	3200
April 1-15	2300	3400	3700
April 16-30	2000	3099	3400
May	1700	3000	3300
June	1000	2809	3200
July	1325	1900	2000
Aug 1-10	1325	1900	2000
Aug 11-31	1400	1900	2000
Sept	1400	1900	2000
Oct	1200	1900	2000
Nov	1800	2720	3000
Dec	1800	2701	3000
Jan	1900	2640	3000
Feb	2300	2700	3000

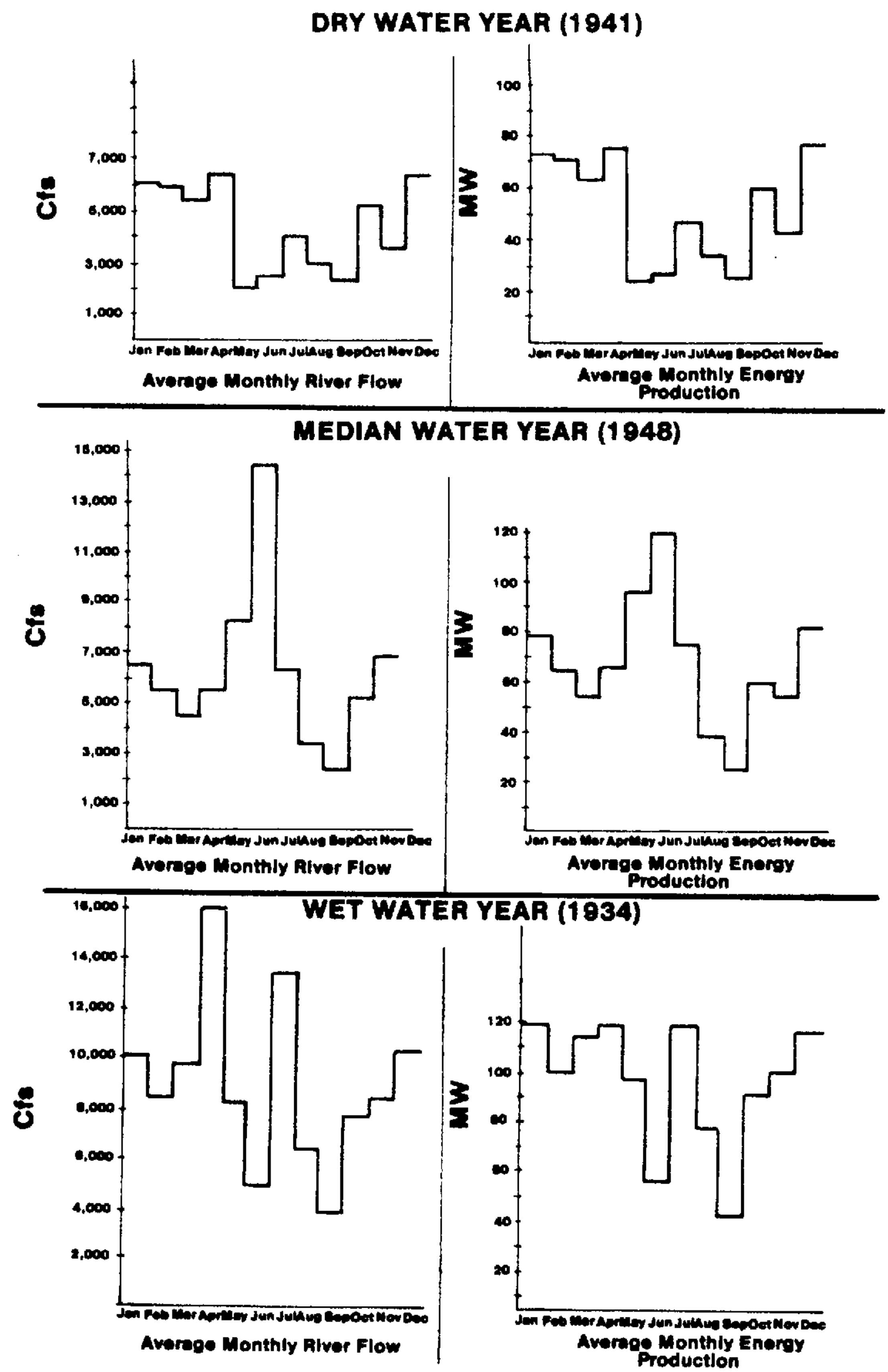


Figure 9. Projected Copper Creek Output

Reservoir Fluctuations

Despite the reregulating role of the Copper Creek Reservoir, reservoir fluctuations are expected to be small. Daily fluctuations should be less than one foot in the summer and less than two feet in the winter. Even in a worst case, accumulated drawdown should not exceed ten feet.

DESIGN VARIATIONS

A second basic type of dam considered during initial work on the project was one of concrete. Such a dam would either have to be built on bedrock, which would necessitate a 300-foot deep excavation down through the river deposits, or, if it were built on the river deposits, the dam would have to be jointed so that it could respond to movements in the riverbed without cracking. Either of these variations would present considerable engineering problems. A 300-foot deep trench down to bedrock would be very difficult, if not impossible, to construct and keep dry. On the other hand, a concrete jointed dam on top of 300 feet of river deposits is without precedent.

Three sites for dam construction were evaluated in engineering studies. The upper site is located in a narrow section of the Skagit Valley, about six miles downstream from Newhalem. The middle site is also located in a narrow section of the valley, almost a mile downstream from the upper site. The lower site is located ten miles downstream from Newhalem, in a wider section of the valley. The recommended site is the lower site at Copper Creek.

Upper Site Alternative

This alternative calls for construction of a dam near Damnation Creek. Construction costs for developing this site are higher, due to the confined space for construction. Peak power capability and average energy production are significantly lower than those at the other sites, due to the lower head of the project. With these higher construction costs and with lower power and energy production, cost per kw of average energy is 27 percent higher for the upper (Damnation Creek) site than for the lower (Copper Creek) site. Cost of peak power capability is 33 percent higher at the upper site.

Middle Site Alternative

This alternative calls for construction of a dam at a point where the valley is quite narrow. However, unfavorable foundation conditions were discovered in drill holes of the left abutment. Abutments are unsatisfactory, and two studies of this site concluded that successful construction of a dam would be doubtful. No further consideration has been given to this site.

Lower Site Alternative

This alternative calls for construction of a dam at a relatively wider section of the Skagit Valley, downstream from Copper Creek. Engineering studies show that this area has ample room for construction activities. This site would yield 38 percent more power and energy than a similar development at the upper site. Capital cost for a project at this site would be eight percent higher than for a similar development at the upper site.

Height of Dam

Engineering studies of the various project proposals have been done to evaluate dams constructed to various heights. For the recommended rockfill dam at the Copper Creek site, economic comparison of dams built having normal water levels of 480 feet or 495 feet show the cost of energy and peak power do not vary significantly. However, the high dam yields 15 percent more peak power and 13 percent more firm and nonfirm energy.

Generation Discharge Capability

Engineering studies of the various project proposals have limited plant generation discharge capacity to 10,000 cfs. Twenty years of river flow records indicate releases from Copper Creek reservoir will exceed 10,000 cfs about six percent of the time. This water will be wasted for energy production unless larger turbines are installed. Further economic studies are necessary to determine costs and benefits associated with installing higher capacity machines.

The key points of several of the dam alternatives are presented in Table 2.

TABLE 2. Comparison of Key Elements of Skagit River Dam Variations

SITE	LOCATION	TYPE OF DAM	HEIGHT OF DAM	RESERVOIR SURFACE LEVEL	SIZE OF RESERVOIR	SOURCE OF BLDG. MATERIAL	POWERHOUSE & SPILLWAY	POWER PRODUCTION	OTHER FACTORS
Near confluence of Copper Creek	5 miles NE of Marblemount, Wa. 120 miles NE of Seattle	Earth and rock-fill	180 ft. above river bed	495 ft. above sea level	2,200 acres (3.4 square miles) extending to Gorge powerhouse	May need as much as 770,000 cubic yards of silt and clay material from Bacon Creek area. Gravel and rock fill could come from riverbed above dam, and from excavation for powerhouse and tunnel.	Concrete powerhouse on north side; diversion tunnel (later used as power tunnel) excavated through rock wall of valley. Concrete spillway on south side. Tailrace would be a 1,000 ft. long, 100 ft. wide channel returning water to the river.	49.3 mw firm energy 110 mw peak	Earth and Rock-fill construction is a well established dam type believed to be flexible enough to withstand earthquake shaking
same	same	same	165 ft. above river bed	480 ft. above sea level	1,700 acres (2.6 sq mi) extending nearly to Gorge powerhouse	Slightly less material from Bacon Creek site. Rockfill as above.	same	46 mw firm 96 mw peak	
same	same	Concrete arch	500 ft. above bedrock incl 320 ft. through river bed	480 ft.	same	Concrete from off site	same	same	This type of dam must be built on bedrock, so a 300 ft. deep trench would have to be excavated from river bank to river bank. This would be difficult, expensive, & perhaps impossible.
same	same	concrete gravity buttress	165 ft.	480 ft.	same	same	same	46 mw firm 105 peak	This type of dam, built on this type of river deposit, would need flexible, water tight joints within it. The design may be feasible but it would be unprecedented.
Near confluence of Damnation Creek	3 miles upstream from Copper Creek	Earth & rockfill	130 ft. above river bed	495 ft. above sea level	1,500 acres (2.3 sq mi) extending to Gorge powerhouse	up to 575,000 cu. yds. of impervious material from Bacon Creek	Underground powerhouse on north side, discharging to tailrace of several hundred foot length. Concrete spillway on South side.	37 mw firm 76 mw peak	
same	same	same	115 ft. above river bed	480 ft. above sea level	About 1,000 acres extending nearly to Gorge Powerhouse.	Slightly less material from Bacon Creek	same	Slightly reduced firm and peak from above	

ENERGY AND POWER PRODUCTION

The energy production of the alternatives are differentiated by time and quality into four categories.

Firm Energy During Peak Hours

This firm energy provided during peak demand hours by a resource is that amount of energy which can be produced with confidence during the 200 hours of extremely cold weather occurring sometime between 8 AM and 10 PM Monday through Friday, for sixteen consecutive weeks, mid-November through mid-March. Copper Creek would produce 22,000 mwh of this type of energy.

Firm Energy During Intermediate Demand Hours

This firm energy provided during intermediate demand hours is that amount of energy which can be reproduced with confidence during the 1,000 hours occurring sometime between 7 AM and 10 PM Monday through Friday, for sixteen weeks, mid-November through mid-March, which were not peak demand hours. Copper Creek would produce 110,000 Mwh of this type of energy.

Firm Energy During Off-Peak Hours

This firm energy provided during off-peak hours is that amount of energy produced with confidence in a full year, less the amount of energy provided during peak and intermediate demand hours. Copper Creek would produce 299,868 Mwh of this type of energy.

Nonfirm Energy

This energy provided by the resource is the total energy produced under median water conditions less the total firm energy produced. Because this energy cannot reliably contribute to Seattle City Light's load-carrying capability, it is segregated in utility power studies from firm energy required to carry firm load. Copper Creek would produce 107,748 Mwh of this type of energy.

CHAPTER III. EXISTING CONDITIONS, IMPACTS AND MITIGATION

Part 1. Physical Environment

Section A. Geology

An important factor to consider in dam design, construction and safety is the geology of the dam site and the surrounding region. A general description is given below for the geology and potential geological hazards of the Copper Creek Project.

GEOLOGICAL SETTING

The project is located in the North Cascades, a mountainous area with high jagged peaks, steep slopes, and both V- and U-shaped valleys. The dam sites are located in the Skagit River valley close to the western border of the Cascade Range. The valley lies along a northeast-southwest axis in a 9 1/2-mile-long, straight, narrow valley between Newhalem in Whatcom County and Bacon Creek in Skagit County.

As shown in Figure 5 (Chapter II), Copper Creek and Damnation Creek are at relatively narrow, steep walled points in the river valley which descends rapidly. Below Copper Creek, the Skagit falls only 320 feet in 83 miles before it reaches Skagit Bay.

In general, the dam and reservoir sites are underlain by igneous and metamorphic rocks. Fractures, joints, and lineation patterns were formed in response to regional stress patterns. Overlying the bedrock at the dam site are glacial deposits (generally silt and sand, with some gravel and boulders) and alluvial deposits (clay, silt, sand, gravel, and some boulders) of various thicknesses. On the valley floor, under the dam axis, the alluvial and glacial deposits are present in total thicknesses of about 325 feet. On the valley slopes, sporadic thin glacial deposits are present.

The geologic history of the project area has included various periods of tectonism and quiescence, producing a complex mixture of rocks. The rocks were strongly metamorphosed and later intruded by large igneous bodies. Throughout its evolution, the area was also subjected to periods of volcanism and sedimentation.

At least four periods of glaciation have occurred in the area. Alpine glaciers increased in size and eventually coalesced to meet a continental ice sheet that covered the area with ice as much as 7,400 feet thick. Glacial deposits associated with these advances and recessions are found within the area. Volcanism created the higher peaks present in the North Cascades.

Sporadic exposures of water-laid volcanic ash deposits are present on the valley sides and along the road cuts. This ash was probably deposited in a prehistoric lake formed when a landslide blocked and backed up the river. Soil development in the valley is not extensive because of the short time since the last glaciation. River alluvium and glacial deposits are found in great thicknesses (more than 325 feet) on the valley floor, as indicated by borehole and seismic data.

GEOLOGIC HAZARDS

Five main areas of possible hazard to the integrity of a dam have been outlined by Seattle City Light with the help of its independent Geologic Advisory Committee. These hazards are evaluated below. The information is provided in more detail in Fugro Northwest, Inc.'s "Preliminary and Interim Reports on Geologic Feasibility Studies for Copper Creek Dam" (Fugro 1979, 1980). Because the Copper Creek site is the preferred dam site for power production, the geological work has focused on that site.

Earthquakes

Earth shaking is a concern because of the possibility that it may disrupt the dam embankment, leading to failure. Earthquakes were considered to be a potential problem because a large (Magnitude 7) earthquake occurred in 1872 in the North Cascades area. Other evidence also suggested that a large major fault in the project vicinity, the Straight Creek Fault, was active (but probably not the source of the 1872 earthquake). To be on the conservative side, Seattle City Light has assumed the Straight Creek Fault is active.

With this assumption as a starting point and after a review of historical earthquake data, Fugro Northwest calculated two levels of earthquake for the design of the dam. The first is the "Operating Level Earthquake." This is the level of shaking expected to occur within a long period of time, approximately once in 200 years. Such an earthquake would produce acceleration equal to 20 percent of gravity. This value is considered appropriate for the design of all parts of the project, except those essential to preventing dam failure.

The dam embankment would be designed to withstand the second calculated level--the "Safety Level Earthquake". This is the largest earthquake which could reasonably be expected ever to occur, regardless of the level of probability. Fugro decided that this would be a 7.5 Magnitude earthquake occurring on the Straight Creek Fault at its point of closest approach to the dam site. This size of earthquake translates into a horizontal acceleration of bedrock equal to 70 percent of gravity (0.7g). Shaking at the ground surface may be either somewhat more or less than this (see section below on "Foundation").

The present level of knowledge is that a rockfill dam can be designed to safely withstand a horizontal acceleration of 0.7g. This conclusion has been verified by a dam design firm.

Induced earthquakes are another possible concern. Past studies have indicated an increase in seismic activity at some dam sites as a result of reservoir filling. It is generally believed that the weight of the water in the reservoir creates an increase in pore pressure in the underlying rock. The increased pore pressure can fracture the rock, thus creating in some cases an induced earthquake. Local geology is often an influence on induced earthquakes.

Induced earthquakes have been recorded in only 0.7 percent of the large dams built and are most frequent in large reservoirs (those deeper than 390 feet and with a storage capacity of at least 820,000 acre-feet of water). Copper Creek Dam would be 180 feet high, and its reservoir would contain 120,000 acre-feet of water. Consequently, earthquakes are not expected to be induced by a Copper Creek reservoir.

Abutments

It is important that the abutments of a dam be stable and relatively impervious so that leakage will not undermine the embankment of the dam. Fugro analyzed the rocks of the abutments and found them to be sound with few potential areas of leakage. A few small talc bodies were found but these present no problem to dam safety. Hazards due to abutment leakage are, therefore, not believed to exist.

Large Landslides into the Reservoir

Land and rockslides are of concern because a catastrophic release of a large landmass into the reservoir could conceivably cause a large wave to overtop the dam. This could cause erosion and possibly lead to the failure of the embankment. Several large old landslides were detected in the reservoir area but they appeared to be (1) ancient (greater than 5000 years old), (2) presently inactive, (3) of limited lateral movement, (4) shallow and, (5) of the type that move only moderately slowly. Because of these factors, landslides in the area are not thought to present significant hazard to the project.

Foundations

A potential hazard in some foundations is the existence of particular types of sand or silt which, having lost their strength, flow like a liquid when shaken. This phenomenon is called liquefaction, and it can be detected by sampling the soil material in question and subjecting it to various tests. Fugro spent part of June, July and August of 1980 drilling boreholes to collect samples to perform such tests. Their results show that liquefaction hazard is not present.

Fault Movement

This concern is related to, but different from, that of shaking caused by an earthquake. It poses an important question: "Is there a hazard of the dam being disrupted by the movement of a fault underneath the dam?" The results of Fugro's work mapping the faults in the project vicinity are summarized in Figure 10 and discussed below.

Though there are many faults in the area, most of them do not impinge on the dam site. One group that does project toward the dam site is a family of N-NW trending faults to the south. These faults may or may not be related to the Straight Creek Fault. This family consists of several faults roughly parallel to each other. The members of this family that have different rock types on either side are relatively easy to distinguish. However, once they enter areas of a single rock type, it is hard to know how far the faults extend. The "Surface Trenches" in Figure 10 may (or may not) represent other members of this family of faults. Some of the faults or "surface trenches" project in the direction of the dam, but there is no evidence that they come close to the dam at all. If the project were constructed, excavation on the south abutment would allow a confirmation of this conclusion.

As of September 1980, the inferred Skagit Valley Fault (Figure 10) was the main area of concern. In the summer of 1980, Fugro continued further studies designed to obtain information on the existence, extent, orientation, age and scale of movement of the inferred fault. Figure 10 shows how these latest studies have revised our understanding of the site geology. A reexamination of the NE trending fault to the north of the dam site on Bacon Point showed that: a) the fault has a more northerly

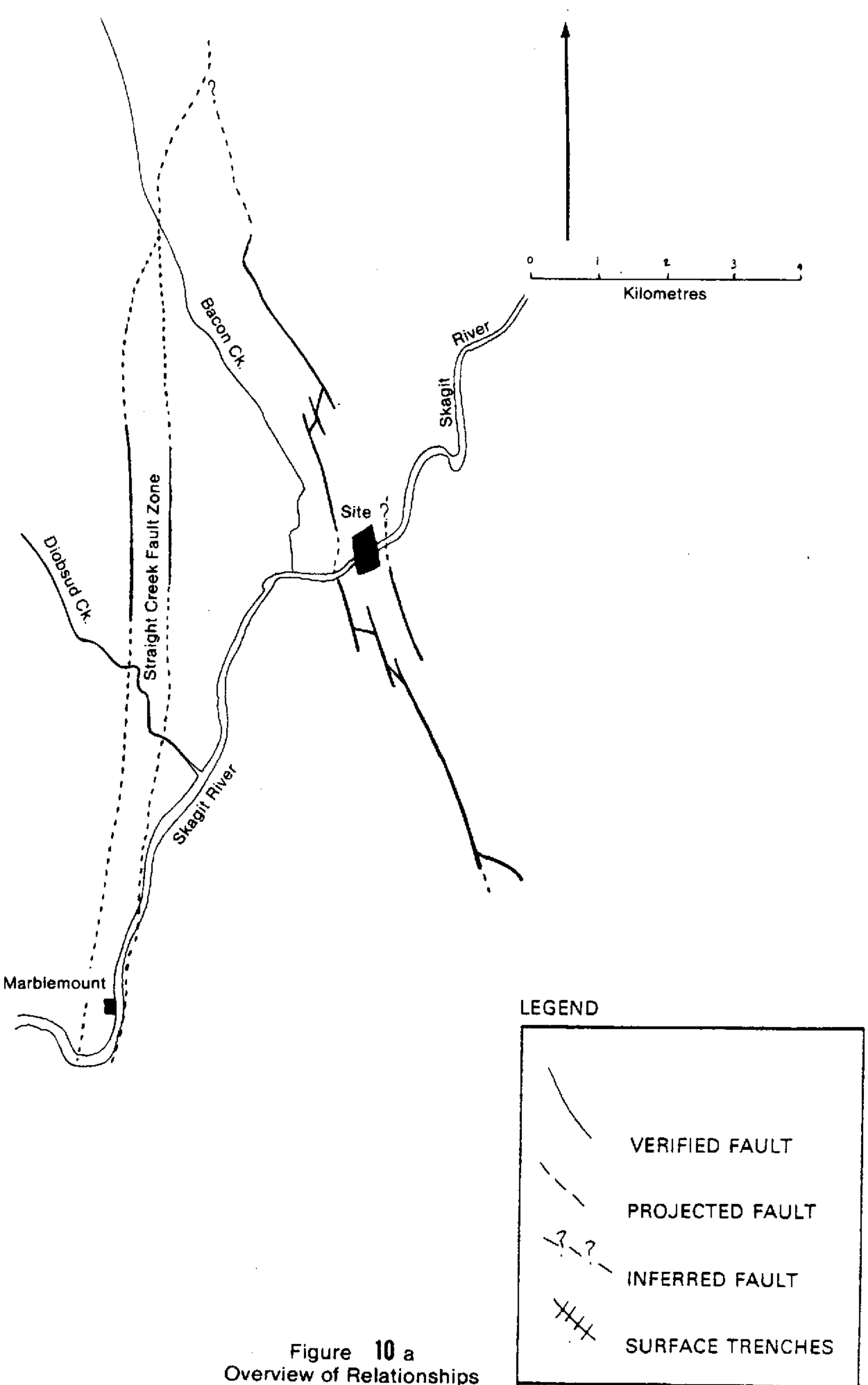


Figure 10 a
Overview of Relationships
of Local Faults

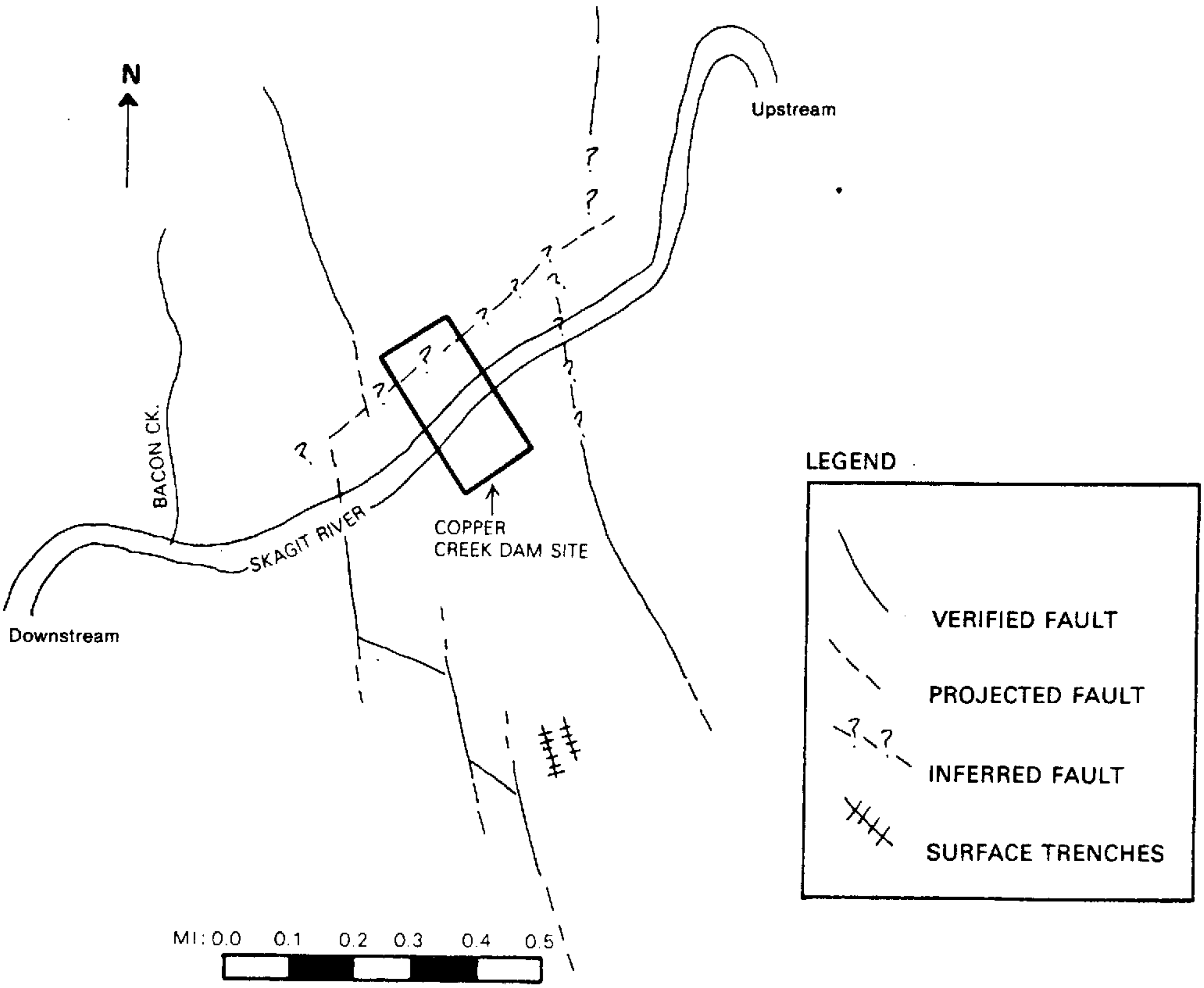


Figure 10 b

Geologic Faults Near the Copper Creek Dam Site
As Previously Understood

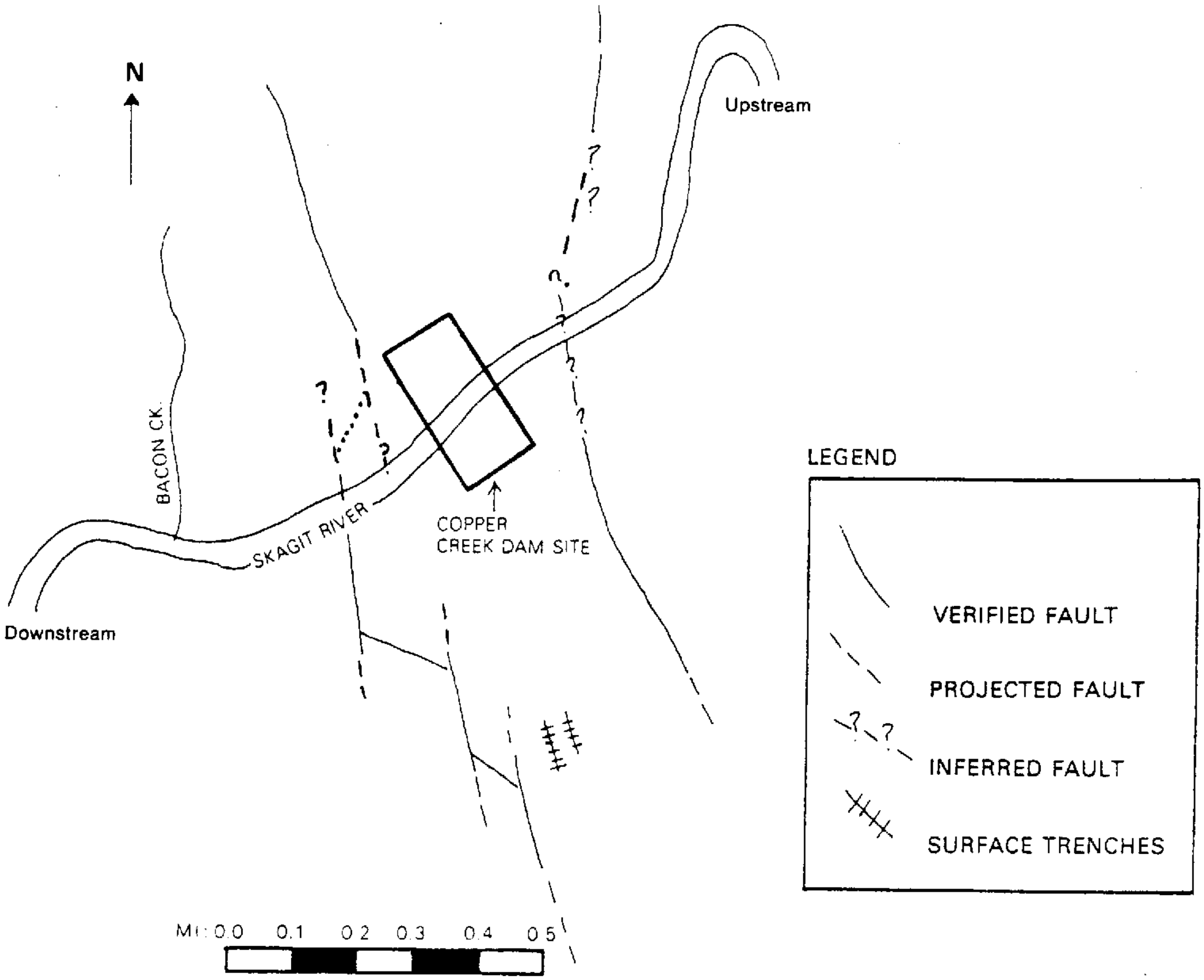


Figure 10c

Geologic Faults Near the Copper Creek Dam Site
As Presently Understood

orientation than was previously believed, and b) the NE trending fault is offset by the N-NW trending faults, not the reverse. Extrapolating these new data to the inferred Skagit Valley fault leads our consultant to conclude that the Skagit Valley fault, if it exists, does not intercept the dam site. In addition, seismic refraction surveys failed to find any fault in the bedrock floor or near the site.

DAM FAILURE

Fear of failure of a rockfill dam was one of the most serious concerns expressed by the public during the assessment process. Consequently, intensive study has been focused on dam safety in order to assess the risk to persons living downstream of the dam and to identify design and construction procedures which minimize this risk.

A detailed analysis of past dam failures, conducted during the environmental assessment, showed there have been no failures of rockfill dams since 1930. Of the failures that occurred before then, few, if any, would have occurred if today's design practices had been available.

On the basis of the analysis, the historical failure rate of rockfill dams (without regard to the year of design, the quality of construction or the presence of faults), has been one failure for every 318 years of operating experience for this type of dam. This failure rate is far too high, however, to be indicative of the probability of failure of a modern engineered rockfill dam such as would be constructed at Copper Creek. Significant improvements have been made since 1930 in rockfill dam design and construction technology, and no rockfill dam built since that time has failed.

Pre-1930 dam failures were attributed to four principal causes: natural disasters, engineering failures, maintenance and operating failures, and deliberate actions such as vandalism and sabotage. Design or construction errors have been responsible for most of the rockfill dam failures studied. The last such failure was that of the Apishapa Dam, built in 1920 and destroyed in 1923. This was the last engineered rockfill dam in the United States to fail due to any cause. The engineering techniques developed since 1920 have made rockfill dams among the country's safest structures. The last two dam engineering failures to cause deaths and widespread property destruction in the United States were the St. Francis Dam (concrete) and the Teton Dam (earth). Such failures can still occur, but an engineering error today would be more likely to result in a minor accident than in sudden total failure.

Despite the low probability of dam failure, a detailed study was performed to determine the nature of the impacts of dam failure.

This study was performed using a mathematical model to determine the extent and route of a flood resulting from total failure.

A modern, engineered rockfill dam is highly resistant to sudden total failure of the type that was projected for the failure impact assessment model. A massive, complex structure such as an engineered rockfill dam would more likely take from 1 to 24 hours to release the entire contents of its reservoir. It is far more probable that an actual failure would involve a steadily deepening flood rather than a wall of water or a flood wave. Nevertheless, for ease in constructing the mathematical model, the worst case was chosen for the failure analysis and a flood wave was assumed. The reader should, however, keep in mind the extremely low probability of such an event occurring at Copper Creek.

The effects of a complete failure are shown in Figure 11 for the reach of the river down to Rockport. The possible extent of flooding for other downstream reaches is described elsewhere (CH_2M Hill, 1979, Tech. Rept. 12). Also shown is an estimate of the impact of a partial failure. In the case of complete failure, the towns of Marblemount, Rockport, Hamilton, Lyman, Concrete, and Sedro Woolley would suffer severe damage. Damage downstream of Sedro Woolley (i.e., Mt. Vernon, Burlington, LaConnor) would be equivalent to some of the largest recent floods. A relatively minor impact due to a dam failure would be damage to the fishery from habitat destruction and post-failure siltation due to runoff from unprotected soil.

In the long term, the greatest impacts would be possible loss of lives and social and personal disruption of the survivors in totally devastated communities. Also lost would be tourism and recreational trade and a valuable ecological and scenic area that could take decades to recover, as well as transmission lines and highway segments.

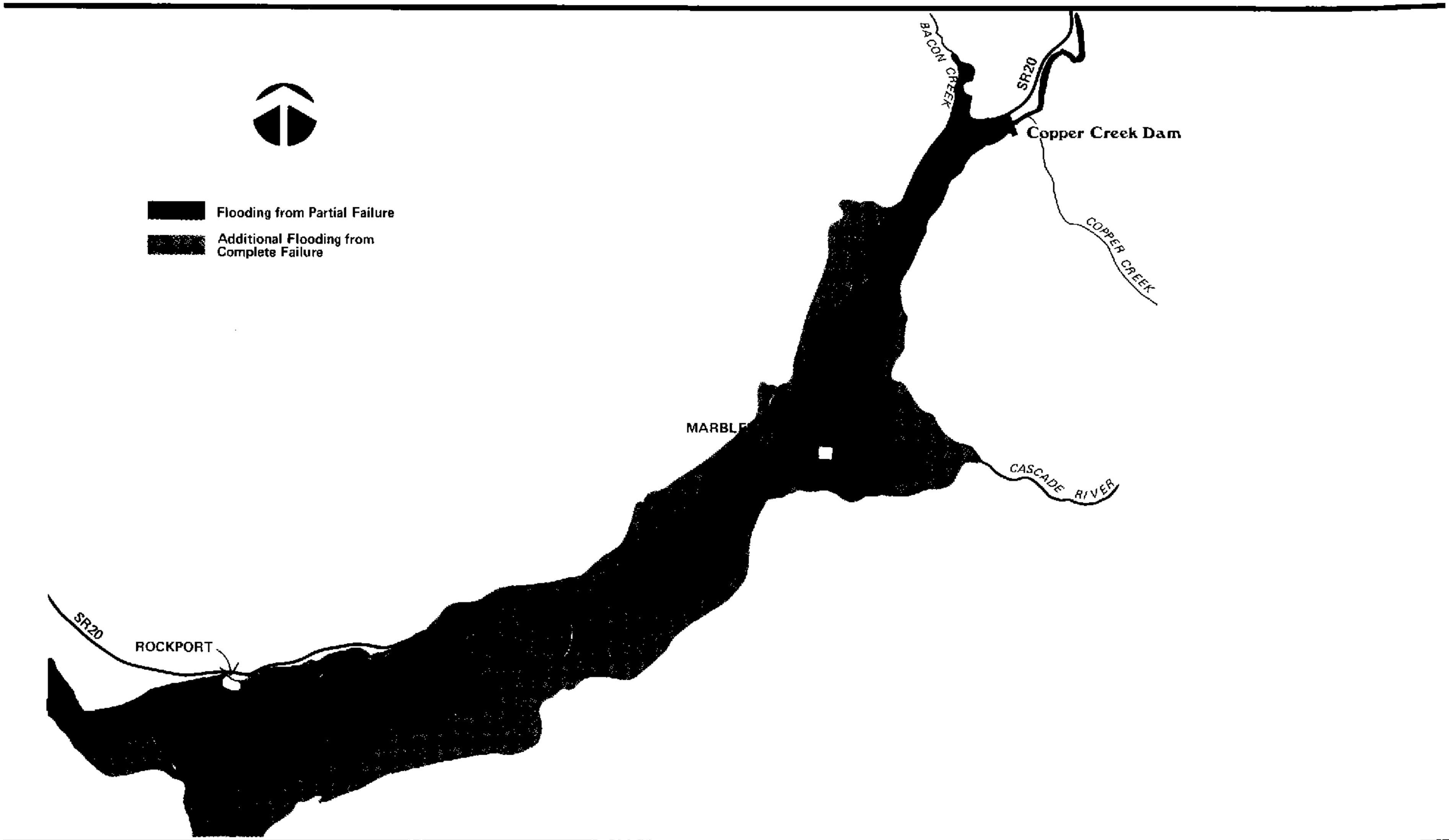


Figure 11. Dam Failure Flood Route

Mitigation

Mitigation of dam failure or accidents is discussed here in two categories: 1) prevention of the incident and 2) warning and relief measures if failure occurred or was imminent.

Given the current status of engineering design of rockfill dams, almost all risk of failure or accident to the proposed dam can be eliminated by careful design and thorough construction and operation monitoring. A rigorous quality control program would be a basic part of the construction program. Design would give careful attention to all the characteristics of the site and the region surrounding it, as well as to the wise choice of construction materials.

The licensing procedure for the dam would require numerous reviews of the dam design for safety purposes. Likewise, rigorous quality assurance inspections would be conducted during construction to ensure compliance with the reviewed and approved dam design specifications for materials and construction. Mandatory rules, regulations, and license procedures would be developed for dam operations. Other safety measures could include installation of permanent instrumentation on the dam and its foundation materials and abutments to detect settling or seismic effects. All these procedures have been developed to ensure the safety of hydroelectric projects and are applied as a standard practice if a license is awarded and accepted.

Nevertheless, all possibilities should be considered. In the unlikely event of failure, other measures would be taken to minimize damage to life and property. A detailed emergency action plan, required under all project licenses, will be prepared in consultation with all affected agencies. This plan and any warning system associated with it would have to take into consideration nighttime users of the river (e.g., American Indian fishers). In addition, there are several other possible mitigation measures. Most of these would be the responsibility of appropriate local, state and federal agencies. Long-range measures that could be, and to some extent have been, instituted include land use planning and floodplain management, catastrophe insurance, and public education. Restoration and recovery measures could include plans for:

- Temporary and permanent relocation of affected persons
- Reconstruction and replanning of destroyed property
- Reconstruction, major repair, or relocation of dam

- Legal issues (lawsuits, settlement by voluntary agreement, and insurance)
- Impact on insurance industry
- Social issues (equity, dealing with personal and family problems, and neighborhoods)
- Economic issues (inflation, financing of public expenditures for relief and rehabilitation, replacing individual losses, and long-range impact on Skagit Valley)

Further information on dam safety can be found in CH_2M Hill's Technical Report 12, which was prepared during the earlier, environmental assessment phase of work. This document is available from City Light.

UNAVOIDABLE ADVERSE IMPACTS

A dam would not be constructed at the Copper Creek site unless it was considered safe in the best judgement of City Light engineers, City Light's dam design consultant, the independent consultant engineering review board, the Washington State Department of Ecology, and the Federal Energy Regulatory Commission. A dam would be designed to maximize safety in view of information about site conditions available at the time of construction. However, there would remain a small, unquantified risk of partial or total dam failure.

Part 1. Physical Environment

Section B. Hydrology

SEASONAL FLOWS

In September or October, the monthly average Skagit River streamflow increases from the yearly low to a peak in December. Colder weather generally decreases runoff during the December to March period. As temperatures begin to rise in April, snowmelt fills streams, and flow peaks by the middle of June. Following the snowmelt peak, streamflow drops to minimum base flow. By the end of August, snowpack is usually depleted. At this time, river flow is sustained by discharge from groundwater storage and melting glaciers. Major tributaries originating in glaciers also contribute to low-flow discharge, as does the release of storage water from Ross Reservoir. Because of flow regulation by the power-producing reservoirs on the upper Skagit, higher than natural minimum flows occur in October through March, and lower than natural base flows occur during the spring when the reservoirs are being filled. Figure 12 shows the median monthly flow at Newhalem for the period 1945 to 1970.

Copper Creek reservoir would not be large enough to provide seasonal storage and, therefore, would not significantly alter the seasonal flow pattern of the Skagit River. Reservoir inflow would essentially equal outflow over a week's period, and there would be no seasonal fluctuation of reservoir level.

DAILY FLOW FLUCTUATIONS

Flow from Gorge Powerhouse varies daily. During the 10 PM to 6 AM period, flow is 2,000 to 3,000 cfs (cubic feet/second) lower than during the daytime, reflecting higher daytime demand for power in Seattle. This fluctuation in release from the powerhouse creates a daily fluctuation of river level of one to two feet at Bacon Creek and 0.5 to 1 foot at Marblemount. During certain times of below average temperature in Seattle in the winter (late November to February), the high demand for power in Seattle causes Gorge Dam Powerhouse to release a constant maximum flow of 7,200 cfs.

Operators of Gorge Powerhouse presently change the powerhouse's discharge at a uniform rate called the ramp rate. The present ramp rate is equal to an increase or decrease of 2,000 cfs in an hour (e.g., Gorge Powerhouse requires one hour to reduce river flow from 4,000 cfs to 2,000 cfs).

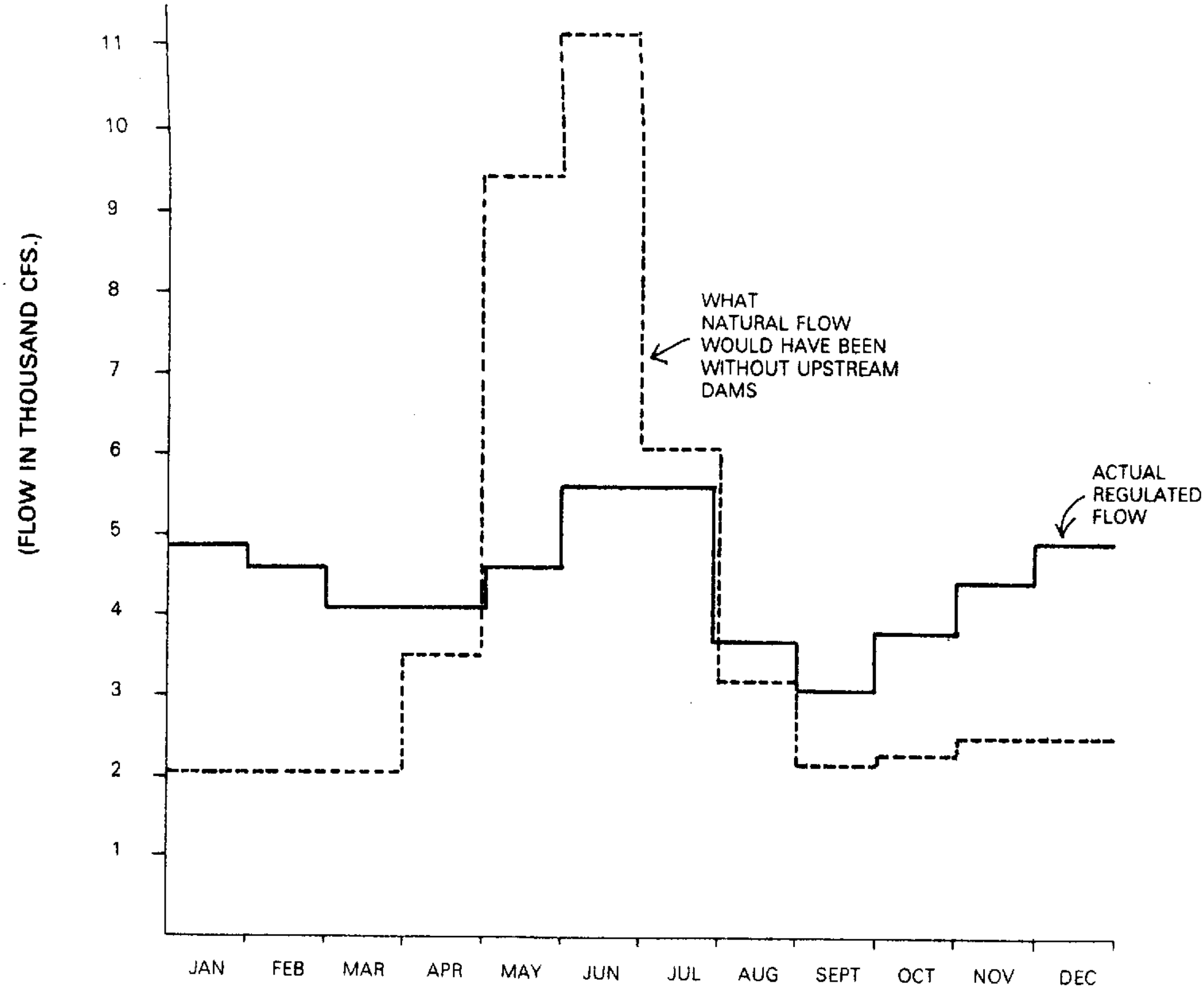


Figure 12. Median Monthly Flow at Newhalem 1945-1970

City Light and federal, state, and tribal fisheries agencies are presently negotiating provisional changes in the operation of Gorge Powerhouse through the Skagit Interim Flow Agreement. One of these changes is the use of a more gradual ramp rate for flow decreases. The ramp rate tentatively agreed upon produces an average decrease of 1,000 cfs per hour in the moderate-to-low flow range. Present studies and those planned for the next several years will provide further information on the tradeoff of operational flexibility vs. fisheries impacts for various ramp rates.

The changes expected from Copper Creek are outlined in Chapter II. The main changes are a decrease in daily fluctuations. The peak discharge of Copper Creek would be greater than that of Gorge Powerhouse.

FLOODING

Flooding in the Skagit River basin occurs during both the winter and the summer. Winter floods, the result of heavy rainfall on a heavy snowpack during unseasonably warm periods, are marked by rapid rises and falls in water level. Summer floods are the result of snowmelt from glaciers and snowfields at high elevations. The summer floods last longer and are characterized by greater volume but lower crests than winter floods. Maximum discharges recorded on the Skagit River are shown in Table 3. The average annual flow after 27 years of record is 5,800 cfs at Newhalem.

The absence of major flooding between 1951 and 1977 on the Skagit upstream of the Cascade River confluence indicates that the combined storage of the three reservoirs has been effective. Diablo and Gorge furnish only minor flood control storage. The major contribution comes from Ross Dam, which provides 120,000 acre-feet or more for winter flood storage.

Current practice requires that dams be designed to safely pass the probable maximum flood (PMF), which is the runoff that would occur under the worst probable combination of conditions. The PMF for the Skagit River at Copper Creek is currently calculated to be about 220,000 cfs, about six times larger than the largest flood (38,500 cfs) that has occurred just upstream of the Copper Creek site since completion of the existing dams.

Copper Creek would be designed so that its spillway could safely accommodate the PMF. The reservoir would be sized so that it would not significantly increase or decrease flood storage. Its freeboard (empty space from the

Table 3. Maximum discharges on the Skagit River

Station	Period of Record	Maximum Discharge (cfs)
At Newhalem	69 years (1909-1977)	63,500 (November 29, 1906)
Above Alma Creek (approximately 1 mile above Copper Creek dam site)	27 years (1951-1977)	38,500 (June 21, 1967)*

*The flow at Newhalem on this date was 36,700 cfs.

maximum water surface to the crest of the dam) would be large enough to make up for any valley floor flood storage that would be taken up by the reservoir.

SKAGIT RIVER STREAM BEDS

Preliminary studies (based on grain size analyses of riverbed materials, surveys of river slope and cross-section, computed river velocities and lithologic analysis) have been undertaken to determine if erosion of the river downstream of the dam site may occur if the dam is built. The studies to date have concentrated on determining the existing river's response to flood conditions. The response of the river to varying flow conditions will not be altered by the dam except in degree of response.

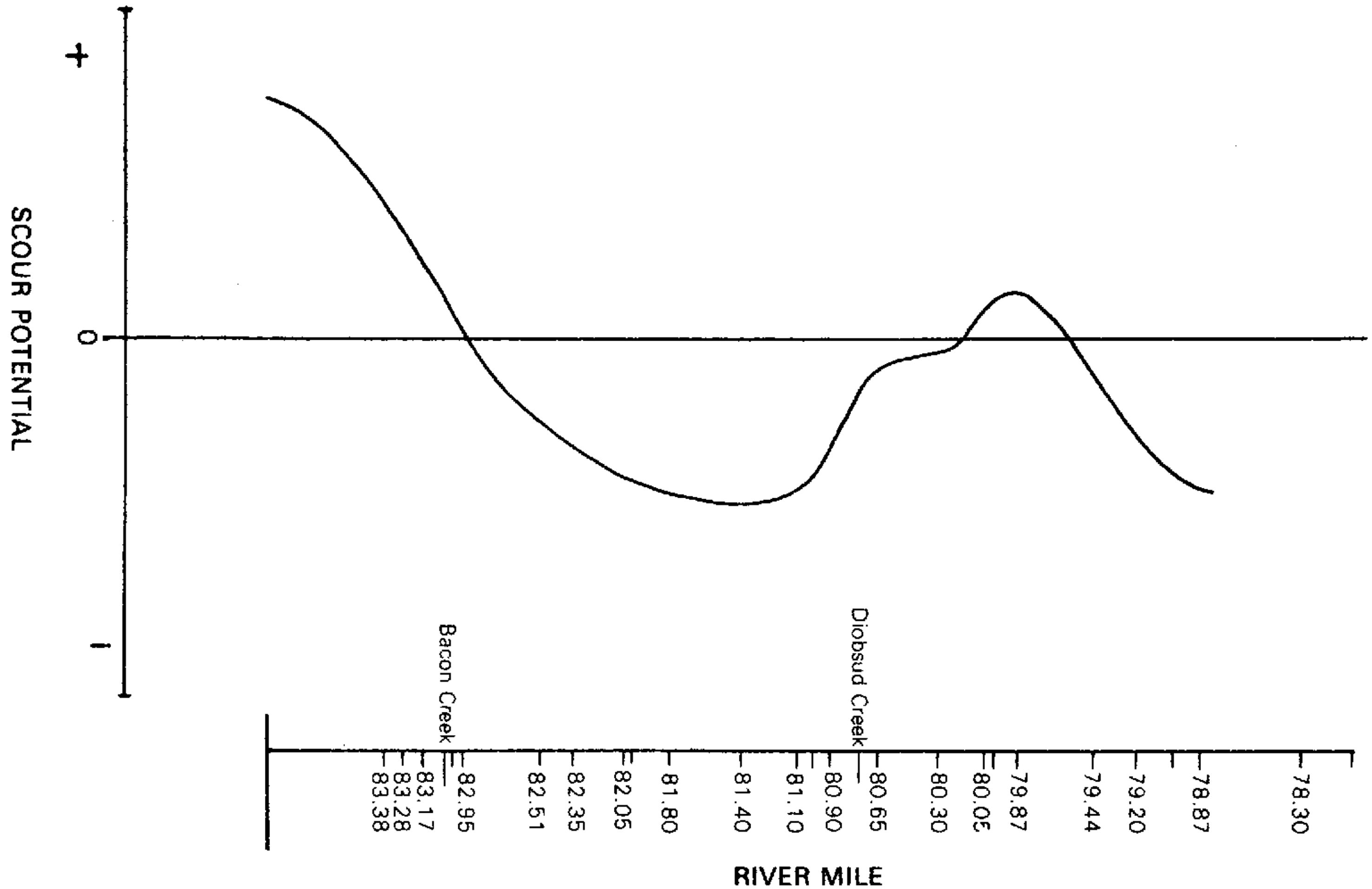
Existing Conditions

The studies to date indicate that the riverbed is stable below discharges of 20,000 cfs, with the exception of the one half-mile reach immediately below the proposed dam. In this area, discharges between 12,000 and 20,000 cfs may cause erosion of material smaller than three inches.

Floods above 20,000 cfs have the capacity to alter channel characteristics between the Copper Creek Dam site and Marblemount. Scour begins to occur at 20,000 cfs between river miles 79.44 and 80.65 and also between the dam site and Bacon Creek. Deposition occurs in the mile and a half above the confluence with the Cascade River at this discharge.

Rare flood events play a dominant role in modifying the Skagit River above the Cascade River confluence. Floods with recurrence intervals of ten years or greater cause the greatest and longest-lasting impacts on gravel bars and on the streambed.

The pattern of erosion and deposition under existing river conditions is given in Figure 13 for the ten-year flood. A positive scour potential is indicative of possible continued erosion and armoring; a negative potential indicates possible deposition. Significant scouring above Bacon Creek is indicated, as is some scouring in the vicinity of river mile 80.0. Deposition occurs between Bacon Creek and river mile 80.9, and between the confluence with the Cascade River and river mile 79.44. Most material is eroded above Bacon Creek and river mile 80.90. The surface armor here consists of gravels and cobbles. Finer materials would be carried through to the lower depositional reach. The preponderance of materials deposited there would be gravels and cobbles up to



(DISCHARGE = 36,000 CFS)

Figure 13. Scour Potential, Ten-Year Floor

approximately four inches in diameter, but some materials as large as 12 inches in diameter from the scoured reach at river mile 80.00 may also be deposited. The amount of deposition that occurs at the Marblemount area is probably much less than that occurring below Bacon Creek during rare floods. The stability of the river increases as one progresses downstream toward Marblemount, and the amount of material the river is scouring or depositing decreases.

Between the rare flood events, the river is expected to carry the finer materials, sands and gravels that these events expose or deposit. The net effect of large floods is to coarsen the riverbed by removing finer materials.

The river will transport most of its exposed sands and fine gravels past Marblemount during high flows. The amount of such materials exposed in the river at any given time is presently less than ten percent by area, and as such, is a minor constituent of discharge. It is comparable to the amount of material of similar size entering the Skagit River through the Cascade River system.

Impacts

Increased erosion is directly attributable to lost gravel recruitment from above the dam. The impact of the dam on the downstream riverbed should be considered in 3 phases: (1) the erosion of gravels and armoring of the streambed; (2) the effect of an armoring process on gravels within the range suited for salmon spawning; and (3) the effect of (2) on fish spawning success.

In general, the dam would be expected to increase the erosiveness of erodible reaches of the stream, and decrease the amount of deposition occurring in the depositional reaches due to removal of Newhalem Creek and Goodell Creek material from the system.

The proposed dam will have no impact on erosion of gravel in bars in the Skagit River during normal operations where discharge is less that 10,000 cubic feet per second. The riverbed will also remain stable below Bacon Creek when discharges remain less than 20,000 cfs. The reach between Bacon Creek and the Copper Creek dam site is subject to increased erosion from the streambed of materials smaller than three inches. The reach could be scoured to depths averaging up to one-and-one-half feet by discharges between 12,000 and 20,000 cfs.

The effect of the dam on downstream erosion during rare flood events is expected to be most severe above Bacon Creek and in the vicinity of river mile 81.40. The river is more stable and, therefore, would be less affected by the dam further downstream toward Marblemount.

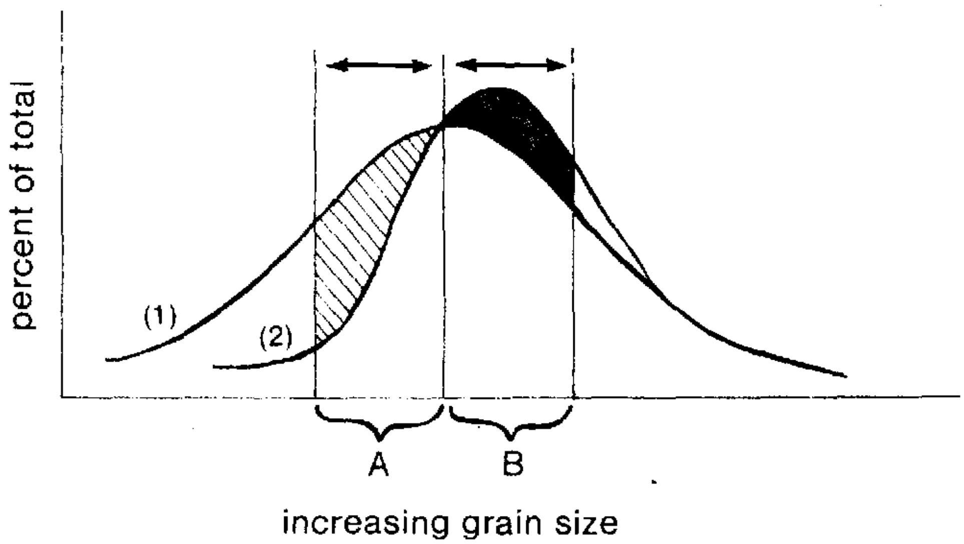
Gravel recruitment from above the dam site is estimated to account for 30 to 60 percent of gravels in transport in the Skagit at Marblemount. (This is estimated by pebble lithology counts of bed materials from Bacon Creek, the Skagit at Copper Creek and the Skagit at Marblemount.) These materials would be lost to the river downstream if the dam were constructed. The percentage of sediment transport of silt and sand-sized particles that would be lost due to the dam could be somewhat higher. The impact that loss of these materials would have on the river downstream of the dam is contingent upon the absolute rate of transport in that portion of the river. The studies conducted to date indicate that the Skagit in this stretch has a relatively low sediment budget. This may be attributable in part to the loss of recruitment due to the existing dams, and possibly due in part to sediment sinks above the dam site, i.e. depositional areas reducing net sediment transport. Whatever the causes, the river between the dam site and Marblemount is mostly armored with materials that are stable except under large floods.

The effect of large flows on the streambed is to disturb the surface armor and put into transport a portion of the armor layer. The dam could be expected to coarsen the armor layer, especially above Bacon Creek. This effect is believed to be minor, however, and the overall degradation of the streambed, such as might be measured with transects, is also expected to be minor.

The studies to date have not focused on the impacts of the dam on the substrata below the surface armor, however. The substrata consists of upwards of 30 percent sands and fine gravels. If the surface armor is disturbed during high flows, these materials would become subject to transport. In the presence of the dam, a coarsening of the substrate materials would be expected to occur as a result of floods. The amount of coarsening is unknown, but would be expected to follow the general trends illustrated in Figure 14.

The hypothetical grain size distribution of substrate materials under existing conditions (prior to flooding) is given by curve (1). During a severe flow, the surface armor protecting the substrate is supposed destabilized, and the armoring effect is nullified. Without the dam, erosion of substrate materials would likely occur; however, the dam would reduce the amount of materials from upstream sources that would tend to replenish the substrate materials. The effect of the dam is illustrated as a

Hypothetical Ranges of Suitable Gravel



Hypothetical grain size distributions, showing grain sizes in the substrate before disturbance of the surface armor, (1), and following, (2). Hypothetical ranges of suitable salmon spawning materials lie between the vertical lines. Range A and range B represent different scenarios for the relationship of the desirable range of salmon spawning gravel to the actual substrate grain size distribution.

Figure 14. Hypothetical Grain Size Distributions

coarsening of the substrate from curve (1) to curve (2). A larger percentage of fine materials (such as sands) would be lost to the substrate than would coarser materials. As curve (2) of Figure 14 shows, grain size distribution would shift to the right (toward increased size) following a large flood.

If the loss of materials in the substrate coincides with the size range of gravels most suited for salmon spawning, there could be an impact on the spawning bed. If the grain sizes of suitable gravels lie between the vertical lines in Figure 14, the percentage loss of spawning materials attributable to presence of the dam would coincide with the hatched area. Such a loss might have ramifications upon hatching success. However, if the suitable size range of materials lies in range B of the figure, this condition would represent removal of a large portion of unsuitable fine materials and virtually no change (or an increase, see speckled area) in the amount of suitable materials present. In this case the armoring process of the substrate would not be expected to have a negative impact on the spawning beds.

Once the effect of the dam on the availability of suitable sizes of spawning gravels is understood, it will remain to be ascertained what effect this change in availability would have on survival rates. The answer lies in part on the suitability of the gravels in their present condition and the sensitivity of the species to changes in the spawning materials.

In summary, the impact on the surface armor layer is believed to be fairly well understood. Impacts on the substrate layer need further study during the license application process.

BORROW SITE EXCAVATION

Approximately 950,000 cubic yards of compact glacial till (a mixture of clay, silt and sand) would be excavated to provide fill material for dam construction. The excavation site, or borrow area, is 2 1/2 miles from the Copper Creek Dam site on moderately steep slopes along and above Bacon Creek Road. The proposed borrow site, an area about 7,000 feet by 1,500 feet, is covered by second growth timber. Several year-round and seasonal streams drain the area and eventually contribute their flows to Oakes and Bacon Creeks. Bacon Creek flows into the Skagit River less than one mile downstream from the proposed dam site.

The first step in excavating the fill material would require clear cutting all vegetation and removing (or grubbing) the topsoil. The fill material would then be excavated with heavy equipment and carried to the dam site over unpaved roads. Since considerable absorbent soil would be lost in clearing and grubbing, surface runoff from rainfall would be increased, both in amount and rate. Construction activities associated with excavating the borrow pit would increase total runoff from the site (both over the surface and in streams) by 28 percent. The total increase in runoff into Bacon Creek, however, would total only 1.5 percent of the Creek's flow. Therefore, the effects of the borrow pit project on Bacon Creek would be limited to effects on water quality rather than quantity. Specifically, sedimentation and turbidity (or muddiness) could be increased. The borrow site would be reclaimed in consultation with the Forest Service by regrading the surface, if necessary, replacing the topsoil, and revegetating the area.

According to present schedules, the borrow pit would be cleared and grubbed during the second year of the project. Excavation of the borrow pit for the embankment would commence during early fall of the third year. Completion of borrow pit operations is scheduled for April of the sixth year.

Part 1. Physical Environment

Section C. Air Quality

EXISTING CONDITIONS AND IMPACTS

There are presently few recorded air pollution problems in the area of the dams and reservoirs. However, some observers have noted smoke and haze in the National Recreation Area from slash fires outside the park complex.

Heavy equipment and haul traffic and blasting may be expected to stir up dust during construction. Dust levels could be minimized by watering thoroughfares during dry periods. The equipment would also emit some pollutants from internal combustion.

With requirements to minimize dust, the existing high air quality, and the dispersing ability of the winds, no significant air quality impacts would be expected from construction work.

Burning of cleared vegetation in the reservoir and borrow pit areas could aggravate smoke pollution; however, much of the impact could be avoided by careful timing and design of burning procedures and by compliance with the Washington State Department of Natural Resources Smoke Management Program.

Part 1. Physical Environment

Section D. Noise

The project area is now a quiet one, with traffic from SR 20 being the major source of intermittent noise.

During construction, machinery noise would substantially increase noise levels near the dam site. It is not possible to predict the distance over which this impact would be heard. Construction machinery will be equipped with all required noise control devices but there would still be some unavoidable adverse impact during construction.

After the reservoir is filled, it would conduct noise better than the forested area does now. Highway noise and, if permitted, powerboat noise, could become more audible to nearby recreational users in the Recreation Area and Park. This impact could be avoided, in part, by routing the highway away from the shore and by regulations restricting powerboats and their noise; however, if such regulations are not within the authority of the National Park Service, powerboat noise could not be mitigated.

The sound of the river rapids presently heard along the valley bottom, roadway and valley slopes would be lost.

Part 1. Physical Environment

Section E. Water Quality

EXISTING CONDITIONS

The State of Washington Department of Ecology (DOE) has given the upper Skagit River, which includes Bacon Creek and the rest of the Skagit River tributary system, the highest water quality rating--AA. Generally, the State would oppose any project in this area that might cause the water quality to dip below the AA standard. The DOE sets its water quality ratings on the basis of several parameters. These parameters are described in Table 4. Values are given both for class AA standards, where applicable, and for Skagit River water.

CONSTRUCTION IMPACTS

Borrow Pit

An estimated 67 cubic yards of soil could be lost each year through erosion in the runoff from the borrow area. Unless measures were taken to prevent or treat this erosion, Bacon Creek and its tributaries could become turbid and cloudy. These streams would probably no longer meet the State of Washington's water quality standards.

To reduce the effects of erosion, a number of techniques could be employed. These include dikes, levees, diversion channels, terracing and stabilizing stream banks. The most effective measures to reduce sedimentation and turbidity of waters in Bacon Creek would involve construction of settling ponds in its tributary, Oakes Creek. Settling ponds slow the flow of water and allow suspended particles to settle by gravity. To speed this process, chemicals can be added which cause small particles to settle out. Based on expected erosion rates and maximum runoff, a settling pond four feet deep covering three acres would be required. Settlement ponds can remove all material with particle sizes down to those of sand grains. Removal of suspended silt may require the addition of chemicals.

Washington State Department of Ecology standards for stream turbidity would probably not be attainable in water flowing from settlement ponds into Bacon Creek. Excess turbidity might be tolerable for short periods, but turbidity standards might have to be enforced to meet special situations--for example requirements of fisheries. Excess turbidity probably would be a seasonal problem because settlement ponds would likely produce no outflow in drier months.

TABLE 4. Key Characteristics of Skagit River Water

Water Characteristic	Water of Skagit River near dam sites	AA Standard
Turbidity (cloudiness)	2.9 Turbidity Units	Less than five units
Temperature	13.9 degrees C.	No more than 1.3 degrees C. Change from natural conditions, and 16 degrees C. maximum
Maximum dissolved oxygen (needed by fish)	11.8 - 13.7 mg/l	Exceed 9.5 mg/l
Biochemical oxygen demand (a measure of decaying matter)	2.6 - 1.0 mg/l	No standard. Up to 5.0 mg/l is good quality
Color (from minerals or plant matter)	5 - 10 color	No standard. Up to 15 color units would be acceptable for drinking water
Nitrogen Gas (dissolved into water from the air. Too much causes gill problems for fish)	98 - 105% of normal	Not exceeding 110% of normal
Nitrogen Compounds (plant nutrients)	0.03 - 0.42 mg/l	No standard. Less than 0.4 mg/l is typical of pristine, infertile waters
Phosphorous (plant nutrient)	Less than 0.03	No standard. Less than 0.1 mg/l prevents excess plant growth

A detailed discussion of the borrow pit's impacts on hydrology is presented in the Hydrology Support Document.

Other Construction Activities

Activities during dam construction will impose a number of temporary impacts on water quality. Table 5 lists those activities for which potentially substantial impacts may result, even following mitigative measures. The dates given are according to the expected completion schedule for the dam. The months given are the calendar year months; the years are calendar years from initiation of construction. The schedule may be modified by construction delays. The timing of all activities which might increase sedimentation or turbidity in the river will be regulated by the Washington State Fish and Game Departments. All construction activities will come under National Pollution Discharge Elimination System permits. Monitoring of turbidity and/or sediment, pH, discharge and temperature above and below the site will be required as a condition of the NPDES permit. The National Environmental Policy Act (NEPA) and the Federal Water Act Amendments must be followed, and all legal specifications must provide the prospective construction bidders information on water quality standards. Methods for treating wastewater in order to meet existing water quality standards or providing for best construction practices may be defined in specifications that are acceptable to appropriate governmental agencies.

Throughout construction of dam and powerhouse facilities, an unavoidable small increase in turbidity may be expected. These levels will be insignificant when compared to existing turbidity levels downstream of the Cascade River confluence, but they may exceed Class AA standards during periods of rainfall.

Clearing and burning forest material will minimize oxygen depletion in the reservoir while it is being filled.

Domestic sewage wastes at the construction site will be contained in sani-cans and transported for appropriate treatment away from the river. Petroleum products and other special construction fluids or substances will be rigorously contained to prevent spilling into the river.

OPERATIONAL IMPACTS

Except for turbidity and siltation, the water quality impacts of the Copper Creek Project are expected to be minor or nonexistent. The reservoir would be small enough that it would not significantly change downstream

TABLE 5. Construction Impacts and Mitigation

Construction Activity	Dates	Impacts	Mitigative Measures*	Intent of Mitigative Measures	Impacts Following Mitigative Measures
Logging of dam site. reservoir, and borrow pit, and of logging roads	10/1/1 - ?	Increased storm runoff, occasional increase in turbidity, sedimentation.	Buffer strip along river, sediment control measures.	Partial reduction of increased storm runoff, turbidity, sedimentation.	Increased storm runoff, occassional violation of AA turbidity standards, increased sedimentation during construction.
Clearing and grubbing of dam site, reservoir, and borrow pit (only part of reservoir grubbed)	10/1/1 - ?	As above, but with greater frequency and severity.	As above.	As above.	As above.
Concrete batch plant operation.	11/1/1 - 5/31/4	Turbid wastewater with high pH.	Sedimentation or filtration ponds, acid treatment.	Reduce turbidity to acceptable range.	Nonsignificant if closely monitored.
Excavation of abutments and powerhouse	11/1/1 - 3/31/2	Increased turbidity and sedimentation.	Channelize river at south abutment and place sediment control measures.	Prevent direct runoff to river, reduce sedimentation and turbidity following blasting.	Short term violation of AA turbidity standards.
River diversion	?	Short term increase in sedimentation and turbidity.	Design diversion channel with rock armor.	Reduce erosion at diversion channel	Short term increased turbidity and sedimentation.
Excavation of dam foundation	11/1/1 - 1/31/3	Increased turbidity and sedimentation from pumped muddy water.	Sedimentation or filtration ponds.	Remove suspected sediments, reduce turbidity	Increased turbidity.

*Measures could include contingency plan for adjusting protective measures as actual field conditions become apparent.

temperatures from what they are now. (See analysis in Technical Report 13 of the Environment Assessment.)

Gas supersaturation caused by water spill has sometimes caused "gas bubble disease" in fish in some rivers. This is not expected to be a problem with Copper Creek Dam because it would be lower than the existing Skagit dams. Ross, Diablo and Gorge Dams meet state standards by maintaining a full powerhouse discharge during times of spill. Copper Creek could be operated in a similar manner, if necessary.

UNAVOIDABLE ADVERSE IMPACTS

The only unavoidable adverse impacts predicted are inevitable small amounts of short-term sediment runoff, turbidity, and siltation that would escape mitigation techniques.

Part 2. Biological Environment

Section A. Vegetation

EXISTING CONDITIONS

To assess the impacts of a Skagit River dam on vegetation, we chose a botanical study area that extends lengthwise from Bacon Creek east to the Gorge Powerhouse at Newhalem. In width, the study area extends northward approximately 200 feet above the elevation of the proposed new power line transmission route and to the south approximately 200 feet above the elevation of the highest proposed pool level. Although it includes land that would not be directly inundated or cleared for a dam project, the area provides a reasonable context in which to look at the impacts.

Four percent (194 acres) of the study area contains vegetation which has not been disturbed. The rest (96 percent or 4,700 acres) has been disturbed by human or natural activities such as logging or burning (which could have been either natural or human caused). The undisturbed areas--those in which a completely natural, gradual succession of plant types has occurred--presently contain some interesting distinctive groups of plants.

Figure 15 is a detailed vegetation map. It shows that disturbed areas include:

- 1,581 acres of coniferous forest of various ages
- 1,275 acres of deciduous (non-evergreen) forest of various ages
- 1,039 acres of mixed conifer-deciduous forest of various ages
- 811 acres of maintained disturbance--roads and power lines, for example

The map shows that undisturbed areas include:

- 100 acres of riparian vegetation, defined here as vegetation directly affected by river flow and fluctuation
- 24 acres of coniferous forest at its climax; i.e., a stage that would sustain itself without much overall change. These 24 acres are contained in 1) a four-acre stand of cedars on a river terrace near Newhalem, 2) a ten-acre "peninsula" of fir-cedar forest across from the Newhalem ponds, 3) a ten-acre cedar-hemlock forest west of the Newhalem ponds.

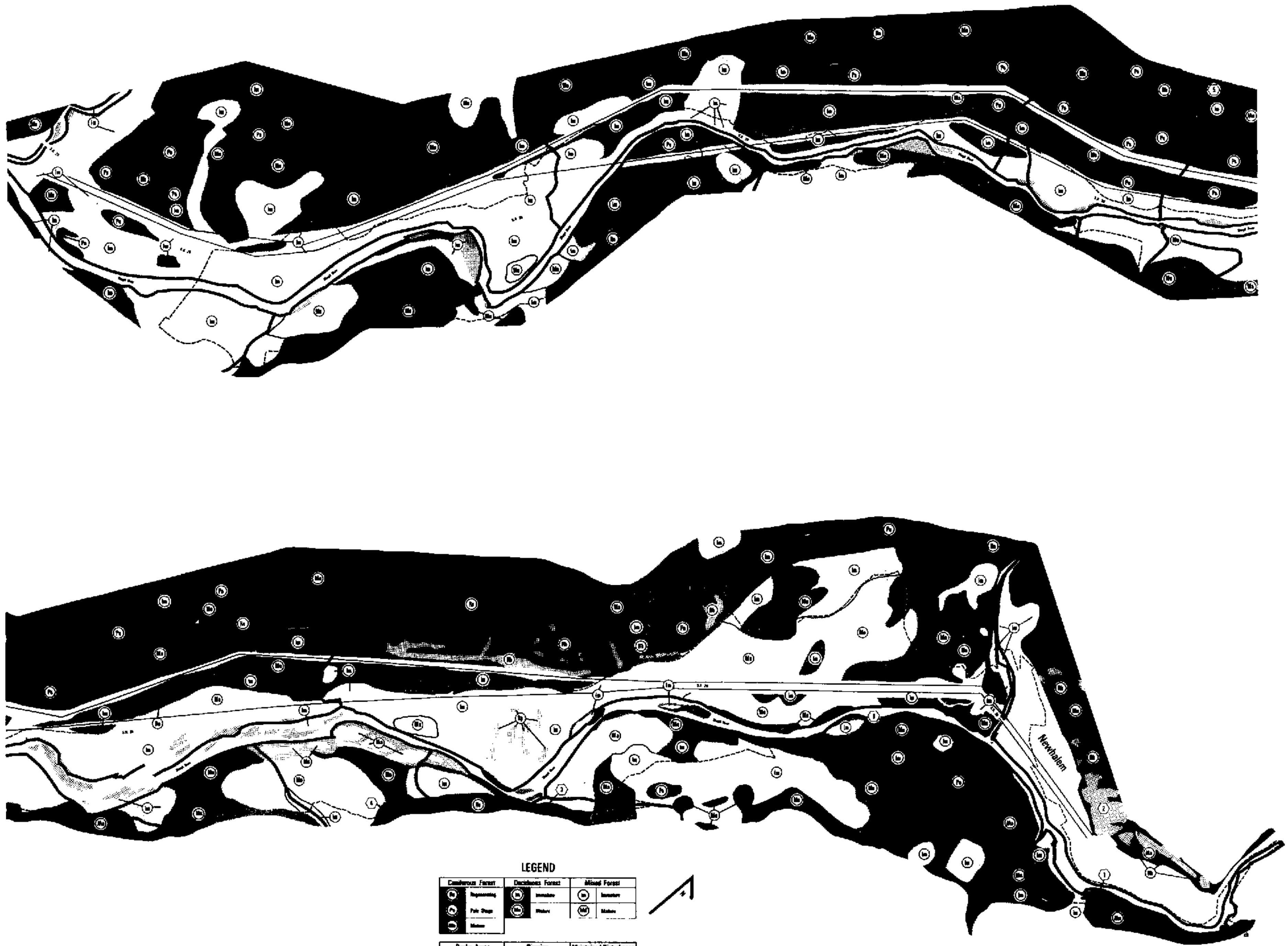


Figure 15 Vegetation Map of the Copper Creek Project Area

- 70 acres of rocky bluffs on the north valley walls.

Rare Plants

No candidate plant species for threatened or endangered status were found in the study area as of July 1, 1980. There is available habitat on the rock bluffs for Erythronium oregonum, which is known from similar habitat in the Puget Sound region. Although this plant is proposed as threatened in the 1975 Federal Register, it has proven to be more abundant than previously thought and will probably be removed from this status in the future (W.N.H.P. 1980). Because of lack of available habitat, it is unlikely that any other proposed threatened or endangered plants would occur in the study area, and if they did, they would be outside their known range.

Washington Natural Heritage Program records show an historical sighting of Impatiens aurella which has not yet been verified. Searches for this species were conducted within the study area without success.

IMPACTS

Tables 6 and 7 show the acreages of vegetation that would be lost by construction and operation of a new Skagit River project. The significance of these losses depends on three factors:

- the proportion of the vegetation lost in each category,
- the botanical importance of that category, and
- the importance of that vegetation to wildlife (as discussed in the wildlife section).

The numbers in these tables are based on the extreme assumption that the borrow pit would be permanently lost to vegetation. In fact, that area would be revegetated, but affected acreages cannot now be predicted.

Botanical Significance

The small climax stands of cedar, fir and hemlock do not contain species which are unusual or uncommon in the region. But such climax stands are becoming increasingly rare in the lower elevations of western Washington. The study area is like a finger of low elevation land extending unusually far into an area of much higher elevation. (Even though the site is 83 miles upriver, the proposed dam would be less than 600 feet above sea level.) Since elevation often has a major effect on the types of

TABLE 6

Existing Vegetation and Projected Impacts Of Copper Creek Dam Construction

Vegetation and Habitat Types	Total Acreage for Entire Study Area, Including Borrow Pit	Acreage Loss Due to Copper Creek Dam Site 495' Pool (a)	Acreage Loss From Borrow Pit	Vegetation and Habitats Remaining Outside 495' pool	Acreage Loss Due to Highway Construction (b)	Acreage Loss Due to Transmission Line Corridor (c)
Vegetation Type:						
Coniferous Forest	1605	215	101	1275	60	155-180
- Climax	24	10		13		
- Mature	1002	140	87	762	25	100-110
- Pole State	339	50	14	275	20	20-30
- Regenerating	240	15		225	15	35-40
Mixed Forest	1039	385	4	650		60
- Immature	754	135	4	500	25	60
- Mature	285	250		150	0	0
- Deciduous forest	1275	900		375	13	15
- Immature	890	350		340	10	10
- Mature	385	550		35	3	5
Riparian	100	100				
Rocky Bluffs	70	0		70	2	5-10
Other:	811					
- Transmission Line Corridor	270	150		125		
- River	370	350				
- Ponds	50	50				
- Road	55	50				
- Miscellaneous	66	Unknown				
TOTAL:	4900	2200	105	2595	100	235-265

(a) The values shown represent acreage lost by inundation, as a result of the 495-foot pool level of the proposed Copper Creek Dam. The next table compares the dam variations.

(b) These values would not change significantly for middle road and would be somewhat less (approximately 20%) for lakeshore road.

(c) The values shown represent the range of acreage loss for the three proposed power transmission line corridors, which do not vary significantly enough to warrant separate tabulation.

TABLE 7

Vegatation and Habitat Loss Within The Inundation Zone
Of Each Of The Three Dams

Vegetation Type	Subtype	Copper Creek Site 495 Ft. Pool (acres)	Copper Creek Site 480 Ft. Pool (acres)	Damnation Creek Site 495 Ft. Pool (acres)
CONIFEROUS FOREST	Climax	10	5	10
	Mature	140	40	115
	Pole Stage	50	20	30
	Regenerating	15	10	5
DECIDUOUS FOREST	Mature	550	470	300
	Immature	350	250	325
MIXED FOREST	Mature	250	170	145
	Immature	135	70	30
RIPARIAN		100	100	90
OTHER	Transmission line clearing	150	135	120
	River	350	340	250
OTHER	Ponds	50	50	50
	Road	50	40	30
TOTAL		2200	1700	1500

vegetation, the study area has an intermingling of plant species and communities. The details of such intermingling are usually of interest to botanists and foresters in understanding how a forest grows, changes, and reproduces itself. Such transition areas, simply because they exhibit the interplay of natural processes, are often also of interest to knowledgeable recreationists.

Construction of a dam and reservoir would diminish the study area area's botanical interest; however, the importance of that loss is unknown and is largely a value judgment. Obviously, the loss would be more important to professional botanists than to others.

Riparian Vegetation

The effects of a dam on riparian vegetation would differ above and below the dam. Upstream of the dam, existing riparian vegetation would not be replaced by similar vegetation surrounding the reservoir. As is the case around the existing reservoirs, the upland forest would extend (without transition to riparian) virtually to the edge of the highest reservoir pool. Depending on the operating regime of the dam, the daily and weekly lowering of the reservoir would expose a strip of unvegetated rocks. If the reservoir level fluctuated ten feet, a bare strip averaging 25 feet wide would be exposed. In some areas near Newhalem, several acres could be exposed. Alteration of natural river flows by dam construction could alter riparian vegetation below the dam. (Bliss, 1967; Bell, 1974; Gill, 1970; Hook, 1973; Hosner and Boyce, 1962; Sigafoos, 1961; and Silker, 1948.)

Approximately 75 acres of riparian vegetation lie between the proposed Copper Creek Dam site and the confluence of the Skagit and the Cascade Rivers. Flow fluctuation effects on the Skagit River would probably be insignificant below the Cascade River confluence. Copper Creek will reduce daily fluctuation downstream during the summer and spring. It is likely that reduced downstream daily fluctuation will reduce riparian vegetation, but it is impossible to predict to what extent.

MITIGATION

We do not identify any measures to mitigate dam impacts on vegetation because:

(1) no proposed threatened or endangered plants have been identified in the area, and
(2) some features that would be lost (for example, a stand of mature trees) cannot be replaced.

Part 2. Biological Environment

Section B. Wildlife

INTRODUCTION

The various plants and animals found together in an area constitute a biotic community. Every organism found within the community plays some role in the dynamics of the community system. Thus, certain species of flora and fauna may be expected to occur together. The locality where the organism may generally be found is called the habitat. Habitats generally provide in some measure the various life requirements for species including, but not limited to, food, shelter, water, and breeding space, although the suitability of available habitat varies according to several parameters.

Wildlife within the project area would be impacted by loss of and changes in habitat because of the dam. The difficult questions include: how much, where, and to what extent would habitat be lost or changed and what other consequences would the project have on these populations?

Three separate project impact areas are considered: 1) the proposed area to be flooded behind the dam structure, including three possible variations in dam height and location; 2) the borrow pit proposed for a 100-acre area on the northeast side of the existing Bacon Creek road; and 3) the corridors resulting from relocating those portions of the present powerline and highway that will be flooded as a result of the project.

The three alternatives for the dam structure itself (Table 8) call for either 1) a high pool which would inundate approximately 2,200 acres; 2) a low pool which would flood 1,700 acres, and 3) a high pool about 3.1 miles upstream from Copper Creek, which would flood about 1,500 acres.

From the borrow pit, proposed for the Bacon Creek-Oakes Creek area, 950,000 cubic yards of impervious material would be removed for dam construction. The actual area to be impacted by borrow removal is estimated at 105 acres, and is land now largely covered with mature coniferous forest (see site description, Chapter II).

Relocation of transmission lines (10.3 miles) and road (10.4 miles) on the north side of the river will impact or remove cover from about 265 acres and 115 acres, respectively, affecting to varying degrees mature conifer forests and exposed, rocky, vegetated slopes.

TABLE 8. Numbers of Acres of Habitat Inundated by Project Alternatives

	HABITAT TYPES	495'HIGH POOL COPPER CREEK		480' LOW POOL COPPER CREEK		DAMNATION CREEK 495' POOL	
		#acres	%total	#acres	%total	#acres	%total
1)	Old Growth Cedar	10	0.4%	5	0.3%	10	0.6%
2)	Mature Conifer	227*	9.8%	127*	7.0%	202*	12.6%
3)	Pole Conifer	63*	2.7%	33*	1.8%	43*	2.7%
4)	Regenerating Conifer Forest	15	0.6%	10	0.5%	5	0.3%
5)	Mixed Mature Forest	140*	6.0%	75*	4.2%	35*	2.2%
6)	Mixed Immature Forest	250	10.8%	170	9.4%	145	9.0%
7)	Deciduous Mature	350	15.2%	250	13.8%	325	20.2%
8)	Deciduous Immature	550	23.9%	470	26.0%	300	18.7%
9)	Riparian	100	4.4%	100	5.5%	90	5.6%
10)	Powerline Corridor	150	6.5%	135	7.5%	120	7.5%
11)	River	350	15.2%	340	18.8%	250	15.6%
12)	Ponds	50	2.2%	50	2.8%	50	3.1%
13)	Roads	50	2.2%	40	2.2%	30	1.9%
	TOTALS	2350	100.0%	1805	100.0%	1605	100.0%

*Includes: 87 acres added to Mature Conifer; 13 acres to Pole Stage Conifer and 5 acres to mixed mature.

Information about wildlife populations and the probable impacts of the project comes from two sources: previous work by biologists, discussed in a later section, and application of the Habitat Evaluation Procedure (HEP), developed by the U.S. Fish and Wildlife Service, discussed in Appendix B. Combined with data from previous work and some professional judgement, the HEP enables a fair assessment of the impacts of Copper Creek Dam on wildlife species and their habitats, and the means to estimate the number of acres needed for full mitigation for loss of these habitats.

The term compensation, as used in the discussion of the HEP analysis, refers to replacement of lost habitat values through on- or off-site habitat management to increase carrying capacity for fish and wildlife. Acres needed for replacement for lost habitats do not imply a commitment by the utility but merely are presented as goals calculated from the HEP analysis.

STATUS OF ANIMAL SPECIES IN WASHINGTON

Because special attention has been directed at the bald eagles on the Skagit, they are discussed separately in Section C of this chapter.

The Nongame Wildlife Program of the Washington Department of Game has been developing preliminary lists of various species, according to their known or suspected status. In Appendix B is the draft list of Washington's Threatened Species, and the list of species of indeterminate status. A third draft list (not included) is available which shows those species of special concern.

No complete biological inventory specific to the Copper Creek Project area has been taken. But one can safely assume that numbers of species from the above-mentioned lists use the habitats in the area to some degree. The consequences to the viability of these species from project-caused habitat loss is unknown. This issue should receive further consideration, if and when the City of Seattle decides to make application to FERC for a license to proceed with the project.

HABITAT IN THE PROJECT AREA

Methods for HEP, in general, allow a determination of the amounts and relative values of the habitats to be lost or changed. Knowing this information, one can plan to replace lost habitats by looking for substitute areas suitable for management to increase their overall value to wildlife.

One can get a fairly good idea of what wildlife species occur in an area by looking at the availability and proportion of suitable habitats divided into ten categories which form a picture of the mosaic of habitat types. HEP was applied to the problem of deciding the relative suitability of these habitats for supporting selected wildlife species representing the diversity of habitat in the project area. Each habitat in turn was evaluated for its suitability in providing for these species' specific needs and ranked on a scale of one to ten, with the high end of the scale being the most suitable. An interagency evaluation team of biologists performed the field evaluation. For the Copper Creek HEP, the Washington Department of Game, U.S. Park Service, Seattle City Light, U.S. Fish and Wildlife Service and an independent ecologist were represented.

Table 9 shows the average ratings of suitability of each habitat as it relates to the wildlife species selected (Appendix B) by the interagency HEP team. The figures are merely averages. That is, some sample plots of a particular habitat type received higher scores than others of the same type. The numbers of sample sites per type varied. In some cases (for example, regenerating conifer forest) there were not enough sites to give a valid sample. Also, some particular sites were given lower ratings because of adjacent roads or high human disturbance. However, when reading across, one gets a relative idea of how well a species does in each of the habitats considered. Reading down, the table shows how suitable a habitat type is in meeting a range of wildlife needs. For instance, Douglas squirrels, pileated woodpeckers, and red-breasted nuthatches did best in mature conifer forests. In the vertical direction, one can see that regenerating conifer and powerline corridors were not thought to be heavily used by the species considered.

The HEP is not without its drawbacks. It is subjective in the selection of the evaluation species as well as the scores given the various habitats. To minimize this subjectivity, these wildlife were selected by the interagency HEP team. The HEP also makes the assumption that lands identified for compensation will have the potential to have their relative values increased by a certain factor. No doubt, management potential exists for most categories of habitats, but to what degree they can be enhanced is questionable and somewhat speculative. In addition, management to increase value of a habitat for a particular species quite possibly is detrimental to other species.

However, the HEP has certain advantages such as generating relative, non-monetary values for habitat types and needs

TABLE 9. Average Suitability Rankings of Habitats for Selected Species Made by the Copper Creek HEP TEAM, June, 1980.

SPECIES	Old Growth Conifer	Mature Conifer Forests	Pole Stage Conifer	Regenerating Conifer	Mixed Mature Forests	Mixed Immature Forests	Mature Deciduous	Immature Deciduous	Riparian	Powerline Corridor
black-tailed deer	6.0	6.0	4.3		6.4	5.5	6.7	6.0	5.0	5.8
black bear	5.0	5.5	5.0	1.0	6.8	4.8	7.0	5.7	5.7	3.6
ruffed grouse	4.5	4.0	2.0	1.0	6.4	5.3	7.4	5.2	1.7	2.6
Pacific tree frog	1.0		0.7		1.6	1.2	2.2	2.5	5.0	1.4
beaver							1.8	0.8	5.3	
Douglas squirrel	4.5	7.8	5.0	1.0	5.4	3.7	1.8	0.8		
yellow warbler	2.0	1.8			3.2	3.2	5.3	6.0	5.0	
red-breasted nuthatch	7.5	8.2	6.7	3.0	5.6	3.8	2.1	1.2		
spotted owl	7.5	6.2	1.7		4.6	0.8	1.2			
northern alligator lizard	1.0	2.0	2.7		1.8	0.8	2.2	1.3	3.7	7.0
Copper's hawk	5.0	4.8	3.7		7.0	3.5	8.1	3.5	2.3	1.8
pileated woodpecker	5.0	7.2	4.7	3.0	6.8	2.5	3.3	1.3	3.7	1.0
bobcat	5.0	5.7	5.0	1.0	6.0	5.2	6.1	5.5		3.2
osprey*	2.5				2.2		1.6			
Non-Stand .x̄HU Value	58.5	59.2	41.3	10.0	63.8	40.3	56.8	39.8	37.3	26.4
No. sample sites	2	6	3	1	5	6	10	6	3	5

*OSPREY (Pandion haliaetus) - feeds within the aquatic zone rather than in the communities and successional stages associated with the aquatic zone. Feeding is displayed in the communities and successional stages only to allow interpretation relative to other species listed; i.e., the osprey is not limited in feeding by the successional stage of the community surrounding the aquatic zone (Thomas, et. al., 1979).

for compensation. Currently, HEP is the accepted procedure for evaluation of wildlife habitat losses and mitigation involved with water resource-related projects. HEP involves a diverse group of agencies and interests in the evaluation process, while requiring a minimum of field work; and HEP takes the habitat perspective, looking at the whole rather than limiting it to the specific parts as the traditional approach does.

Habitat Evaluation, Impacts and Mitigation Needs

Mature conifers (Douglas fir, cedar and hemlock associations), mixed mature (Bigleaf maple, alder, cottonwood) and old-growth conifer forests ranked first, second, and third respectively in overall suitability for wildlife. Approximately 380 acres of these types would be lost, eliminating in the process nesting and feeding habitat for hole nesting birds and mammals, cover and food for deer, bear, and other animals. This loss could be compensated by replacement in kind (for example by purchase and preservation of a like habitat elsewhere threatened with destruction) or by increasing the habitat value of other existing areas. Replacement in kind may not, of course, be an achievable objective.

Table 10 gives estimates of acreage needed for full mitigation at three levels of management potential. The smaller the potential to increase the value, the greater the number of acres needed for full replacement. (See Appendix B for further discussion.) Thus, about 2,269 acres of managed lands are needed to make up for loss of 227 acres of mature conifer forest, if the potential increase in its value is only ten percent. Similarly, about 700 acres (at 20 percent management potential) would be needed to compensate for the loss of 140 acres of mixed mature forest. There is little room for improvement for old-growth conifer forests; only time can permit succession to proceed to this stage.

Fourth in ranking of suitability was the riparian habitat; 100 acres would be lost to the project. Replacement would require as much as 1,000 acres (at ten percent management potential). Most likely this would require rehabilitating existing, highly disturbed riparian corridors. This could be extremely difficult and costly, if not impossible.

Forests of pole stage conifer type (i.e., immature) were ranked fifth in the analysis. About 63 acres would be lost to the project, and according to the HEP analysis, as much as 630 acres would be required to be managed for compensation.

TABLE 10. Estimates of Compensation Needs for Loss of Habitats from the High Pool Alternative at Copper Creek

	Habitat Type	Area Lost to Project (acres)	Habitat Unit Value	Area (acres)* Needed for Full Replacement at Management Potential of:		
				10%	20%	30%
1)	Old Growth Conifer	10	45.0	100	50	33.3
2)	Mature Conifer Forest	227	53.8	2269.6	1141.1	756.5
3)	Pole Stage Conifer	63	37.6	629.5	314.7	209.8
4)	Regenerating Conifer	15	16.7	149.8	74.9	49.9
5)	Mature Deciduous	350	40.6	3497.4	1748.7	1165.8
6)	Immature Deciduous	550	33.2	5498.3	2749.2	1832.8
7)	Mixed Mature	140	49.1	1399.4	699.7	466.5
8)	Mixed Immature	250	33.6	2500.7	1250.4	833.6
9)	Riparian	100	41.5	999.5	499.8	333.2

* Not additive, i.e. full replacement would require the total acreage listed for each habitat type.

Immature deciduous and mixed immature forests ranked nearly the same, but the former is more important by virtue of the number of acres involved. For compensation, nearly 5,500 acres of immature deciduous and 2,500 acres of mixed immature would be needed if their relative values could be increased through management by only 10 percent. Both are important stages in the succession to mature forest habitats, and for that reason, their values should increase with time. Thus, the HEP indicates the number of acres outside of the affected area that could be managed to offset the habitat lost due to the project.

WILDLIFE SPECIES IN THE PROJECT AREA

Mammals

Black-tailed deer (*Odocoileus hemionus columbianus*) are known to rear their young and winter in the area to be inundated. Signs of deer noted by BEAK consultants (1978) and Washington Department of Game (WDG) (Stendal, pers. comm., June 1980) indicate variations in the use of different areas by deer. Generally, highest use occurs on flat benches between the road and the river or gravel bar and island habitat adjacent to the river.

Few data exist on seasonal deer migration, either up or down the Skagit Valley or vertically into upland conifer areas to summer range. Substantial numbers of deer appear to use the valley area throughout the year, but its specific value to deer is difficult to determine from available information.

The best information to date on deer density in the Copper Creek area results from Stendal's unpublished report of deer pellet analysis (see Appendix B). Deer density estimates varied seasonally and yearly from about 13 to 50 deer per square mile. Density figures from hunter harvest are generally lower, averaging about four deer per square mile in the Diablo deer management area.

Black bear (*Euarctos americanus*). There is no quantifiable information on the number or distribution of bear in the vicinity of the proposed dam. Signs of bear, however, were observed throughout the area, particularly on the south side of the river and near the Newhalem and County Line ponds. Most evidence of bear was found in less accessible areas.

Although bears are primarily omnivorous (feeding on both plants and animals), they may be most abundant in the proposed reservoir area during periods when salmon are migrating upstream to spawning areas. Bear may travel from adjacent areas during salmon runs to take advantage of this timely resource. Thus, the small amount of habitat near the river may help support as many as 30 bears within the adjacent 90 square miles (BEAK, 1979).

Small mammals. Four sites in the dam area were live-trapped during the 1978 season (BEAK, 1979). The most common small mammals found were Trowbridge shrews (Sorex trowbridgii) and deer mice (Peromyscus maniculatus). Small mammals were more abundant at the County Line Ponds than at either the upland conifer site or the other mixed bottomland sites, indicating that all bottomland habitat is not equally suitable for small mammal populations.

No additional information on these little-studied species is available. They are of interest, however, because they act as a barometer indicating the relative health of the wildlife community, and because they play a dynamic role in the community food web.

Medium-sized mammals. The groups of medium-sized mammals of concern are fish-eating mammals (because of their dependence on aquatic food resources) and furbearers (because of their historical economic importance). There is considerable overlap between these two groups of animals, although little information is available on their populations.

Fish-eating mammals, including black bear, coyote (Canis latrans), fisher (Martes pennanti), river otter (Lutra canadensis), and western spotted skunk (Spilogale putorius), were considered by BEAK (1979). River otter and mink (Mustela vison) have the highest proportion of fish in their diet, while bear and coyote (Canis latrans) eat fish only during salmon runs, when fish are plentiful. Raccoon, fisher (Martes pennanti) and skunk, on the other hand, eat small fish or other animal flesh.

Furbearers include several of the above mentioned species. Beaver and river otter were historically important to trappers. Trapping records for the 1979-80 season, however, indicate that only one trapper was active throughout the entire season, with two others using the area sporadically (Davidson, M., pers. comm., May 1980). Harvest figures were low. Only eleven beaver were taken from the Copper Creek area.

Beaver are the most conspicuous furbearer in the area and therefore appear to be the most abundant. Signs of beaver were concentrated near the two pond areas and associated slack-water river areas.

No additional information on medium-sized mammals within the study area is presently available, but no doubt the area supports populations of bobcat (Lynx, rufus), fox (Vulpes, fulva), mink and other mammals of interest.

Impacts on Mammals

Important deer habitat (2,200 acres) used to varying degrees for foraging and fawning would be inundated by the project. The area may support two deer populations, one resident year-round, and another wintering there and migrating elsewhere to summer range. The blacktailed deer lives most of its life in the area where it was born (Ingles, 1965), and consequently, the loss of this habitat would eliminate the resident population. The mixed conifer/deciduous forests and riparian-associated vegetation provide cover and forage for species not common to the more upslope coniferous forests.

Fish-eating mammals and aquatic furbearers would be impacted by loss of habitat due to project flooding. For most of these mammals, suitable habitat would not exist along the steep banks of the reservoir, nor would the pool itself provide the food resources necessary to support present species diversity. For example, river otter and mink, which require a year-round source of fish, would be highly affected by loss of foraging and denning areas.

Bear and coyote generally use a wide range of food items but take full advantage of spawned-out salmon during the late fall. Bear require large fat deposits to sustain them through their winter torpor, and may thus suffer because of the diminished salmon resource. Flooding would also destroy bear den sites and foraging areas. Bear may be displaced downstream, but suitable habitat there may already be in full use by other bears.

Construction of the dam would significantly reduce the number of salmon carcasses drifting downstream from the dam site (Glock, et al., 1980) which would have an undetermined downstream impact on fish-eating bird and mammal populations. (More information on this topic is contained in Section 3: Eagles.)

The reservoir would flood the beaver dens at Newhalem Ponds, destroying denning and rearing habitat. Fluctuations in reservoir water level would preclude the use of the banks by beaver. Consequently, beaver would likely be lost from this stretch of the river.

Flooding would lead to a loss of small mammal populations in the proposed reservoir area but should not significantly impact the small mammal community nearby. Clearing forested areas for new transmission lines would alter the makeup of the plant species in the cleared areas and, consequently, the associated mammal population. Populations in the borrow pit area would be eliminated totally during fill removal and for some time after site restoration until revegetation provides essential food and cover.

Operation of the proposed dam would produce minimal impacts since resident mammals would already be lost from habitats flooded by the reservoir (BEAK, 1979). Most aquatic mammals would not become re-established in the reservoir because of daily fluctuations in water level. The reservoir may serve as a barrier to migration and movements of deer, bear, bobcat, and other large mammals.

The low pool alternative would flood about 500 fewer acres than the high dam (1,700 vs. 2,200 acres), mostly in the upper reaches near Newhalem (Table 1). About 100 fewer acres of both mature conifer and deciduous forest would be lost. Thus, deer would still be significantly affected but to a lesser extent than by the higher pool alternative. Similarly, aquatic and small mammal populations would still be significantly affected but to a lesser extent.

The third alternative (high pool at Damnation Creek site) would inundate considerably less acreage than the high Copper Creek Dam (1,500 acres vs. 2,200 acres), including about 3.1 miles less of the river. The bench area near Jennings Siding would not be flooded and would thus continue to serve deer populations. In addition, the riparian and stream-side habitat would remain available for aquatic-oriented species. The two pond areas would still be lost.

Birds

Recent surveys (BEAK, 1979) identified 79 bird species within the study area, a figure which agrees closely with that found for other west Cascade river drainages (Juelson, et al., 1980; Weins, 1978). Important aquatic species include common mergansers, dippers, common goldeneye, bufflehead, and trumpeter swans. The most frequently recorded land species were the hairy woodpecker, raven, common crow, chestnut-backed chickadee, winter wren, golden-crowned kinglet and dark-eyed junco. Bald eagles are considered in the following section of this document.

Bird densities in both lowland and upland deciduous mixed/coniferous forests were highest in June (BEAK, 1979). This observation is in disagreement with recent findings in the North Fork Snoqualmie River Basin, where bird density in most habitat types was highest during either spring or fall migration (Juelson, et al., 1980). A precise comparison of bird densities among different habitat types is difficult, because sample sizes vary and habitat types are not clearly defined. Sampling design was not described for the BEAK study.

No further survey work on bird density has been done in the upper Skagit valley, except for the Habitat Evaluation Procedure (HEP), described elsewhere. Data from the North Fork Snoqualmie basin, however, are relevant to the Skagit study area (Juelson, et al., 1980). Generally, these data show that birds are less dense in open canopy communities, such as early successional forests, than in more established forest types. This underscores the concept that mature forests provide more structural complexity and thus habitat diversity for birds (Balda, 1975).

Raptors (birds of prey). Only those birds of prey active during daylight were observed in previous surveys of the proposed dam area (BEAK, 1979). These included: *Accipiter* sp., red-tailed hawk (*Buteo jamaicensis*), Swainson's hawk (*B. swainsoni*), bald eagle (*Haliaetus leucocephalus*), and American kestrel (*Falco sparverius*). There have also been numerous sightings of osprey (*Pandion haliaetus*) in recent years within the proposed reservoir area by National Park Service personnel, including one osprey nest verified by FWS biologists. Bald eagles are also believed to nest in the vicinity, and several sightings have been recorded during late summer (Wasum, B., pers. comm., June 1978). The existing information from these sightings of raptors is insufficient to make statements about their habitats and population status.

Previous survey work did not include nocturnal birds. One would expect screech owls (*Otus asio*), pygmy owls (*Glaucidium gnoma*), and saw-whet owls (*Aegolius acadicus*) to be fairly common in the area. In addition, other species, such as great horned owl (*Bubo virginianus*), barred owl (*Strix varia*), and spotted owl (*S. occidentalis*) may reside in the area. A barred owl was found along State Route 20 between Bacon Creek and Newhalem during January, 1980 (Allen, H., pers. comm., February 1980). Great horned owls have been sighted in the study area (Wasum, B., pers. comm., June 1980).

The spotted owl is of particular concern because of its narrow habitat requirements and tenuous population status.

This species is dependent on old growth, mature coniferous forest and was once common to the forested slopes of the west Cascades. Clearcut logging in the last 60 years has eliminated much of the old growth forest on which the spotted owl is dependent for nest sites. The spotted owl appears on the latest (June 1980) Washington State draft list (in Appendix B) as "threatened", and is being proposed for consideration for federal classification as "threatened" under the Endangered Species Act. The Washington-Oregon Interagency Committee on Wildlife recently gave the spotted owl "sensitive" status. In addition, it is listed as "threatened" on the Oregon State list and in the U.S. Fish and Wildlife Service Red Book; as "endangered" on the Oregon State list and as "unique" in Region 6 of the U.S. Forest Service.

Approximately 237 acres of old growth/mature conifer forest habitat and 140 acres of mixed mature forest habitat will be lost or altered due to project impacts. Use of this habitat by spotted owls has not been investigated.

It is currently accepted that one pair of breeding spotted owls requires a minimum breeding territory of 300 acres of old growth/mature forest and an additional 900 acres of similar habitat as home range.

Upland game birds. Ruffed and blue grouse were the only upland game birds noted in the study area. Blue grouse were most commonly found in conifer forest areas on the valley slopes. Ruffed grouse were found in mixed lowland forests, especially where shrubby understory vegetation provided cover. No population status information is available.

Impacts on Birds

Portions of the various habitat types and their associated bird life would be lost to project construction and inundation of the reservoir. Initially, these bird populations would be displaced to other similar habitats in the vicinity, but most displaced birds can be considered lost. Their influx into suitable nearby habitat, already supporting its own maximum complement of fauna, could put stress on available but limited resources, increase competition for these resources, and affect both displaced and resident populations, particularly during the breeding season. Both population and community relationships may be disrupted.

Some additional habitat for aquatic and semi-aquatic birds may be created by the reservoir, but the species able to take advantage of this situation are limited in number. Kingfishers, dippers, sandpipers, and herons would not find their full complement of habitat needs fulfilled under such circumstances. Puddle ducks and diving ducks would fare better, but they are not abundant in the study area at present.

Loss of habitat in the early successional stages of deciduous and mixed forests will significantly impact resident populations of ruffed grouse, for which suitable habitat in the region is quite limited. As noted in the BEAK (1979) report, "If woody riparian and mixed bottom-land vegetation proves intolerant to intermittent flooding and is not reestablished, this loss may indirectly and adversely affect ruffed grouse. Frequent and severe fluctuation in water levels of the impoundment may also discourage nesting by waterfowl and nongame birds along the shoreline."

Impacts associated with either of the two alternatives would be similar to the high dam at Copper Creek, but would result in a smaller portion of the mixed forest type being lost to inundation.

Reptiles and Amphibians

Surveys of reptiles and amphibians by BEAK (1979) identified four species: red-legged frog, western toad, Pacific treefrog, and northern alligator lizard. Additional observations by the interagency HEP team have found common garter snake and northwestern garter snake. Incidental observations provide clues to habitat distribution of individual species, but these cannot be considered complete. The habitat of the Pacific treefrog was evaluated by the HEP team. Reptiles and amphibians known or expected to occur in the upper Skagit Valley are listed in Appendix B with comments on their respective habitats. More work needs to be done to verify occurrences of these species in specific areas, including the Bacon Creek borrow pit area and along the ponds and slack-water areas of the river.

Impacts on Reptiles and Amphibians

The proposed reservoir area, when flooded, would eliminate essential wetland habitat for several amphibians including western toad, Pacific treefrog, red-legged frog, and rough-skinned newt. River-dwelling amphibians, such as the tailed frog and Pacific giant salamander would be eliminated from the area. Major reproductive habitat, such as the two pond areas, will be inundated by the reservoir. For most amphibians, the water level fluctuations in the impoundment would provide little stable habitat to help offset the loss of their preferred habitat (Juelson, et al., 1980).

Reptiles and amphibians associated with streams in the borrow pit area near Bacon Creek would be totally eliminated, due to the diversion of year-round streams from the site to facilitate removal of the fill material.

The common garter snake, which prefers wetlands, would be the most seriously impacted reptile. The number of Northwestern garter snakes and alligator lizards, both of which favor clearings and woodlands, would be reduced in proportion to the land area lost to inundation. Some habitat may be created in the new powerline corridor, but this possible addition would not significantly mitigate the diversity of habitats lost.

The low pool alternative would affect amphibians and reptiles to a slightly lesser degree than the high pool alternative at Copper Creek because a smaller portion of the mixed lowland habitats would be inundated. However, the important County Line and Newhalem pond areas would still be flooded. The scenario is similar for the dam site alternative at Damnation Creek.

MITIGATION POTENTIAL

Since the major impacts to wildlife and their habitats involve total loss by flooding of the reservoir, mitigation potential is limited to management of the remaining habitat. Some possibilities include:

1) Creating small, year-round wetland habitats by impounding small streams or seep areas along the shore of the reservoir where topography permits. Suitable flat areas that would exist after flooding are quite limited, however, and current recreational uses preclude several of these sites, such as the U.S. Park Service campground at Newhalem. The design of small impoundment areas of this type are being worked out as part of the mitigation plan for High Ross Dam. However, the impacts of blocking small streams in order to create wetland areas may, itself, be detrimental.

2) Managing the new highway right of way to provide maximum use by wildlife. The U.S. Federal Highway Administration (Leedy, D., 1975) has summarized current research and guidelines on this subject. One practical recommendation is to maintain road and powerline corridors by mechanical means. This is

cost effective and provides much more plant diversity and habitat than when herbicides are used.

3) Leaving snag trees standing along the shoreline and in the pool near the shore. Cull trees could also be left to provide future snags. These would provide feeding and nesting habitat for a variety of cavity nesting birds and perch sites for many other species, including raptors.

4) Creating small clearings in the adjacent woodlands to provide for habitat heterogeneity and transition zones, and thus support a greater diversity of species in these areas.

On-site mitigation potentials for the proposed Copper Creek Project are limited by the topography of the surrounding area and are insufficient to significantly offset the total loss of the wide diversity of river-associated habitats. There may be, however, some off-site opportunity to mitigate part of this loss. The Habitat Evaluation Procedure (HEP) described elsewhere provides goals for full mitigation which involve the enhancement or development of existing habitat to increase its relative suitability to support wildlife. In practice, in-kind replacement may be difficult or impossible to achieve for certain lost habitats. For example, riparian habitats cannot easily be re-created once removed, but cutover streamsides off site can be restored by planting, gravel cleaning and bank stabilization.

Other areas of high habitat value within the study area will be most difficult to compensate. Of particular interest are the two pond areas, the County Line Ponds and the Newhalem Ponds, each formed by past gravel-removal operations. These areas are characterized by numerous ponds in close association with emergent vegetation surrounded by mature/immature deciduous woodlands. The transition from the aquatic to the terrestrial vegetation provides a diversity of habitat and associated niches supporting a group of species found in no other single habitat type within the study area. Following duplication off-site of such ponds, it could take years to reestablish the plant community structure and associated habitat characteristics.

Suitable areas with enhancement potential need to be identified (if they exist), and the costs associated with acquisition or easement and management need to be determined. Any area identified for mitigation of impacts caused by Copper Creek Dam could possibly be considered as a mitigation site by any other entity considering a land-use development, e.g., City Light's High Ross development. Techniques for management to enhance suitability for wildlife can involve such things as vegetative manipulation through planting, cutting and burning to retard plant succession, and girdling trees to create future snags.

Mitigation levels and the methods to achieve them will be thoroughly outlined if the decision is made to proceed with the FERC license application. The overall impacts on the viability of wildlife populations and habitats resulting from the project on the regional level are unknown. For some animal populations, it is unlikely that even the best mitigation measures taken would significantly make up for the total loss of 2,400 acres of mixed riverine habitat.

Part 2. Biological Environment

Section C. Bald Eagles

EXISTING CONDITIONS

The bald eagle is protected under the federal Endangered Species Act, which classifies species according to the danger of their extinction. In most of the U.S., the bald eagle is classified as "endangered", meaning that it is in danger of extinction. In five states, including Washington, the eagle is in the slightly less critical category of a "threatened" species, meaning that it is likely to become endangered within the foreseeable future.

The Skagit River is a major wintering area for bald eagles. Census data indicate that 300 or more eagles have been known to spend the winter there, foraging on spawned-out salmon carcasses. In 1979, 381 birds were counted between the mouth of the Skagit and Newhalem, which represented about 35 percent of the 1,126 bald eagles counted statewide (Washington Dept. of Game, 1979). In that year, in the spring, summer and fall months, the eagles moved to breeding territories, probably on the Olympic Peninsula and in the San Juan Islands, British Columbia and Alaska.

The major food resource for the Skagit-wintering eagles is spawned-out salmon carcasses that wash up on gravel bars in the river. Because the timing of the chum spawning run and the eagle migration coincide, chum salmon appear to be the eagles' most important source of food.

Consultants to City Light conducted two related studies on bald eagle ecology and their salmon carcass food resource during the winter of 1979-1980. That winter, only 16,000 chum ran up the Skagit to spawn, fewer than in any run recorded since 1971. (Chum salmon runs vary in natural cycles, with significantly fewer fish spawning in odd years than in even years.) Further, during December of 1979, there was a flood on the Skagit of a magnitude that can be expected to recur about once in fifty years. The high waters washed away almost all of the chum carcasses, eliminating them from the eagles' food supply for the winter.

Therefore, the past winter during which City Light gathered information on eagles was unusual, because the flooding and the low chum run resulted in an abnormally low food supply which was associated with an uncommonly low influx of birds. Detailed results of the consultant's studies are reviewed in the Bald Eagle Support Document. The consultants' reports are also available from City Light.

What follows is a condensation of the study findings.

Biosystems Analysis consultants estimated that the wintering eagle population during the winter of 1979-80 was approximately one-third that of the previous year (Figure 16). The census for 1979-80 shows a peak number of 174 eagles, while counts peaked near 250 birds for a shorter river stretch in 1978-79. All biweekly averages in 1979-80 were less than those of the previous year. In the 1979-80 winter, it is reasonable to assume that the low chum run, compounded by the flood, caused the drop in eagle numbers. In other words, lack of food reduced the eagle population in the Skagit study area.

Other researchers observed during the 1979-80 winter that more eagles than usual moved into areas along the Nooksack River, which is about forty miles north of the Skagit. The Nooksack had an exceptionally good chum run. The unusually large number of eagles on the Nooksack could be explained by a combination of the good food supply there and the poor supply available on the Skagit. Some of the eagles that wintered on the Nooksack probably would have wintered along the Skagit if more salmon carcasses had been available there.

Eagles' use of the Skagit River habitat changed as the winter progressed (Figure 17). During the first two months of the winter, eagles concentrated in the lower stretch, particularly in the Bald Eagle Natural Area. But in the third and fourth months, another concentration of eagles occupied an area known as County Line Ponds, above the proposed dam site. These ponds were used by an average of 30 eagles in January and February, and a sustained peak use by over 40 eagles lasted for two weeks in mid-February.

Eagles gathered at County Line Ponds to feed on spawning coho salmon. The ponds support a population of coho, documented since 1958 by WDF, which continued to spawn into March. Because of the timing and distribution of spawning, coho were largely spared by the winter flood. Coho spawn primarily in tributaries and swift-moving waters off the main river; although adult coho will run up the Skagit earlier in the season, their spawning activity will extend later than that of chum, perhaps even into late February or March. Coho were thought to be too sparsely distributed and available in too few numbers to be of much importance as a winter food resource to eagles.

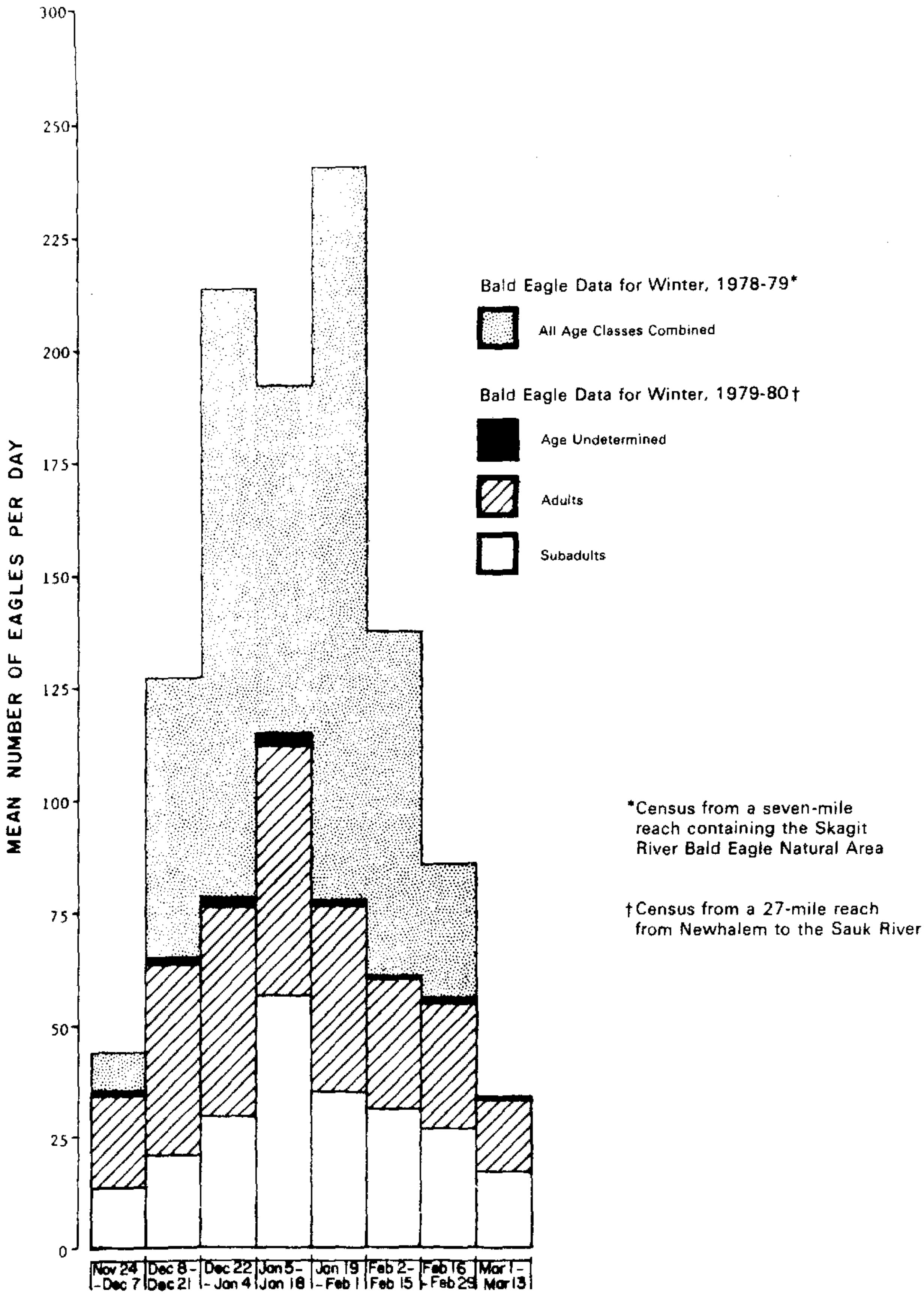


Figure 16. Skagit River Eagle Census Results

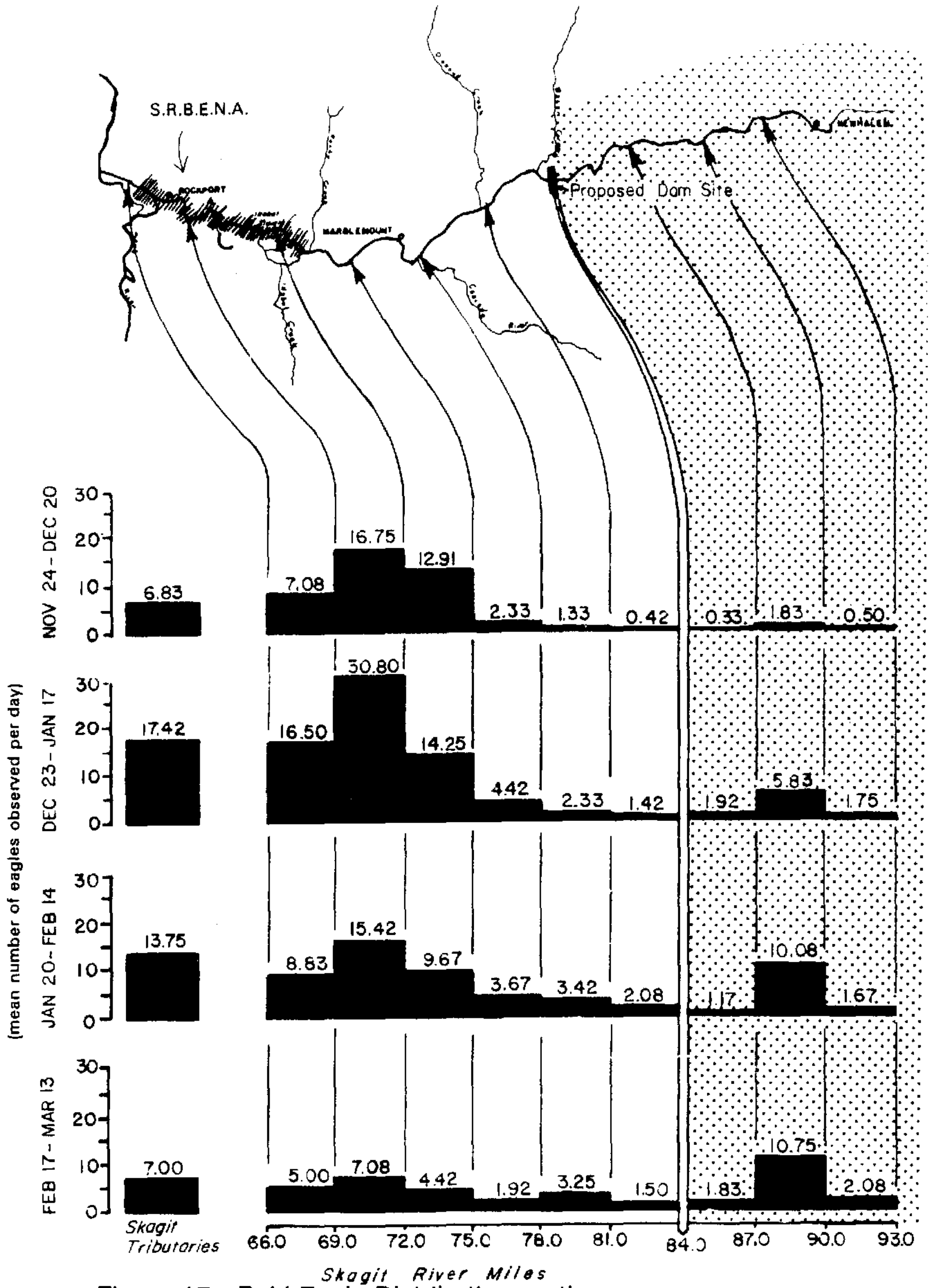


Figure 17. Bald Eagle Distribution on the Skagit River, 1979-80

The study period is divided into four-week blocks (from top to bottom) which are correlated to nine three-mile river segments (from left to right on map). Shaded bars represent the mean number of eagles observed per day. These data show that eagle usage of the habitat varied through the winter.

During this winter of chum scarcity, eagles were found to feed on coho salmon carcasses much more than previously suspected.

Though it is now known that coho sustained some eagles through the past winter, it is unknown what role this species plays as an eagle food resource during times when normal amounts of chum are available. Conversely, we cannot predict what contribution chum salmon in County Line Ponds and at other locations in the proposed impoundment area would make toward sustaining eagles.

Studies indicate that eagles used the area above the dam site primarily because of the availability of food there rather than because of any other habitat factors. Throughout the study area, eagles were observed where the food was available, even when that food was in areas where human disturbances occurred. The eagles appeared to tolerate boaters, fishermen, and other human disturbance in order to continue their feeding activities. This degree of tolerance may be unusual and may be a response to the limited availability of food this winter. Radio-tracking of 17 eagles showed that during the winter they flew to several other geographic areas, such as the Nooksack River, Fraser River, San Juan Islands and Gulf Islands. They may do this every year, or this may have been a response to the low food supply on the Skagit. It is unknown whether these other areas would have the habitat or food supply to support Skagit Valley eagles on a permanent basis.

IMPACTS

Biological Resource

Any of the Copper Creek alternative designs or a Damnation Creek dam would affect the wintering population of bald eagles, primarily by affecting their food supply. Spawning grounds for salmon would be flooded, which would reduce the food supply in two ways: eagles could no longer feed in the area above the dam, and chum carcasses that would have originated above the dam sites and then floated downstream would no longer be available. Habitat preferred by 40 bald eagles during the late winter of 1979-80 would be inundated. The major coho salmon food resource at County Line Ponds would be lost. Chum spawning grounds (redds), producing an average of 15 to 40 tons of biomass, would be flooded. However, a portion of this average year's salmon run normally would be lost to eagles due to natural causes, such as sinking, being buried in places out of their reach, and being eaten by competitors (e.g., crows and ravens).

Because it had been hypothesized that eagles fed almost exclusively on carcasses which drifted downstream from spawning grounds above Copper Creek, a study was designed to measure carcass drift. The study showed that approximately 52 percent (plus or minus 10 percent) of radio-tagged salmon that spawned above the proposed dam sites eventually drifted downstream past Copper Creek and into the Bald Eagle Natural Area. This research was affected by the flood, and the estimate of drift in the absence of the high flows might have been lower by 5-10 percent.

Additionally, flooding effects made it impossible to determine what portion of these "drifters" normally become available to the eagles as food on gravel bars, because virtually all carcasses were buried or swept away. The river dynamics that influence deposition of salmon carcasses on gravel bars are unknown, and it is impossible to determine the proportion of salmon carcasses that become available to eagles. It may be reasonable to speculate, however, that less than half of the chum biomass actually becomes available as food for eagles.

The net effect of the Copper Creek Project on the eagles' winter food resource is therefore difficult to determine. Based on the 1979-80 observation of eagles' apparent flexibility in moving to areas where food was available, it is probably accurate to assume that any carcasses of salmon spawning above Copper Creek that become available may be eaten by eagles. Salmon estimated to spawn above Copper Creek number between 2,200 and 6,600 fish. Probably between 900 and 4,100 of those eventually drift back down below the dam site.

It is useful to question how many eagles theoretically can be supported by the chum spawning above Copper Creek. Eagle food consumption can vary widely, depending upon temperature, diet and other variables. If we assume some likely rates of fish consumption by eagles and some average fish weights (see Bald Eagle Support Document for explanation of assumptions), and if we conservatively assume that only 10 percent of the carcasses washed up where eagles could reach them, then carcasses of salmon which spawn in the proposed project's impoundment area could support somewhere between 12 and 40 eagles for 20 weeks (a full winter). Perhaps half that number could be supported by those carcasses that eventually drift into areas below the proposed dam (if only 10 percent were ultimately available). It is still not known with any accuracy, however, how crucial these carcasses are as food to the eagles' supply. It is also not known what maximum number of salmon could be utilized for food by eagles.

It is clear, however, that a dam at Copper Creek would reduce the food supply on the Skagit for wintering bald eagles. If salmon carcass availability varies between 10 and 50 percent, up to two hundred birds could be affected. Eagles searched elsewhere for food last winter, and it appears that the birds were capable of finding enough to sustain themselves.

It is not known how many birds might ultimately be displaced, and whether or not they could be accommodated elsewhere on a sustained basis. Further study is planned to answer these questions, but the results will not be available until 1982. It is also not known how practical and acceptable it would be to augment the food supply with salmon carcasses from hatcheries or from artificial spawning channels. An eagle population dependent upon man is not a secure population. Because County Line Ponds are man-made (they are old gravel borrow pits), it has been suggested that simply creating more such ponds below Copper Creek, and stocking them with coho, could mitigate the dam's impact. Coho spawn under unusual circumstances in County Line Ponds. The species requirements for oxygen suggest an upwelling of groundwater may occur in the ponds, making it possible for them to be found or duplicated at the mitigation site.

Human Resources

The recreational and aesthetic value humans place on eagles would be affected by the Copper Creek Project. Eagles are the primary resource of the Skagit River Bald Eagle Natural Area, located in the dam impact area, and are an important resource in the stretches of the Skagit River designated in the Wild and Scenic River System and in the North Cascades National Park/Ross Lake National Recreation Area. Each of these areas represents either direct social investment in eagles or social investments in recreation and conservation which are enhanced by the presence of bald eagles. Survival of displaced eagles outside of these Skagit River areas will not mitigate impacts upon these investments in eagles in the Skagit.

The Skagit River Bald Eagle Natural Area, about ten miles below Copper Creek between the Skagit confluences of the Sauk River and Rocky Creek, is co-owned by the Nature Conservancy and the Washington Department of Game. This 2,100-acre preserve is managed to protect critical wintering habitat of bald eagles, to provide a winter refuge for eagles, and to allow the public nondisruptive viewing of eagles. The land investment represents a total present value in excess of one million dollars; the value to The Conservancy of that investment depends on the maintenance of the habitat for its intended uses. The issue of the potential effects of human activity on wintering bald eagles may be investigated by the U.S. Forest Service as a part of their management plan for the Skagit recreational river.

The Skagit River, between Sedro Woolley and Bacon Creek, was designated a "Recreation River" by the U.S. Congress November 10, 1978. The U.S. Forest Service is responsible for the management of this river within the Wild and Scenic River System and is charged with preserving the values for which the river was designated. Among these are "outstandingly remarkable . . . wildlife values . . . significant to local, regional and national populations" (Gilbertson, D., pers. comm., July, 1980). Natural salmon stocks and the large concentration of wintering bald eagles are among the Skagit's wildlife resources. The acquisition and management of recreational river resources for the Skagit involves an initial investment of $12 million for scenic easements and land acquisition and a projected $100,000 a year for management (Gilbertson, pers. comm., July, 1980).

In addition to their rarity and value as a national symbol, bald eagles are a source of aesthetic enjoyment and recreation for numerous individuals who travel to the Skagit to observe them. In 1980, the Washington Department of Game conducted a survey of recreational and consumptive users along the Upper Skagit River (Rockport and Marblemount). Of nearly 700 respondents, over ninety percent were on the river for "nature study and recreation." Nearly two-thirds of those interviewed came from Seattle and Tacoma and almost all of these were there for "nature study and recreation". This indicates that a majority of people using the upper Skagit River come from urban areas a few times each year, primarily for nature study and nonconsumptive recreation, while a lesser number from smaller communities visit the Skagit more often to fish. Weighing the value of this experience to those users who made the trip to observe bald eagles in the Skagit requires some judgement of the intangible social value of wild bald eagles. Furthermore, bald eagles have special significance in the spiritual reality of American Indians.

LOCAL CONSTRAINT

The federal Endangered Species Act protects organisms that are in danger of extinction due to loss of habitat, over-exploitation, disease, predation, or lack of other protection. The Act requires the protection of both endangered or threatened species and the habitats upon which they depend. It requires an elaborate process to ensure that proposed actions would not jeopardize the continued existence of species such as the bald eagle. If City Light applies for a license from the Federal Energy Regulatory Commission to build Copper Creek Dam, the U.S. Fish and Wildlife Service, which has provided advice and consultation in City Light's studies to date, would provide a biological opinion on the significance of the dam to eagles. The U.S. Forest Service has similar powers in enforcing the preservation of the values for which the Skagit was designated a Recreational River, pursuant to the Wild and Scenic Rivers Act.

Part 2. Biological Environment

Section D. Fisheries and Aquatic Biology

INTRODUCTION

The River

The Skagit River is similar to most other river systems flowing into Puget Sound from watersheds along the western slopes of the Cascade Mountains. But it differs in several respects:

- It contains waters of exceptionally high quality.
- It supports Puget Sound's largest natural salmon spawning runs. All five species of Pacific Salmon, along with steelhead trout, spawn in the river and its tributaries.
- Its flows are controlled by human action.

Current operation of City Light's three existing hydroelectric dams causes daily variations of about a foot in downstream flows at and below Newhalem, and subsequent changes in the Skagit River water level. These flow fluctuations significantly influence aquatic plants and insects and the migratory and resident fishes that feed on them. City Light's plants, however, do not affect flows on the Skagit's major tributaries--the Cascade, the Sauk and the Baker.

Because of questions raised by fishery agencies with respect to the High Ross and Copper Creek Projects and the present mode of operation, and because of those agencies' and the Indian tribes' interest in improving the fishery, the Skagit system has been the subject of extensive biological study for the past several years. The following discussion highlights existing knowledge of the Skagit River ecosystem. More detailed information appears in the Aquatic Biology and Fisheries Support Document.

General Background

Waters of the Skagit River basin downstream from Newhalem provide spawning and rearing habitat for all five species of Pacific Salmon, steelhead trout and several resident fish species. The mainstream Skagit supports stocks of summer-fall chinook, pink (commonly odd years only) and chum salmon, as well as steelhead trout. These fish also use tributary spawning grounds, such as the Cascade, the Sauk, the Baker, and many of the minor tributaries.

Once at the spawning grounds, the female deposits her eggs in nests (redds) she digs in the stream bottom gravels. Eggs are fertilized by the male and covered by the female as she excavates another egg pocket immediately upstream. This process continues until the female is spent and the redd is complete.

Fertilized salmon and trout eggs develop within the gravel, with the developing embryo receiving nourishment from the egg yolk. About midway through the incubation period, the eggs hatch and the young fish (termed alevins) continue to absorb nutrients from their protruding yolk sacs, while remaining within the gravel substrate. The yolk sac gradually recedes until it is completely absorbed. At this point, the juvenile fish (now termed fry) become dependent on external food sources and begin to emerge from their redd sites. The rate and length of development depend on water temperature and vary from species to species.

Upon emergence, chinook and coho salmon and steelhead trout fry seek quieter water along the banks of larger streams, such as the Skagit and Sauk rivers, and forage along shallow gravel bars and pool areas. Pink and chum salmon fry tend to move seaward immediately following emergence. Both feed to a small extent during their relatively short, freshwater residence. Juvenile summer-fall chinook generally develop for about three months in freshwater prior to their seaward movement. Juvenile coho migrate seaward in the spring of their second year, while young steelhead trout probably develop for two years in freshwater before going to sea.

FOOD WEB

Periphyton

The river ecosystem supports many levels of life that are connected by the energy cycle, or food web. The small plants (periphyton) that grow on the rocks and gravel of the river bottom provide food for insects and other invertebrates, which in turn supply food for fish. Two physical factors limit periphyton growth in the Skagit:

1) Scouring

- High water velocities in midchannel can prevent periphyton from becoming established or can wash it away. (Upstream dams do limit water velocity during certain times of the year, as compared to natural conditions).

2) Drying out (desiccation)

- Although periphyton can withstand some exposure to air, if the river level drops too quickly for too long, growth is inhibited.

Studies comparing periphyton in the Skagit to that in nearby undammed rivers (Graybill, et al., 1979) show that periphyton is not as abundant in the Skagit, with its daily fluctuations, as it is in other rivers that fluctuate from natural causes only.

Rooted plants

Cattails, rushes, sedges, grasses, varonica, and water parsley grow along the river margins and on many gravel bars. Besides helping to physically stabilize these areas, decomposing plants contribute nutrients to other parts of the river ecosystem.

Aquatic Insects

Aquatic insects provide food for resident fish and for juvenile salmon and steelhead trout. Insect numbers, too, are affected by water velocity and by water level fluctuations. High flows can wash insects away; daily flow variations (much more frequent and abrupt than natural seasonal fluctuations) can leave them stranded.

Presently, the aquatic insect community in the Skagit during years of very little flow fluctuation is similar in abundance and species composition to that in nearby rivers. Key insect species are mayflies, midges, caddisflies, and stoneflies.

However, studies by FRI found that insect production during years of daily fluctuation (such as 1976) was less than one-third of that during a year of nearly steady flow.

Plankton (floating plants and animals)

Plankton is usually more abundant in still or slow water than in mid-river. Most of the plankton in the Skagit comes from upstream reservoirs, especially Ross. The organisms include several microscopic, shrimp-like crustaceans, such as copepods and cladocerans.

Young salmon fry will feed on these crustaceans when they are available. Chinook fry feed on plankton more extensively than do other salmon species. For pinks, chums, cohos, and steelhead trout fry, these crustaceans are an occasional, but not important, source of food.

Salmon Fry Diet

Salmon and steelhead fry eat aquatic insects, such as immature flies, midges, mayflies, stoneflies and caddisflies, as well as plankton. Differences in insect use occur between fish species and from year to year. For example, during the summer of 1977 the river fluctuated little, and insect production was higher than in 1976, when flows varied considerably. In 1977, chinook, coho, and steelhead fry were distinctly bigger and in better condition (a ratio of weight to length) than were fry sampled in 1976. However, rough estimates of food availability indicate that even during years of smoother flow, there may be no significant excess of food for salmon (chinook) fry. In years when flows fluctuate, the lack of adequate food supplies may limit fry growth.

EFFECTS OF PRESENT AND FUTURE FLOWS (WITHOUT COPPER CREEK DAM)

Skagit River aquatic plants, and the insects that eat them, are sensitive to the rise and fall of the river's water level. Fish feed on these insects; so, flow fluctuation can exert an indirect influence on fish by its impact on food supplies. The degree of overall impact of this factor on returning adult salmonids is, however, unknown.

The present flow regime diminishes the stream area potentially available for algae growth by creating daily flow fluctuations that reduce the width of the zone in which periphyton grow. Repeated exposure during low flows prevents periphyton from growing near river margins and limits it to permanently submerged areas or those exposed to infrequent drying for short periods. Flow fluctuations also adversely affect aquatic insects by drying out the stream bed, reducing food supplies (e.g., periphyton), and by altering conditions in the submerged portions of the river. As river levels fall, aquatic insects not able to move or drift rapidly enough toward deeper water remain stranded and die from drying out or freezing. Even aquatic insects in deeper areas that never dry out can be affected if water velocities exceed their tolerance range or high flows cause substrate shifting or scouring.

On the other hand, if the more stable flow pattern now called for under the draft Skagit Interim Flow Agreement is used in the future, insect production could be greater than it has been during recent years. The stream bed would not be allowed to dry out as much or as often as during periods of high fluctuations, and more insects would survive to provide fish food.

In brief, then, during periods of more stable flows, both periphyton and aquatic insect numbers per unit area increase significantly, indicating that flow stability is directly correlated with greater insect production. Salmon and other fish production, in turn, is directly correlated with levels of insects that serve as food supply for the fish.

IMPACTS OF COPPER CREEK DAM ON FOOD WEB

In general, under the proposed Copper Creek reregulation operations plan, the aquatic food web could be improved in the river below the dam site that was previously affected by daily flow fluctuations. The magnitude of this effect is uncertain. Any gains would be offset, in large part, by the loss of benthic production above the Copper Creek Project.

FRY LIFE STAGE

Power generation at Gorge Powerhouse produces fluctuations in downstream river flow that, under certain conditions, can strand salmon fry and kill them. Stranding has caused major losses of chinook salmon fry. Pink, chum, and coho salmon and steelhead trout have been less affected by stranding.

One estimate states that stranding could lead to losses of up to 41 percent for summer-fall chinook, with a range of 32-50 percent (CH_2M Hill, 1979).

The evidence from past years, however, doesn't support the concept that more stranding produces fewer returning adult fish (Hoopes, D. T. and S. A. Edson, 1980. R. L. Burgner, pers. comm., July, 1980). It's likely that during years when stranding is frequent, those fish that survive have less competition for food. Thus, they develop as well as fish that emerge during years when river flows are more stable.

IMPACTS OF COPPER CREEK DAM ON FRY LIFE STAGE

Fry mortality studies have been made to determine what effects the Copper Creek Project might have if it were operated as a reregulating dam to stabilize river fluctuations. These studies show that stranding could be reduced under reregulation. However, stranding is likely to be reduced significantly with the improved flow regime anticipated from the Skagit Interim Flow Agreement.

SALMON AND STEELHEAD HABITAT

Spawning Areas

Particular efforts have been devoted to determining how many salmon spawn above the Copper Creek dam site. Uncertainties as to distribution and use still remain, although a variety of survey techniques (such as helicopter visual surveys and photo interpretation) have been used. Of those fish that ascend the mainstem Skagit to spawn, an estimated 14.3 percent of the summer-fall chinook, 3.0 percent of the coho, 11.0 percent of the chum, and 30.0 percent of the pink salmon, as well as 2.8 percent of the steelhead trout, spawn upstream from the Copper Creek Dam site (Graybill, et al., 1979). The estimates presented here reflect known river fluctuations and species preferences for water depths and velocities. Although there is unused spawning habitat below the dam site, it is not certain how many of the former upstream spawners could or would use these lower areas instead or how successful they would be if they did use them.

Tributary Streams and Ponds

Salmon and steelhead trout spawn in several streams entering the Skagit River upstream from the proposed dam site (Egan, 1978; Graybill, et al., 1979). These tributaries are accessible to spawning salmon for various distances which total 8.8 miles. In addition, one group of ponds created by construction activities is available for spawning salmon. Downstream from Newhalem, the County Line Ponds provide a diverse population of insects and other aquatic life. The major ponds directly connect to the main river and maintain a population of coho salmon. The most important function the ponds might serve is to provide shelter from river fluctuations and adverse winter conditions for juvenile fish who may move into ponds from the river.

IMPACT OF COPPER CREEK DAM ON SALMON AND STEELHEAD HABITAT

The above-described habitat would be lost with the construction of the Copper Creek Project. The spawning area lost with Damnation Creek would be about 80-90 percent of that lost with the preferred dam configuration.

EXPLANATION OF FISHERIES LOSSES DUE TO COPPER CREEK DAM

Cost figures for losses due to Copper Creek are based on losses of spawning habitat, escapement records and projected escapement goals. All figures are only approximate because of the following factors:

- The reregulation benefits of Copper Creek. Smoother flows from Copper Creek could improve food production for salmonids downstream from the Copper Creek Project. The extent of this improvement is unknown.

- The possibility that spawners could utilize downstream spawning habitat more intensively if Copper Creek were constructed than is now the case. It is not known if this is possible or not. If it were possible, calculated losses would be lower. The net effect of this factor and the one listed above on the loss of spawning grounds is not known.

- The reproductive success of fish stocks spawning above the dam site may vary from that of stocks using areas below the site for spawning. If overall reproductive success is higher above the dam site, then recruitment to the total population may be higher and, similarly, impacts of the proposed Copper Creek Project might be more serious.

- Fisheries losses based on attainment of full state escapement goals should be qualified by the realization that, while these goals appear realistic and have already been met or exceeded during recent years for some species, their consistent attainment may be prevented or delayed in practice as a result of institutional constraints outside the scope of this proposal. If this is true, the projected losses from Copper Creek will be less.

- Even setting aside the uncertainties in the above factors, the loss values in the calculation (e.g., dollar worth of a pound of fish) vary enough that the presented values should be considered accurate to within only ± 50 percent. That is, if all factors cited previously combined to reduce salmon stocks, losses might exceed estimates by 50 percent. Conversely, if all factors operated in concert to reduce losses, accompanying reductions in value might be as much as 50 percent less than current estimates.

- It is not known to what extent armoring (loss of fine substrate suitable for spawning) would take place below the proposed project. (We expect some armoring to take place, however, the effects of which are explained in the Hydrology Section.)

NOTE: Changes in salmon production are not necessarily directly correlated with changes in resource value because of the differences in value between species. That is, an increase or decrease in number of pink salmon would have less impact on the value of the fishery than would a like increase or decrease of chinook salmon because chinooks have a higher unit value.

COMMERCIAL FISHERY

The Skagit River system supports a commercial fishery that comprised six percent of the entire North Puget Sound catch in pounds landed during 1979. The Treaty Tribes harvest about 70 percent of the salmon taken in the Skagit Bay and Skagit River terminal fisheries. The total annual commercial Skagit harvest (Indian and non-Indian combined) has averaged $600,000 in ex-vessel value since 1971 (ex-vessel value is price paid to the fishermen). This figure represents a minimum commercial value since the number of fish bound for the Skagit system that is intercepted and harvested elsewhere is not known.

The Washington Department of Fisheries (WDF) has developed a long-range plan to manage and enhance Puget Sound salmon stocks, including runs on the Skagit (WDF, 1979). The department has set escapement goals that, if reached every year, would increase average numbers of salmon returning to the Skagit. In even years, escapement goals call for a total of 123,000 fish (of all species) on the Skagit, an increase of 58 percent over the current average even year escapement (Hoopes and Edson, 1980). Likewise, in odd years the goals call for 405,000 returning fish, an increase of 31 percent over current average odd year levels (based on WDF estimated escapements, 1965-79). The odd year goal has been attained only once in recent years, in 1979. The total even year goal has yet to be reached, although goals for individual species have been met more frequently.

Impact on Commercial Fishery

The Copper Creek Project would remove 10.2 miles from the mainstem river and an additional 8.8 miles of tributary streams accessible to anadromous fish now containing habitat available for spawning and rearing. THe estimated impact of this removal would be to reduce the commercial harvest by some factor based on the reduction in spawning distribution. Our best measure of this effect results in an estimated loss of about $100,000 annually, given no change in current average production of salmon in the Skagit system. Should WDF escapement goals for the Skagit be fully realized on a sustained basis, catches could be increased substantially and potential losses would be greater--on the order of $600,000 per year.* These losses include the Treaty Tribes commercial fisheries,and the derivation of these losses appears in Tables 5 and 6 of the support document (Hoopes and Edson, 1980).

SPORT FISHERY

The Skagit River ranked second among the ten most fished streams for steelhead trout in a recent survey of Washington anglers. During the 1978-79 season, anglers on the Skagit spent almost 150,000 fishing hours to catch a little over 4,000 winter steelhead. In other words, it took the average angler more than three and a half days to catch a fish.

No records are available to assess the amount of fishing in areas above the proposed dam site. Casual counts, however, indicate angler use is relatively low above Copper Creek, in comparison to downstream areas. Fishing was highest near Steelhead Park in Rockport.

Impact on Sport Fishery

The freshwater sport fishery for chinook and coho salmon could be reduced in proportion to the loss of spawning areas, just as in the commercial fishery. The estimated loss, based on values placed on a day's fishing by the Washington Department of Game (WDG) and the National Marine Fisheries Service (NMFS), would range from about $10,000 to $16,000 annually under present escapement levels. The entire Skagit River freshwater sport fishery in the Copper Creek reach for steelhead and salmon (coho and chinook) represent an estimated annual loss of $20,000 to $50,000, based on current escapement and management conditions.* This figure represents an estimated minimal value since there is no way to include possible additional losses to the Puget Sound and ocean sport fishery as a result of additional reductions in Skagit River stocks.

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* See page III-69 for explanation of fisheries loss values. The sport fishery figures could be further reduced if the loss of fishing days was not proportional to the loss of sport fish or markedly increased if the saltwater catch of fish destined for the Skagit system was known.

Unlike for salmon, an optimum escapement goal has not been set for steelhead trout by the WDG. Therefore, the 1963-64 season has been used as a baseline to represent the highest potential production on the river. Should steelhead escapements and production be returned to these former levels through careful management, catches could increase and losses attributed to the project would also become larger. These losses are estimated at between $70,000 and $100,000 for the steelhead fishery alone.*

In addition, those who fish for steelhead would lose some nineteen miles of free-flowing river now available for sport fishing. This reach contains a large part of the Skagit River that is most accessible and best suited to bank fishing. A large portion of Skagit River downstream can only be effectively fished or reached by boat; therefore, the quality of stream and access for recreation this reach offers is a valuable and irreplaceable resource.

AMERICAN INDIAN FISHERY

Throughout their history, Pacific Northwest Indians have been closely linked to salmon, steelhead and other marine life. Salmonids not only provide food for the Indians, but they also occupy a central role in Indian culture, religion, and way of life. Since the coming of Whites to the region, Indians have frequently been deprived, by law and force, of their rights to take salmon and steelhead. Recent court decisions, however, have reaffirmed the Indians' rights to fish in their "usual and accustomed grounds and stations." The recent court decision in United States v. Washington, Phase II, also describes Treaty Indian interest in fishery habitat protection and water rights. This decision further affirms Native American rights, not only regarding fish but for the management of their environment as well.

Members of the Skagit River Tribes and Tulalip Tribes who fish take salmon and steelhead for commercial, subsistence, and ceremonial purposes. Records of subsistence and commercial fishing by Skagit tribes are unavailable or incomplete, but the latest information indicates that commercial fishing contributes substantially to the economic well-being of the tribes. In fact, some American Indians view the Skagit as the cultural and economic base of the three Skagit system tribes. The goal of the Upper Skagit Tribe is to build the spring chinook run so, when

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*See III-69 for full explanation of fisheries loss values.

exploited in conjunction with other salmon runs, the entire fishing season lasts longer and provides a broader economic base.

Fish runs in the Skagit have other intangible values to Indians that would be affected if the fishery were reduced or modified by building Copper Creek Dam. These values were expressed during a meeting with members of the Copper Creek team and American Indians on April 22 and 23, 1980. The following statement is in the words of a tribal leader:

> "We can't afford to lose even one fish." Andy Fernando, Asst. Director, Skagit System Cooperative; Vice Chairman, Upper Skagit Tribal Council.

Impacts of Copper Creek Dam on Native American Fishery

Copper Creek Dam would affect Indian fisheries economically and culturally. The nine Point Elliot Treaty tribes fish for all five species of salmon and steelhead trout found in the Puget Sound region. Indian fisheries account for about 70 percent of the commercial harvest from the Skagit Catch Area. The Copper Creek Project would impact the fishery economically by reducing salmon production through elimination of some spawning grounds. At present levels of production, this loss would amount to about $70,000 annually. If, through tribal and/or state management, levels of fish production are increased to meet optimum escapement goals, then potential yearly losses could total $400,000.*

OTHER FISHES

During 1977 and 1978, FRI conducted a survey to determine what species of fish, other than salmon and steelhead trout, reside in the mainstem Skagit River between Newhalem and Rockport (Graybill, et al., 1979). Fish found to live in this reach included mountain whitefish (Prosopium williamsoni), large-scale suckers (Catostomu macrocheilus), three-spine stickleback (Gasteroteus aculeatus), sculpins (Cottins sp.), Longnose dace (Rhinichthys), brook lamprey (Lampetra richardsoni), and brook trout (Salvelinus fontinalis). Anadromous or resident species included Dolly Varden char (Salvelinus malma) and resident rainbow trout (Salmo gairdneri). A

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* (See page III-69 for explanation of fisheries loss values.) Also affected would be the intangible values mentioned above.

suspected resident, the cutthroat trout (Salmo clarki), was not found in either mainstem or tributary waters sampled within the study area. No rare, endangered, or threatened fish species have been identified in the Skagit River system.

Mountain whitefish were the most abundant species found, comprising about 89 percent of the total catch during the two-year study. Large-scale suckers, Dolly Varden char, and rainbow/steelhead trout constituted six, three, and two percent of the catch, respectively.

Impacts on Other Fishes

The fish mentioned above that reside in the Copper Creek stretch would be replaced by the reservoir fishery which would likely be similar to the resident lake fishery in the upstream reservoirs.

MITIGATION

Regardless of benefits that may result from more stable flows on the Skagit River, some ten miles of river containing spawning habitat will be lost as a result of the project. This loss may be mitigated, in part by more stable flows throughout the remainder of the river. Also, it may be possible to mitigate spawning area loss in any one of several ways. The most feasible approach would be artificial or artificially-induced propagation. Spawning channels may be the most acceptable alternative biologically, because they provide the most natural spawning and rearing conditions and directly replace lost spawning ground. Using an earlier estimate (CH_2M Hill, 1979) of about 8,000 feet of channel 36 feet wide and a construction cost estimate of $375 per foot, capital costs for a spawning channel would be about $3 million, not including land acquisition. A hatchery facility sufficient in size to replace the number of spawners estimated to be lost based on the full escapement figures could be constructed for $640,000 and operated for about $150,000 per year. Replacing salmon production with artificially reared fish presents no great technical problem, provided a suitable propagation site can be found and adequate donor stock are available. Other considerations, however, may influence this type of mitigation.

Each river system, like the Skagit, supports a number of salmon stocks. A stock is comprised of a group of salmon that share a common environment and gene pool. One river system may support several stocks and a run of salmon can include many stocks that migrate through an area open to commercial fishing.

The ability of salmon to return to their streams of birth to spawn is well documented. This homing instinct results in genetic adaptation to the specific environment encountered by each stock. Thus different stocks display numerous variations in behavior, morphology and ecological requirements. A salmon's size and age at maturity, spawning time, and migratory behavior have been shown to be under strong genetic control. These and many other heritable traits are adaptive to the particular environmental experience of each stock. Thus, each stock is genetically unique,and any reduction in spawning opportunity may result in a like diminution in genetic variability.

Attempts to enhance existing salmon stocks by transplanting eggs, juveniles or adults from one area to another is hazardous at best and should be avoided until critical evaluations can be made to establish the necessary requirements. Much genetic variability is essential in the gene pool of wild salmon stocks, since it enables stocks to adapt to extremes or changes in the environment. A high degree of adaptive genetic variability would also be desirable in a hatchery stock. Even when the donor stock is obtained locally, however, some common hatchery practices tend to reduce variability and could change the genetic composition of a stock. Selection and inbreeding, for example, reduce genetic variability. If, as commonly happens, hatchery incubators are filled with eggs from only a small segment of the run, genetic variability will be reduced. If hatcheries are filled with eggs from the early portion of a run, there will be strong selection pressure for early-run fish.

Selection for large size is also frequently practiced by hatchery operators. Such selection may be intentional or unintentional. Given a choice, a hatchery operator will usually choose the larger, plumper fish for spawning, because they look like better brood stock. It should be pointed out, however, that one gene affects more than one characteristic. Therefore, when one selects for size, one is also selecting for other, usually unknown, characteristics.

A second major consideration centers around the often disproportionate mixture of hatchery and wild fish returning through the commercial fishery. When natural and hatchery-produced salmon stocks of varying strengths are harvested while mixed (as is the case in the Skagit Bay fishery), one of two conditions prevails. Either natural stocks are overfished, or some of the effort put toward developing hatchery stocks goes wasted. Hatchery stocks have the advantage of being incubated and reared by humans. Thus, more of them survive than do their naturally reared cousins. By virtue of sheer numbers and strength, they can sustain more fishery exploitation than can natural stocks. Consequently, full harvest of hatchery fish will almost always entail some adverse impact on the numbers of naturally reared fish that migrate in common with the hatchery fish.

Artificial spawning channels are considered a biologically preferred means of increasing runs of wild salmon and trout stocks. In a spawning channel where natural mating occurs, the potential for unintentional genetic change is less than in a hatchery where matings are controlled by humans. Generally, the use of spawning channels in the lower 48 states has not been successful in rehabilitating natural salmon stocks. Canadian spawning channels, however, have shown promise for enhancement of chum, pink, and sockeye salmon runs. The selection of a best method of mitigating potential fishery losses will require cooperative effort between the city and appropriate state, federal and Indian agencies.

UNAVOIDABLE ADVERSE IMPACTS

About ten miles of the Skagit River which supports a diverse fishery would be permanently lost. An additional 8.8 miles of tributary streams presently available to anadromous fish would be, for all practical purposes, eliminated from anadromous fish use. The greatest unavoidable adverse impact on fisheries would be genetic if a hatchery were employed. A high degree of adaptive genetic variability within hatchery stocks is desirable, but often not achievable. Mitigation by hatchery production tends to reduce genetic variability within a stock. This problem may be reduced if spawning channels are utilized and fish are permitted to spawn at random, although the opportunity for significant genetic selection still remains.

Part 3. Human Environment

Section A. Local Communities

EXISTING CONDITIONS

Construction of a dam at Copper Creek or Damnation Creek would have an effect on the people living in the surrounding region, on their economy and unemployment rates, housing, public services and transportation--the human environment.

City Light determined that the area which could be affected is as shown in Figure 18. The affected communities are all in Skagit County, except for the City Light-owned towns of Diablo and Newhalem, which are in Whatcom County.

Local Population and Economy

These Skagit Valley communities and the surounding rural population are linked by a common historic, and continuing, economic dependence on the region's abundant natural resources: on the Skagit River system and its fish, on forestry, agriculture and mining, even on the scenery which attracts tourists every summer.

The Skagit River has special cultural, economic and legal significance to American Indians in the region. Three tribes--the Swinomish, Upper Skagit and Sauk-Suiattle--have legal rights according to the Treaty of Point Elliot to fish at their "usual and accustomed fishing grounds" on the Skagit River system. In addition, the tribes have the right to protect the quantity, quality and potential of the Skagit stock. These rights have been affirmed by Phases I and II of United States v. Washington (1974 Boldt Decision and 1980 Orrick Decision).

Treaty fishing is essential to the livelihood of the three tribes. Many tribal family cooperatives purchase fishing gear together and share labor and fishing income. Because of the capital costs of purchasing and maintaining gear and high unemployment during the off-season, income levels tend to be low for tribal members who fish (Boome, L., pers. comm., April 1980; Fish, J., pers. comm., June 1980). Tribal fishing is not limited to commercial sales. All enrolled tribal members are entitled to subsistence fish, which provide an important source of protein in their diets. (No count is made of the number of fish caught for subsistence purposes.)

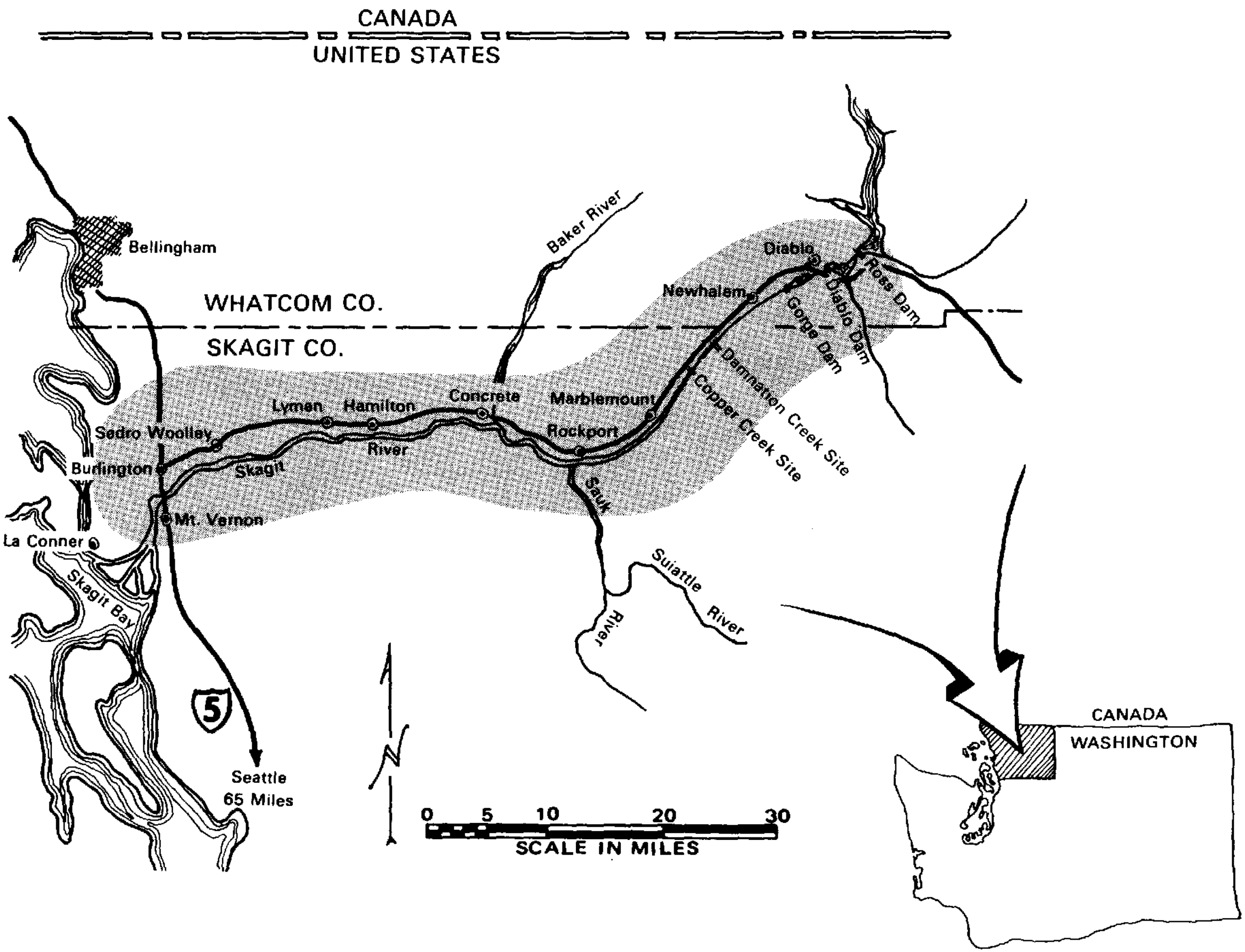

Figure 18. Study Area Communities

The Swinomish, Upper Skagit and Sauk-Suiattle Tribes are federally recognized governments under provisions of the Indian Reorganization Act of 1934 (Boome, L., pers. comm., November 1980). Elected tribal chairpersons and councils are responsible for decision-making as well as providing direct services to and protecting the interests of enrolled members regardless of where they live. Services provided by the tribes include health clinics, housing assistance, counseling and education/enrichment programs; funding for these services comes from a 3 to 4-percent tax levied on the gross treaty fishing income of licensed fishers as well as federal and state support (Boome, L., pers. comm., November 1980).

The Skagit System Cooperative, a fisheries agency organized by the three tribes for more efficient management of the shared fisheries resource, is responsible for fisheries harvest management and enhancement; it enforces fishing regulations, administers federal fish management funds allocated to the tribes under Phase I of U.S. v. Washington and maintains a tribal court system for adjudicating violations of tribal fishery regulations by tribal members. The Cooperative also conducts public information and environmental protection activities. Representatives from the three tribes oversee the activities of the Cooperative Administrative Director and staff.

The cultural significance of fishing in the Skagit River to the tribes is incalculable; it is the cohesive element binding many enrolled members to their tribes, traditional ceremonies and social functions. Prior to the Boldt decision, when the tribes were discouraged or prohibited from fishing in their usual and accustomed fishing grounds, members left their ancestral homes; since the restoration of their fishing rights, many are returning.

Fish runs on the Skagit have other intangible values to Indians that would be impacted by building Copper Creek Dam. These values were expressed during a meeting with members of the Copper Creek EIS study team and American Indians on April 22 and 23, 1980. The following statements are in the words of tribal leaders:

> "The only time I come to life is when I am along the river." Robert Joe, Chairman, Swinomish Tribal Senate

> "My spirits pick up when I am along the river." Lawrence Boome, Sr., Chairman, Upper Skagit Tribal Council

The three tribes oppose any projects which could adversely affect existing natural runs. According to one tribal member, the loss of the natural fish cannot be mitigated, and if they were destroyed, the Skagit River would lose all value (Fernando, A., pers. comm., April 1980).

The Tulalip Tribes also have legal rights guaranteed by the Treaty of Point Elliott to harvest a portion of Skagit salmon stocks and are thus committed to protecting and enhancing the remaining natural runs.

Because much of the economy in the Skagit Valley is tied to harvesting, processing and distributing natural resources, especially lumber and food products, employment tends to be highly seasonal in nature. In 1979, unemployment rates for local residents ranged from a high of 15.8 percent in February to a low of 7.2 percent in August (Employment Security Department, 1980).

The major employment sectors in Skagit County are outlined in Table 11. A pertinent aspect of the Skagit Valley economy is the presence in the county of a large number of construction workers (Raymond, et al., pers. comm., July 1980). Table 12 shows the current numbers of construction workers in trades that would be needed for the dam construction.

The service, retail and wholesale trades, which only recently became the largest employment sector in Skagit County, are concentrated in Mount Vernon, where the area's most rapid population increase is taking place. In addition to the growth caused by newcomers moving into the county, the population within the Skagit Valley is shifting. The smaller communities located up the Skagit Valley have a stable or declining population. Young residents are moving to the Mount Vernon area, leaving the upper valley towns, especially Lyman and Hamilton, with a relatively older population. Fifty percent of those towns' populations are over age 50 (Parker, L. and King, M., pers. comm., April 1980); the county-wide figure is 30 percent (Office of Financial Management, 1980). Overall, the growth rate in the county is slowing, but population increases are predicted to continue especially in the areas near Interstate 5. Tables 13 and 14 show present populations and future projections for selected cities.

Housing and Community Services

Housing vacancy rates are generally low across the county (3.6 percent for 1978 and 1979) (Lowe, T., pers. comm., April 1980) and are lowest in the upper valley towns,

TABLE 11. Skagit County Wages by Major Industry

Industry	Wages Paid in 1979 Dollars	% of Total Wages
Agriculture, forestry, and fishing	$ 11,108,579	4.3%
Mining	241,976	.09
Construction	22,862,392	9
Manufacturing	76,351,958	30
Transportation and public services	15,102,003	6
Wholesale trade	11,807,368	5
Retail trade	37,392,269	14
Finance, insurance, real estate	7,949,733	3
Services	23,220,669	9
Government	54,316,539	21
	$260,853,440	

Sources: Adjusted from 1978 statistics by the Consumer Price Index, U.S. Department of Labor, Bureau of Labor Statistics.

Washington State Employment Security Department, 1978, "Employment and Payrolls in Washington State by County and by Industry."

TABLE 12. Construction Workers Living in North Puget Sound Area Based on Union Rolls

Trades Necessary for Copper Creek	Maximum Number of Workers / Trade needed at any time	Active Union Members	Area Union Covers	Number of Workers Now Unemployed
Foreman	20			
Operating Engineers and oilers	48 22	12,000	Eastern WN. to Tacoma and AK	1,300 200 (in Skagit County)
Teamsters (heavy constr.)	34	70 (a)	Skagit Co. & part of Island Co.	50
Carpenters	32	150	Swinomish Channel to Whatcom & Snohomish County Lines	44
Laborers Concrete Powdermen Labor-drillers Loggers	40 34 8 24 8	250	Skagit County & Whidbey Island Can refer locally first	176
Plumbers & Pipe Fitters	14	400	Snohomish, Skagit San Juan & Island Counties	40
Electricians	22	802	King Co. line to Canada & Island County. Can hire locally first	25
		120	Skagit Area	5-10
Cement Masons	32	140	5 NW Counties	15 (in Skagit County)
Iron Workers	54	175	5 NW Counties	85
		125	from Skagit, Whatcom and Snohomish Counties	
City Light Estimated Total (c)	396			
Piledrivers & Millwrights (b)	8 4	600	Seattle to the Canadian border	50, many from Skagit & Snohomish County
Union Total (c)	404			

(a) Have limited membership because of high unemployment rates.
(b) Included in union job breakdown, based on Seattle City Light job descriptions.
(c) Total does not include survey crews, office staff, or City Light inspection survey personnel.

Source: Raymond et. al., Union Representatives, pers. comm., July, 1980; Robertson, W.D., Engineering, Seattle City Light pers. comm., June, 1980.

TABLE 13. Present and Projected Population Estimates for Selected Cities and Skagit County.

CITY	1975	1980	1985	1990	2000
Mt Vernon	10,000	13,600	17,900	21,600	28,100
Burlington	3,400	3,700	3,800	4,000	4,000
Sedro Woolley	5,200	5,700	6,900	7,600	9,000
Skagit County	54,000	62,300	71,300	79,300	93,400

Source: Skagit Regional Planning Council, 1980

TABLE 14. Current Population for Selected Incorporated Cities and Unincorporated Areas of Skagit and Whatcom Counties

Location	Population
Lyman	318 1/
Hamilton	260 1/
Concrete	600 1/
Rockport	125 2/
Marblemount	385 2/
Newhalem	105 3/
Diablo	55 3/
Unincorporated Areas (Skagit County)	27,397 1/

Sources:
1/ Office of Financial Management, 1979
2/ Hornbeck, C. (rough estimates), pers. comm., 1980
3/ Newby, W. (rough estimates), pers. comm., 1980

where floodplain ordinances (as in Hamilton), zoning restrictions, and inaccessibility to services restrict future development. The newly adopted County Comprehesive Plan (1980) encourages growth in cities where services and facilities are already available (Walberg, O., pers. comm., February, 1980). Tables 15 and 16 summarize the utilities and other community services in the potential impact area, with special reference to their capacity to meet present and future demands of the population.

Primary educational facilities are briefly analyzed in Table 17. Because of enrollment increases, budget constraints, and lack of building space, enrollment in some of the programs offered by Skagit Valley College is limited. The college offers both academic and vocational programs, including several technical majors in construction skills such as welding, diesel and heavy mechanics, automotive mechanics, and civil engineering technology. The college is interested in setting up programs to train employees for the Copper Creek project, if needed (Ford, J., pers. comm., March 1980).

Transportation

Skagit County is a primarily rural county where private vehicles are the major form of transportation. Considerable variation exists in the average daily traffic (ADT) volume on State Route 20 (North Cascades Highway), with volumes generally lower the further east one travels. Traffic on State Route 20 (SR 20) is also substantially higher during summer months because of tourist traffic and logging trucks.

There are presently several congested and high accident areas along the SR 20 corridor, including sections through Burlington, Sedro Woolley, Concrete and Marblemount (Dept. of Transportation, 1978). Traffic volumes have grown beyond planned roadway capacity on some portions of the highway and other local roads, and some sections of the highway are in poor condition. Because of budget constraints, many sections that require upgrading are not scheduled for work.

It is difficult to predict future traffic volume, because traffic along the SR 20 corridor in Skagit County actually decreased in 1979; 1980 figures are not yet available to determine if this trend continued (National Park Service, 1979; Dept. of Transportation, 1978, 1979, 1980).

TABLE 15. Utility Service in Impact Area

UTILITY	AREA SERVED	SERVICE CAPACITY
Gas:		
Cascade Natural Gas Corp.	Burlington, Mt Vernon, Sedro Woolley	Supplies and facilities availabe to extend services whenever there is sufficient demand
Electricity:		
Puget Sound Power & Light	All communities in Skagit County	Increase in demand beyond 6% would strain capacity of system, especially near Concrete
Seattle City Light	Newhalem and Diablo	Extension of service limited only by need to obtain and install additional transformers (about 8 months)
Telephone:		
General Telephone	Burlington, Mt Vernon & Sedro Woolley	New equipment to accommodate large increases in demand would require 18-30 months to obtain and install
Continental Telephone	Other areas in Skagit County	Same as above
Seattle Centrex Phone System	Newhalem and Diablo	New equipment would require 12-18 months to purchase and install
Waste:		
Sewage systems	Burlington, Concrete, Diablo, Mt Vernon, Newhalem, Sedro Woolley	Mt Vernon is approaching organic loading capacity and plans are underway to upgrade the system; Burlington has annexed more land than its system can handle. Others could serve a moderately larger population.
Septic Tanks	Remainder of impact area	Soil types and floodplain limit suitability of septic tanks in most of area
Solid Waste Disposal-Landfills	Burlington, Mt Vernon, Sedro Woolley, Concrete, Lyman, Hamilton, Rockport, Marblemount, Newhalem, Diablo	Skagit County is applying for permit to use the second unused half of the Inman Pit; 40-acre Sauk Pit serves up-river area. Alternatives to landfills being considered.
Coin operated depositories	Unincorporated areas of County	Six sites hold 30 cubic yards of waste each
Water:		
Skagit County Public Utility District #1	Burlington, Mt Vernon, Sedro Woolley and rural areas in county	County has standby wells not needed at present
Baker River Power, Light and Water Company	Concrete	Significant increase in population could strain severely the limited capacity of the system
Municipal water systems	Lyman, Hamilton, Rockport	There are present plans to upgrade Hamilton system, significant population increases could strain all three severely
City Light owned and operated water system	Newhalem and Diablo	

TABLE 16. Existing Community Services in Impact Area

SERVICE	COMMUNITIES	STATUS
Police:		
Municipal Departments	Burlington, Concrete, Mt Vernon Sedro Woolley	Sedro Woolley may be understaffed at present and will require new officers for projected population increases. Mt. Vernon will need new officers by 1985 to meet standard of 1.5 officers/1000 residents. Concrete may be losing two CETA officers by January 1981, reducing the department to two men.
Washington State Police	Skagit and Whatcom Counties	Understaffed in the upper Skagit Valley
Skagit County Sheriff	Unincorporated areas of Skagit Cty	Presently understaffed in upper Skagit Valley
Whatcom County Sheriff	Newhalem and Diablo	Adequate for present population
Fire:		
Municipal Departments	Skagit County incorporated towns, Newhalem and Diablo	Improvements to water system in Concrete needed for adequate fire protection; other fire hydrant systems adequate for projected population increase
(Volunteer) Fire Districts	Unincorporated areas of Skagit Cty	Availability of water is limited, tanker trucks must be used
Health Care:		
Hospitals	Mt Vernon, Sedro Woolley	Occupancy at both hospitals is high, bed increases may be necessary
Emergency Service	Skagit County Medic 1	Services capable of expanding, but there are problems with the emergency communication systems in the upper valley. Travel can be difficult in winter
Physicians and Dentists	Most in Mt Vernon, Burlington and Sedro Woolley	Have capacity to meet increased demand, may be access problems in upper valley
Employment & Welfare:		
Washington State Employment Security Department	Mount Vernon	
CETA Center	Burlington	Needs two new staff
Other employment agencies and union hiring halls	Mt Vernon, Sedro Woolley	
State Department of Social and Health Services	Mt Vernon	Applicants for services must travel to Mt Vernon
Municipal Libraries:	Concrete	
	Mt Vernon	Currently adding space
	Burlington	New library has room to expand
	Sedro Woolley	At capacity
Whatcom County Libraries:	Newhalem and Diablo	Open one day per week at each community
Public and Commercial Transportation:		
Greyhound, Evergreen Trailways		No service to upper valley, terminal site in Mt Vernon could handle other transit functions
Burlington Northern Railway	Rail line as far as Concrete	Current loading facilities at Concrete are inadequate; no passenger service

TABLE 17

Capacity of Primary and Secondary Schools in Impact Area

District	Capacity
Burlington Edison	There is additional space for 250-300; no expansion plans
Mt. Vernon	There is no additional capacity; bond issue for expansion to be submitted, Sept. 80
Sedro Woolley	Little ability to handle increased enrollment; there are preliminary plans for new facilities
Concrete	There is additional space for 90-150 at new elementary school; high school has space for 150-200 students. Newhalem Elementary contains space for approximately 80 students. However, current City Light plans call for conversion of the school to office space in 1981 (Sickler, W., pers. comm., September, 1980).

Sources: Erickson, L., 1979. Atwood, W., et. al, pers. comm., March - May, 1980.

Quality of Life

Communities in the upper Skagit offer a limited variety of indoor recreational and cultural opportunities. Leisure-time facilities include local libraries, swimming pools, taverns and theaters; residents tend to drive to Mt. Vernon for many entertainment and shopping needs. However, many people make up for the lack of commercial entertainment facilities by participating in local civic, school, and church organizations, as well as by taking advantage of the many outdoor recreation opportunities (described in the Recreation and Aesthetics Section).

Residents of the Skagit Valley value their rural way of life. Many families have lived in the valley for several generations, and newcomers move to the area to attain a slower-paced life-style that is not available in an urban setting. Members of the community know and watch out for each other, which allows for a personal and informal approach to local government and law enforcement. County zoning codes and regulations reflect the local desire to retain these rural qualities, and outsiders who propose changes in the area's status quo are often met with hostility.

Recently, residents effectively organized to prevent construction of Puget Sound Power and Light's proposed nuclear power plant near the towns of Lyman and Hamilton. Their opposition was based partly on the plant's perceived disruption to their way of life. Many people living in the valley have also expressed opposition to the proposed Copper Creek project, at workshops held by Seattle City Light and in responses to the environmental report, because they feel that the dam, like the proposed nuclear plant, would diminish the quality of their lives. Although they may recognize City Light's need to generate additional power, many do not want the natural resource of the river to be used by the City of Seattle with few benefits going to the local area. Losses of the fisheries and the free-flowing river would be financial, cultural and aesthetic in nature. Many residents perceive construction and operation of the dam as a threat to their safety and well-being.

Residents of Concrete do not value isolation and remoteness to the extent that the rest of the upper valley does. Newcomers from urban areas have become an active part of the community, which has created a more open and receptive atmosphere in the town. Many local citizens are also interested in increasing business and residential growth in a controlled manner (Ladd, S. pers. comm.; Evans, O. pers. comm. July 1980; Seattle City Light, 1979).

Concrete has experienced economic and social change in the past such as construction of lower and upper Baker Dam, creation of a national park and opening of the North Cascades Highway, and many local residents look forward to future development. They also value the rural characteristics of the valley, however, and want to preserve them.

Further information about the upper Skagit communities is contained in Technical Report 5 of the earlier Environmental Assessments (available from Seattle City Light, Office of Environmental Affairs).

IMPACTS AND MITIGATION - CONSTRUCTION WORK FORCE

Construction of a dam at Copper Creek or Damnation Creek would require the presence of a relatively large work force in the Skagit Valley. The presence of this work force would be responsible for most of the project's impacts on the local human environment. The Seattle City Light Engineering Division and CH_2M Hill, consultants to City Light, each made estimates of the crew size which would be needed. Figure 19 shows both projections over the estimated project schedule.

A peak work force estimate of 450 construction workers was determined by averaging the two crew size estimates shown in Figure 19. At this time, we don't know how many of these workers would be nonlocal,* nor do we know where the local workers would come from in the Skagit Valley. The possibilities range from all local workers to a work force entirely comprised of workers who would move to the Skagit Valley for the duration of their employment on the project. These possibilities will be discussed in the following pages.

Local Work Force

It would be highly desirable to hire local residents as much as possible, in order to minimize impacts resulting from a nonlocal work force and to give Skagit County residents an opportunity to derive some economic benefit during the construction phase. For example, on the Chief Joseph Project, where almost 60 percent of the work force was made up of local residents who were already established members of the community, no significant changes in community cohesiveness appeared (U.S. ACOE, 1978).

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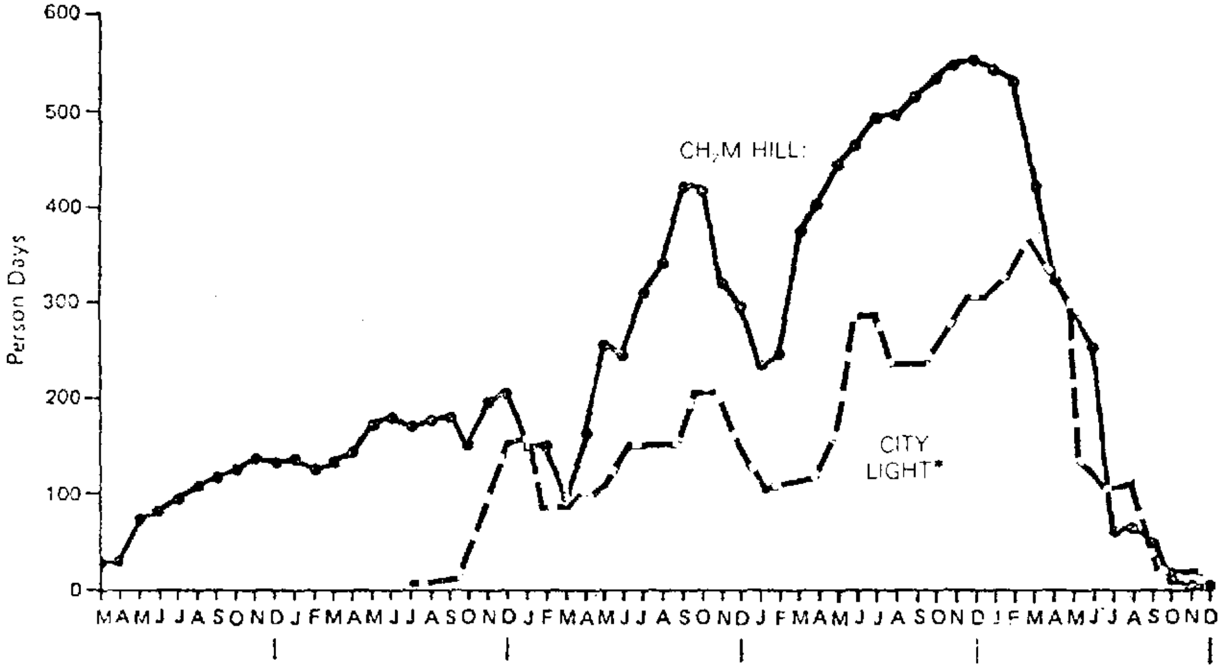
* Nonlocal is defined as a worker who moves in order to live closer to the work site (Mountain West Research, Inc., 1977).



*City Light estimate does not include workforce for highway or transmission line relocation

Figure 19. Dam Construction Labor Force Estimates

Preferential hiring could be arranged by Seattle City Light, construction contractors and local union representatives.

According to union representatives, there are enough local laborers with the appropriate skills for a project of this type (Raymond, et al., pers. comm. July 1980). The only legal constraint on local hiring, according to the Seattle Department of Human Rights (Standifer, R., pers. comm., July 1980), would be compliance with affirmative action regulations, since there are few women and minorities in the area with the type of skills needed for this project. However, Skagit Valley College has indicated an interest in cooperating with Seattle City Light to train employees for the Copper Creek Project. If members of minority groups and females could receive training for skilled work on the project, this could help fill affirmative action positions with local workers.

If most workers are hired locally, the main impact would be increased traffic on SR 20 caused by commuters travelling from their homes to the construction site. If most workers drive to the site with only 1.19 people per vehicle (Seattle Energy Office, 1980) a peak work force of 450 would add 378 cars to peak hour traffic flow; if the figure is 1.305 per car (Sachdev, 1977), traffic volume would increase by 345 vehicles. Increased commuter traffic could be mitigated by the use of park-and-ride lots with crew buses and van pools operating between the project site and population centers. Ride-matching services to facilitate car pools could also be provided. However, there still would be some increase in traffic congestion, noise, and accidents on the North Cascades Highway during the life of the project, especially in the summer season.

Nonlocal Work Force

Because the availability of local workers is uncertain, and because the size of the work force will fluctuate over the duration of the project, we cannot predict the exact number of nonlocal workers who may move to Skagit County. At worst, the entire estimated peak work force of 450 would relocate to the valley. Although this is unlikely, it would be possible if there were other construction projects (e.g., raising Ross Dam) going on in the area at the same time. For this reason, the following discussion assesses the impact of the worst case (450 nonlocal workers) and, for comparative purposes, a median case of 225 nonlocal workers.

Recent studies of the nonlocal construction force at similar projects show that many workers moving to the job site area are accompanied by dependents (Mountain West Research, Inc., 1977 and U.S. Army Corps of Engineers, 1978). Table 18 shows the percentages and estimated numbers of single and married nonlocal construction workers that could be expected for the two cases.

On the basis of these figures, Table 19 shows the estimated numbers of family members, school children and total nonlocal population which would move into the Skagit Valley under the worst case and median case.

The impacts of accommodating a nonlocal work force and their dependents would be significant in the small communities of rural Skagit County. Nonindustrialized, socially cohesive, rural areas--such as the Skagit Valley--are particularly vulnerable to this type of rapid population influx (University of Denver, 1978).

Provision of adequate housing has been the most difficult problem experienced by many communities (Mountain West Research, Inc., October 1977). Low income groups in particular would likely be impacted by rising costs of housing due to increased demand. In addition, Skagit County zoning regulations discourage the development of mobile home parks on the outskirts of towns--areas where they would otherwise most likely be located.

A nonlocal work force would also increase traffic volume along SR 20, adding to the congestion that already exists at key intersections throughout the corridor. (See the previous discussion of traffic impacts under Local Work Force.) The impact of these additional vehicles could be reduced by housing nonlocal workers closer to the project site, and by those mitigation measures already described. In addition to the impacts of vehicles commuting to and from the dam site, there would be a general traffic increase due to non-work-related trips by a nonlocal work force and their families. The amount of extra driving would depend on location and types of households. Persons living in single-family residences outside a city travel approximately 15,100 miles per year per household, while those in multiple-family housing drive about 12,080 miles annually* (U.S. Dept. of Energy, Region X, February 1979).

Besides increases in traffic, there generally are significant increases in vandalism, theft, family disturbances, and alcohol-related incidents. Local law enforcement

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* These figures include work-related trips.

TABLE 18. Percentages & Estimated Numbers of Single and Married Non-local Workers (a)

	Worst Case 450 Non-local Workers		Median Case 225 Non-local Workers
	percent (b)	number	number
Workers not married	14.0	63	31
Workers married without dependents	30.0	135	68
Workers married with dependents	56.0	252	126
TOTAL	100.0	450	225

(a) Percentages used derived from ACOE, "Chief Joseph Dam: Community Impact Report Update III: Conditions at Peak Impact, 1978."
(b) Based on 89% response rate regarding marital status and number of children under 18.

TABLE 19. Estimates of Non-local Work Force and Dependents

Non-local Work Force Size	Married Workers with Family Members present (a)	Total Estimate of Married Workers with Dependents Present (b)	Range of Children Present (age 6-18) (c)	Total Est. of Single & Married Workers & Dependents Present
450	232	754	210 to 290	972
225	116	377	105 to 145	486

(a) Based on total percentage of married nonlocal workers. 60% of all married nonlocal workers brought families with them.
(b) Based on average family size of 3.25, U.S. ACOE, 1978.
(c) Based on City Light calculations and ACOE (1978) ratio of 90 students per 100 workers.

personnel generally handle most problems on an informal and selective basis and are not used to dealing with such a diversity of offenses. Although sufficient numbers of trained professional officers and a policy of nonselective law enforcement would minimize the problems, increased offenses could be expected throughout the construction project.

On some projects similar to Copper Creek, children of construction workers produced the most severe impacts on local services and facilities (U.S. ACOE, 1978). Yet workers moving into an area generally contribute less financial support to schools than local residential home owners, because the majority rent or live in mobile homes (which have lower assessed valuations). Therefore, it is important to prevent situations where additional school district expenses related to a construction work force are paid by long-term property owners in the community.

Tables 20 and 21 describe, respectively, the impacts of and possible mitigation measures for accommodating a nonlocal work force in the eight communities located closest to the proposed dam site.

Construction work camp. The constraints outlined in Table 20, especially the lack of housing and trailer space in the upper valley, would prohibit a concentration of nonlocal workers and their families in any one community. Given these constraints, the majority would probably have to live in Mount Vernon or Sedro Woolley and commute to work, with the remainder distributed throughout the valley where possible. However, according to an Army Corps of Engineers study (1978), nonlocal workers generally prefer to live as close to the project site as possible in order to reduce commuting distances. For these reasons, and because the impacts and mitigation measures could be concentrated in one area, a temporary construction work camp would be desirable from a planning perspective. It would also mitigate impacts on low- and fixed-income residents by reducing demand on housing stock in the upper valley.

A work camp housing some or all of the nonlocal work force could be a self-contained unit with necessary amenities, including a sewage treatment plant, laundry and recreation facilities. A preliminary examination was conducted to see if any areas were available for such a camp, and three potential sites emerged: Sedro Woolley and vicinity, Concrete, and Newhalem. It would be premature to assume that any one of these communities has been selected based on preliminary examinations; additional investigation would be required to identify the optimum site or sites if

TABLE 20. Constraints of Accomodating a Non-Local Work Force

	SEDRO WOOLLEY	LYMAN	HAMILTON	CONCRETE
Utilities	18-30 months lead time for increased telephone service. Electricity supply would be inadequate.	Major phone design changes would be needed; 18-30 mos. lead time. No sewage system. Water supply would be inadequate. Electricity supply would be inadequate.	Major phone design changes would be needed; 18-30 mos. lead time. No sewage system. Water supply would be inadequate and unsafe. Electricity supply would be inadequate.	Major phone design changes would be needed; 18-30 mos. lead time. Sewage collection system would not be adequate. Water delivery system would not be adequate. Electricity supply would be very inadequate.
Housing	Very low vacancy rate; vacant land available for about 100 single family units or work camp in vicinity of town.	Very low vacancy rate; city on floodplain; little construction occurring; residentially-zoned lots are in unincorporated area.	Very low vacancy rate; no construction permitted in floodway; residentially-zoned lots in unincorporated area outside town.	Very low vacancy rate; vacant lots exist for construction but are owned by Lone Star.
Police	Number of officers would be be inadequate; no detention facility; must transport prisoners.	No local department; served by one County Sheriff's officer; State Patrol is understaffed in area.	No local department; served by one County Sherrif's officer; State Patrol understaffed in area.	Department personnel would be inadequate (may be losing two officers); no detention facility; must transport prisoners.
Fire Protection	Equipment might be inadequate depending upon size of non-local work force.	No fire hydrants; must rely on tanker trucks; equipment may be inadequate.	Inadequate water supply system; no fire hydrants; must rely on tanker trucks; equipment may be inadequate.	Inadequate water distribution system; equipment may be inadequate.
Health Care	Hospital has high occupancy rates.	No medical personnel; must travel for medical and dental care.	No medical personnel; must travel for medical and dental care	Medical and dental services may be inadequate; emergency service communication problems currently exist.
Schools	District has no additional capacity to expand; unable to expand in some areas.	District has no capacity to expand; some students would have to be bussed; SVC unable to expand in some areas.	District has no capacity to expand; some students would have to be bussed; SVC unable to expand in some areas.	District able to accomodate additional students; SVC unable to expand in some areas.
Recreation	Limited entertainment facilities; must travel to lower valley.	Very limited entertainment facilities; must travel to Mt. Vernon area.	Very limited entertainment facilities; must travel to Mt. Vernon area.	Limited entertainment facilities; must drive to lower valley; travel often hazardous in winter.
Transportation	No public transportation; SR 20 through Sedro Woolley congested in summer, high accident rate in and around Sedro Woolley. SR 20 needs work from Sedro Woolley to Concrete.	No public transportation; only one gas station.	No public transportation; two gas stations.	No public transportation; SR 20 congested in summer; up-grading needed east of town; higher rate of accidents between Concrete and Rockport.
Growth Management		Strangers not welcome; closeknit community.	Strangers not welcome; closeknit community.	

TABLE 20. (continued) Constraints of Accomodating a Non-Local Work Force

	ROCKPORT	MARBLEMOUNT	NEWHALEM	DIABLO
Utilities	Major phone design changes would be needed; 18-30 mos. lead time No sewage system No water system Electricity supply would be inadequate	Major phone design changes would be needed; 18-30 mos. lead time No sewage system No water system Electricity supply would be inadequate	Additional equipment and trunk lines would be needed (12-18 months) Sewage system would need expansion Water system would need expansion Additional electric equipment would be needed	Additional equipment and trunk lines would be needed (12-18 months) Sewage system would need expansion Additional electric equipment would be needed
Housing	Very low vacancy rates; seasonal transients live in community; 160 acres zoned residential (most would be excluded due to floodplain restrictions and service and facility constraints)	Very low vacancy rates; 320 acres zoned residential (most would be excluded due to floodplain restrictions and service and facility constraints)	Existing units used by SCL employees or reserved for temporary workers; limited space available for temporary housing units	Existing units used by SCL employees or reserved for temporary workers; limited space available for temporary housing units
Police	No local department; served by one County Sheriff's officer; State Patrol understaffed in area	No local department; served by one County Sheriff's officer, State Patrol understaffed in area	No local department; one Whatcom County Sheriff's Officer for the area; State Patrol also understaffed in this area	No local department; one Whatcom County Sheriff's officer for the area; State Patrol also understaffed in this area
Fire Protection	Inadequate water system; no fire hydrants (must use tanker trucks)	Inadequate water system; no fire hydrants (must use tanker trucks)	Only one fire engine; water system would need expansion; equipment may be inadequate	Only one fire engine; equipment may be inadequate; water system may need to expand
Health Care	No medical personnel; must travel for regular care; emergency care can expand, but emergency communication problems currently exist	No medical personnel; must travel for regular care; emergency care can expand, but emergency communication problems exist	No medical or dental personnel; travel difficult in winter; emergency care can expand, but emergency communication problems exist	No medical or dental personnel; travel difficult in winter; emergency care can expand, but emergency communication problems exist
Schools	District prepared to acomodate additional students; no local school; students must be bussed to Concrete	District prepared to acomodate additional students; no local school; students must be bussed to Concrete	District prepared to accomodate additional students; no local school; students must be bussed to Concrete	District prepared to accomodate additional students; local school closed; students must be bussed to Concrete
Recreation	Limited entertainment facilities; must travel to Mt. Vernon area	Limited entertainment facilities; must travel to Mt. Vernon area	Limited entertainment facilities; must travel to Mt. Vernon area; can be hazardous in winter	Limited entertainment facilities; must travel to Mt. Vernon area; can be hazardous in winter
Transportation	No public transportation; SR 20 congested in summer, needs work from Rockport to Marblemount; higher accident rate between Concrete and Rockport; only one gas station	No public transportation; SR 20 congested in summer, cannot handle increased traffic from Bacon Ck. to dam site; more accidents in area; only one gas station	No public transportation; travel difficult in winter; only one gas station	No public transportation; travel difficult in winter; only one gas station
Growth Management	Strangers not welcome; conservative community	Community not equipped to handle substantial growth		

TABLE 21. Possible Mitigation Measures for Accommodation of a Non-local Work Force in the Upper Skagit.

UTILITIES	GOVERNMENT	PUBLIC SERVICES
Give advance notice to telephone company. Assist with expansion of water and sewer systems. Give advance notice to Puget Power to expand electric power distribution system. Arrange for additional solid waste pick-up.	Coordinate project with Mayor, City Council, and other officials Offer assistance with extension and expansion of services, e.g., utilities, police, fire protection. Apply for necessary permits.	Police: Fund additional personnel and equipment; fund additional City officers and cars; if necessary, fund additional County officer and car. Fire: Facilitate improvement of water delivery systems where necessary; upgrade or fund additional equipment when needed; pay for cost of additional calls; provide fire protection at dam site. Health Care: Establish emergency facility at dam site; improve emergency communication system if necessary; arrange for provision of additional medical, dental and social services where needed (e.g., family counseling and alcohol treatment); contract with local hospitals to provide additional bed space. Recreation: Provide recreation center with activities for youths and adults, (e.g., arts & crafts, basketball court , weight-lifting room, card room, movies, bowling), and summer youth programs. Transportation: Arrange for provision of park & ride lots, and crew buses; facilitate van and car pool programs, and limit parking at site; divide work force into two shifts to reduce peak hour traffic volume. Arrange to upgrade some sections of SR20. Investigate use of alternate routes around Sedro Woolley; use train to transport materials where cost effective, and build off-loading facilities in Concrete.
HOUSING	ECONOMY	
Provide housing for non-local workers; set up construction work camp. Apply for permit for mobile home development under subdivision code where necessary.	No mitigation necessary.	
	SCHOOLS	
	Pay in-lieu taxes to cover actual additional school expenses, including increased transportation costs and temporary units. Work with school districts to assess and plan for impacts on schools. Contract with SVC to train local workers for project if needed, and to offer continuing education classes.	

it is determined that a work camp is necessary. There would still be constraints for locating a work camp in any of the Skagit Valley communities, but mitigation measures (as shown in Table 21) could be achieved with cooperation among local government agencies, contractors and Seattle City Light.

When construction is completed (approximately 50 months), it is assumed that most of the nonlocal work force would leave the Skagit Valley area. The work camp could then be dismantled and the property returned to an agreed-upon condition. No more than fifteen workers would be necessary for operation of the proposed dam, with occasional temporary maintenance crews. The disruptions to the local human environment from the influx of construction workers would be temporary. If proper mitigation measures are implemented, impacts could be minimized, and net changes would be permanent improvements to services and facilities. However, communities would be forced to adjust to temporary growth followed by decline, which may have a long-term effect on the quality of life for local residents.

OTHER IMPACTS

In addition to stresses caused by the influx of a construction work force, the proposed dam itself would have a significant effect on the Upper Skagit, Swinomish and Sauk-Suiattle Tribes. The cumulative effect of project construction and operation would limit natural run fish for commercial, subsistence and cultural uses by tribal members, who have treaty rights to Skagit system fisheries. The financial loss to the three tribes could amount to about $70,000 annually for the commercial fish catch. Because the personal income of tribal members is low, this loss could be significant. In addition, the tribes provide services that are funded by the tax levied on gross treaty fishing income; these services could be reduced. (The details of fisheries impacts and possible mitigation measures are described in the Aquatic Biology and Fisheries Section of this document.) In addition, areas of cultural significance to the American Indians would be flooded by the proposed dam's reservoir; this could not be mitigated. (See the Cultural Resources Section of this chapter.)

Construction of Copper Creek Dam would remove ten miles of river habitat now available for fish spawning ground. The monetary loss to the Skagit economy of this removal is estimated to total between $100,000 and $150,000 annually for both commercial and sport fisheries (assuming no mitigation). (See the Fisheries and Aquatic Biology

Section for detailed information regarding methods for estimating fisheries losses and further discussion of this impact.)

According to City Light calculations of fuel needed for construction of the proposed dam, an estimated 852,000 gallons of diesel fuel and 153,000 gallons of gasoline would be used over three years. Increased fuel demands created by the project should not cause any disruption in fuel to the impact area. Transportation of construction materials and equipment to the project site would add to any traffic problems on SR 20 caused by commuting workers. Some roads would need to be improved, particularly for truck traffic; Cook Road could be used as an alternative route to bypass Burlington. In addition, some goods could be moved by rail, at least as far as the end of the line in Concrete. (The materials contracts for Copper Creek could require this where cost effective.) Movement of construction vehicles and materials could also be scheduled so as to reduce traffic problems, and an overpass could be used to separate construction from recreation traffic.

Relocation of SR 20 and increased traffic due to dam construction could have an adverse effect on tourist expenditure in the upper Skagit valley during the road and dam construction period. The value added to the Skagit County economy by the presence of the North Cascades Recreation Area has been estimated bo be $5,177,011 in 1979 dollars, based on tourist-related trade and services dollars spent in up-river communities. (Thompson, R., pers. comm., June 1980). However, there is no way to determine the permanent impact of the completed project on tourist-related expenditure.

No mitigation would be possible for the loss of income to commercial river-rafting companies since the dam would destroy the last stretch of whitewater on the Skagit River. The income to the commercial river-rafting companies on the Skagit in 1980 is conservatively estimated to be $45,260 (Steinhaus, B., pers. comm., November 1980). (Refer to Recreation and Aesthetics Section.) Jobs would be eliminated for all full-time boatmen living in the area.

Dam construction would also require the removal of an estimated maximum 2,200 acres of forest or 0.3 percent of the total in the county, which would not be a significant impact (Basabe, T., pers. comm., June 1980). Manufacturing, retail trade (other than tourist-related), agriculture and other elements of the Skagit County economy would not be adversely affected by the dam.

Unavoidable Adverse Impacts

As communities in the upper Skagit Valley are small, an influx of construction workers and their dependents would have a significant effect on residents. The informal rural life-style of the upper valley would be disrupted during the construction phase of the project. This disruption could be minimized, but not completely avoided. If additional families decide to remain in the area, the personal sense of community that existed before the project may be changed. In addition, some residents of the area might choose to leave because of increased development.

During the construction phase, some services will need to be increased to compensate for dislocations that occur, and careful planning would be necessary to reduce overexpansion of services.

Many residents have expressed fears about the safety of the dam. Feelings of insecurity would undoubtedly remain, despite efforts to explain the geology of the area and type of dam selected.

Increased congestion caused by construction activities would have a negative effect on local traffic and tourism during the construction phase of the project. Relocation of the highway near the construction site would also cause adverse delays, despite careful planning.

Operation of the proposed dam could adversely affect the existing natural salmon and steelhead runs fished by the three Skagit System Tribes. Tribal members have expressed a strong preference for natural runs, which they feel cannot be adequately replaced by artificially propagated runs.

Part 3. Human Environment

Section B. Cultural Resources

EXISTING CONDITIONS

Fifteen prehistoric and historic cultural resource sites have been identified and investigated in areas potentially affected by a new dam. Seven archeological sites bear evidence of prehistoric living and food-gathering by American Indians (Upper Skagit Tribe). Eight historical sites relate to the heritage of the Skagit Valley settlement and development; two of these are possible candidates for the National Register of Historic Places.

The archeological sites investigated include three which probably composed a dispersed village of the Upper Skagit Tribe, two traditional fishing sites, and two other activity areas. The dispersed village consisted of three dispersed hamlets, probably occupied by extended family groups. One was immediately west of Damnation Creek, another was at Bacon Creek, and the third--at Goodell Creek--might have functioned as the nucleus of this village. These sites contain basalt flakes, fire-cracked rock, and charcoal, ash and decomposing wood concentrated beneath the present surface. A Damnation Creek activity site is heavily disturbed.

Historic sites in the area include the remains of several structures (two cabins, a barn and a small ranch), an old railroad trestle of City Light (abandoned in 1954), a river landing and roadhouse established in the late 1800's to supply local miners, a talc mine and the town of Newhalem. These areas provide an historical record of the activities which shaped the Skagit Valley, from settlement by early trappers and pioneers through a mining and logging period, extending to ultimate development of the basin by City Light.

The Skagit Talc Mine, located above the proposed reservoir level and, therefore, not subject to flooding, contains extensive remains which are significant in the mining and economic history of the region. Consequently, the site is a possible candidate for the National Register of Historic Places. The site is located 350 to 400 feet above the southeast bank of the Skagit River at Damnation Creek. Structural remains, some of which are essentially intact, are scattered throughout the area and consist of mill buildings, a dressing shack, storage sheds, and cabins. The entrance to the tunnel driven into the soapstone deposit is visible at the uppermost part of the site.

Below this, considerable evidence of the mill operation remains, although pathways, tramways, skid roads and some collapsed structures are heavily overgrown. Remains of the mill machinery abound and include a steam engine, saws, a tram car, flat car, rails, cables, hoists and booms, and fragments of various other machine parts and tools. Unrelated remains, such as old automobile hulks, are also present. A considerable stock of tailings is visible, especially around the mine entrance and cutting shed.

The town of Newhalem, the other nominee for the National Register of Historic Places, played a primary role in the settlement of the Upper Skagit and the development of hydroelectric power on the river. The oldest existing structures in Newhalem date from the 1920's, and there has been construction in the town in every decade since then. The successive building campaigns have created a visual diversity reflecting the changes in style and construction forms. Two historically significant areas remain in addition to Goodell's Landing (river landing and roadhouse). One is the central core of the town, consisting mostly of buildings of the 1920's and 1930's. The other is a row of 13 houses at the western edge of the community built in 1939 and 1948.

A letter commenting on the DEIS informs us that an American Indian traditional healer resides near the dam site and works with a clientele from northern Washington and British Columbia.

IMPACTS

Aboriginal and historical sites would be affected by both reservoir flooding and dam operation. Those which would be flooded include both traditional fishing sites, the Damnation and Goodell Creek winter villages, both aboriginal activity sites, both of the historical cabins and the barn site, and the Thornton Creek railroad trestle, now being removed by the State Highway Department.

Operation of the dam could also threaten two prehistoric sites and one historic site lying outside the proposed pool area. A Bacon Creek winter village site lies in the direct part of the spillway and could possibly slough into the river. Another Bacon Creek aboriginal living site is located at the confluence of Bacon Creek and the Skagit River (one mile below the dam site) and could experience minor erosion, although this is not expected to be significant. The Bacon Ranch, located on the south bank of the Skagit approximately one mile below the dam site, could experience the same slight erosion. Additional investigations may take place at all sites that would be affected by development or operation of the project.

In addition to these direct threats to cultural sites, increased recreation and public access afforded by the reservoir and associated National Park Service facilities could result in long-term loss of site integrity at two historic sites through such activities as unauthorized artifact collecting and pedestrian traffic. The Skagit Talc Mine and the Goodell's Landing site, although located well above the pool level, would become more accessible to recreationists such as boaters on the lake and would be subject to overuse.

The low dam at Copper Creek would have the same construction and operational impacts. Because the Damnation Creek reservoir would be shorter, several sites potentially inundated by the preferred or low dam at Copper Creek would in this case be located downstream of the dam structure and, therefore, out of the zone of permanent flooding. The sites that would be preserved are the north side aboriginal activity site, both aboriginal fishing sites, and Jackson's barn site. However, most of these sites are close to the present riverbank and could experience a slight increase in bankside erosion from altered stream flow characteristics, depending on their proximity to the dam. The south side fishing site, located approximately 300 meters below the proposed dam, is the only such site that definitely would be subject to this type of impact.

Construction activity may deter the patients of the traditional healer from traveling to the area to receive his services. If this were the case, it would be difficult to mitigate.

MITIGATION

Mitigation of impacts on archaeological resources generally consists of conservation, preservation, or investigation of the sites. Conservation is a passive mitigation measure in which the site is left uninvestigated and unprotected from project impacts, but it remains available for possible future investigation. Preservation is an active conservation measure requiring initiation of measures to protect a site from potential project-related impacts. Investigation, the most intensive form of mitigation, consists of active recovery of culturally significant information designed to render the site amenable to employment of other mitigative alternatives.

Either conservation or preservation could be carried out prior to flooding. Sites could be identified and left unprotected (conservation) or they could be protected from water damage (preservation). The reservoir could then be filled, leaving investigation of the sites for the future.

Where possible and practical, conservation and preservation are the preferred mitigation methods. Not only are these measures often more cost-effective than investigation, they also save a resource for future generations that will have better investigative tools and techniques. In addition, investigation destroys a site because of the excavation required.

Suggestions for specific mitigative action for each site are not possible until additional site-specific information is obtained.

Since the significance of these cultural sites is unknown, the importance of their loss is also uncertain. However, archaeologic or historic information not yet uncovered from these sites could, in the long run, be irretrievably lost. More information about the cultural sites is contained in Technical Report 4 of the earlier Environmental Assessment documents.

Part 3. Human Environment

Section C. Land Use

EXISTING CONDITIONS

The proposed dam sites and reservoir areas are located within the Ross Lake National Recreation area where the National Park Service manages land use. According to its Master Plan, the purpose of Ross Lake NRA is to provide "superlative and diverse recreational use and enjoyment of the Skagit River, and surrounding lands, and to preserve the wealth of scenic, historic and scientific values within them".

However, several other governmental agencies have an interest in land use management within the project area. The Federal Energy Regulatory Commission (FERC) has final authority over use of lands within the boundaries of FERC-licensed power production projects.

The dam sites and most of the reservoir area are in Skagit County, which has jurisdiction insofar as the National Park Service needs county concurrence. Guiding Skagit County is its Shoreline Management Plan, which is the local, specific plan required by the Washington State Shoreline Management Act of 1971 and the Federal Coastal Zone Management Act. The County Shoreline Plan designates the north bank of the Skagit River above Copper Creek as Conservancy and the south bank as Natural. The Natural category is more stringent, prohibiting permanent structures or activities which would deplete natural resources. A hydroelectric dam would not be permitted at a site in the Natural category.

A portion of the reservoir area is in Whatcom County, which designates both banks of the river as Conservancy. A shoreline conditional use permit would be required in both Skagit and Whatcom counties for all uses not specifically set forth. A hydroelectric project is such a use. Whatcom County would also require a Shoreline Substantial Development Permit for the relocation of SR 20, as well as for the creation of the reservoir, since it "interferes with the normal public use of the shorelines."

Both counties also have comprehensive land use plans. Most of the area around Rockport and Marblemount is zoned Forestry, which requires a special use permit for the construction of a power-generating facility. Whatcom County would require a Zoning Conditional Use Permit because the area involved is zoned "General Protection."

Downstream floodplain restrictions severely limit the growth of Lyman and Hamilton.

Relocation of SR 20 would be required because the Copper Creek reservoir would flood about ten miles of the existing highway. The proposed highway realignments lie on the north side of the lake and would require permits from both Skagit and Whatcom Counties. If roadways are constructed outside FERC project boundaries, permits would also be required from the National Park Service.

The river downstream of the dam sites, from and including the mouth of Bacon Creek to the pipeline crossing at Sedro Woolley, was designated a recreation river on November 10, 1978 under the Federal Wild and Scenic Rivers Act. The U.S. Department of Agriculture is responsible for management of the Skagit River Wild and Scenic River System. Upstream river uses that would unreasonably diminish the scenic, recreational and fish and wildlife values present in the area on the date of approval of this act are prohibited.

The one potential borrow pit identified so far is on U.S. Forest Service land near Bacon Creek. This site could provide impervious core material for the dam. Additional undetermined sites may also be needed.

Another federal law bearing on land use in the upper river area is the Endangered Species Act. This act seeks to prevent development which would diminish populations of rare animals or plant species or the habitats essential for their survival.

IMPACTS ON LAND USE

A new dam and reservoir would change the land use along the flooded portion of the river and possibly downstream of the dam.

From the perspective of Skagit County, the south bank of the Skagit River would no longer fit into the Natural classification. The National Park Service has advised that they believe the reservoir would diminish the diversity and value of the Ross Lake National Recreational Area.

From the perspective of the U.S. Forest Service, the dam might significantly diminish the value of the Skagit River within the Wild and Scenic River boundaries.

From the U.S. Fish and Wildlife Service's perspective, the project would interfere with the habitat of at least one endangered species, the bald eagle. It would also inundate approximately 2,400 acres of floodplain habitat needed to support a number of fish and wildlife species.

A number of local, state, and federal agencies will review the project's license application. The licenses and permits that would be required for a new Skagit River dam are listed in Table 22.

MITIGATION

Mitigation measures for the land use impacts discussed above may be found in other sections of this EIS, e.g., Recreation, Wildlife, Fisheries and Hydrology.

TABLE 22. Licenses, Permits and Approvals for Skagit Dams

Authority	Action that would be needed	Explanation
City of Seattle	Project endorsement by Mayor and City Council	Decision required before FERC license application can be made. Application for the remainder of licenses and approvals is dependent on this policy approval.
Skagit County	Change Shoreline Management Master Plan	South bank of Skagit River in the reservoir area is now designated "Natural", which does not permit permanent facilities.
	Substantial Development Permits under Shoreline Management Plan	North bank of Skagit River in reservoir area is designated "Conservancy". Conditional use permits would be needed for construction of a dam and relocation of SR 20. A conditional use permit also may be required for the Bacon Creek borrow pit site as Bacon Creek is classified as a Conservancy shoreline.
	Special Use Permit under Skagit County Zoning Code	Skagit County Code requires a special use permit for power generating facilities in areas zoned Forestry.
	Construction permits	Construction permits would be required for building a dam and relocating SR 20.
Whatcom County	Substantial Development and Shoreline Conditional Use Permits under Shoreline Management Plan	Skagit River in upper reservoir area designated "Conservancy". A Shoreline Conditional Use Permit required for all uses not set forth by the County Shoreline Program. Substantial Development Permit required for creation of reservoir, since it "interferes with the normal public use of the shorelines," as well as the relocation of SR 20.

TABLE 22. Licenses, Permits and Approvals for Skagit Dams

Authority	Action that would be needed	Explanation
Whatcom County	Zoning Conditional Use Permit under Whatcom County Zoning Ordinance	The area is zoned "General Protection".
U.S. Forest Service (Department of Agriculture)	Special use permit for borrow pits	At least one would be on National Forest land.
	Review FERC license application for conformity with Wild and Scenic River Management Plan	Skagit River from the mouth of Bacon Creek to the pipeline crossing at Sedro Woolley is protected by Wild and Scenic Rivers Act.
U.S. Fish and Wildlife (Department of Interior)	Prepare biological assessment of project	Federal Endangered Species Act mandates study and consideration of effects on rare, threatened or endangered species such as bald eagles.
National Park Service	Review FERC license application for conformance to North Cascades Complex Master Plan	Reservoir would be within National Recreation Area.
	Permits required for construction activity	Construction within NRA
Advisory Council on Historic Preservation (Deparment of Interior)	Review of FERC license application for its impacts on historic resources	Federal law mandates Council to protect public's interest in historic resources.
Department of the Army, Corps of Engineers	Dredge and fill permit	Required under Section 404 of the Clean Water Act.

TABLE 22. Licenses, Permits and Approvals for Skagit Dams

Authority	Action that would be needed	Explanation
U.S. Department of Commerce	Certification of compliance with Federal Coastal Zone Management Act	Must review State Department of Ecology's action on Shoreline Management.
Federal Highway Admin. (Department of Transportation)	EIS on Highway relocation	Required. May be combined with FERC's EIS.
Council on Environmental Quality	Review EIS(s) for compliance with National Environmental Policy Act	Federal actions, such as issuing licenses, must take environmental aspects into consideration.
State Department of Ecology	Approval of counties' changes and permits under Shoreline Management Plan (SMP)	Department has authority to approve or deny both changes to the SMP and county approval of a variance or conditional use shoreline permit.
	Water Right Permits	Separate permits required for dam site and borrow pit.
	Water Quality Certification	Required for federal permits.
	Short-term modification to water quality standards	Required during construction of project.
	Dam Safety and Water Impoundment Review	Covers planning and construction phases.
	Western Washington Instream Resources Protection Program	Will advocate minimum flows before FERC.
	Flood Control Zone Permit	Project would affect floodwaters.
State Department of Game and Fisheries	Hydraulic permits	Permit needed for construction in river beds.

TABLE 22. Licenses, Permits and Approvals for Skagit Dams

Authority	Action that would be needed	Explanation
State Department of Natural Resources	Forest practices application	Application needed for timber harvesting.
State Department of Natural Resources	Burning permits	Required from Northwest Area office.
	Right-of-way application	Must receive permission to overflow banks. Establish value of banks for compensation.
State Office of Archaeology	Permission to alter archaeological resources	State law required that this office protect the public's interest in these resources.
Federal Energy Regulatory Commission (Department of Energy)	License to construct hydroelectric project	License necessary for construction. In an application for license, City Light would have to provide extensive documentation on engineering and environmental aspects.
		Before issuing license, FERC would have to prepare its own EIS and consult with other agencies and the public.

Part 3. Human Environment

Section D. Recreation and Aesthetics

EXISTING CONDITIONS

The proposed dam at Copper Creek would directly affect the visual character of about ten miles of the Skagit River Valley south of Newhalem, which, in turn, could have a significant impact on the demand and opportunities for recreational use of the project area and surrounding region. The boundaries of the National Recreation Area were adjusted, however, to include the Copper Creek Dam site, and Congress left the authority for licensing hydroelectric development with FERC.

Present Visual Character

This portion of the upper Skagit valley offers a variety of largely unspoiled landscapes from delta to mountain passes, all visible from a major highway (SR 20). The locale of the proposed dam site, primarily a flat-bottomed, narrow opening between steep mountain walls, serves as an entry from the broad-floored open valley downstream to the dramatic mountain gorge upstream.

The most prominent landscape features in the project area are the floodplain, with its river terraces, alluvial fans and landslide areas, and the steep slopes with slight hillside shoulders. The river drops 130 feet in this ten-mile stretch, which contains its last remaining rapids and offers a wide variety of shoreline and channel patterns. There are 15 steep, small mountain streams and 30 acres of gravel pit ponds. A rich deciduous and mixed lowland forest covers the valley floor.

Each year, many visitors enjoy the diverse scenery from SR 20. The Skagit River, in the project area, is the largest North Cascade river landscape that is visually and physically accessible to cross-state travelers. A variety of bends, bars and islands, sloughs, and rapids can be seen from the road for a two or three mile stretch. Other views from the highway include the valley wall across the river, the lowlands up in the Alma Creek basin, and distant views of the Picket Range up Goodell Creek, as well as the surrounding high Cascade peaks to the northeast.

Because of the intrusion of highly visible development related to City Light's hydroelectric facilities (upstream), the setting is not completely natural.

Existing transmission lines, service roads and rights-of-way sometimes disturb the natural vistas in the valley. However, there are places where the lines and their structures are hidden in the trees high on the hillsides, and clearing for rights-of-way at the gravel pit ponds and at Newhalem are well blended. The existing road fits well, and the former railroad cut in granite near Sky Creek has weathered to become a visual asset.

Present Recreational Opportunities

A variety of recreational opportunities exist in the project area, which is located within the North Cascades-Ross Lake National Recreation Area Complex. This area serves as a gateway to the North Cascades and as a base camp for visitors to nearby high-mountain trails and reservoirs.

Many travelers limit their experience here to sightseeing from the highway and to other roadside uses, such as picnicking. Camping is currently limited to the Goodell Creek Campground, where there are 26 sites plus two large group camps. The Newhalem Campground, a large, fully equipped facility, is currently under construction. Roads and campsite spurs, ranger stations, comfort stations, and an ampitheater have been completed, and the development of 135 individual sites is being planned. The campground is expected to open during the fall of 1981 or spring of 1982.

Several hiking trails lead off into the wilderness from the project area, including one to Thornton Lakes, where primitive camping is available. There are also two developed nature trails maintained by City Light on the Skagit River near Newhalem.

The upper Skagit is a popular destination for bird watchers, since this is one of the prime locations in the continental United States where eagles can be observed feeding on salmon; several other species of birds as well as other wildlife can also be seen. Some hunting (mostly of deer) is allowed in the vicinity.

The river itself provides many of the area's opportunities for recreation. This stretch of the Skagit has the only remaining whitewater in the Ross Lake National Recreation Area and is an increasingly popular area for commercial and private rafting as well as a challenging resource for kayaking and canoeing. It is particularly popular with beginners and offers the novice river runner a challenging and exciting but relatively safe experience. The rapids are very accessible, with good put-in and take-out points near roads and parking. A 500-yard section of the "S-Bend" in the river has been used as a competitive kayak course. In 1980 (as of October 31), there were 315 float trips providing service to a total of 2,248 park visitors (NPS, 1980). Data from Canyoneers, Inc., owners of Skagit Float Trips, indicate yearly increases of 20 percent or more in the number of commercial and private float trips since 1978 with an annual "industry" income of roughly $45,000 from Skagit River trips in 1980, at the 20 percent growth rate this income would double in four years.

Fishing is also popular in this area, including some steelhead fishing in the Skagit. Although the river water is generally too cold for swimming, the gravel pit ponds on its west bank are often used on a walk-in basis for water play, as well as fishing, picnicking and birdwatching.

Table 23 shows the levels of recreational use in the project area for the last five years.

Potential Recreational Use

Although Table 23 shows a generally declining trend in recent years for vehicle camping within the project area, existing recreation use is not necessarily a good or consistent indicator of recreational potential. Public use is now largely restricted to the limited number of developed National Park Service facilities, and in some cases highly attractive areas (such as the area of naturalized gravel pit ponds) have been made less accessible by management practices. However, there are several sites which have good recreational potential, as shown in Figure 20. Table 24 shows acreages remaining at these sites if any of the alternative dams were constructed. Further information on potential recreation sites is contained in the Recreation and Aesthetics Support Document.

Potential Sites. The Goodell Creek area, the current site of a campground and two group camps, has more than 500 acres available for further intensive recreation development. There is ample space here for a full range of activities associated with a national park, including a resort facility and a park center or headquarters.

Across the Skagit River from Newhalem are approximately 540 acres suitable for recreation development. When the Newhalem Campground is finished, it will be one of Washington State's largest, with 436 vehicular and walk-in units, amphitheaters, interpretative trails and other permanent facilities. Outside the Newhalem Creek area, the south side of the Skagit is accessible only by foot,

TABLE 23. Recreation Use in Project Area, 1975-1979

Type of Use	1975	1976	1977	1978	1979
Goodell Creek Campground					
R.V.	5,563	6,562	6,642	5,913	5,117
Tent	4,101	3,597	3,454	3,007	3,015
Backpacker Visitor Nights	24,959	21,471	17,761	18, 968	33,510
Highway Visitors	804,527	693,891	628,735	823,001	672,433

Source: U.S. National Park Service, pers. comm., May, 1980.

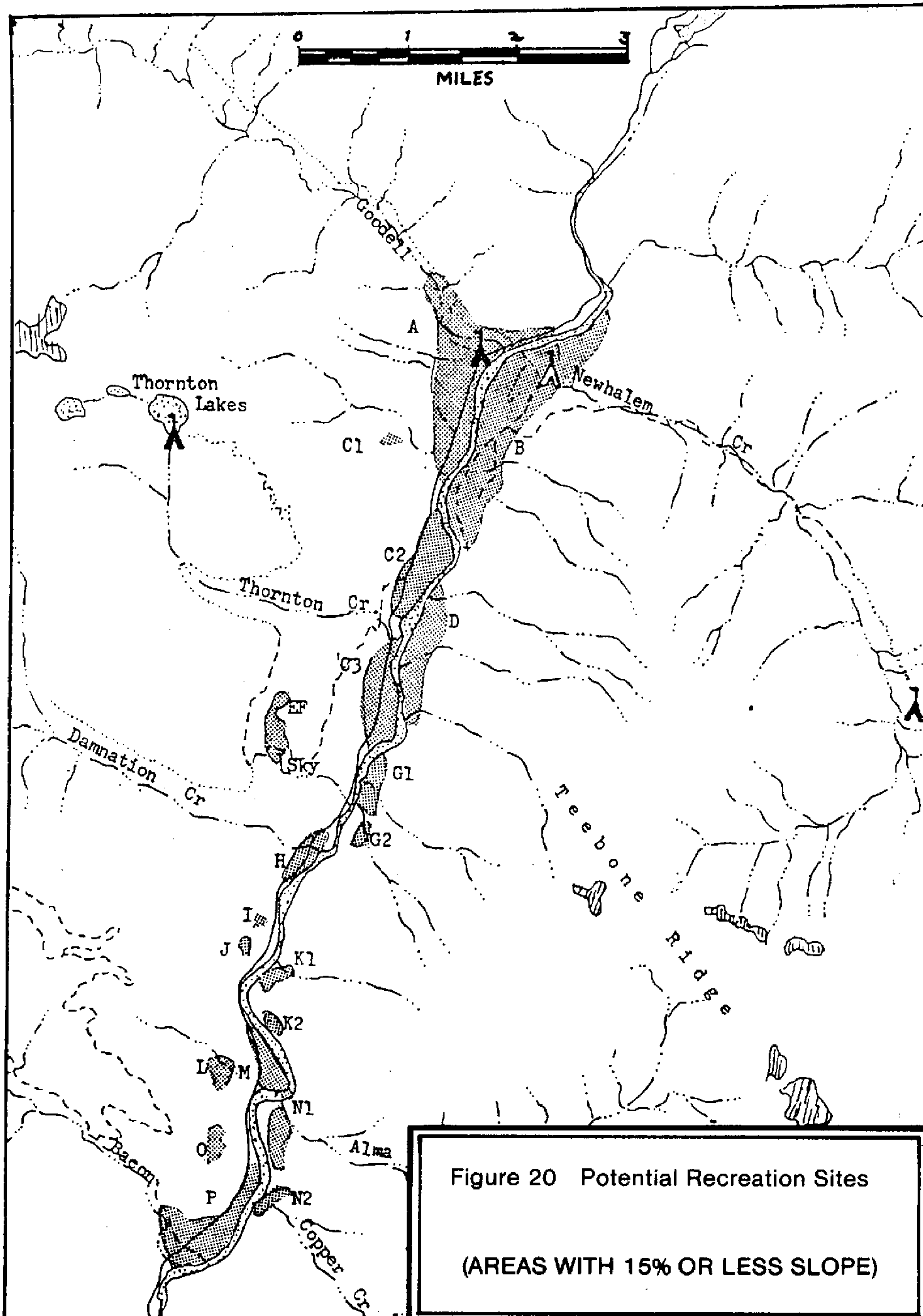

Figure 20 Potential Recreation Sites

(AREAS WITH 15% OR LESS SLOPE)

TABLE 24. Potential Recreation Acreages

SITE	EXISTING or No Dam	Copper Creek - 495 ft	Copper Creek - 480 ft	Damnation Creek - 495 ft	Damnation Creek - 480 ft	USGS
A	517	198	293	198	293	570
Town	97	52	75	52	75	-
B	542	319	401	319	401	550
C1	14	14	14	14	14	-
C2	156	34	34	34	34	310
C3	142	-	-	-	-	
D	197	-	-	-	-	200
E	114	114	114	114	114	40
F						75
G1	75	-	-	-	-	100
G2	10	10	10	10	10	
H	45	-	-	-	-	75
I	5	5	5	5	5	5
J	20	20	20	20	20	10
K1	45	45	45	45	45	30
K2	39	-	-	39	39	
L	50	50	50	50	50	65
M	90	-	-	90	90	95
N1	90	-	-	90	90	160
N2	34	-	-	34	34	
O	46	46	46	46	46	55
P	219	175	175	219	219	240
TOTAL	2,547	1,082	1,282	1,379	1,579	2,580

horseback or boats, but hiking or horseback trails could be developed.

Around 220 acres are available for recreation in the Bacon Creek valley, which is generally under the jurisdiction of the U.S. Forest Service. There is a fully developed picnic area near the highway at the mouth of the creek, and several campsites further up the valley have been developed by campers themselves.

On the valley floor on the north side of the Skagit, there are also four sizable sites, totalling about 433 acres, which would be well suited for uses such as camping, hiking, fishing, nature trails and birdwatching. There is easy access to both the highway and the river, and exposure to sunlight is good. The gravel pit areas could be very attractive campgrounds.

Recreation Demand. Established as a National Park in 1968, the area experienced a rapid increase in visitors from 1971 through 1973; since that time visitations have had either a relatively static pattern or have declined. The relatively undeveloped nature of the Park and, since the mid-1970's, an unfavorable exchange rate for Canadians are two of the major reasons suggested for the Park's failure to meet originally projected levels of use. The Park is a summer season facility, since snow closes SR 20 at the mountain pass during the winter.

Visitors to the North Cascades fall into three broad categories. The most numerous are through-travelers on SR 20, who experience only the roadway corridor and its attendant views. Second in number are vacationers who use the Goodell Creek Campground or visit the attractions in Newhalem. The third category consists of hunters, fishers, hikers and river floaters. Trends among these users are shown in Figure AP III-16 of the Recreation Support Document.

Statewide recreation planning efforts are designed to balance regional demands with facility development. The 1979 Statewide Comprehensive Outdoor Recreation Plan (SCORP) indicates that facilities in the planning district for Island, San Juan, Skagit and Whatcom counties satisfy 67 percent of the current demand for camping, 77 percent for picnicking, 99 percent for hiking and 100 percent for boating. Projections of growth in demand through the year 2000 indicate a need for over 4,500 new campsites, 1,350 picnic tables and 350 miles of new trails within the four-county area. Certainly the North Cascades National Park Complex will play a major role in meeting these demands.

IMPACTS AND MITIGATION

The major recreational and aesthetic impacts of a dam at Copper Creek would result from the flooding of about ten miles of the Skagit River. Because developed recreational facilities in the North Cascades Complex are almost entirely located near lakes and reservoirs, the replacement of a free-flowing river and lowland valley with another reservoir would reduce the overall recreational and visual diversity of the complex.

Loss of River

The Copper Creek Project would result in the loss of ten miles of river including about 1.5 miles of rapids, the last whitewater stretch on the Skagit. (The Damnation Creek alternative dam site would flood seven miles of river, preserving a short section of these rapids at the "shovel spur" portion of the Skagit.) In addition to the aesthetic changes (i.e., loss of the sight and sound of moving water), this would mean the loss of whitewater recreation (floating, kayaking, canoeing and rafting), instream and river bank fishing, and river-oriented day use and camping. In addition, opportunities for eagle observation and other birdwatching would be diminished, especially during the construction phase. These changes could attract a different set of recreation users to the area.

Some of these losses would be partially offset by the replacement of this river environment with a long, winding lake and shoreline created by the dam. Flat water recreation uses of the reservoir could be enhanced by adding boat launches, piers, docks, boat rentals and side-trails; by fish stocking; by improving the shorelines (especially removing stumps); and by creating better access to the water.

However, although the project would replace the river with another water resource, the new reservoir would essentially duplicate recreational opportunities now found at Gorge, Diablo and Ross Reservoirs. Considering the relatively light use of these lakes, the recreational value of another reservoir in the North Cascades Complex is questionable.

The loss of river recreation could be indirectly mitigated by a replacement-in-kind program--purchase of access to similar unprotected river segments. Such a program might be suitable on the westerly section of the Skagit from Bacon Creek to Sedro Woolley, which has been given a recreation classification under the Wild and Scenic River

Act (see Eagles Section). However, since the portion of the Skagit within the project area contains the river's last remaining rapids, it is unlikely that a comparable whitewater river segment could be found for a replacement-in-kind program which is not already managed by another agency and being used for recreation.

Loss of Lowland Valley

In addition to the loss of ten miles of river, about 2,200 acres of lowland valley floor would be flooded by the proposed dam, including one of the last large flatlands in the Ross Lake National Recreation Area. The only other large, relatively flat area in the RLNRA is Big Beaver Valley, most of which would be flooded by the High Ross Project. Other losses from the Copper Creek Project would include about 30 acres of naturalized gravel pit ponds with wooded dikes and deciduous riparian woodlands. Visually, the mountain gateway vista of the Alma-Copper Creek confluence would be made less prominent.

The reservoir would cover the campground at the mouth of Goodell Creek and partially flood the Newhalem campground (now under construction), inundating a total of more than 290 sites, including 264 units and some permanent facilities at the Newhalem development. (143 units would be lost with the low reservoir.) In addition, several potential recreation sites would be affected (see Table 24).

Acreage for further recreation development at Goodell Creek and Newhalem would be reduced. Most of the potential sites on the valley floor north of the river would be flooded, including the gravel pit ponds, although one site in the vicinity of the Thornton Lakes Road would have good potential for a camping area with reservoir access. Finally, the Bacon Creek area would be undesirable for recreation purposes during the construction period; the potential for future recreation here would depend on the location and extent of borrow pit activities.

Creation of the proposed Pacific Northwest Trail on the south side of the Skagit River would also be affected, although it could be rerouted to follow the shoreline of the reservoir.

The aesthetic losses caused by flooding of this portion of the Skagit Valley would be partially offset by the visual addition of the reservoir and the long views to surrounding mountains from its shores; mitigation could be enhanced by increasing opportunities to see the lake. However, because the lowland river valley characteristics are unique in this area, reduction in overall visual diversity of the North Cascades Complex could not be fully mitigated. Also, those who come to observe wildlife would not find the same number of lowland species, particularly birds, in the area.

As a possible measure to prevent loss of campsites and facilities, a weir system could be constructed around flood-threatened portions of the campgrounds to the level of the reservoir; however, a more reasonable mitigation measure would be to replace the flooded campsites and other facilities elsewhere in the area along the reservoir. Table 24 indicates that with the preferred alternative, 1,082 acres of land suitable for recreational development would remain.

Roadway Relocation

If the Copper Creek Project is built, ten miles of SR 20 would have to be relocated. Because of the the difficult terrain, this would require up to six miles of new cuts and fills, which would scar the land for many years until they became weathered and revegetated.

During the construction period, recreation in the area would be limited because there would no longer be access from the road to river-oriented activities and because of congestion caused by heavy construction traffic. An overpass or underpass could be built to separate construction from recreation traffic; dust-inhibiting methods could also be used to reduce nuisance to motorists.

The visual impact of highway relocation could be mitigated by careful design of the new corridor and roadway; by blending the road with the topography, scale and character of the existing landscape; and by routing to avoid slides and reduce cuts and fills. Grading scars could be minimized by sculpting cuts and fills, and an intensive program of revegetation could be carried out to prevent erosion. Alternatively, parts of the roadway could be placed on concrete pilings (as is being done on new I-90 construction near Snoqualmie Pass) to reduce cuts and fills.

The new highway segment could also be routed and designed to maximize views and recreational opportunities; this may require relaxation of State Department of Transportation design standards for curvatures, grades, widths and other highway features. Roadside recreation facilities, such as rest stops, viewpoints and trailhead parking, could be incorporated in the relocated highway design.

Transmission Line Relocation

Up to ten miles of transmission lines would be relocated. Cutting new right-of-way corridors through forests and over hills could make the transmission lines more obvious and could scar the land. New access roads may have to be cleared to service the lines, and switching facilities would be created in the area.

These visual impacts could be partially mitigated by locating the transmission lines at high elevations where they could be hidden from both the highway and the lake by topography and trees. The scars from new corridors could be minimized by keeping the lines as close together as possible, avoiding clearcutting, using selective thinning, and making the right-of-way edges irregular and thus more natural. Switching facilities could be screened with vegetation, and towers could be designed and painted to blend with the landscape.

Reservoir Drawdown

Under normal operation, the reservoir level would be drawn down for generation purposes an average of two feet in the winter and one foot in the summer. This would create a thin, 24-mile long unvegetated shoreline around the lake. In rare cases, winter drawdown could be as much as ten feet, exposing a wider strip.

The aesthetic effects could be mitigated by grooming the lake edge, removing all stumps and debris from the high water level down to a clearance depth of four feet below the low water level, and by screening the shoreline strip with vegetation. If the highway is relocated along the reservoir, the stark lake edge could be softened by establishing a landscaped strip between the road shoulder and the water. Sculpted edges and, where possible, man-made gravel beaches could also improve the appearance and recreational potential of the shoreline.

Decrease in Rural Character

Construction of the dam, powerhouse, switch station, borrow areas and other facilities would alter the rural scenery in the project area. The natural wilderness atmosphere would be diminished by cuts, fills and erosion areas, and work in the borrow area would result in a visual scar created by deforestation and excavation.

These impacts would be mitigated by designing the downstream face of the dam to simulate a natural bank of large rocks and vagetation. The powerhouse, switchyard and service roads could be carefully screened; the tailrace could also be screened by vegetation designed to simulate rapids. Cuts, fills and borrow areas could be revegetated with fast growing ground cover.

Finally the highway could be located to bypass most of the visible structures so that they would not intrude upon the scenery.

Construction Impacts

During the construction phase, recreational experiences near the project area would be diminished in direct proportion to the users' proximity to construction activity. Both consumptive and nonconsumptive users would probably either visit other areas in the National Park or RLNRA, or travel to other recreation sites in the vicinity. The influx of a construction work force and their families would most likely alter current visitation patterns, possibly increasing overall visits during the construction phase.

Unavoidable Adverse Impacts

A certain amount of disruption of recreation from construction traffic, dust and noise would be unavoidable but minor. More important, however, the river and valley bottom type of recreational and aesthetic experience would be exchanged for the recreational and aesthetic experiences offered by a lake. Some people would consider this exchange an improvement; other recreationists (white water enthusiasts, for example) would probalby not agree. For this latter group, measures such as improving access to other river areas are incomplete mitigation at best. Free flowing rivers, once lost, cannot be replaced.

Part 4. Tradeoffs of Short-Term Gains vs. Long-Term Environmental Impacts; Irreversible and Irretrievable Commitment of Resources

This section briefly recapitulates the Impacts chapter, highlighting the following:

- Short-term gains vs. long-term environmental losses
- Benefits and disadvantages of delaying the proposal
- Possibility of foreclosing future options by implementation of the proposal
- Impacts narrowing the range and degree of beneficial uses of the environment
- Impacts posing long term risks to human health
- Identification of all substantial quantities of natural resources committed by the proposal on a long term basis

SHORT-TERM GAINS vs. LONG-TERM LOSSES

Electrical power from the dam would be a renewable resource and would persist for a longer time than many of the impacts described in this chapter. However, some potential impacts (reduction of eagle and other wildlife habitat, reduction of salmon spawning area and its indirect impacts on American Indians, reduction of river-based recreation, and the low risk of dam failure) can be viewed as long-term in comparison to the relatively shorter-term benefits of the Copper Creek Project.

DELAYING THE PROPOSAL

The main disadvantage of delaying a decision on Copper Creek or some other alternative is the increasing likelihood of shortfall in City Light's energy resource base. The capacity contribution of Copper Creek (or other alternative) would be vital if High Ross Dam is further delayed, and would still be important even if High Ross or its equivalent is available. The chief benefit of delaying a decision is that more information could become available to use in the decision. However, it is City Light's judgement that at this stage, further information will not put the City in a significantly better position to make a decision. This does not mean that further study would not be necessary should a decision be made to proceed with Copper Creek. However, it has been the consensus of City Light, the Mayor's Office and City Council that further intensive studies are appropriate if a commitment to build the dam is made.

FORECLOSING FUTURE OPTIONS

Proceeding with Copper Creek certainly would not foreclose the pursuit of other energy options. Continuing increase in demand will require utilization of other energy resources in the future.

LONG TERM IMPACTS AND IDENTIFICATION OF COMMITTED RESOURCES

Geology

The unknown, low level of risk of dam failure can be seen as a long-term risk to human health. Borrowing soil and rock materials for the dam is a commitment of natural resources that is not particularly important. Pumicite, talc, and gravel deposits would be flooded by the reservoir, but none of these are presently worked; therefore, this loss is not judged significant.

Vegetation

The most serious long-run impact is the loss of several stands of mature cedar, fir and hemlock. As these stands cannot be called rare or unusual, this is not considered a major impact, though it is perhaps significant.

Wildlife

From the wildlife habitat perspective, the significant impacts of the proposal involve the irretrievable loss of 2,400 acres of habitat by road construction and flooding. The consequence will be the loss of the spectrum of wildlife populations dependent upon those habitats and, in a broader sense, the loss of these populations from the regional ecosystem.

Eagles

Eagles depend on natural runs of spawning salmon in the Skagit, and the impacts of a dam upon these fish will diminish the eagles' ability to winter in the Skagit and to respond flexibly to erratic fluctuations in their food base. A permanently reduced carrying capacity for bald eagles in the Skagit River will result from habitat degradation that is not mitigated.

If an application is made to license the dam, judgement on this potential impact on the eagles of northwestern Washington will be formally rendered by the U.S. Fish and Wildlife Service, pursuant to the Endangered Species Act. The bald eagle is threatened with extinction in

CHAPTER IV. ALTERNATIVES TO THE PROPOSED ACTION

Part 1. Introduction

The State Environmental Policy Act (SEPA) requires an examination of alternative energy resources in preparing an environmental impact statement. The Federal Council on Environmental Quality, in response to broad public concern, has recently issued further guidelines which require early consideration of reasonable alternatives comparable to the proposed action. The reasonableness of alternatives must be evaluated on the basis of technical, economic, environmental and institutional considerations.

In this chapter, we have attempted to take the reader through the process of narrowing down the long list of possible technologies to a manageable number of feasible alternatives. Feasible alternatives are those which supply about the same energy and peaking capability as Copper Creek (49 Mw energy and 110 Mw peaking) within roughly the same time frame, and which are cost effective. Preliminary screening is based on a number of criteria, none of which is paramount. For some, geographic limitations or environmental problems may be sufficient to rule out an alternative. For others, economic or technical considerations may be dominant. The determination of which technology may warrant further review is largely a matter of reasoned judgement.

Preliminary screening is summarized in Table 25. After a brief description of eliminated technologies, we discuss the remaining technologies as specific alternatives to the proposed action. Each alternative is more or less comparable to Copper Creek in terms of energy and peaking capability.

Finally, we summarize our assessment in a comparison chart and discuss directions the utility might take in developing new resources.

Part 2. Preliminary Screening

In order to better distinguish among diverse technologies we have separated renewable from non-renewable resources (in conformance with City Council Resolution No. 25260). We made a secondary division between central station resources, such as hydroelectric or coal-fired steam plants, and decentralized resources. The latter usually consist of small, on-site generation or methods to reduce demand or make generation more efficient. Decentralized resources are important since their use avoids transmission and distribution costs and losses.

TABLE 25. Preliminary Screening of Alternatives

List of Alternatives Considered

Renewable Resources	Further Review Indicated
Central Station	
Large Wind System	Yes
Large Hydroelectric	No - lack of sites
Small-Scale Hydroelectric	Yes
Geothermal	Yes
Ocean/Tidal	No - cost, environmental
Wood-Fired Generation	No - cost, transportation, environmental
Solar Energy	No - cost, location
Solid Waste	Yes
Decentralized	
Wind Systems	No - inadequate winds
Wood Stoves	No - costs, pollution, availability of wood
Solar Energy	Yes
Non-Renewable	
Central Station	
Nuclear Fission	Yes
Nuclear Fusion	No - technology, engineering
Combustion Turbine	No - peaking facility, fuel use limits
Combined Cycle	No - primarily peaking, fuel use limits
Cogeneration	Yes
Oil/Gas Fired	No - cost, size, uncertain fuel prices
Coal Fired	Yes
Coal Synfuels	No - technical and commercial development needed
Magneto Hydrodynamics (MHD)	No - technical and commercial development needed
Decentralized	
Cogeneration/On-Site	Yes
Storage Technologies	
Batteries	No - technical, economic
Pumped Storage	No - not cost-effective at this time
Non-generation Alternatives	
Purchase	No - not expected to be available; BPA in-sufficiency
Load Management	Yes
Conservation	Yes

Table 25 (continued)

PRELIMINARY SCREENING CONSIDERATIONS RENEWABLE RESOURCES/CENTRAL STATION

CRITERIA \ TECHNOLOGY	WIND	HYDRO	GEOTHERMAL	OCEAN	WOOD	SOLAR ENERGY	MUNICIPAL SOLID WASTE
BRIEF DESCRIPTION	1200-2500 KW most efficient at present requires storage or integration with other utility power	small hydro is less than 20 mw can be built on irrgation canals or existing non-hydro-electric dams large hydro (over 100 mw) require a dam	for the Northwest hot water (rather than vapor) reserves have some potential can use steam turbine generators or binary cycle can be used as end-use heating but only close to source	utilized wave power thermal gradients, or tidal power	special boiler for steam turbine most pollutants removed prior to discharge requires good, reliable supply of fuel fairly close to generation	solar thermal and solar photovoltaic possible requires central receiver and distributed collector to transfer a working fluid to a steam or gas turbine	cogeneration possibilities direct combustion or methane conversion direct burning may be combined with fossil fuel can be combined with disposal facility
POWER CHARACTERISTICS	can be located where wind density and fluctuation is optimal	with irrigation canals, operate only from March to November: available by 1985	steady power availability	not surveyed	not enough in SCL area for full requirements	usually less than 10 MW power availability depends on insulation and storage technology (needs backup)	enough at least in area for 20 MW
TECHNICAL FEASIBILITY	established with multiple-use development projects planned for construction in California and Hawaii	developed throughout the U.S.	uncertainty in fixed exploration costs binary cycle demonstration plant in Idaho	both technologies still in early stages of development	well developed technology cogeneration possible depending on location	experimental stage	successful demonstration of suspension-firing with coal
GEOGRAPHIC LIMITATIONS	sites with sufficient wind exist in Eastern Wash. requires large site	all outside service area no sites for large hydro other than Copper Creek or Damnation Creek	potential sites in Washington; some in Idaho and Oregon	outside area	most waste wood in area is already used transportation to area may be prohibitive	not feasible for Seattle but possible for Eastern Washington	considerable odor if unprocessed waste is used should be done in connection with waste disposal site

TABLE 25 (continued)

PRELIMINARY SCREENING CONSIDERATIONS RENEWABLE RESOURCES/CENTRAL STATION

CRITERIA \ TECHNOLOGY	WIND	HYDRO	GEOTHERMAL	OCEAN	WOOD	SOLAR ENERGY	MUNICIPAL SOLID WASTE
MARKET AVAILABILITY	by mid - 1980's	no problem	needs to be developed	none	plant is conventional wood source may be difficult to plan on	photovoltaic is "off the shelf" solar thermal not commercially available	primarily a management problem
COSTS AND ECONOMIC FEASIBILITY	1050$/kw peak 25-50 mills/kwh	700 - 1700 $/kw 19 - 35 mills/kwh (17 - 18 mills/kwh current SCL projects)	1500$/kw installed capacity 25-30 mills/kwh	could be competitive when developed	depends entirely on transportation costs and collection costs of wood 50 - 76 mills/kwh 1100 $/kw for 25 MW plant	solar thermal 1000 - 2000 $/kw 60 - 115 mills/kwh solar photovoltaic 2500 - 5000 $/kw 60 - 120 mills/kwh	1950$/kw capacity 35-45 mills/kwh
INSTITUTIONAL CONSTRAINTS	only those associated with any centralized generation can be located on agricultural land flight obstacles	not significant	reserves are on federal and state land which must be leased	ownership rights could be an issue	not significant	none	none, unless EPA standards require offsets
ENVIRONMENTAL IMPACTS	land use, aircraft, radio-TV interference, and potential habitat disruption	depends on whether new site has to be developed	disruption of local environment (surface and groundwater quality, noise) from drilling through construction air pollutants	tidal systems require impounding water, affecting the estuarine environment	if properly managed, forest environment can be improved - but at higher cost harvesting, rather than residue collection, has more severe impacts	high land use requirements microclimatic effects	- odor - transportation, if necessary - reduction of sanitary land fills - particulate removal requires scrubbers - some air emission and water pollutants such as chlorine gas
FOR FURTHER CONSIDERATION?	yes	small hydro Yes large hydro No	yes	no - cost and environmental problems	no - cost, transportation and environmental	no - cost and location	yes

TABLE 25 (continued)

PRELIMINARY SCREENING CONSIDERATIONS NONRENEWABLE RESOURCES/CENTRAL STATION

CRITERIA \ TECHNOLOGY	NUCLEAR FISSION	NUCLEAR FUSION	COMBUSTION TURBINE	COMBINED CYCLE	COGENERATION	OIL/GAS	COAL-FIRED PLANT	COAL SYNFUELS	MAGNETO HYDRODYNAMICS
BRIEF DESCRIPTION	- Seattle City Light participates in WPSS plants (7% No. 1, 7-12% No. 2, 7-12% No. 3) but will receive its share through BPA purchase - boiling water reactor (1000 MW rated capacity) - uranium dioxide fuel	combination rather than splitting of atoms fuels are hydrogen and deuterium (from water)	burn natural gas and/or liquid fuels high fuel costs require limited use, generally for peaking	a combustion turbine plant with a heat recovery boiler to convert exhaust into steam for turbine generation	can be topping-cycle (process heat after turbine generation or bottoming cycle use of residual heat for turbine generation) can be fired with fossil fuels, solid waste or combination	oil can be treated at refinery to reduce sulfur and particulates plants are usually greater than 600 MW	possibly located in Western Washington with coal from Montana and Wyoming	low, and intermediate BTU gasses and methanol can be produced, or synthetic crude oil can be made gasification uses combined cycle system	coal is used in thermal conversion to electricity and heat for steam cycle
POWER CHARACTERISTICS	generally serves as base load because of high capital costs; energy available for system peaking is same as average energy	adequate	not used for base-load quick startup time for peaking needs	available for both peak and intermediate load	depends on type and fuel generally best when baseload	both peaking and baseload	baseload	can be used for peaking or base load	adequate
TECHNICAL FEASIBILITY	developed and operating throughout U.S. but changes in design, specifications, fuel prices, safety standards and operating characteristics have lead to higher costs	difficulty in sustaining fusion because of high temperatures engineering problems availability of lithium over long-term	well developed	well developed	well established	well developed but fuel supplies uncertain	developed	low BTU technology well developed and used commercially outside U.S.	not developed
GEOGRAPHIC LIMITATIONS	requires large site with source of cooling water	none at present time	may require remote location because of noise and air pollution	same as combustion turbine	requires proximity to process steam users; several possibilities in area	sites may be limited, esp. because of plant emissions	plant could not be located in city and coal transportation costs would require location closer to source	sites may be limited by plant emissions	same as coal

TABLE 25 (continued)

PRELIMINARY SCREENING CONSIDERATIONS NONRENEWABLE RESOURCES/CENTRAL STATION

TECHNOLOGY / CRITERIA	NUCLEAR FISSION	NUCLEAR FUSION	COMBUSTION TURBINE	COMBINED CYCLE	COGENERATION	OIL/GAS	COAL-FIRED PLANT	COAL SYNFUELS	MAGNETO HYDRODYNAMICS
MARKET AVAILABILITY	commercially available now	not considered available until at least the end of the century	readily available	readily available	readily available	readily available	readily available	limited	only Soviet Union has built MHD
COSTS AND ECONOMIC FEASIBILITY	- WPPS No. 2: 21.5 mills/kwh in 1982 (for 35 yr. annulization - WPPS No. 1: 35.9 mills/kwh in 1984 - 66 mills/kwh for private plant in 1995	45-55 mills/kwh (1979 dollars) if built in 1990	120-130 mills/kwh	45-55 mills/kwh used as intermediate load facilities they are less expensive than combustion turbines	capital costs for 25 MW and 510,000 lbs./hr. of steam; $65 million 1080$/kw capacity 45-60 mills/kwh	50-60 mills/kwh (for a 600 MW plant; more for a smaller one)	960$/kw capacity 45-60 mills/kwh	35 - 55 mills/kwh depending on cycle and type of operation	data not available
INSTITUTIONAL CONSTRAINTS	- Seattle City Council has placed nuclear after conservation, hydro and fossil generation - current participation in WPSS's plants may be irrevocable	low priority by City Council	FERC restrictions on hours of use (1500/year)	same as combustion turbines	generally encouraged as "new" technology	low on City Council preferences	low on City Council preferences	none	none
ENVIRONMENTAL IMPACTS	problems in plant construction, waste management, fuel transportation, safety and decomissioning - spent fuel storage	some radiation, though it remains on site	noise, pollution fossil fuel shortages	same as other fossil-fired plants	same as other thermal but more severe if pollution offsets have to be found	air emissions and water pollution use of fossil-fuel uncertain	those associated with coal excavation disposal of ash combustion results in air pollutants - particulates	requires large amounts of water and space for solid waste disposal some health problems in gasification	those associated w. coal
FOR FURTHER CONSIDERATION?	yes	no — technology and engineering constraints	No- peaking facility and fuel costs	No- intermediate load facility, fuel costs	yes	no — cost, size, and uncertain fuel prices	yes	no — more technical and commercial development needed	same as coal synfuels

TABLE 25 (continued)

RENEWABLE RESOURCES/DECENTRALIZED

CRITERIA \ TECHNOLOGY	WIND	WOOD STOVES	SOLAR	SMALL HYDRO
BRIEF DESCRIPTION	100 kw or less but most recent applications are less than 3 kw requires storage batteries and inverters for 60 cycle use; with synchronous inverters, can be integrated with utility circuit	used by residential customers for winter heating and some cooking stoves or modified fireplaces for heat exchange	passive relies on building design orientation and materials active requires mechanical or fluid movement for heat exchange some storage is required	less than 5 MW can use streams, existing dams or irrigation canals
POWER CHARACTERISTICS	intermediate power availability, usually in morning and afternoons not dependable for morning system peak	appropriate for peak reduction	not as effective for morning and evening peaks	adequate for peak and base load
TECHNICAL FEASIBILITY	long history of successful use prior to cheap electricity recent developments have concentrated on electrical power	newer model stoves more efficient may require some lifestyle changes	well developed but requires more local demonstration may be most effective where capital investment is low, such as passive	well developed, long history of successful use
GEOGRAPHIC LIMITATIONS	winds in Seattle average less than 10 mph; not cost effective on a wind density basis	none, except supply (cost) of wood when used extensively	insolation rate low but passive heating/cooling potential	several hundred potential sites exist in Washington

TABLE 25 (continued)

RENEWABLE RESOURCES/DECENTRALIZED

CRITERIA \ TECHNOLOGY	WIND	WOOD STOVES	SOLAR	SMALL HYDRO
MARKET AVAILABILITY	readily available	readily available	readily available	readily available
COSTS AND ECONOMIC FEASIBILITY	$3000-4000/kw at maximum wind speed O & M about 19% of installed cost 30-200 mills/kwh energy cost	$300-900 capital cost $75 per cord in 1980 energy cost depends on stove efficiency, location, lifestyle	solar H/W system energy cost is 100 mills/kwh for a $60 per ft^2 collector ($30/10^6 BTU) many passive systems are cost effective with present electricity rates	$700-1700/kw or 19-55 mills/kwh 17-18 mills/kwh for current City Light projects
INSTITUTIONAL CONSTRAINTS	may be a problem if load factor is lowered	increased air pollution lack of consumer protection	solar access issues lack of financial incentives public attitude	not significant
ENVIRONMENTAL IMPACTS	some people may find them aesthetically unappealing radio/TV interference	particulate emissions indiscriminate cutting if used widely	not significant	not significant if damless or installed at existing dams some water quality and land use impacts if a dam is built
FOR FURTHER CONSIDERATION?	no - insufficient winds in Seattle	no cost, pollution and availability of wood	yes	yes

TABLE 25 (continued)

NON-GENERATION ALTERNATIVES TO CITY LIGHT GENERATION

TECHNOLOGY / CRITERIA	STORAGE BATTERIES	PUMPED STORAGE	PURCHASE	LOAD MANAGEMENT	CONSERVATION
BRIEF DESCRIPTION	modular blocks of batteries from 10 MW to 20 MW	water, pumped to a storage reservoir is released when used for peaking	purchase is available from BPA until 1983	immediate options available in industrial sector extension of interruptible rates using customer backup generation other long term controls may be feasible	should include only those measures not accounted for in the load forecast
POWER CHARACTERISTICS	readily recharge when cheap energy is available and discharged during system peak	mostly peaking but some intermediate load uses	both energy and capacity can be purchased but latter is on a 12 month basis	peak load only	primarily average energy reduction with some peak reduction
TECHNICAL FEASIBILITY	conventioanl lead-acid, nickel-cadmium are developed	reversible pump turbine is available appropriate sites available in Pacific Northwest	not available beyond 1983	requires implementation plan	programs and implementation plans required
GEOGRAPHIC LIMITATIONS	none	needs an upper and lower reservoir	none	none	none

TABLE 25 (continued)

NON-GENERATION ALTERNATIVES TO CITY LIGHT GENERATION

CRITERIA \ TECHNOLOGY	STORAGE BATTERIES	PUMPED STORAGE	PURCHASE	LOAD MANAGEMENT	CONSERVATION
MARKET AVAILABILITY	commercial types available now	such facilities are in operation	availability from BPA is uncertain after 1983	timer devices, used in some techniques, are available	readily available
COSTS AND ECONOMIC FEASIBILITY	conventional types are several times as costly as expensive gas turbine capacity costs ($/kw) new types may be 300-400/$kw	$200/kw	6 mills/kwh in 1980 $24/kw in 1980	peak energy savings evaluated at the cost of combustion turbine generation, 120 mills/kwh some administrative costs	favorable economics for additional community improvement programs
INSTITUTIONAL CONSTRAINTS	none	none	none	requires industrial load service policy	none unless mandatory standards are adopted
ENVIRONMENTAL IMPACTS	minor, but some associated with manufacturing process	road construction and facility itself	minimal if from hydro others if associated with thermal	possible lifestyle changes	possible lifestyle changes
FOR FURTHER CONSIDERATION?	no technical/economic limitations	no not cost-effective at this time	no	yes	yes

Part 3. Eliminated Technologies

Each of the technologies which was dropped from further consideration is briefly described below:

LARGE HYDROELECTRIC FACILITIES

Conventional large hydroelectric facilities typically use falling water to generate electricity. The necessary head (distance the water falls, ranging typically between 100 and 1000 feet) is obtained by constructing a dam on a river to create a storage reservoir. The water may then be released and channeled via a penstock to drive a turbine which drives a generator and produces electricity. Large hydroelectric was eliminated as an alternative on the basis of lack of environmentally and economically suitable sites (other than Copper Creek and Damnation Creek).

ENERGY FROM THE OCEANS

There are currently three technologies that have the potential to exploit the potential energy in the earth's oceans: tidal, wave, and thermal energy conversion. Both tidal and wave technologies utilize the movements of the ocean to generate electricity. Ocean thermal energy conversion (OTEC) is based on translating the differences in ocean temperatures at various depths into electrical power, via a working fluid such as ammonia. Costs and environmental problems limit further consideration of these technologies.

WOOD-FIRED POWER PLANTS

Wood-fired steam generation utilizes conventional steam boiler technology, similar to oil and coal steam boilers, and ranges in size from 5 Mw to about 50 Mw. The two principal sources of wood fuel are wood waste from forest industry operations and forest residues. Cost and environmental problems eliminate wood-fired power plants from further consideration. Wood is also better used as biomass for liquid fuel. However, City Light is currently involved in a demonstration tree farm that would be harvested for biomass fuel. Although a wood-fired power plant has been eliminated from comparison with Copper Creek, it is definitely a renewable resource worth pursuing for the future.

CENTRAL STATION SOLAR THERMAL SYSTEMS

Centralized solar electric systems use heliostats (sun-tracking mirrors) to collect and concentrate solar radiation. The concentrated solar energy is then converted to thermal energy via absorption in a working fluid (e.g., high pressure water). The working fluid drives a heat engine with an attached electric generator. This is an unproven technology with potentially high economic and environmental costs.

SOLAR PHOTOVOLTAIC CELLS

Sunlight can be converted into electricity through the use of semiconductor materials such as silicon, cadmium sulfide, or gallium arsenide. Silicon cells are the most widely developed photovoltaic technology, and are used either in flat arrays or concentrators. Economic costs presently eliminate photovoltaics in the Pacific Northwest.

DECENTRALIZED WIND SYSTEMS

Small wind systems generally have power ratings of 1/2 kw to 100 kw and rotor diameters of up to 100 feet. The fundamentals of small wind systems are the same as those of large scale systems. However, energy storage capability assumes greater importance if the system is not hooked into the utility grid. Small wind system designs include the sailwing, windsail, Jacobs, darrieus, Gillete Dynamo, and Chalk turbine. There is insufficient wind in the Seattle City Light service area to use decentralized wind energy conversion systems.

WOOD STOVES

There are three basic types of woodburning stoves: open (Franklin), box, and airtight. Open and box stoves are designed primarily for aesthetics and offer little heating potential, whereas airtight stoves are designed for heating large areas over long periods of time with little supervision. Airtight stoves are also more efficient than open or box stoves, since air can get into the combustion area only via air inlet dampers. Environmental costs would be very high if wood stoves were used extensively in the city.

NUCLEAR FISSION/FUSION HYBRID REACTORS

The hybrid uses a laser fusion system to produce large quantities of neutrons which in turn are used to convert fertile material (e.g., U-238) to fissile material (plutonium) for use in conventional fission reactors. This is an unproven technology with potentially high economic and environmental costs.

NUCLEAR FUSION

Nuclear fusion is the combination of the lightest nuclei of an atom. In this case, as in nuclear fission, the mass of the end products is less than the mass of the original nuclei. This lost mass is converted into energy. The sun is the best example of a nuclear fusion process. Nuclear fusion is an unproven techology with potentially high economic and environmental costs.

COAL SYNFUELS

Coal-derived fuels employ two processes: gasification and liquefaction. Gasification results in low, intermediate and high Btu gases and methanol fuel. Liquefaction produces synthetic crude oil. Economic and environmental costs limit this technology from further consideration at this time.

MAGNETO HYDRODYNAMICS (MHD)

MHD generates electricity by extracting the electrical current that is generated when a hot gas is passed rapidly through a magnetic field. Coal is the preferred fuel and acts as a conductor when burned in a combustion chamber. Technical problems associated with the high temperatures produced limit this technology from further consideration.

IN SITU-GASIFICATION

This process for deriving energy from coal consists of injecting air into existing natural coal beds, setting the coal afire and capturing the escaping low Btu gases for use as power plant fuel. This is an unproven technology.

Technical problems with control of combustion eliminate this as a current resource.

COMBUSTION TURBINE

Combustion turbine power plants operate by compressing incoming air in a rotary compressor and injecting the compressed air into a combustion chamber along with a gaseous or vaporized liquid fuel. The high pressure, high temperature combustion process provides the driving force to a turbine which in turn drives both the compressor and an electric generator. Combustion turbines are presently used for peaking capacity with distillate oil or natural gas as fuel.

Although combustion turbines are a known and commercially available technology, there are noise and pollution problems associated with their use.

COMBINED CYCLE PLANTS

A combined cycle plant is basically a combustion turbine with the addition of a recovery heat boiler for capturing exhaust heat to produce steam-generated electricity. Such a plant can burn most hydrocarbon liquid or gaseous fuels but normally uses natural gas or a high-grade distillate. The technology is well established and equipment is commercially available.

Combined cycle plants are intermediate load facilities designed to meet the predictable load variations that occur between the extremes of peaking and base load.

STORAGE BATTERIES

Storage batteries consist of modular blocks of batteries from 10 to 29 Mw and can be discharged over 3-5 hours at a consistent rate. This storage technology is still in the demonstration phase and is not expected to be commercially available within the proposed project time frame.

PUMPED HYDRO STORAGE

Pumped storage is an option for supplying electric power to meet peak energy needs. Potential energy is stored by pumping water from a reservoir at a lower elevation to a reservoir at a higher elevation. Electricity is generated by passing water from the higher to the lower reservoir through a turbine, which drives an electric generator. Economic costs eliminate this technology from further consideration.

POWER PURCHASE

Power transactions are defined as power acquisition, sales, exchanges or other arrangements thast result in power flows between adjacent regions or systems over high voltage transmision interties. These transactions are possible due to such system peculiarities as seasonal load diversities and hourly peak load diversities. Economic costs and the fact that power purchases will be regionally limited in future years restrict this option.

Part 4. Feasible Alternatives

Of the remaining technologies, we combined several for discussion as alternatives to the proposed action. Although such combinations are not necessary for technical reasons or for resource planning, comparing alternatives of essentially the same generation capability makes the analysis easier. Each alternative is discussed according to technical, economic, environmental and institutional criteria.

The following alternatives are reviewed:

I. NO ACTION
II. LARGE WIND SYSTEM AND SMALL-SCALE HYDRO
III. DECENTRALIZED SOLAR, CONSERVATION AND LOAD MANAGEMENT
IV. MUNICIPAL SOLID WASTE AND COGENERATION
V. GEOTHERMAL
VI. COAL-FIRED PLANT
VII. NUCLEAR PLANT

Part 4. Feasible Alternatives

Section A. Alternative I: No Action

It is a legal requirement that a "no action" alternative be considered. Under this alternative, City Light would neither build a Skagit River dam nor take any other planning actions to meet the need which the dam would satisfy.

City Light's latest forecasts predict, even with a slower growth in demand, that there will be an energy deficit after 1987. A no-action alternative would cause dislocations and disruptions on the economic and human environment of Seattle through interruptions of service. Most relevant is the fact that this alternative would violate the mandate of City Light, as a department of City Government, to prevent such deficits.

Part 4. Feasible Alternatives

Section B. Alternative II: Large-Scale Wind Systems and Small-Scale Hydroelectric Facilities

TECHNICAL DESCRIPTION

Wind

A combination of large wind systems and small hydro facilities could provide both average and peak energy comparable to the proposed project. Wind energy conversion systems depend upon the kinetic force of the wind to drive a rotor, which in turn drives an electrical generator. Utility wind systems have rated capacities ranging from 100 kw to 2 Mw or more. The application of these systems for utility use would involve an array (or wind farm) consisting of several systems that would tie into the transmission network. Because wind is an intermittent resource which varies with the seasons, the array would be located where the wind blows the most. Since wind peaks in the winter, wind energy could complement the use of solar energy, which peaks during the summer. A good wind site would have mean wind speeds of at least 13 to 17 mph and be located relatively close to existing transmission facilities.

A study carried out for Seattle City Light (United Industries, 1979) indicated that there are at least 600 square miles of land area suitable for wind systems in the North Cascades and Olympic Peninsula. Table 26 lists sites, their annual mean wind speed, and their available power density, as identified by United Industries.

Additional sites exist along the Columbia River Gorge, such as at Goodnoe Hills, and a potential site may also exist in the South Fork Tolt River watershed in east King County (Yamagiwa, 1980). From the land areas identified in the City Light study, Energy Ltd. estimated that recoverable wind energy is equal to 93 percent of all the electrical energy sold by City Light in 1978 (Energy Ltd., 1980). This includes electricity sold both to City Light customers and to customers outside of the service area.

According to Energy Ltd., a field of 25 machines (assumed to be the size of the Danish Gedser Mill) sited on one square mile with an average wind velocity of 13.4 mph would yield 8.2×10^6 kwh per year, or the equivalent of 201,632 gallons of home heating oil.

TABLE 26. Potential Wind Turbine Generator (WTG) Sites on the Olympic Peninsula and in the North Cascades

Potential WTG Areas	Annual Mean Speed (mph)	Available Power* Density (watts/ft^2)
Upper Skagit River (Diablo)	16.8	42.0
Stevens Pass	15.8	34.5
Mt. Baker	15.8	34.5
Port Angeles	16.8	42.0
Lilliwaup	17.9	51.4
Fortson	15.8	34.5
Concrete	14.3	27.1
Skykomish	14.3	27.1

*Watts per ft^2 of area swept by the rotor of the wind turbine. NOTE: This available power density is an estimate based on the numerically estimated annual mean speed and an emperical relationship between available wind power density and annual mean wind speed. The empirical relationship was developed by Widger (1976) using data from six anemometer stations in the Eastern U.S. The available power density estimates are only valid for relative comparisons of wind power between potential WTG areas. To obtain a more relevant estimate of available power density, direct measurement of wind speed and direction is required.

Additional research on wind energy and other renewable electrical generating resources is being done by the Social Management of Technology Department at the University of Washington and will be published in 1981.

Small Hydroelectric

A small hydroelectric facility may or may not require a dam, depending on the type of system. An integral part of the system is the turbine, which is chosen for a particular site on the basis of water flow and head (the distance the water falls). The Pelton Turbine is a good example of a system that does not require a dam but does need a relatively high head. Conversely, a reaction turbine can be used with a head of as little as 15 feet, but it requires a dam.

Small hydro systems have received much study in recent years. According to the Army Corp of Engineers, the undeveloped resource in Washington of sites larger than five Mw is 21,288 Mw and 31,173 for sites less than five Mw (U.S. ACOE, 1976). In another study, 137 sites larger than ten Mw capacity were identified in the Puget Sound region; however, some of these are located in national parks (Pacific Northwest River Basins Commision, 1969-1977).

A recent study for City Light identified six candidate sites of 20 Mw or more, at a cost of less than 25 mills/kwh (R. W. Beck and Associates, 1977). However, all of these sites are currently being used by other utilities.

An abandoned 1.8 Mw site (3.6 Mw potential) at Bear Creek on the Skagit River has also been identified by the University of Washington (McCoy, G., pers. comm., July 1980).

The Washington Water Research Center has identified a number of potential sites in the Skagit, Snohomish, Cowlitz, Yakima, and Wenatchee river basins (Washington Water Research Center, 1979).

Power Characteristics

A wind/hydroelectric combination may be attractive for the Northwest because it has sites with high average wind velocities and because of the effectiveness of hydro as a storage medium. During periods of high wind output (which peaks in the winter) water can be stored and used to generate power during low wind periods. Moreover, the seasonal peaks in wind velocity coincide with seasonal peaks in electricity demand. A potential wind/hydro combination might consist of a wind farm of from 30-40 2-Mw to 2.5-Mw and 2 to 4 10-Mw to 30-Mw small hydroelectric facilities. Such a combination would have capacity equivalent to Copper Creek, within the required time frame.

ECONOMICS

Although there are few suppliers of large commercial wind systems, a number of designs have been proposed and demonstrated. On the other hand, small hydroelectric systems have existed for over fifty years. Some of the wind designs include the Hutter Hi (Germany), Gedser Mill (Denmark), NASA-ERDA WECS, Lockheed WECS, Boeing Mod. II, and Bendix WECS (USA). Wind demonstration projects are currently underway at Goodnoe Hills, Washington; Boardman, Oregon; and Eugene, Oregon.

Energy costs for large wind systems are estimated at 25-50 mills/kwy and $1050/kw peak. Costs for small hydroelectric systems range from 19-55 mills/kwh (17-18 mills/kwh for current Seattle City Light projects) and $700 to $1700/kw. Combined, the costs would be 25-40 mills/kwh and $1125/kw (derived from BPA Role EIS, 1980, and Seattle City Light Energy Data Base Report, 1980).

ENVIRONMENTAL IMPACTS

Although wind power is a clean, renewable energy source, significant environmental impacts could be associated with large systems. Land use requirements would be substantial. The land area required for WECS is one-third acre/100 kw machine or three and one-third acres per Mw. However, agriculture could take place within a wind farm. Moreover, wind systems would have to be spaced far enough apart to prevent aerodynamic interference among them. A wind farm consisting of 30 to 40 2-Mw wind systems would require 6.3 square miles of land.

Large scale climatic impacts would probably be minimal, but impacts on local climate have yet to be fully studied. The aesthetic effect of large arrays of systems could be unpleasant to some people. While noise may be another impact, little quantifiable data are available to determine the degree of the impact. Finally, wind systems may interfere with radio and television reception and bird migratory routes.

The addition of small hydroelectric generators at existing dams would have some adverse environmental impacts similar to those associated with large hydroelectric projects but on a smaller scale. For example, building new small dams or raising the height of existing dams could affect water quality and temperature, dissolved gases, nutrient content, color, sedimentation above and below the dam, natural flow regimes, fish and other aquatic organisms, wildlife and vegetation, and aesthetic and recreational values of the waterway.

INSTITUTIONAL CONSTRAINTS

Wind driven electric generators have become increasingly popular. However, based on a recent public opinion survey conducted by the Seattle Energy Office, wind systems do not seem to have gained broad support in the Seattle area (Energy Ltd., 1980).

Legal problems may involve issues of "wind robbing" (the diminishing of the wind energy potential in neighboring areas), nuisance (due to excessive noise), and taking (the arbitrary taking of property without just compensation). Large wind systems may also be subject to the National Environmental Policy Act, as well as regulations of the Federal Energy Regulatory Commision and the Occupational Safety and Health Administration.

Small central station hydroelectric systems are subject to the same permit and licensing procedures as larger projects. However, a FERC license is not required for on-site applications of small hydro systems. Questions of dam ownership, equipment ownership, and maintenance on existing dams may also be potential problems.

Part 4. Feasible Alternatives

Section C. Alternative III: Decentralized Solar, Conservation, and Load Management

TECHNICAL DESCRIPTION

A combination which employs decentralized solar energy systems, increased conservation, and load management could meet both base and peak energy requirements. It would also have the advantage of providing energy or offsetting energy consumption at the point of end-use, thus eliminating the costs of transmission and distribution.

Solar Energy

Solar heating results from capturing the sun's radiant energy to heat a building's space and/or water. Solar heating systems may be either active or passive. Active systems employ pumps to transport the heated fluid (air or water), to a storage tank or to the point of end-use. Passive systems collect and transport heat through radiation, convection and conduction; they store heat directly in the floors and walls of the structure. According to some studies, passive solar heat could contribute up to 75 percent of the space heat requirement in new, single-family construction and 50 percent in a single-family retrofit (Hinman, 1980; Mazria, 1979).

Although a number of residential solar systems are already in use in the Seattle area, the Seattle Department of Community Development is currently surveying the Wallingford community for solar access potential, and the results have been favorable up to this point. It has been estimated that approximately half of the residential and commercial structures in Seattle have adequate solar exposure (Energy Ltd., 1980).

Conservation

Conservation programs, like solar energy systems, operate at the point of end-use, thus eliminating transmission and distribution costs associated with new generation. Basically, conservation measures either affect consumer lifestyles or improve energy end-use efficiency. Unlike new generation, conservation programs require substantial program costs to initiate, and capital costs are borne by the customer. Many utilities, however, recognizing higher marginal costs of new generation, partially subsidize conservation improvements. Under provisions of the Northwest Power Act, certain conservation measures will be encouraged by the Bonneville Power Administration through billing credits to the utility.

A number of specific solar/conservation programs are identified at the end of this section. Two of the more important elements are heavy conservation for new residences and acceleration of existing weatherization programs.

Heavy conservation includes increased insulation of ceilings, walls, and floors; automatic night setback of space heating thermostats; and reduction of cold air infiltration. Since lighter building structures can have an adverse impact on health and comfort, a heat exchanger is used to provide fresh air to the house interior while capturing 60 to 90 percent of the heat from the exhausted air. Use of an exchanger is common in northern Europe and required by law in Sweden (Dumond, et al, 1978; Battele, 1979; Roseme, 1980).

The City's present weatherization effort could be accelerated by increasing the annual retrofit rate from two percent to ten percent, and encouraging energy-use efficiency through zoning and incentives for energy-efficient building development.

Load Management

Customers of a utility such as City Light do not use, or demand, electricity at a constant rate. Rather, peaks of demand occur during a typical day. At night, demand is lowest. It rises to a sharp peak around 9 AM, levels off until about 4 PM, then peaks again. Demand begins to fall around 9 PM until it reaches it's nighttime low. Although the utility must supply peak demand during only a short segment of the day (or during short periods of an unusually cold winter or hot summer), it must have sufficient generating capacity all the time to meet peak demand.

Load management (the third component of this potential combination) refers to taking actions or using devices that partially level out periodic demand peaks and transfer load to off-peak hours. Many U.S. and European utilities are successfully using a variety of load management techniques designed to decrease or prevent the increase of electrical demand over a short time--from a few hours up to a day. By decreasing peak load, the utility avoids or defers the capital costs of building new generating resources to meet peak demand and avoids the cost of capacity contracts. It also avoids the use of limited fuel resources generally used by peaking generators.

The techniques fall into two general categories: (1) customer, and (2) utility load management programs. Customer programs depend on consumer reactions to various incentives; for example, lower rates for accepting voluntarily curtailed or interrupted service, time-of-use rates, and seasonal rates. Utility load management techniques allow the utility more direct control over the load; consequently, the effects are more predictable. Despite the uncertainties associated with predicting customer response to the various programs, preliminary estimates indicate there is at least 110 Mw of controllable load in the Seattle City Light System (this is discussed in more detail in a Peaking Needs DEIS to be published by City Light in January 1981).

City Light currently provides reduced rates to some industrial customers who are willing to curtail their electricity consumption upon the request of the utility. Estimates for the 1980-1983 time period show 40 Mw of currently interruptible customers and another 44 Mw of potentially interruptible customers.

It is possible to rewrite the customer requirements in order to expand the number of customers eligible (primarily to smaller loads) for the rate. There is also some evidence (Economic and Engineering Associates, 1980) that industrial customer response would be positive. Further advantages of voluntary curtailment and interruptible service rates are low administrative costs and short lead times (approximately one year) required for implementation.

POWER CHARACTERISTICS

Solar energy is a resource that peaks in the summer. However, the winters in Seattle are such that when the weather is cold, it is also clear (due to Canadian high pressure systems). When the weather is overcast, however, the temperatures are moderate. Thus, solar insolation (amount of sunlight) is available when it is needed most. In fact, one study (Kayser, 1979) has shown that insolation in Seattle increases as the temperature drops below 32°F.

Conservation, which relies heavily on insulation, is a necessary complement to the use of solar energy, since solar energy cannot reach its full energy saving potential in a poorly insulated building. Conservation is, therefore, a base upon which to build renewable resource energy systems.

Load management may reduce peaking demand during those periods when solar energy and conservation cannot meet the load. According to Kayser, five to six percent of winter days in Seattle will have insufficient sunshine to offset peak demand. To alleviate this problem, a "priority relay" between major electrical appliances (such as hot water heater and bedroom heater) can be used to turn off one appliance as the other is being used.

A solar/conservation/load management combination would have capacity in excess of Copper Creek. It could be available within the ten-year time frame.

ECONOMICS

Both active and passive solar systems are well-established, proven technologies. Passive systems have existed for hundreds of years, and active systems have been used in the Southwest and Florida since the 1930's. There are a number of good solar systems that are commercially available (National Center for Appropriate Technology, 1979), and a number of consulting firms and education programs in Seattle are available to assist the do-it-yourselfer. Costs for a solar hot water system are 100 mills/kwh ($30 per 10^6 Btu's) for a $60 per-square-foot collector. Many passive solar options are cost-effective under current electric rates, particularly those in new construction.

The conservation actions mentioned are all readily available and have great potential for expansion; economics for these actions are favorable. Costs for load management are associated with equipment, installation, and program administration. Peak energy savings are calculated at the cost of combustion turbine generation--around 120 mills/kwh.

Costs and benefits will vary with the operating characteristics of the system. Time-of-use meters and load cycling devices must be purchased, installed, and maintained for each controlled customer. Time-of-day (T.O.D.) rates require point-of-sale metering, which costs from $110 to $225. The higher cost is for remote-controlled metering, but that would not be necessary if experimental data accurately show the timing and effectiveness of the rates. Installing $150 meters for all 252,505 residential customers of City Light would cost $38 million, or $194/kw.

Since this alternative depends on the selection of a few possible conservation measures out of many, it is difficult to precisely estimate costs. Since publication of the DEIS, we have determined that the levelized cost of this alternative will be between 15 and 20 mills/kwh.* This is discussed more fully in the final part of this section.

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* MSNW estimated the costs of their suggested programs at about 15 mills/kwh. SCL added 5 mills/kwh to account for additional administrative costs.

ENVIRONMENTAL IMPACTS

The negative environmental impacts of decentralized solar systems are relatively minor, whereas the positive impacts could be substantial. Potential negative impacts may include air pollution, water pollution, solid waste production, noise from pumps, broken glass, and glare. Air pollutants may result from the release of gases (formaldehyde) from solid material at high temperatures. This may occur in an active system if the working fluid is absent and thus not absorbing excess heat. Water pollutants--antifreeze, corrosion inhibitors, bactericides--may be a problem if disposed of improperly.

Solid wastes (aluminum, copper, steel, and glass) may be created by the disposal of solar systems. Other materials, such as insulation and plastic, have a poorer recycling potential. Additional health and safety problems include glass breakage, noise, and glare. However, these problems are easily mitigated by the system's owner.

On the positive side, solar systems can displace enough fuel to make environmentally hazardous options unnecessary, create additional space (in the case of a passive solar greenhouse), enable simplicity in design and operation, provide free "fuel", and give a degree of energy self-reliance.

Conservation is a relatively benign energy option, but potential impacts include deterioration of indoor air quality in completely sealed buildings lacking heat-exchangers (Gold, 1980). Other impacts are associated with manufacturing, transporting and installing conservation products.

Environmental impacts from load management would be minor. In fact, as peak demand is distributed throughout the day, positive effects would be realized--more efficient use of generating facilities (although little shifting is possible during cold winter peak days), reduction in water fluctuations downstream of dams, and a reduction in the use of peaking generation facilities.

If electric power interruption forced an industrial customer to use backup generation, however, fossil fuels would be consumed, contributing to continued dependence on imported fuels. Some air pollution would result as well. Conflicts with traditional fuel users would depend on the type of backup fuel and the amount of customer storage. Creation and use of large stores of natural gas or residual oil would minimize fuel-use conflicts.

Social impacts of load management might be greater than environmental impacts. Time-of-day pricing, for example, could benefit businesses and industries which can adjust loads to off-peak hours, but firms which maintain 24-hour operations could be severely hurt. In addition, those industries that can shift loads will also shift workers, thus affecting lifestyles, as well as increasing labor costs due to overtime pay. In some cases, shifted hours can cause worker health problems. If power is interrupted, schedule changes can cause inconvenience. If interruptions cause lost production, lost income would presumably be a side effect. In short, load curtailment can raise a host of social problems ranging from who gets cut off to who accepts the economic hardships of not working because of a lack of power. However, load management options have been proposed which are not expected to cause much economic hardship.

INSTITUTIONAL CONSTRAINTS

There appear to be a number of institutional constraints on the widespread implementation of decentralized solar systems. Public attitudes toward solar energy are generally favorable in the Seattle area (Energy Ltd., 1980). However, because of limited information about solar and low electricity rates in Seattle, homeowners have little incentive to seriously consider solar hot water or space heating systems. These constraints could be addressed by increased publicity and education programs carried out by the City of Seattle. Financial incentives could also make solar systems more economically attractive. The major kinds of financial incentives that can be considered by local, state, and federal governments are tax incentives, loan incentives, government transfer incentives, conservation purchase, and the elimination or reduction of incentives that benefit competitive energy sources (Hyatt, 1979). Financial incentives are warranted, since solar programs are often cost-effective for the utility when displaced energy is measured at its marginal replacement cost.

Legal constraints on solar systems include the lack of a zoning ordinance, building code, or comprehensive plan that protects solar access. Without these, there would be a host of legal problems with solar access and the issue of "taking" of private property without just compensation (Hayes, 1979).

There are generally few legal constraints on residential conservation, with the exception of land use regulations (Harwood, 1977); the greatest constraint seems to be human behavior. However, according to a number of studies, public opinion in Seattle favors conservation as the main tool for meeting our current and forecasted energy consumption (Energy Ltd., 1980; Communication Design, 1979). One study has concluded that "advertising, outreach, and technical assistance projects will do the most good if they focus on how to best help consumers systematically lay out some specific actions for decreasing their energy consumption in a cost-efficient manner" (Communication Design, 1979).

There are legal constraints on utility financing of conservation in the commercial/industrial sector, as well as constraints on bonding for conservation investment by City Light. Implementation of some load management techniques on a scale which would cause significant disruption and cost to individuals, business, and industry must be carefully considered. Customer acceptance, as well as cost effectiveness are important for the implementation of large-scale load management.

SPECIFIC PROGRAMS

Since publication of the Copper Creek DEIS, we have further developed the conservation alternatives. Table 27 is a summary of existing and potential programs administered by the Conservation and Solar Division of City Light and new potential programs described by a consultant for the Copper Creek EIS, Mathematical Sciences Northwest (MSNW). The right hand column of the table shows the conservation included in Forecast 1979/80. Where savings are shown on the same line, one must be subtracted from the other to get net savings. Net savings which can be achieved by 1990 and which exceed the forecast total more than 235 megawatts.

The MSNW programs were selected from a larger list of possibilities on the basis of their costs and benefits in relation to alternative thermal costs, then in relation to the costs of Copper Creek itself. Most of the elements in Table 27 are more economical than Copper Creek, either on the basis of levelized cost (mills/kwh) or net present value per energy unit ($'s/kwh avg). For a weighted average of most of their conservation elements (84 Mw), MSNW has calculated a levelized cost of about 13 mills/kwh.

Each possible conservation program was evaluated for its independent contribution to total energy savings, and combined in ways which would minimize program and labor costs. Some possible programs, such as addition of solar greenhouses, were found not to be cost-effective, even in terms of thermal power costs.

In most cases there is some uncertainty in estimating heat losses resulting from solar/conservation changes to a building's shell. There is also some uncertainty in the estimates of labor, materials, and City Light program costs. For these reasons we have arbitrarily extended the range for our overall cost estimate. We can thus anticipate a range of 15 to 20 mills/kwh.

Average Estimated Cost-Effective Savings From Conservation Programs by 1990 (Mw)
(all savings that appear on the same line are considered overlaps)

Program	Mathematical Sciences Northwest (1)	Solar/ Conservation Office (2)	Forecast (3)
RESIDENTIAL			
Home Energy Check		4.5	
Acceleration of Weatherization Programs (4)	25	{10.9 15.1	
Federal Appliance Efficiency Standards			18
Residential Structural Changes			31
Life-Style Changes			13
Heavy Conservation and Simple Solar in New Construction	4		
Structural Codes (apartments only)			37.5
Master Metering Elimination	2		
Heat Pumps and Thermal Traps on New Hot Water Heaters	25		
COMMERCIAL (5)			
Management Service		89	40.5
Lighting Incentive Program		4.3	
Lighting Surveys		2.5	
Structural Code			37.5
Upgrade Energy Code to BEPS	22		
Streetlighting	3		
Ceiling Insulation Retrofit	13		
Lighting Improvements	20		
INDUSTRIAL			
Industrial Management Services	6	67	30.5
Lighting Incentive Program		3.2	
Lighting Surveys		2	
Motor Drive Improvements	9		
Process Heat	6		
TOTALS	135	198.5	208 (3A)

MSNW savings minus overlap	109 Mw
Solar/Conservation savings minus overlap	127.5 Mw
Total additional savings which exceed the forecast	236.5 Mw

Notes:

(1) The MSNW savings are based, in part, on computer prototype simulations. All of the programs are in excess of the approved 1979-1980 Forecast.

(2) Based on an internal City Light memo of December 8, 1980. Additional savings will become apparent as new programs are developed and as evaluation techniques assist in determining specific savings for other programs. These estimates do not include certain elements included in Forecast 1979-1980, such as the Energy Code, new construction, the effect of service requirements (not yet calculated), and the effect of federal appliance efficiency standards. There is some overlap in the areas of weatherization and commercial/industrial savings, but the exact extent is unknown. The forecast includes 71 Mw in the commercial/industrial sectors and 44 Mw in the residential sector.

(3) Approved 1979-1980 Forecast, from memos presented at Seattle City Council hearings.

(3A) Based on a recent review of conservation in Forecast 1979/1980, the total may be 218 Mw.

(4) Includes Low-Income Weatherization and HELP program broken down in middle column as 10.9 and 15.1, respectively.

(5) The forecast indicates a total estimated savings of 71 Mw in commercial/industrial management service programs. However, for the purposes of this chart we have disaggregated the total based on 57% and 43% shares in the commercial and industrial sectors respectively.

Program Descriptions

RESIDENTIAL

Home Energy Check. Free home energy audit to determine where cost-effective conservation improvements can be made. Over 2,770 HEC's were completed during the first half of 1980.

Acceleration of Weatherization Programs. This includes the Low-Income Weatherization Program and Home Energy Loan Program (HELP). The goals of the Low-Income Weatherization Programs are to reduce residential electricity demand and provide rate relief to low-income persons who heat with electricity by weatherizing approximately 1,000 low-income homes. The goal of the HELP program is to reduce residential electricity demand, especially during peak hours, by offering low-interest, long-term financing to electric space heat customers for conservation improvements.

Federal Appliance Efficiency Standards. Appliances purchased after 1979 will be 16 percent more efficient with a replacement cycle of 15 years.

Residential Structural Changes. Effect of the Seattle Energy Code on new units and weatherization of existing homes. The forecast assumes that new and retrofit units are 30 percent more efficient with a retrofit rate of 2.28 percent of existing stock.

Lifestyle Changes. Simple measures, such as turning down the thermostat.

Heavy Conservation in New Construction. Use of heavier insulation (R-38 ceilings, R-19 walls, R-19 floors over unheated spaces, and R-10 for concrete slabs), tighter construction to reduce infiltration, automatic night setback, air-to-air heat exchanger, and simple passive solar techniques (e.g., sunspace).

Thermal Traps in New Electric Hot Water Tanks. A thermal trap is a loop of pipe that is used to interrupt the normal convection patterns in the inlet and outlet pipes. With the thermal trap in place, the hot water rises to the top of the loop and cannot continue any further. As the hot water in the trap cools, it will flow down the pipe, back into the tank and complete a very short convection cycle. Installed with new hot water tanks as turnover occurs (7%/yr.).

Structural Codes (apartments only). Effect of the Seattle Energy Code in new apartment buildings. Assumes a sliding scale of savings from 27 percent in 1974 to 54 percent in 1990.

Elimination of Master Metering. According to current Seattle City Light estimates, approximately 13,000 apartments are currently master metered in the utility's area. With master metering, the apartment has only one meter and tenants have no way of knowing how much energy they consume. By eliminating master meters, 22 percent to 35 percent savings can be realized when tenants pay directly for their consumption (Energy Users News, October 13, 1980).

Heat Pump Hot Water Heaters. A heat pump utilizes equipment to transfer heat from a low-temperature source to a high-temperature source. In hot water heating, an accessory circulating pump is mounted on or near the indoor water-source heat pump. Water from the hot water heater is circulated through a water-to-refrigerant heat exchanger to absorb the heat of compression. There are 213,000 electric water heaters in Seattle. Over half of the water heaters could be replaced with a combined system by 1990, assuming a natural 7 percent turnover rate.

COMMERCIAL

Management Service. Technical advice to existing customers. Includes 15 percent more efficient lighting with a replacement cycle of 25 years, 44 percent improvement in HVAC efficiency with a replacement cycle of 25 years, and a 55 percent increase in building envelope efficiency with a 75-year replacement cycle.

Lighting Incentive Program. Rebate on a portion of the cost of installing energy-efficient flourescent lamps in place of standard lamps.

Lighting Surveys. Survey of efficiency and recommendations to improve commercial lighting.

Structural Code. Effect of Seattle Energy Code in new commercial buildings. Assumes a sliding scale of savings from 27 percent in 1974 to 54 percent in 1990.

Upgrade Energy Code to BEPS or New ASHRAE Code. In the fall of 1979, the Department of Energy proposed the Building Energy Performance Standards (BEPS) which establish energy budgets for major building types. The average building complying with the current Seattle Energy Code uses approximately 52,000 Btu/sq. ft./yr (on site). the BEPS would reduce this energy use about 29 percent to 37,000 Btu/sq. ft./yr.

Streetlighting. Relamp or redesign streetlamps as they burn out. High pressure sodium lamps are 45 percent more efficient at lighting levels similar to those of conventional lighting.

Ceiling Insulation. Over half of the commercial space in Seattle consists of one- to four-story buildings, many of which do not have ceiling insulation. Heating requirements could be reduced by approximately 10,000 Btu/sq. ft./yr. by installing minimum levels of ceiling insulation. This could be done in educational workshops and audits.

INDUSTRIAL

Management Services. Same as for commercial.

Lighting Incentive Program. Same as for commercial.

Lighting Surveys. Same as for commercial.

Motor Drive Improvements. Selection of higher efficiency motors, as well as better matching of motor size to load. With a 80-95 percent efficient motor, electricity use could be reduced by 1-10 percent. This could be done in educational workshops and audits.

Process Heat. Use of waste heat to improve energy use of industrial processes. This could be done in educational workshops and audits.

Part 4. Feasible Alternatives

Section D. Alternative IV: Solid Waste Plant and Decentralized Cogeneration

TECHNICAL DESCRIPTION

A solid waste plant, used in conjunction with cogeneration by some of City Light's customers, could, in theory, produce base and peak energy approximately equivalent to that of a new Skagit River dam. However, peaking capacity from cogeneration is highly dependent on the scheduled use of cogeneration by industry.

Solid Waste

Solid waste plants are similar to conventional steam electric generating plants, except that the fuel burned is residential and commercial solid waste. In some solid waste plants, the solid material is partially burned (pyrolyzed) to produce a gas which can then be burned more efficiently. Additionally, non-burnable materials must first be removed from the solid waste, which is about 79 percent combustible material. The remainder is primarily metal and glass, 70-90 percent of which can be removed (Birheisel, 1978). The combustible material has a heating value of about 5,500 Btu/lb (Stanton, 1978). Coal, by comparison, has a heating value of 7,500-10,000 Btu/lb.

This alternative has technical problems associated with reliability of the fuel supply, fuel handling, and combustion equipment. However, solid waste power-generation plants are operating in a number of cities in the United States and overseas. Ames, Iowa, for example, has had an operating plant since 1975. A pyrolysis demonstration plant built by Union Carbide has been operating periodically since 1974. And proposed plants in California range from 8.5 to 40 Mw capacity.

The City of Seattle and King County are currently studying sites for, and the economic feasibility of, building a solid waste plant (Lee, pers. comm., June 1980). The Port of Seattle is also investigating the possibility of burning solid waste to heat and cool the Seattle-Tacoma Airport. It isn't known yet if enough solid waste would be available to supply more than one plant in the Seattle area.

Cogeneration

Cogeneration systems burn fossil fuels or wood waste to produce steam, which powers a generator. The exhaust steam is then used for various industrial processes. The sequence can also be reversed: steam is first used for industrial processes, and the waste heat then powers a generator. In either case, the amount of useful energy obtained from the fuel is greater than that from a conventional boiler or generator alone. Fuel is used more efficiently as a result.

Cogeneration systems can be designed in sizes ranging from tens of kilowatts to hundreds of megawatts. California currently has over 500 Mw of capacity in cogeneration facilities and has tentative plans to expand to 1,000-2,000 Mw (California Energy Commission, 1979).

Cogeneration presently supplies only about five percent of the United States' generating capacity, whereas in 1950 it provided about 15 percent. The decision to use cogeneration (or in-plant generation) is based on the price of purchased electricity compared to the cost of in-plant generation. Significant differences between utility and industrial financing capabilities, coupled with questions of fuel cost and system reliability, have limited the development of cogeneration facilities throughout the country.

However, several utilities and industrial plants have been collaborating on cogeneration projects. San Diego Gas and Electric and Rohr Industries are two examples (Energy Mgt., Greenberg, G., 1980). In Tacoma, a joint public/private study is under way to assess the cogenerating potential in an existing steam plant owned by Tacoma City Light. In Bellingham, a district heating scheme is under investigation that would harness the cogenerating potential of the Intalco aluminum plant. Another district heating project is already under way in St. Paul, Minnesota. The 200-Mw project will serve four hospitals and most of the central business district.

Recent fuel price increases have made cogeneration more economically attractive, and the number of operating cogeneration facilities is expected to increase.

Among City Light's large industrial customers, it may be technically possible to encourage or arrange for installation of cogeneration systems sufficient to meet customer needs. However, cogeneration schemes are designed specifically for each industry and utility involved. Industrial load cycles and market operation must be accounted for before full potential can be determined by industry and City Light.

With 40-50 Mw of capacity generated by solid waste burning and the remainder supplied by cogeneration, a solid waste/ cogeneration combination could potentially meet the same capacity requirements as Copper Creek and be available within the same time frame. However, as previously noted, peaking capacity from cogeneration is dependent on the scheduled use of cogeneration by industry. Therefore, this combination may not always be capable of providing peaking capacity equivalent to Copper Creek.

ECONOMICS

Solid waste costs are 35-45 mills/kwh and $1950/kw. Cogeneration costs for 25 Mw and 510,000 lbs/hr of steam are $65 million. Energy costs are 30-60 mills/kwh depending on the fuel, and $1080/kw. Combined costs are estimated at 40-60 mills/kwh and $1500/kw (derived from BPA Role EIS, 1980, and Rocket Research, 1980).

ENVIRONMENTAL IMPACTS

Air pollutant emissions from solid waste plants are similar to those of a coal fired plant--particularly, nitrogen and sulfur oxides, carbon monoxide and organic gases. However, quantitative data are unavailable on these emissions for solid waste. Solid waste plants could also emit combustion products from the large number of potentially toxic chemicals contained in solid waste. These might include improperly discarded pesticides and chemicals used in the home. There will also be emissions associated with the use of supplementary fuels, such as coal.

Solid waste contains many trace metals and organic compounds. Without adequate treatment of water used in the operation, natural waters could be contaminated.

The siting of a solid waste plant can pose land use, aesthetic and odor problems, especially because of the need for storage space for the solid waste.

A plant equipped for cogeneration will probably burn more fossil fuel (although more efficiently) than if it burned fuel to produce process steam. Depending on the fuel, plant and location, the increase in fossil fuel burning can increase air pollution problems.

INSTITUTIONAL CONSTRAINTS

According to one study (California Energy Commission, 1979) development of solid waste generation facilities may be impeded by 1) technical and economic uncertainties compounded by uncertainties in pollution control laws; 2) financial constraints compounded by inflation, lag in rate relief, high interest rates, insuffficient investment capital, reliance on fuel adjustment clauses, and the possibility that solid waste energy investment costs will not be allowed in a utility rate base; and 3) costs to recover the energy, which may be greater than the recovered energy can command in the marketplace. This last point is particularly significant for Seattle since much solid waste disposal is handled by private contractors, who recognize waste as a resource that should be paid for.

Cogeneration is not now commonly used because many industrial customers are concerned that 1) they would come under government regulation as if they were a utility; 2) they would no longer be able to obtain electrical energy from the utility, if the need arose; and 3) they would have to finance, operate and maintain the new equipment themselves (or finance the construction operations and maintenance) without utility help.

However, there are two important pieces of federal legislation that address many of these problems. They are the Northwest Regional Power Act and the Public Utilities Regulatory Policies Act (PURPA). The Regional Power Act encourages cogeneration as an alternative resource and provides help to finance cost-effective projects immediately if they are under 50 Mw. PUPRA also encourages cogeneration for industrial and commercial heating/cooling by exempting cogenerators from regulations applying to utilities and requiring utilities to buy cogenerated power at a fair price.

Part 4. Feasible Alternatives

Section E. Alternative V: Geothermal

TECHNICAL DESCRIPTION

Geothermal energy is produced by heat from the earth's interior which is created by high pressures and radioactive decay. If the temperature of the geothermal source exceeds 250 degrees F. (150 degrees C.), the production of electricity is considered practical primarily as a baseload resource. If the source is less than 250 degrees F., only direct-heat applications, such as district heating, are considered feasible.

The most common geothermal resource is hydrothermal energy, obtained from the hot water or steam of a hydrothermal reservoir. To tap energy from hot water, either a flash steam or binary process is used. In the flash steam process, hot water under great pressure is quickly brought to the surface, where the pressure is reduced, turning the water into steam. In the binary process, a secondary fluid, such as isobutane, absorbs heat from the hot water. The isobutane, which has a low boiling point, vaporizes and then passes through a turbine.

Geothermal energy can also be generated in a hot dry-rock geothermal process. In this case, water is piped directly through a super-heated geologic formation and then back to the surface. During the process, the water is converted to steam that can drive a turbine.

City Light contracted a preliminary study of geothermal energy potential which indicated some tentative sources of geothermal heat in the State of Washington (Delaney, et al., 1979). The utility is also developing a geothermal plan that will address key issues in acquiring and developing geothermal resources.

Recent activity at Mount St. Helens and a study in progress by the Washington Department of Natural Resources both indicate great potential for geothermal energy in Washington (Washington Department of Natural Resources, pers. comm., July 1980). There is also good potential for high-temperature geothermal resources in Washington that are suitable for the generation of electricity (Bloomquist, et al., 1980). In King County, a site in Black Diamond may be a potential 50 Mw source.

ECONOMIC

Boise, Idaho, and Klamath Falls, Oregon are the only Northwest locations in the United States where geothermal energy has been extensively used. In both locations, hydrothermal district heating provides space and water heat for new multi-family residences. In both areas the resource is located at a shallow depth and is close to the point of end use, thus minimizing heat loss during transport.

The binary process is being demonstrated at the Raft River Project (5 Mw) in Idaho. In Canada, a 50 Mw hot water plant has been established at Meager Creek by B.C. Hydro. The Meager Creek site is particularly interesting since it is similar to the type of resource that could be developed in Washington and has relatively low environmental and economic costs (Stauder, pers. comm.).

Commercial availability of other geothermal technologies has also been demonstrated in areas outside of the Pacific Northwest. An application of the dry steam process currently provides 660 Mw of capacity in the Geysers-Calistoga region of California.

Additions in excess of 800 Mw of capacity are presently under construction or in the application process with the California Energy Commission. The Geysers project has come on line for $350-400 million (18 mills/kwh). The flash steam process is being used commercially outside of the United States in Mexico, New Zealand, Iceland, Japan, Italy, the Philippines and Central America.

Although there is a lack of site-specific information for geothermal energy in Washington, current studies indicate that there appears to be enough energy potential, equivalent to or greater than the energy and capacity output of Copper Creek, within the required time frame. Energy costs are estimated at 20-30 mills/kwh, and $1500/kw of capacity (derived from Seattle City Light Energy Data Base, 1980).

ENVIRONMENTAL IMPACTS

All phases of geothermal development, ranging from surface and off-road vehicle impacts to the disturbances caused in the actual drilling of wells, can result in loss of wildlife habitat.

Gaseous emissions vary widely over time for a single well. The most offensive of the gases, hydrogen sulfide, has been released naturally into the atmosphere for thousands of years. However, it can add to the acid content of rain following its atmospheric conversion to sulfur dioxide. Carbon dioxide, normally the most predominant noncondensible gas, is nontoxic but may contribute to climatic warming by adding to the greenhouse effect in the atmosphere. Mercury represents a minor portion of geothermal atmospheric emissions but is of great concern due to its toxicity and volatility. Particulate emissions, in the form of drift (water vapor, heat, and droplets of liquid water and solutes) from cooling towers and spray ponds and dust during construction, are potentially serious impacts.

Fluid discharges from hot water plants cannot be safely released into surface waters or aquifers because of high concentrations of boron, flourine and arsenic.

Subsidence, or settling, and seismicity are both factors that are a direct result of drilling. Subsidence of the surface occurs when a large volume of fluid is removed from an underground reservoir and is not replaced. Seismicity can be produced by changing conditions in rock when fluid is withdrawn or injected and can increase the possibility of earthquakes.

A safety hazard is also associated with the uncontrolled release of fluid during a blowout or pipeline rupture. However, recent advances in blowout prevention technology have reduced this possibility.

Potential environmental benefits of geothermal development include water production for fish and wildlife management. Thoughtful mitigation measures taken during geothermal development could also improve habitat.

INSTITUTIONAL CONSTRAINTS

The principal restraints on rapid development of geothermal energy in Washington State include lack of tax incentives for drilling; a regulation system that discourages exploration; and lack of a distinct legal framework for the exploration, leasing and development of geothermal resources. However, the U.S. Department of Energy does have a substantial Geothermal Loan Gaurantee Program. To date, DOE has approved for gaurantees under the program projects with total costs of $43 million. Later commitments to the projects will total another $102 million. Four additional applicants are requesting loans totaling $88 million.

Part 4. Feasible Alternatives

Section F. Alternative VI: Coal-Fired Power Plants*

TECHNICAL DESCRIPTION

Coal plants, in which coal is burned to produce steam to turn generators, are a well established system for providing baseload energy. In the past, coal plants were located near or in cities, and fuel was transported long distances; now, plants are often located at the mine site, and the electricity they produce is transmitted to the customer. Coal deposits are found in several areas of Washington, Montana, Wyoming, and Alaska in quantities sufficient to support large power plants.

ECONOMICS

Energy costs for a new coal-fired power plant are 45-60 mills/kwh, and $960/kw (BPA Role EIS, 1980).

ENVIRONMENTAL IMPACTS

The most significant impacts of coal plants are those associated with air and water quality, coal mining and transportation, and social and economic issues. Air pollution impacts have been well documented (Dvorak, 1977). Particulates, carbon monoxide, nitrogen oxides, sulfur dioxide, and hydrocarbons can be emitted in quantities that significantly degrade air quality. Electrostatic precipitators can remove a portion of the particulate matter, and stack scrubbers partly remove sulfur compounds. Scrubber sludge should be disposed of such that its acidic leaching products do not pollute ground or surface waters. Water pollution problems are associated with blowdown from cooling towers that may be discharged into rivers and carry with it heat and chemicals. The cooling cycle also requires large amounts of water.

Coal mining, usually by strip mining in western states, can have ecologically disruptive effects. Improved reclamation techniques can avoid and repair at least part of the adverse impact in some cases. However, it is not possible to say that all significant damage to the terrestrial and aquatic ecosystems of any given site could be avoided.

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*Subsequent to publication of the DEIS, City Light began considering participation (with a 15 percent share) in a 2000 Mw coal-fired plant in Creston, Washington. These studies have not been completed, and they address planning needs larger than Copper Creek.

The major impacts of coal transportation are associated with plant operation and include noise, pollutant emissions, fire potential, chemical leaching, and aesthetic degradation (Szabo, 1978).

As with most large construction projects, impacts on local socioeconomics are described as "boom-bust" effects. That is, substantial swelling of the population and economic bases during construction is followed by a considerable deflation when construction ends. The need to expand housing and public services (utilities, health, schooling safety) in a short time results in a significant drain on the local economy after the project has ended and the work force has left.

INSTITUTIONAL CONSTRAINTS

Institutional constraints include state and federal air quality regulations, mining regulations, availability of sites, and Seattle's probable need to share ownership of a coal plant with at least one other utility.

Part 4. Feasible Alternatives

Section G. Alternative VII: Nuclear Fission

TECHNICAL DESCRIPTION

Of the three main types of nuclear power plants, only one, the nuclear fission light-water reactor, operates commercially in this country. The other types are not expected to be ready until the late 1990's; therefore, we do not consider them as practical alternatives. In the simplest sense, nuclear fission generating plants work on the same principles as coal-fired generation; the major difference is in the source of energy. In a coal-fired plant, coal is burned to generate heat; in a nuclear power plant, heat is generated through controlled nuclear fission reactions. The heat converts water into steam, and the steam either directly or indirectly powers a turbine; the turbine then drives a generator, and electricity is produced.

For both technical and economic reasons, the generation of electricity by nuclear fission is a source of baseload energy only. While nuclear fission offers a potential solution to fully or partially meet Seattle's future baseload energy demands, there are several areas of uncertainty. These concerns are focused for the most part on environmental, safety and financial issues.

ECONOMICS

Plant construction impacts compound the problems of a nuclear alternative. Construction delays make nuclear generation the most capital intensive ($ per kw) power plants in commercial operation. However, nuclear operating costs are the least expensive types of thermal plants to operate. Energy costs are estimated to be 40-60 mills/kwh and $1500/kw (BPA Role EIS, 1980).

ENVIRONMENTAL IMPACTS

Considering the complete fuel cycle, the environmental impacts of nuclear fission are extensive. The potential for exposure to radiation is encountered at most stages of the cycle: in mining and milling, in fuel fabrication and transportation, in reactor operation, and in waste management and disposal operations. In particular, the disposal of nuclear wastes remains a critical problem. They also pose a considerable waste heat problem, known as thermal pollution. They are less efficient than coal-fired plants (coal plants have 36-40 percent efficiency, versus 30-33 percent for nuclear), and produce up to 30 percent more waste heat. For the cooling capacity required to dissipate this heat, nuclear plants must be located close to sources of water. The long-term effects of this waste heat rejection on the aquatic environment are unknown but have been the subject of considerable debate. There may also be potential problems associated with copper toxicity.

The safety of nuclear plants has caused considerable public concern and is a central issue in the future of nuclear energy. Variables affecting the degree of safety include plant location, prevailing weather conditions, population densities at various distances from the plant, and promptness of evacuation. A major accident has the potential to cause thousands of deaths and ultimately tens of thousands of cases of cancer. However, a Ford Foundation study concludes that the probability of a major accident associated with current operations is about one chance in 200 million years of reactor operation.*

INSTITUTIONAL CONSTRAINTS

Currently, there is a moratorium by the Seattle City Council on the participation of City Light in the construction of additional nuclear power plants.

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* This study has been disputed by a number of energy analysts. See Nash (ed.), The Energy Controversy.

Part 5. Conclusions

EVALUATION MATRIX

Table 28 shows a ranking of alternatives, combining both quantitative and qualitative information. Energy costs have been culled from a variety of published sources, recognizing the uncertainties in assumptions on which the calculations are based. Developmental costs are critical for unconventional resources, but they can only be considered qualitatively at this stage. A second level of economic analysis would develop the quantitative information to calculate the net present value of actual programs. We have instead combined, according to our judgement, energy and program costs into a ranking. Other qualitative and environmental considerations serve as a secondary basis for ranking.

INTERPRETATION OF RESULTS

In this chapter the alternatives were compared with each other but not with Copper Creek (this is done in Chapter V). The ranking should be interpreted as a proposed direction for research and development leading toward implementation.

TABLE 28. Alternatives Evaluation Matrix

	Alternative	Estimated Energy Cost (mills/kwh)[1]	$/kw	Required Developmental Programs (2)	Economic Ranking	Qualitative and Environmental Considerations	Environ. Ranking
I.	No Action	n.a.	n.a.	None	7	Severe economic and social impacts	7
II.	Wind & Small Hydro	25-40[(3)]	1125	Wind - extensive Hydro - minimal	3	Wind - land use impacts Hydro - minimal	2
III.	Solar, Conservation & Load Management	15-20[(3)]	n.a.	Solar - intensive Conserv - moderate L.M. - moderate	1	Solar - some design conflicts Conserv. - minimal L.M. - some social impacts	1
IV.	Solid Waste[(4)] & Cogeneration	40-60[(5)]	1500	MSW - moderate Cogen. - moderate	4	MSW - air pollution Cogen. - noise, air pollution	4
V.	Geothermal[(6)]	20-30	1500	extensive	2	Land use impacts & air pollution	3
VI.	Coal-fired[(7)]	45-60	960	minimal	5	Land use, pollution, health	5
VII.	Nuclear[(8)]	40-60		Most already included in costs	6	Safety, waste management, decommissioning	6

(1) Estimated busbar costs (excluding transmission and distribution) in 1980 dollars; do not include costs of research, development and institutional support.

(2) Generally not included in estimated energy costs but necessary for use in 1990-2000 required time frame,

(3) Based on 15 mills/kwh estimate by MSNW; SCL added 5 mills/kwh for potential administrative costs (includes only a small proportion of passive solar savings)

(4) 15-30 mills/kwh (BPA Role EIS, 1980).

(5) Costs to the utility depend entirely on how steam and electricity costs are allocated by the producer and Public Utilities Regulatory Policies Act requirements for purchase; solid waste costs depend on waste disposal allocation. The energy cost figures come from a recent Rocket Research study (1980) for Cogeneration.

(6) (BPA Role EIS, 1980)

(7) 19-78 mills/kwh (BPA Role EIS, 1980)

(8) 66 mills/kwh (BPA Role EIS, 1980)

CHAPTER V. ECONOMIC AND ENVIRONMENTAL ANALYSIS

INTRODUCTION

As an information document an EIS serves two main purposes: (1) it identifies and describes the existing environment and how it may be affected by a proposed action, and (2) it reveals the nature of the decision-making framework for processing intangible environmental concerns alongside hard economic data. Ironically, the thrust of NEPA law has always been directed toward the former while actual decisions have been heavily influenced by the latter. As a consequence, many impact statements are highly descriptive, but somewhat irrelevant, documents. The economic analysis in EIS's has always been of a "by the way" nature.

Within the past few years the President's Council on Environmental Quality (CEQ) has solicited comments on ways to improve EIS procedures and standards. One frequent recommendation endorsed by CEQ is to make the EIS more of a decision-making instrument. Largely, this has entailed early incorporation of potentially feasible alternatives and mitigation measures into that process, and explicit description of the economic analysis underlying the decision. Environmental impacts are, of course, still of primary importance, but cost and value considerations are assuming increased importance.

There is a potential conflict between choosing the "environmentally preferable alternative " and policy concerns that "man and nature live in productive harmony." CEQ recommends that cost-benefit analysis include a discussion of "unquantifiable environmental impacts, values and amenities." They point out, however, that such environmental values need not be quantified and should not be quantified when there are important qualitative considerations. There are, however, systematic ways of processing qualitative information.

In the light of these related but conflicting goals, this section attempts to combine some of the diverse information contained in greater detail throughout the EIS study. The balance of the discussion is organized in the following way:

- Energy Requirements
- Decision Process
- Economic Analysis of Copper Creek
- Comparison of Alternatives
- Major Environmental Concerns
- Overall Evaluation

Appendix C, Economic Methodology, is a technical discussion of the economic analysis of the project.

Part 1. Energy Requirements

Future energy requirements are calculated on the basis of a load forecast, a summary of existing and future resources, and reserve margins. Each of these is discussed in turn. Where appropriate, a distinction is made between "most likely" and "unlikely but necessary in planning for uninterrupted service."

THE LOAD FORECAST

Future loads are taken from Seattle City Light's Forecast 1979/80 (September 1980). The average annual rate of growth is about 1.44 percent, which is less than the 1.8 percent growth forecast in 1978.

Peak loads are not forecast explicitly but are instead derived from past load factors (i.e., the ratio of average to peak loads). City Light's Power Management division uses the mean value from 1968-79 less two standard deviations. Thus, the estimated peak is not expected to be exceeded more than two and one-half percent of the time.

Two elements of the forecast important to the EIS review are large additions to industrial load and conservation.

Discrete Load Additions

Over the next eight years it is anticipated that several customers will ask for firm power, ranging from a few megawatts to 80 megawatts capacity; in response, 57 Mw average energy has been included in City Light's forecast to 1988 and extrapolated to 1999. For these new loads, the effects of alternative generation, interruptible (secondary) rates, load management, and nonconventional generation can easily be identified.

Conservation

Estimated energy load is shown after accounting for reduction resulting from the city energy code and new federal standards on appliance efficiency. In 1980 this is estimated to reduce energy and capacity requirements by 12 percent, and in the year 2000, by 20 percent. No separate accounting has been made for peak load dampening, such as that accomplished by various load management or demand control measures. The accuracy of long-range conservation effect estimates is questionable, since it is not known to what extent this effect is the result of temporary "belt tightening" or of improved efficiencies in end uses.

RESOURCES

Baseline resources include Seattle City Light's hydro facilities on the Skagit, Pend Oreille, and Cedar rivers; its share of coal thermal power at Centralia; BPA allocation; and other purchase contracts. High Ross Dam, or equivalent power from British Columbia Hydro, is assumed to be completed by 1985. Other additions under study (Copper Creek; capacity increases at Diablo, Gorge and Boundary; and the Tolt River development) have not been included in baseline resources. Each type of generation (owned hydro, thermal, and purchased hydro) carries with it a different proportion of peaking capability. New, nonspecific generation is, therefore, assumed to provide on the average 10 Mw capacity for each seven Mw of energy.

Reserve Margin

Planning for adequate resource capability requires a reserve margin to account for generation equipment failure and uncertainty in the load forecast. An average energy reserve of five percent of load is required after 1983 to meet unexpected load increases. Prior to that time, the Bonneville Power Administration will supply average energy reserves as part of its contractual arrangement with City Light. Capacity (or forced outage) reserves amounting to eight percent of peak load are required under the Pacific Northwest Coordination Agreement. These ensure against equipment and transmission failures in relation to peaking load characteristics.

Another kind of "reserve" is provided by the way water resources are evaluated. By regional agreement, Pacific Northwest utilities measure hydropower potential on the basis of a "critical period of record" during which water availability was at an all-time low. This is expected to occur once each ten to twenty years. Critical water is about 15 percent less than median water. However, since system reliability is defined on the basis of the former, the difference does not contribute to firm energy resources; instead, it provides secondary (or surplus) energy, which is exchanged within the regional power pool or marketed outside the system.

Adjustment for Realization

Hydropower resources have traditionally been evaluated for their potential to deliver peaking energy over a short duration. As system peak loads become more sustained, an adjustment to declared peak capability must be made to account for broader peak requirements. This realization adjustment is currently estimated at 56-Mw reduction for capacity, which is due to loss of head at Ross and Boundary Dams during sustained peaking. A four-Mw reduction of average energy capability is made on power from the Skagit system. This results from downstream spillage as Ross Dam is operated for greater peaking capability.

System Flexibility

The way in which Seattle City Light's own hydro resources are operated to maximize peaking or energy needs is balanced according to short-term needs. In the short term there is also some flexibility in meeting peak and energy deficits. Until 1983, the BPA allocation guarantees energy sufficiency; after 1983, the allocation no longer guarantees energy sufficiency but replaces the declining amount of energy from the Columbia Storage Power Exchange (CSPE).

For extreme or unanticipated capacity needs, Seattle City Light can purchase capacity from BPA under a 12-month commitment or buy capacity from private utilities. In 1979-80, a contract for the right to buy 100-Mw capacity from Portland Gas and Electric cost $200,000 per month for three months. In addition to being costly, these resources are not assured for future years.

A final measure is to adjust large loads. These are accomplished under the terms of Industrial Rate 62, which permits four-hour interruptions unless these customers instead choose to forego a demand credit. In the past two seasons, 40-50 Mw of peaking load have been shifted during critical periods.

RESOURCE BALANCE

Table 29 shows Seattle City Light's total resources, reserve requirements and net resources. Table 30 shows the balance of anticipated loads and resources through the end of the century. A small energy deficit occurs in 1987 and increases to 256 Mw by the end of the period. There is an immediate peaking deficit which is corrected in 1985 only if power from High Ross Dam is available. After several years of surplus, the peaking shortage then continues through the study period.

When energy sufficiency is assumed and some additional capacity is provided from load-shaping resources, the peaking deficit may be reduced to some degree. Figure 21 shows projected load and resources graphically.

Table 29. Seattle City Light Resources to Year 2000
(Megawatts)

Water Year	(A) Hydro (1)		(B) Thermal (2)		(C) Contracted		(D) BPA Allocation (3)		(E) Total Resources		(F) Required Reserves (4)		(G) Net Resources	
	Peak	Avg.	Peak	Avg.	Peak	Avg.	Peak	Avg.	Peak	Avg.	Peak	Avg.	Peak	Avg.
1980-81	1281	603	30	0	122	77	308	308	1741	988	144	0	1597	988
81-82	1281	603	30	0	121	76	333	333	1765	1012	145	0	1620	1012
82-83	1281	603	30	0	116	73	363	363	1790	1039	151	0	1639	1039
83-84	1281	603	135	74	265	133	294	291	1981	1107	153	53	1822	1048
84-85	1281	603	135	74	259	129	298	294	1979	1106	154	53	1819	1047
85-86	1535	639	135	74	252	125	303	297	2231	1141	155	53	2070	1082
86-87	1535	639	135	74	244	120	308	301	2228	1140	156	54	2066	1080
87-88	1535	639	135	74	237	115	316	304	2226	1138	161	56	2059	1076
88-89	1535	639	135	74	229	111	318	307	2223	1137	166	57	2051	1074
89-90	1535	639	135	74	226	108	318	309	2220	1136	168	58	2046	1072
90-91	1535	639	135	74	224	104	317	311	2217	1134	172	59	2039	1069
91-92	1535	639	135	74	210	101	325	313	2214	1133	174	60	2034	1067
92-93	1535	639	135	74	196	98	339	314	2211	1131	176	61	2029	1064
93-94	1535	639	135	74	180	95	351	316	2207	1130	178	61	2023	1063
94-95	1535	639	135	74	166	92	362	317	2204	1128	181	62	2017	1060
95-96	1535	639	135	74	151	88	373	319	2200	1126	182	63	2012	1057
96-97	1535	639	135	74	136	65	384	320	2196	1124	185	63	2005	1055
97-98	1535	639	135	74	131	81	386	322	2193	1122	187	64	2000	1052
98-99	1535	639	135	74	124	72	393	329	2193	1120	189	65	1998	1049
99-00	1535	639	135	74	96	60	421	339	2193	1118	192	66	1995	1046

(1) High Ross or its equivalent from BC Hydro is assumed from 1985 on.

(2) Power from the coal-fired plant in Centralia is contracted out of the system until 1983.

(3) Will vary somewhat with new regional forecasts and generation.

(4) Calculated on the basis of "loss of load probability" (LOLP); eight percent of peak load is assumed as new generation comes on line to meet that load; five percent of average load is assumed.

Source: Resource Analysis 1980, Power Management Division, SCL.

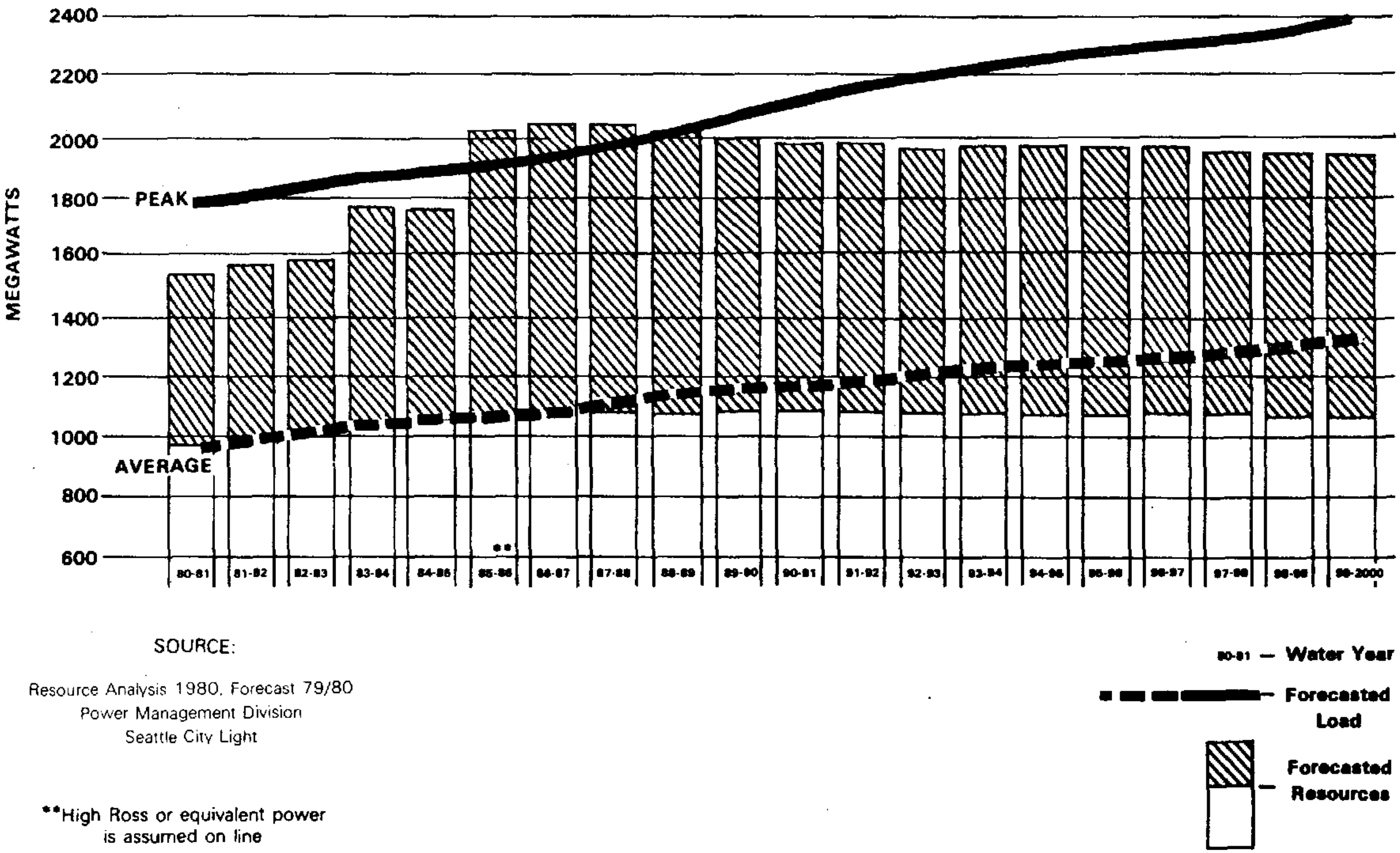
Table 30. Requirements to Year 2000
(Megawatts)

Water Year	(A) Forecast		(B) Resources (Before Realization)		(C) Realization Adjustment (1)		(D) Resources (After Realization)		(E) Surplus (Deficit)	
	Peak	Avg.	Peak	Avg.	Peak	Avg.	Peak	Avg.	Peak	Avg.
1980-81	1800	981	1597	988	(56)	0	1541	988	(259)	0
81-82	1802	1000	1620	1012	(56)	0	1564	1012	(238)	0
82-83	1866	1021	1639	1039	(56)	0	1583	1039	(283)	0
83-84	1881	1029	1822	1048	(56)	(4)	1766	1044	(115)	15
84-85	1888	1033	1819	1047	(56)	(4)	1763	1043	(125)	10
85-86	1902	1043	2070	1082	(56)	(4)	2014	1078	112	35
86-87	1922	1058	2066	1080	(56)	(4)	2010	1076	88	18
87-88	1955	1089	2059	1076	(56)	(4)	2003	1072	48	(17)
88-89	2034	1120	2051	1074	(56)	(4)	1995	1070	(39)	(50)
89-90	2073	1143	2046	1072	(56)	(4)	1990	1068	(83)	(75)
90-91	2121	1167	2039	1069	(56)	(4)	1983	1065	(138)	(102)
91-92	2161	1186	2034	1067	(56)	(4)	1978	1063	(183)	(123)
92-93	2188	1199	2029	1064	(56)	(4)	1973	1060	(215)	(139)
93-94	2213	1212	2023	1063	(56)	(4)	1967	1059	(246)	(153)
94-95	2238	1226	2017	1060	(56)	(4)	1961	1056	(277)	(170)
95-96	2262	1239	2012	1057	(56)	(4)	1956	1053	(306)	(186)
96-97	2285	1253	2005	1055	(56)	(4)	1949	1051	(336)	(202)
97-98	2313	1268	2000	1052	(56)	(4)	1944	1048	(369)	(220)
98-99	2341	1283	1998	1049	(56)	(4)	1942	1045	(399)	(238)
99-00	2369	1298	1995	1046	(56)	(4)	1939	1042	(430)	(256)

(1) "Realization" is an adjustment to declared peaking capability to derive sustained (i.e., 12 hours duration)peaking. Some energy adjustment is necessary to operate Ross Dam for greater peaking capability.

Sources: Resource Analysis 1980, and Forecast 1979/80, Power Management Division, Seattle City Light

20-YEAR RESOURCES AND LOAD TABULATION



SOURCE:

Resource Analysis 1980, Forecast 79/80
Power Management Division
Seattle City Light

**High Ross or equivalent power is assumed on line

Figure 21 Twenty-Year Resources & Load Tabulation

Part 2. Decision Process

PROJECT DECISION

A distinction is sometimes made between a programmatic and a project EIS. The Energy 1990 study in 1976 was a programmatic EIS, reviewing the entire spectrum of Seattle's resource planning needs. The Copper Creek study, a project EIS, is concerned with a specific proposed action to meet future energy needs. A generation mix of 49 Mw average firm energy and 110 Mw peaking energy is potentially available at low cost at Copper Creek.

Design alternatives, such as a similar power generation facility at Damnation Creek, have different power characteristics (see Table 2). Project alternatives, such as increased conservation or alternative energy generation systems, are tailored to correspond to the proposed action--Copper Creek. Each alternative has ancillary benefits and costs, which are not essential characteristics of the alternative but are accounted for in the economic analysis.

CHOOSING AMONG ALTERNATIVES

Having determined power requirements, the investment decision would seem only to be that of choosing the least-cost alternative. This simple maxim is complicated by two factors: the benefits of each alternative vary to some extent and environmental factors must be incorporated in the decision.

Copper Creek would provide reregulating benefits, and it would thus make possible capacity expansion at Gorge and Diablo. It has low operating costs but incurs some difficult-to-quantify environmental costs. Various combinations of energy alternatives, such as passive solar, conservation and load management, provide similar power characteristics and would have fewer environmental problems but do not provide the ancillary power generation benefits of the proposed project. Subsequent sections treat these economic issues and environmental tradeoffs. Methods of treating quantitative and nonquantitative information are discussed in Appendix C.

The decision which is the subject of this EIS is whether or not City Light should prepare a FERC license application to construct Copper Creek Dam or a similar hydroelectric facility on the Skagit River. The option of preparing an application will be considered by City Council in April 1981; the application must be filed with FERC by

December 31, 1981, after which time City Light's preliminary permit will expire.

ALTERNATIVE COURSES OF ACTION

The City Council may take one of two courses of action on the proposed project:

- Endorse the project. City Light would pursue the application and license process for Copper Creek, while coninuing to explore alternative energy resources. The Council may have City Light prepare the application but wait until December, 1981 to grant authority for filing with FERC. Although construction could not begin until a license is granted, the decision to apply would be regarded as a commitment to build the project.

- Place the Copper Creek project in contingency reserve or in abeyance. The former allows studies to reduce implementation lead time but does not grant authority to file. When a project is in abeyance, further studies and expenditures are discontinued. In both cases, City Light would lose its proprietary right, granted by FERC in 1978 and extending for a period of three years, to develop the project. Other utilities or individual corporations would then be allowed to apply for a license at Copper Creek, thereby precluding any further development by City Light. If a negative decision is made on Copper Creek, it is assumed City Light would be directed to pursue one or more of the options developed in the EIS or others as desired.

FUTURE NEEDS AND INVESTMENT TIMING

It is important to realize that energy needs are expected to grow beyond the amount supplied by the proposed project or its power equivalent. Therefore, Seattle City Light may be required to add more than 200 Mw of generating capability or energy displacement in the next two decades. As decisions are made to develop low cost, socially acceptable resources, other available resources move up the list.

A decision on Copper Creek itself, assuming the project is not absolutely ruled out, is largely a matter of timing. Future requirements may revive consideration of Copper Creek, although by then the City may have lost its proprietary right to the site (if a FERC license application is not filed by December, 1981).

Part 3. Economic Analysis of Copper Creek

BENEFITS

The primary benefit of the facility would be to provide 49 megawatts for meeting firm energy needs. With a maximum flow of 10,000 cfs, Copper Creek would also provide 110 megawatts of peaking capability. For intermediate capability (up to 1000 hours during winter), the facility could supply only 80 megawatts because it would function as a reregulating reservoir. These values are reflected in the economic summary.

Copper Creek has some secondary benefits which cannot readily be quantified: (1) Greater regulation of downstream flow would be possible with the dam. This may reduce aquatic food chain losses. A detailed flow regime in conjunction with a fisheries mitigation program and power requirements remains to be worked out, however. (2) With the construction of Copper Creek it would be possible to increase generating capacity at Gorge and Diablo by as much as 334 Mw. The costs, timing, feasibility, and likelihood of such construction have not been developed at this time, and this benefit therefore was not included as an integral part of the proposed action at Copper Creek. (3) Copper Creek will enhance the flexibility of upstream dam operations. This will allow Gorge Powerhouse's 175 Mw of capacity to follow load fluctuation. (4) The facility will, in normal years, produce an additional 13 Mw of secondary energy.

COSTS

Construction costs have been estimated at $245 million in 1980 dollars. Annually, operation and maintenance would cost $1 million, and transmission and distribution $1.6 million. These are summarized in Table 31.

There are other social and environmental costs associated with the construction and operation of the dam, which fall into the following major categories:

- fish and wildlife;
- whitewater activities and other recreation;
- socioeconomic impacts of construction;
- altered local life-styles;
- dam safety; and
- transfer of benefits to outside area (not, strictly speaking, a cost of the project).

TABLE 31. Summary of Costs and Benefits for the Copper Creek Project (1980 Dollars)[1]

DIRECT COSTS	ANNUAL AMOUNT	PRESENT VALUE[2]	METHOD OF TREATMENT[3]
Construction[4]	------	183,891,395	First Level
Interest during construction[5]	------	61,395,349	First Level
Operations and maintenance	902,000	27,285,500	First Level
Transmission and distribution	1,624,700	49,147,175	First Level
TOTAL DIRECT COSTS	------	321,719,419	First Level
INDIRECT COSTS			
Fisheries mitigation		3,500,000[6]	Second Level
Other mitigation[7]		11-13 million	Second Level
Intangible costs		------	Non-Quantified
DIRECT BENEFITS			
Peaking energy	22,000 mwh/yr		First Level
Intermediate energy	80,000 mwh/yr		First Level
Off-peak energy	329,868 mwh/yr		First Level
Secondary energy	107,748 mwh/yr		First Level
INDIRECT BENEFITS			
Reregulation to reduce fish food chain impacts		------	Non-Quantified
Possible installation of 334 Mw added capacity at Gorge and Diablo		------	Non-Quantified
Increase flexibility of upstream operations		------	Non-Quantified

Notes:

1. All values expressed in real (1980) dollars where the year's midpoint is assumed and a 13 percent inflation is assumed (other inflation rates may have been assumed within the engineering cost estimates).
2. Present value dollars are calculated from future cost and benefits using a 3 percent real discount rate.
3. The first-level treatment deals with fairly certain numbers; the second level deals with values which are difficult to estimate or depend on future policy decisions; some values cannot reasonably be quantified.
4. Includes some mitigation costs and highway relocation, contingencies (10%), sales tax (5.4%) and engineering and legal (12%).
5. Assumes 9-1/2% nominal interest rate with 9-1/2% reinvestment return.
6. Upper estimate of spawning channels program based on Washington Department of Fisheries management goals (included in construction cost estimate - $5.6 million for fisheries, campground relocation and minor mitigation).
7. Includes in-lieu property tax payments, wildlife habitat compensation program and possible whitewater compensation programs. (See Summary Table)

Some of these environmental and social impacts may be mitigated by programs which would add directly to construction costs. Others are unavoidable impacts but may require some kind of monetary or alternative resource compensation to affected parties. These will be discussed more fully in a subsequent section, but it is important to realize that both pecuniary and nonpecuniary costs are associated with project development. Fair treatment requires that other energy alternatives be examined in the same light, although necessarily in less detail.

BASELINE CASE

The first level case of analysis considers only definite costs and benefits. A second level adds the costs of mitigation programs. Table 32 shows 1980 present worth of initial and future values. The latter are converted to present values using a three percent discount rate over 50 years. Total costs consist of construction, operation and maintenance (O&M) and transmission and distribution (T&D). The consideration of all costs between generation plant and the consumer facilitates comparison with alternatives which may have lower delivery costs.

In order to calculate benefits of time-differentiated energy output, we followed the procedure currently used at City Light: the costs of thermal facilities are regarded as the next best opportunity if the project in question is not built.

The summary statistics in Table 32 show different ways of evaluating the investment; each is useful in its own way. A positive net present value (NPV) denotes project feasibility. The $190 million net return may compare favorably with the NPV of other alternatives, if they can be described specifically enough to calculate NPV. A savings-investment ratio (SIR) of 1.78 indicates a high rate of return on the initial investment, which might be important when there are practical budgetary limitations. Levelized cost (LC), calculated by dividing annualized costs by average (firm and nonfirm) output, is 23.2 mills/kwh. Although this is low compared to most alternatives, the comparison will be misleading if the assumptions supporting the calculations do not withstand close scrutiny. For this reason a "sensitivity" analysis was undertaken. Table 33 displays the results.

SENSITIVITY ANALYSIS

The baseline analysis evaluated energy benefits at opportunity costs reflecting thermal generation as next best future resources. For purposes of sensitivity analysis we have assumed lower costs, possibly from a combination of conservation, load management, and nonconventional alternatives. These are illustrated in Case III. Case I uses an alternative discount rate of seven percent, comparable to that used in federal water resource proects. Case IV uses a two percent discount rate.

TABLE 32. Economic Analysis
(Baseline Case)

Assumptions

- o 50 year life
- o 3 percent real discount rate (net of inflation)
- o operation in 1990; 5 year construction time
- o thermal costs for energy valuation (1% escalation per year net of inflation)
- o capital, operation and maintenance, transmission and distribution costs escalate by 0.8% per year net of inflation

		Present Value	
I. Costs		First Level	Second Level
Construction		183,891,395	183,891,395
Interest during construction		61.395,349	61,395,349
Operations and maintenance		27,285,500	27,285,500
Transmission and distribution		49,147,175	49,147,175
Mitigation		----	13,000,000
TOTAL		321,719,419	334,719,419
II. Benefits			
Peaking	@ 119 mills/kwh	82,611,000	82,611,000
Intermediate	@ 63.6 "	160,552,000	160,552,000
Off-Peak	@ 21.9 "	227,957,000	227,957,000
Secondary	@ 12.0 "	40,800,000	40,800,000
TOTAL		511,920,000	511,920,000
III. Summary Statistics			
Net Present Value ($)[1]		190,200,581	177,200,581
Savings investment ratio[2]		1.78	1.72
B/C Ratio[3]		1.59	1.53
Levelized cost (mills/kwh)[4]		23.2	24.1[5]

Notes:

1. Total benefits less total costs
2. Net benefits divided by investment costs including interest during construction (e.g., (511,920,000 - 27,285,500 - 49,147,175) ÷ 245,286,744 = 1.78)
3. Total benefits divided by total costs
4. Construction plus operating costs converted to an annualized amount, divided by average energy output.
5. Based on a preliminary assumption of $13 million added mitigation costs (each $14 million adds 1 mill/kwh)

TABLE 33. Sensitivity Analysis

	BASELINE	CASE I	CASE II	CASE III
Discount Rate	3%	7%[2]	2%	3%
Energy Values (mills/Kwh)	(119, 63.6, 21.9, 12)[1]	Baseline	Baseline	(60, 40, 20, 12)[3]
COSTS		$(000)		
Constr. & Int.	245,287	245,287	245,287	245,287
O & M	27,286	13,923	33,840	27,286
T & D	49,147	25,079	60,953	49,147
TOTAL	321,720	284,289	340,080	321,720
BENEFITS		$(000)		
Peaking	82,611	41,610	102,851	41,653
Intermediate	160,552	80,869	199,887	100,976
Off-Peak	227,957	114,820	283,806	208,180
Secondary	40,800	20,551	50,797	40,800
TOTAL	511,920	257,850	637,341	391,609
SUMMARY STATISTICS				
NPV $(000)	190,201	-26,439	297,261	69,889
SIR	1.78	0.89	2.21	1.28
B/C	1.59	0.91	1.87	1.22
Levelized Cost (mills/Kwh)	23.2	38.2	20.1	23.2

NOTES:

1. Based on future fossil-fired generation costs

2. All federally evaluated water resource projects currently use 7-1/8% real discount rate; other federal investments are evaluated at 10%.

3. These values assume the implementation of load management and conservation (or alternatives which have lower costs than gas, oil and coal) for at least a good share of future needs. They are based on judgment and cannot be accurately documented.

Part 4. Comparison of Alternatives

MAJOR ALTERNATIVES

The previous chapter outlined six feasible alternative energy resources. Before comparing each of them to Copper Creek (Table 38) we can eliminate some alternatives from further consideration. When an energy resource is both more costly and environmentally degrading, it is an inferior alternative. Coal-fired and nuclear plants will cost two to three times as much as Copper Creek (energy cost in mills/kwh), and it is our judgement that their environmental costs are as severe as those associated with the Copper Creek Project.* In addition, we recognize the priority, by City Council resolution, given to renewable resources where possible.

Although geothermal may have potential application, we have no way of knowing at this time the extent of development costs. Since there are also significant pollution and land use problems, we can drop geothermal from further consideration in this EIS. It may, however, be considered more fully in future studies.

Remaining alternatives summarized below are in the same range of economic costs (and benefits) as Copper Creek but may have fewer environmental impacts. At the same time, they also require additional expenditures in developmental programs and fail to provide reregulation, operating flexibility, and the possibility for future expansion of Gorge and Diablo plants.

QUALITATIVE CONSIDERATIONS

Wind and Small Hydro Alternative

Small hydro stations may use existing irrigation dams, stream flow or new, small-scale dams. When these are surveyed and their descriptive information organized by

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* Subsequent to the publication of the DEIS, City Light began considering participation (with a 15 percent share) in a 2000 Mw coal-fired plant in Creston, Washington. Since studies on this project have not been completed, and this option addresses general supply needs, we have omitted further discussion of coal-fired generation in this FEIS.

technical and economic priority, we can better compare them to conventional generation options. From other research and literature we can say that their environmental impacts appear to be minor. For example, wind energy conversion systems can be built adjacent to existing transmission corridors to minimize land-use impacts and reduce transmission costs.

This combination alternative will require considerable research and development expenditure, and the time required for implementation may put it at a disadvantage with Copper Creek, which can be on-line in 1990. The major advantages of this alternative are twofold: (1) It is a renewable resource with fewer environmental costs; and (2) it increases energy supply, thus avoiding the costs and uncertainties associated with demand-reducing or demand-controlling options.

Solar, Conservation and Load Management Alternative

For several years, these resources have been considered the most promising of non-generating energy alternatives. Solar and conservation research and development are now under the direction of a single office at City Light. There is no question that saving energy should be examined before planning new generation of energy. Saving energy also reduces transmission and distribution costs as well as other operational costs. At the same time, new programs require development and on-going administrative costs. In addition there are some hardware costs and potential customer inconvenience. Passive solar, for example, requires a re-thinking of design parameters by architects. City Light could offer financial incentives to encourage new design concepts or different operating regimes for commercial buildings.

When all these costs, both pecuniary and nonpecuniary, are accounted for, saving energy may be less economic than developing new resources. In this and the preceding chapter we have taken the view that additional energy-use efficiency is cost-effective. By "cost-effective" we mean that the cost of saving energy would be less than the cost of energy from thermal resources in the future; the cost of energy saved may also be less than that of Copper Creek.*

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* Studies completed after publication of the DEIS have indicated substantial conservation potential at lower pecuniary costs than Copper Creek (see Chapter IV, Part 4, Section C).

There are only minor environmental impacts associated with this combination alternative. Most of the impacts are social because many conservation and solar options now being discussed would operate at some customer inconvenience and economic cost.

If programs are voluntary, and the customer is assumed to have complete information, it can be assumed that most individual customer decisions are cost-effective. If programs are mandatory, then some measure of social costs must be taken into account. In this report we can do little more than call attention to these considerations.

Municipal Solid Waste and Cogeneration Alternative

This combination, like the previous one, represents options that are currently being considered. The City of Seattle and King County are jointly involved in a program to develop solid waste as an energy resource (in conjunction with waste disposal), and City Light is investigating cogeneration possibilities. On-site cogeneration is a good possibility in Seattle since there are a number of industrial firms which currently use fossil fuels for process heat. As long as electrical energy prices do not become relatively too low, it may be to some firms' advantage to develop cogeneration.

As a nonrenewable resource we should view the solid waste/ cogeneration alternative as a transitional technology.* While there are pollution and fuel supply problems associated with the use of fossil and other fuels, we can argue that an improvement of an "inefficient" resource is better than nothing.

The results of solid waste research and attempts to encourage cogeneration cannot be predicted at this time. Results will depend to a large extent on allocation of program development money and effort. One advantage of cogeneration resources may be the relatively short time period required to put them into service.

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* Conversion of solid waste to usable energy is transitional if the level of solid waste produced is regarded as excessive.

Part 5. Major Environmental Concerns

THE ISSUES

In this section we summarize the major issues raised in Chapter III:

- fish and wildlife
- whitewater activities and other recreation
- socioeconomic impacts of construction
- cultural values and local life-styles
- dam safety
- transfer of benefits from Skagit County to Seattle

Even though some of these issues are concerned with intangible values, we have included them in the description of the decision process. Most environmental and social impacts are difficult to identify and quantify. We can, however, mention mitigation/compensation programs and tentatively estimate their costs. The final determination of a program must be negotiated between City Light and concerned agencies. In many cases a conservative (high) estimate of mitigation costs was made exclusively to evaluate the impacts of possible mitigation measures on project cost, not as the most likely level of expenditure.

Many impacts cannot be avoided, and some can only be partially mitigated. The range of impacts and types of mitigation/compensation programs are outlined below:

<u>Mitigation</u>

Avoidance of impacts in project design (e.g., dam location)

Mitigation in design (e.g., type of construction)

Supplemental mitigation measures to reduce direct impacts (e.g., construction of spawning channel for fish)

<u>Compensation</u>

Monetary compensation (e.g. "in-lieu" tax payments)

In-kind compensation (e.g., development elsewhere of the same type of resource)

Resource substitution (e.g., development of flat water recreation for river resources)

<u>Unavoidable Impacts</u>

FISH AND WILDLIFE

Fisheries

Impacts of the proposed dam on Skagit fisheries are determined by two factors: alteration of stream flow conditions and loss of spawning grounds. Under the proposed Copper Creek operating regime, regulated flow would increase insect production and improve the fishery to an unknown degree. The resulting availability of fish food would thus be greater than under the current flow regimes. The impact and costs of the loss of spawning areas above the Copper Creek dam site and removal of about 10 miles of spawning habitat have been estimated in the Fisheries Section of Chapter III. These affect the commercial, sport and American Indian fisheries. The monetary costs are summarized in Table 34 (see the Fisheries Section for full explanation of fisheries loss values).

TABLE 34. Monetary Costs of Fishery Losses

Fishery	Annual Loss	Present Value 1980*
COMMERCIAL		
Current Conditions	$108,000	$ 3,412,692
WDF escapement goals	560,000	17,695,440
SPORT (steelhead & salmon)		
Current conditions	35,000	1,105,970
WDF escapement goals	84,000	2,654,320
AMERICAN INDIAN**		
Current conditions	73,547	2,234,012
WDF escapement goals	382,809	12,096,382

* Calculated to perpetuity at a 3 percent discount rate.

** Included in Commercial (about 70%)

The total loss of fisheries resources, without any mitigation program, is about $140,000 to $644,000 annually, or a present value of $5 to $20 million. The actual amount would depend on negotiated flow regimes. There are no rare, endangered or threatened fish species inhabiting the Skagit.

Mitigation programs. Losses can be mitigated through hatchery production and/or the construction of spawning channels if necessary. A hatchery could be constructed for $640,000 and maintained for $150,000 annually. This amounts to a present value cost of $4.7 million. A spawning channel could be constructed for about $3.5 million, in addition to some minor maintenance costs.

As we discussed in the Fisheries Section of Chapter III, potential damage to the gene pool from hatchery production suggests the superiority of the spawning channel alternative.

Bald Eagles

More than 300 bald eagles (about a third of the number throughout the state) winter on the Skagit River. Based on studies (during an extremely poor food resource year), we can tentatively estimate that construction of the dam may reduce the number which can winter on the Skagit by as much as 10 to 40 percent. Some of these could successfully migrate to other areas, but there is a possibility of a partial loss over the entire region.

In addition to their biological value, bald eagles have an aesthetic and recreational value to Skagit visitors. There is also an "option" value to nonvisitors. The Nature Conservancy and Washington Department of Game maintain the Skagit River Bald Eagle Natural Area. Over 90 percent of the people surveyed during visits were there for nonconsumptive recreational uses. Most of these visits are for viewing eagles.

Bald eagles are protected under the Endangered Species Act as a threatened species. This means that they are likely to be endangered in the future. For this reason, the U.S. Fish and Wildlife Service may set conditions for construction of a dam. The U.S. Forest Service, as administrator of the Wild and Scenic Rivers Act, may also impose conditions. Either agency, if it determined that damage to eagles was too severe, could request that FERC not issue a license. The most likely conditions an agency might impose would be a requirement for mitigation of damages to the fisheries.

Mitigation programs. If necessary, the fish resource could be replaced by hatcheries and/or spawning channels, maintaining the same level of eagle food supplies but at different locations. Additional ponds (such as the County Line Ponds the eagles used during the winter of 1979-80) can be dug and stocked with fish (see Bald Eagles Section of Chapter III). Further studies would be required in order to evaluate how successful any of these programs would be, and whether artificial feeding of eagles would have biological repercussions.

We made no attempt to estimate the costs of mitigation or to place a value on potential eagle losses. We cannot quantitatively evaluate eagles as a biological and human resource because key questions are unanswered. Nonetheless, eagles remain an important, yet intangible, consideration in the Copper Creek decision.

Other Wildlife

Eagles and fish have been singled out for special consideration because of their economic importance and recognized value to mankind. Other Skagit wildlife may be less well known but no less significant. In the Wildlife Section of Chapter III we identified the many species which could be impacted by project construction and loss of 2,400 acres of varied habitat. Because of the complexity and lack of detailed knowledge about wildlife, we did not attempt to estimate specific losses.

Mitigation. Some impacts can be partially mitigated with on-site programs. These include:

- creating small, year-round wetland habitats;
- good management of transmission line right-of-way (no herbicides);
- less shoreline manicuring, allowing growth of natural species; and
- creating clearings in adjacent woodlands for habitat diversity (i.e., transitional zones).

Some or all of these programs may be implemented as a result of a wildlife mitigation plan which will be prepared prior to project construction. It is anticipated that the relative cost of these measures would be minimal.

The permanent loss of the varied habitat (in age, species and mix) of 2,400 acres cannot, in any meaningful sense, be mitigated. We can, however, in part compensate for lost habitat with better management of other areas. The Habitat Evaluation Procedure (HEP) described in Chapter III was an inter-agency survey of species and habitat in the impacted area. Other areas controlled by public agencies may be available for management to a greater degree to enhance the survival potential for many of the same species lost to the Skagit development.

The costs of compensation programs are difficult to determine at this time because equivalent areas would have to be identified and surveyed, and management programs would have to be outlined. Based on similar programs for the High Ross study area, however, such a program may cost $1.3 million. While management costs alone are significant, there are also "opportunity costs" associated with restricting additional areas to limited economic development. The essence of the compensation principle is that productivity gains from Copper Creek (i.e., its net economic benefits) must be greater than the costs of compensation, along with other indirect costs of the project.

Other Nonconsumptive Uses

With or without implementation of mitigation measures, project construction would still cause a significant loss in the wildlife resource on the Skagit. Through flooding, much of the resource would be lost to nonconsumptive use of the Skagit area, although other less accessible areas might be enhanced providing some compensation for lost wildlife resources. This is not an economic loss associated with the project.

Although many impacts are local, most users come from the large urban areas. There would be a temporary dislocation of the recreational site, but over time other (different) resources would be developed. This type of distributional shift is discussed below.

WHITEWATER ACTIVITIES AND OTHER RECREATION

Current recreation activities on the Skagit include fishing and hunting, hiking, picnicking and sightseeing, wildlife observation and whitewater sports. In 1979 there were 5,000 recreational vehicle campers and 3,000 tent campers at Goodell Creek campground, 33,000 backpacker visitor nights and 672,000 highway visitors. The project area currently supports recreational potential in a diversity of physical settings: river and river shore, valley floor and steep hillsides. It is a transitional area between the open valley and the rugged mountain terrain east of Newhalem.

The project area contains the only remaining whitewater in the Ross Lake National Recreational Area. Its one-and-one-half miles of rapids in a ten-mile stretch of free-flowing river is a popular rafting area, as well as a challenging resource for kayakers and canoeists. The relative importance of this resource has increased over the years as dam construction has eliminated many of the region's natural-flowing rivers. This run of the river also has good accessibility at either end. In 1978, there were 462 commercial float trips taken by 1,500 to 1,800 individuals (CH_2M-Hill, 1979).

The major impacts of the Copper Creek Dam are a short-term disruption of recreational activities during construction, permanent loss of whitewater activities and a substitution of lake for river activities. Whether the latter impact is a net gain or net loss is a matter of individual judgement, although there is certainly a loss of recreational diversity.

Mitigation

Table 35 indentifies specific impacts and describes potential mitigation programs. Most programs would alleviate impacts to some extent or provide compensation with other highly-valued recreational resources. It is hard to say, on balance, whether the net social cost is positive or negative. Whitewater activities on the Skagit, however, would be lost, and it is clear that opportunities for substitutes elsewhere are limited and may be impractical. We did not estimate costs of mitigation programs.

SOCIOECONOMIC IMPACTS OF CONSTRUCTION

The five-year construction period of the Copper Creek Project would have a temporary impact on the economy, housing, public services and life-styles of people now living in the surrounding area. While the unincorporated areas have experienced more recent growth, they and the small towns of Lyman, Hamilton and Concrete, which are near Copper Creek, are relatively stabilized and self-sufficient.

In the Human Environment part of Chapter III, we discussed a range of hiring possibilities for the peak construction work force of 450--from all local workers to all nonlocal workers who would have to move to the Skagit Valley for the duration of their employment on the project. The former is feasible if union and affirmative action requirements can be met; the latter is unlikely but possible if there were other major construction projects (e.g., raising Ross Dam) going on in the area at the same time. We have identified the constraints of accommodating a number of nonlocal workers and their dependents in local towns (Table 20). In Marblemount, for instance, electrical, sewage and water facilities would be inadequate and housing would be limited; the town has no local police, medical personnel, or schools. The problems for Marblemount and the other small communities are the familiar ones associated with "boom and bust" economies.

Table 35, Recreational Impacts and Potential Mitigation or Compensation

	Impact	Mitigation/Compensation
1)	Lost river recreation	Lake recreation or in-kind compensation elsewhere by development of river accessiblity
2)	Flooding of 7 to 10 miles of scenic river valley and 2,200 acres of valley floor, including the loss of 290 river campsites at Newhalem and Goodell Creeks.	Increased viewing from lake; relocation of campsites and provision of boat-access
3)	Up to 10 miles of transmission corridor relocation	Location away from shorelines and selective cutting
4)	Ten miles of road relocation to a new highway corridor, creating construction scars and disrupting recreational traffic during construction period.	Making the road as natural as possible and revegetation programs, building an overpass or underpass to separate construction and recreation traffic
5)	Reservoir drawdown by as much as ten feet during winter months and one foot in the summer	Grooming and selective planting of shoreline vegetation

Mitigation

Because of limited facilities, particularly a shortage of housing, most nonlocal workers would not be able to relocate in the small upper valley communities without some type of assistance program. We discussed a number of potential mitigation measures (Table 21) which could reduce the impacts on utilities, public services, housing and schools.

One way of accommodating nonlocal workers in the upper Skagit would be to operate a housing camp and mobile home park. We have crudely estimated net costs at 3.9 million dollars for the five years between 1988 and 1992.

The utility could make annual compensation payments to these communities, although it is more likely that payments would be made to Skagit County. City Light currently pays in-lieu tax payments to Pend Oreille and Whatcom Counties of $270,000 and $230,000 per year, respectively. As an example, an additional $200,000 per year in-lieu payment in perpetuity would have a present value cost of $6,319,800.

CULTURAL VALUES AND LOCAL LIFE-STYLES

The previous section discussed impacts on local communities during construction. There is also some concern over permanent and significant alterations in the upper Skagit valley human environment. Increases might be expected in traffic, flatwater recreation visitors, and numbers of residents. A faster pace of living might come with increased economic activity as well. The nature and extent of these effects are by no means certain, but it is reasonable to discuss them.

A number of personal contacts and interviews have, to some extent, confirmed what might be suspected: residents in the upper Skagit valley enjoy their quieter pace of life and rural values. City Light will be conducting a survey of the entire valley, by geographic area, to gather more information about these attitudes.

The American Indian population in Skagit County is estimated at 900 people. All three tribes - the Swinomish, the Upper Skagit and the Sauk-Suiattle - are included in a treaty which recognized tribal rights to customary fishing grounds. Treaty fishing is, in fact, the economic base for each of the three tribes. Salmon also have an important role in traditional tribal ceremonies and social functions. Impacts on spawning grounds, if not mitigated, would have a special impact on American Indians.

The Copper Creek Project dam would flood a number of Indian archaelogical sites. A dam at Damnation Creek would avoid some of these losses.

Mitigation

Apart from fishing losses, which can to a large extent be mitigated, most of the cultural impact on Indian and non-Indian quality of life is unavoidable. We have not applied any monetary value to these social costs.

DAM SAFETY

The issue of dam safety is not one of earthquake danger, but of construction on a potentially active fault. The present evidence shows that no fault exists at the dam site. This conclusion has been endorsed by City Light's dam design consultant. An independent review board will examine this conclusion and the supporting studies.

Dam safety may be questioned on the basis of the technical information on the capability of the structure to withstand fault activity, the risk and effects of dam failure, and public perception of acceptable risk. No rock-filled dam built since 1930 has failed, when significant design and construction technology improvements were made. An engineering error today is more likely to result in a minor accident than in sudden, total failure (refer to Part 1, Chapter III for fuller discussion). Thus, a failed structure would take 24 hours or longer to release the entire content of the reservoir. The result might be significant ecological damage but probably no loss of lives. The major point to recognize is that there is an extremely low probability of catastrophic, or even gradual, dam failure at Copper Creek.

Mitigation

Other than the possible installation of a siren warning system, mitigation of dam failure occurs in the design of the structure itself. Unlike other environmental issues, the risk of dam failure is either acceptable or it is not. There is no suggested tradeoff between an economic gain and a socio-environmental risk. It is our judgment that current studies support the acceptability of project construction.

TRANSFER OF BENEFITS TO SEATTLE

Development of Copper Creek as a productive resource would result in net economic benefits, even after mitigation costs have been accounted for. Residents of Seattle would enjoy most of the benefits in the form of cheaper energy while paying for few of the unavoidable environmental costs; residents of the upper Skagit may enjoy some net economic benefits from increased local business and tourist activity but would lose some environmental amenities. These effects are not economic costs, but they represent a transfer of social wealth--a distributional or equity issue. Economic analysis cannot determine an appropriate tradeoff between increased economic efficiency and a reshuffling of social wealth.

Environmental law, which addresses nonexclusively-owned resources, attempts to protect both tangible resources (such as the quality of air and water) and intangible values (such as life-style and quality of life). It may be more difficult to protect the latter, because of the difficulties associated with their definition, measurement and associated values. The policymaker is, however, no less obligated to consider both tangible and intangible elements in the final analysis.

On the other hand, hydropower rights reside in the public domain, and the license to develop these resources is granted to private or public agencies by the federal government (through FERC). The citizens of Seattle have as much entitlement to this resource as do nearby residents. There is a clear conflict between using a potential hydro resource and preserving it.

Again, the tradeoff between the economic benefits of hydroelectric development and environmental amenities, while outside the scope of economic analysis, is clearly the dominant consideration in the overall decision-making process.

Table 36 is a very brief summary of major environmental issues and possible mitigation programs. Table 37 summarizes potential program costs, recognizing that the actual programs and costs may vary considerably.

TABLE 36. Summary of Major Environmental Concerns

	Environmental Concern	Issue	Possible Mitigation/Compensation Program	Unavoidable Impacts	Cost of Possible Mitigation/Compensation Program (1980 Present Value)
1)	Fish and Wildlife				
	- Fisheries	Loss of spawning grounds	Spawning channels	Loss of natural habitat	$3,500,000
	- Bald eagles	Loss on Skagit and possibly regionally	Associated with fish replacement	Loss of natural feeding habitat	N.A.
	- Other wildlife	Loss of 2,400 acres of varied habitat	Some on-site plus off-site management program	Some permanent loss on the Skagit	$1-3,000,000
	- Other non-consumptive uses	Alternative uses which may not be as appreciated	Accessibility to other areas	Loss of varied habitat	Not estimated
2)	Whitewater Activities and Other Recreation	Loss of major whitewater areas/Change to lake recreation	Careful design in construction and greater accessibility	Loss of river run	$100,000
3)	Socio-Economic Impacts of Construction	"Boom and bust" impacts on local communities	Housing assistance and "in-lieu" tax payments	Increased activity	$3,888,000 $6,400,000
4)	Cultural Values and Local Lifestyles	Temporary disruption and some permanent urbanization	None, except that associated with above	All	N.A.
5)	Dam Safety	Reality and perception of risk	Included in design	Not significant	N.A.
6)	Transfer of Benefits to Seattle	"Amenity rights" of Skagit residents	Only those listed above	N.A.	N.A.

TABLE 37. Potential Mitigation/Compensation Programs

IMPACTS	PROGRAM	ESTIMATED COST (Present Value 1980 dollars)
Fisheries	Spawning channels	($3,500,000)[1]
Construction	Housing and mobile home park	3,888,000[2]
Social services	In-lieu property tax to Skagit County	6,400,000[3]
Wildlife habitat	Management programs elsewhere	1-3 million[4]
Whitewater recreation	Development of river accessibility elsewhere	100,000[5]
	TOTAL	11-13 million

Notes:

1. Included in construction cost estimates which allowed a total of $5,584,000 for fisheries mitigation, campground relocations, and minor impacts.

2. Based on estimated costs for housing camp and mobile home park. Some costs have been subtracted as recoverable in worker rent payments.

3. Based on experience with Whatcom and Pend Oreille Counties, it is assumed SCL might pay Skagit County as much as $200,000 annually ($6.4 million in perpetuity).

4. Based on similar experience, management costs have been estimated at $ .82 per habitat unit, and there are 64,908 nabitat unites associated with the project. This is an annual cost of $53,224, or $1.68 million 1980 present value. Since there could be additional acquisition costs, we have made the range 1-3 million dollars.

5. A rough estimate of potential costs for purchasing an easement to provide access to comparable whitewater recreation.

Part 6. Overall Evaluation

In this chapter, we have attempted to present the EIS as a decision-making document, with Copper Creek as the focus of the decision. An energy deficit is expected to develop in the mid-1980's, equal to the full output of the Copper Creek Project (see Figure 1). After 1990, there is a growing deficit, but requirements greater than the output of the proposed project are beyond the purview of this EIS.

The proposed action, a generation facility on the Skagit River near Copper Creek (or one of the design alternatives), is one way to meet some of the energy needs as they develop over the next few decades. Most of this document has been devoted to examining the environmental impacts of the proposed action. That is, after all, the main purpose of a project-specific EIS. We have identified a number of feasible alternatives to Copper Creek, some better in some respects and worse in others. Copper Creek is one of the lowest cost alternatives, but it has environmental impacts that others do not have. Our task has been to highlight these potential tradeoffs in order to assist decision-makers.

Table 38 is a summary of the socioeconomic and environmental features of each of the alternatives. Since publication of the DEIS, we have refined descriptions of alternatives and cost information. The alternatives, each of which is comparable to Copper Creek in scale, power characteristics and timing, are compared below.

LEVELIZED COST

Copper Creek energy, at roughly 23 mills/kwh, is less costly than most of the alternatives, even when potential mitigation costs are added. Based on preliminary information, an equivalent amount of energy savings through new conservation programs (not in the forecast) would cost 15-20 mills/kwh.* Other options, such as solid waste, cogeneration or wind/small hydro, are somewhat higher in cost than Copper Creek.

We have used levelized cost as a proxy for economic value because we lack enough specific information on alternatives to evaluate all their costs and benefits (for net present value analysis).** We should point out, however, that each

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* See footnote 2 on Table 38, page V-33.

** Preliminary analysis on the solar-conservation alternative shows that, when time-differentiated power benefits are included, most elements have a lower NPV per energy unit than Copper Creek.

TABLE 38. Overall Evaluation of Copper Creek and Alternatives

Alternatives	Levelized Costs (Mills/kwh)	Program and Development Costs	Potential Institutional Barriers	Customer Impact	Environmental Impacts After Potential Mitigation/Compensation Programs
I. Copper Creek	23-24 [1]	Included in cost estimates	Compliance with Wild and Scenic Rivers, Endangered Species Act, alleged tribal fishing rights	None	Loss of natural fish and wildlife habitat. Loss of some eagles on the Skagit. Disruption of local lifestyles. Loss of significant whitewater resource.
II. Wind and Small Hydro	25-50 [1]	Site identification. Development of best wind system	Both subject to various environmental regulatory agencies. Sharing of dams for multi-pupose use	None	Land use problems with wind if existing transmission corridors are not used. Impacts with new dams, or development of high-head hydro.
III. Solar, Conservation	15-20 [2]	Administrative and program costs for conservation/solar. Development of best solar application	Financial incentive programs. Ordinances and codes. Rate schedule revisions	Range of impacts based on degree of inconvenience, required compliance	All are relatively benign. Food management may have small impact on labor hours.
IV. MSW and Cogeneration	40-60 [3]	MSW depends on city/county research project. Cogeneration requires development of customer cooperation	Pollution control laws. Rate schedule revisions. Joint-function of MSW facility	Cogeneration operation may be influenced by utility needs	MSW air pollution and toxic substances are similar to other fossil-fired plants. Cogeneration impacts are largely those which already exist.
V. Geothermal	20-30 [1]	Site identification. Development of binary cycle turbine	Legal framework for developing resource. Clear Air Act restrictions around many geothermal sites	None	Loss of wildlife habitat associated with land development. Impacts from drilling and testing. Operational impacts largely unknown at this time
VI. Coal-fired	45-60 [1]	Site identification, fuel source, and transportation method (cost included if share were purchased)	Pollution regulations. Possible water rights issues	None	Air pollution and those associated with mining the fuel. Transportation (if necessary) of fuel. Disruption of local lifestyles.
VII. Nuclear	40-60 [1]	Costs would be included in share	Negotiation of shared facility	None	Problems in plant construction, decommissioning, waste management, fuel transportation, safety and spent fuel storage

1. Includes transmission and distribution costs, and possible mitigation measures at a maximum estimated cost of 1 mill/kwh
2. 15 mills is estimate by MSNW; 5 mill range added by SCL for potential unexpected administrative costs (includes only a small proportion of passive solar savings)
3. Includes 1 mill/kwh distribution cost

alternative may have secondary benefits not accounted for in levelized cost comparisons. Secondary benefits of Copper Creek, for example, are reregulation, increased operational flexibility, and making up-river capacity expansions possible.

PROGRAM AND DEVELOPMENT COSTS

Copper Creek has the advantage of being a conventional technology, and it has been under consideration for 12 years. Developmental costs are therefore minimal. Wind and small hydro would require extensive study, site identification, and associated planning costs which have not been included in levelized cost estimates. Solar and conservation options are currently being developed at City Light. Additional program and development costs for solid waste and cogeneration will depend on the results of studies now being conducted. Program and development costs for participation in a coal-fired plant are included in the cost estimate.

POTENTIAL INSTITUTIONAL BARRIERS

Copper Creek faces several barriers before complying with the Wild and Scenic Rivers Act and the Endangered Species Act; it also may conflict with tribal fishing rights. Wind and small hydro would encounter similar, if different, environmental regulations. Solid waste and cogeneration would have to comply with pollution control laws, which will largely influence site selection; some rate structure revisions will also be required for that alternative.

Development of the geothermal alternative would require establishment of a legal framework for partial ownership rights and would face Clean Air Act restrictions on site selection and development. Solar and conservation may require a revision of city housing and building codes, depending on the method of implementation.

CUSTOMER IMPACT

Solar and conservation will impinge on consumer independence, especially to the extent that mandatory rather than voluntary programs are instituted. From the consumer's standpoint, this represents a social cost which has not been included in the economic analysis. Cogeneration, when developed at existing user sites, may require some degree of consumer cooperation in the timing of generation. The other alternatives, acting on the supply side, do not affect customer use.

ENVIRONMENTAL IMPACTS AFTER POTENTIAL MITIGATION/COMPENSATION PROGRAMS

Copper Creek will result in a significant loss of natural fish and wildlife habitat. Some eagles, now wintering on the Skagit, will go elsewhere; others may not survive at all. There will be a loss of a popular whitewater resource, and upper Skagit valley residents will undergo a significant change in their quality of life, for several years at least.

Environmental problems from wind and small hydro depend largely on site location. If areas along transmission corridors could be used for wind systems, impacts would be lessened. The use of small existing, nongenerating dams for power generation would minimize environmental impacts. But new dams and high-head, small hydroelectric appurtenances may have impacts comparable to those of Copper Creek.

Solar and conservation are relatively benign. Solid waste produces air pollutants and toxic substances similar to by-products from other fossil-fired plants. Cogeneration, if on existing user sites, will not materially add to pollution problems.

Geothermal would have impacts associated with construction and land use. The extent of operation impacts are largely unknown at this time.

Coal-fired plants produce air pollution and have impacts associated with fuel production, transportation, construction and operation. Nuclear plants encounter problems in plant construction, decommissioning, waste management, fuel transportation, safety and spent-fuel storage.

CONCLUDING REMARKS

We have identified several technologies which singly or in combination may be alternatives to the proposed action: wind and small hydro, solar and conservation, solid waste and cogeneration, and perhaps coal. The final decision of the City to proceed or not with the Copper Creek license will depend on judgments and weightings given to cost, environmental concerns and customer impact of all the alternatives.

ELEMENTS OF THE ENVIRONMENT

Elements of the Physical Environment

(a) Earth
- Geology
- Soils
- Topography
- Unique physical features
- Erosion
- Accretion/avulsion

(b) Air
- Air quality
- Odor (n/a)
- Climate (n/a)

(c) Water
- Surface water movement
- Runoff/absorbtion
- Floods
- Surface water quantity
- Surface water quality
- Ground water movement (n/a)
- Ground water quantity (n/a)
- Ground water quality (n/a)
- Public water supplies

(d) Flora
- Numbers or diversity of species
- Unique species
- Barriers and/or corridors
- Agricultural crops

(e) Fauna
- Numbers or diversity of species
- Unique species
- Barriers and/or corridors
- Fish or wildlife habitat

(f) Noise

(g) Light and glare (n/a)

(h) Land use

(i) Natural Resources
- Rate of use
- Nonrenewable resources

(j) Risk of explosion or hazardous emissions

Elements of the Human Environment

(a) Population

(b) Housing

(c) Transportation/Circulation
- Vehicular transportation generated
- Parking facilities
- Transportation systems
- Movement/circulation of people and goods
- Waterborne, rail and air traffic
- Traffic hazards

(d) Public Services
- Fire
- Police
- Schools
- Parks or other recreational facilities
- Maintenance
- Other governmental services

(e) Energy
- Amount required
- Source/availability

(f) Utilities
- Energy
- Communications
- Water
- Sewer
- Storm water
- Solid waste

(g) Human health (including mental health).

(h) Aesthetics

(i) Recreation

(j) Archeological/historical

(k) Additional Population Characteristics
- Distribution by age, sex and ethnic characteristics of the residents in the geographical area affected by the environmental impacts of the proposal

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n/a - not applicable

Appendix A

Public Involvement

City Light recognizes a special obligation to involve citizens in decisions affecting them. Our commitment to an open decision-making process is part of our responsibility as a customer-owned utility. In addition, Seattle City Council Resolution 25387 directs that citizens be given opportunities to influence decisions or actions affecting their interests. The Washington State Environmental Policy Act also requires public participation in review of this environmental impact statement.

PAST EFFORTS

During the environmental assessment phase, City Light and its consultant, CH2M Hill, conducted eight public hearings on the Copper Creek Project:

- May, 1978, in Marblemount, Mount Vernon and Seattle;
- November, 1978, in Concrete and Newhalem; and
- March, 1979, in Marblemount, Mount Vernon and Seattle,

The results of these meetings are summarized in three volumes entitled "Citizen Reactions" and are available from City Light.

City Light also invited and responded to written comments on the Draft Environmental Report, issued in 1979. These comments and responses are reproduced in Technical Report 18 of the Environmental Assessment. Copies are available from City Light.

Beginning in April 1978 with the Environmental Assessment, City Light has published issues of a newsletter, "Copper Creek Update", to keep the public informed on the status of its studies. Copies are available from City Light.

The scope of work on this present document was based on the comments received on the Draft Environmental Report, state guidelines, and the results of agency and interest group input during a series of planning meetings which City Light held in September, 1979.

City Light has also involved interested and expert citizens, interest groups and agencies in an Eagle

Advisory Group to help City Light plan, hire consultants, and analyze the results of recently completed Bald Eagle and salmon carcass drift studies.

PRESENT AND FUTURE EFFORTS

Newsletters informing the public of opportunities to make themselves heard and other milestones in the decision-making process will continue to be distributed.

The Eagle Advisory Group will continue to be a resource available to the Mayor, City Council, and public. The city has also selected a Copper Creek Advisory Committee. This Committee consists of representatives from a wide spectrum of interests, viewpoints, and expertise from Seattle and Skagit County. The committee will advise the City on whether to build Copper Creek Dam, as well as any possible mitigation measures, and will highlight important components of the Copper Creek decision.

City Light has received comments on this document and the project as a whole during the Draft Environmental Impact Statement (DEIS) review period (October 3 - November 14, 1980). These comments are duplicated and responded to in the separate Appendix D.

City Light also held public hearings in Mount Vernon, Marblemount and Seattle on November 4, 5, and 12 to hear public concerns and comments on the DEIS. Summaries of those hearing transcripts constitute the separate Appendix E. Additional extensive public hearings on Copper Creek will be conducted by the Seattle City Council between January 15 and April 15, 1981. At least one of these is planned to take place in Skagit County.

The results of all public involvement activities, past and future, will be forwarded to City decision-makers to supplement the knowledge they gain from technical documents and analyses.

OTHER AGENCIES

If the Copper Creek Project proceeds through the licensing process, there will likely be several additional opportunities for public involvement as part of the actions of other agencies. Some of these are:

- Federal Energy Regulating Commission licensing hearings and EIS hearing

- Department of Agriculture Wild and Scenic River determination

- Skagit County Shoreline Management Master Plan change and Conditional Use Permit, Comprehensive Land Use Plan change, and zoning ordinance variance

- Whatcom County Shoreline Management Master Plan change and Conditional Use Permit, and Comprehensive Plan change

Appendix B. Wildlife

Nongame Wildlife Program

Washington Department of Game

Species of indeterminate status that deserve further research and consideration for inclusion in threatened category:

- northern bog lemming - *Synaptomys borealis*
- wolverine - *Gulo gulo*
- fisher - *Martes pennanti*
- flamulated owl - *Otus flammeolus*
- great gray owl - *Strix nebulosa*
- ash throated flycatcher - *Myiarchus cinerascens*
- larch mountain salamander - *Plethodon larselli*
- mountain kingsnake - *Lampropeltis zonata*
- ringnecked snake - *Diadophis punctatus*

Approximately 20 additional species are pending review for inclusion under one or more of the various categories. These are currently listed under species of concern. The latest version of this listing is to be made public in September of 1980. The list will become official when approved by the Washington Game Commission (B. Rodrick, pers. comm., July, 1980).

DRAFT LIST OF WASHINGTON'S THREATENED SPECIES

Pygmy rabbit - *Sylvilagus idahoensis*
Harbor porpoise - *Phocoena phocoena*
Blue whale - *Balaenoptera musculus*[1]
Finback whale - *Balaenoptera physalus*[1]
Gray whale - *Eschrichtius robustus*[1]
Hump-backed whale - *Megaptera novaeangliae*[1]
Right whale - *Balaena glacialis*[1]
Sei whale - *Balaenoptera borealis*[1]
Sperm whale - *Physeter catodon*[1]
Wolf - *Canis lupus*[1]
Grizzly bear - *Ursus arctos*[1]
Sea otter - *Enhydra lutris*
Columbian white-tailed deer - *Odocoileus virginianus leucurus*[1]
Mountain caribou - *Rangifer tarandus montanus*
Brown pelican - *Pelecanus occidentalis*[1]
Swainson's hawk - *Buteo swainsoni*
Ferruginous hawk - *Buteo regalis*
Golden eagle - *Aquila chrysaetos*
Bald eagle - *Haliaeetus leucocephalus*[1]
Peregrine falcon - *Falco peregrinus*[1]
Sandhill crane - *Grus canadensis*
Snowy plover - *Charadrius alexandrinus*
Upland sandpiper - *Bartramia longicauda*
Spotted owl - *Strix occidentalis*
Sage thrasher - *Oreoscoptes montanus*
Bobolink - *Dolichonyx oryzivorus*
Western pond turtle - *Clemmys marmorata*
Leatherback sea turtle - *Dermochelys coriacea*[1]
Green sea turtle - *Chelonia mydas*[1]

[1] Species listed on federal threatened and endangered species list

Source: Nongame Wildlife Program, Washington Department of Game (June 1980)

EVALUATION SPECIES USED IN THE COPPER CREEK HEP

	Common Name	Scientific Name
1)	black-tailed deer	Odocoileus hemionus columbianus
2)	black bear	Euaretos americanus
3)	ruffed grouse	Bonasa umbellus
4)	Pacific tree frog	Hyla requilla
5)	beaver	Castor canadensis
6)	Douglas squirrel	Tamiasciurus douglasii
7)	yellow warbler	Dendroica petechia
8)	redbreasted nuthatch	Sitta canadensis
9)	spotted owl	Strix occidentalis
10)	northern alligator lizard	Gerrhonotus coeruleus
11)	Cooper's hawk	Accipiter cooperii
12)	pileated woodpecker	Dryocopus pileatus
13)	bobcat	Lynx rufus faciatus
14)	osprey	Pandion haliaetus

Copper Creek Deer Transect Data

From Pellet Counts
(Stendal, W.D.G., pers. comm.)

Date	Number of Transects 0.01 Acre	Pellet Groups	Days Use Period	Deer Density/mi.^{2}
3-19-70	42	21	127	19.38
4-05-71	37	28	136	31.20
4-11-72	30	22	158	22.83
9-29-72	32	8	171	12.66
3-08-73	17	17x1.53	113	66.65
3-14-73	20	0.85 grps/ .01 acre	120	34.87
Average ($\bar{x}$) population density for winter 1972-73 = 49.5 deer/mi.^{2}				
4-12-74	20	1.2/0.01 acre	133	44.4
4-27-76	20	0.5/0.01	149	16.5
4-12-77	30	0.6/0.01	133	22.21

AMPHIBIANS AND REPTILES OBSERVED* OR SUSPECTED OF OCCURRING IN
COPPER CREEK STUDY AREA
(Adapted from Juelson, et al., 1980)

Common Name	Species Name	Habitat
Amphibians		
Northwestern salamander	Ambystoma gracile	Humid sites – open grasslands to dense forest often beneath debris along streambanks; lays eggs on debris in ponds, lakes, slow-moving streams. Extremely abundant in some pools.
Pacific giant salamander	Dicamptodon ensatus	Rivers, tributaries, and surrounding cool, humid forests; breeds in river headwaters; eggs attached to submerged timber. Occasiona specimens found in riffle areas along rivers.
Rough-skinned newt	Taricha granulosa	Ponds, lakes, slow-moving streams with submerged vegetation, and adjacent humid forests or grasslands; lays eggs on aquatic plants or submerged twigs.
tailed frog	Ascaphys truei	Usually clear, cold, swift-flowing mountain streams; sometimes found near water in damp forests or in more open areas in cold, wet weather; eggs attached to downstream sides of rocks.
western toad*	Bufo boreas	Near springs, streams, meadows, woodlands; egg strings attached to vegegation in shallow usually still water.
Pacific tree frog*	Hyla regilla	On ground among shrubs and grass, close to water.
Red-legged frog*	Rana aurora	During breeding season, found near ponds or other permanent water with extensive vegetation; egg masses laid in permanent bodies of water; during non-breeding season found in damp forests.

Reptiles

Northern alligator lizard*	Gerrhonotus coeruleus	Usually under rotten logs, rocks or loose bark in cool, moist woodlands. Two specimens seen sunning themselves, one in a cutbank, another near a small creek.
Common garter snake*	Thamnophis sirtalis	Near water--wet meadows, marshes, drainage ditches and damp woodlands.
Northwestern garter snake*	Thamnophis ordinoides	Forest edges, brushy areas. One speciman found in power right-of-way clearing.

HEP EVALUATION - Discussion

Standardized habitat unit values (HUV) per acre were calculated for each habitat type identified. This calculation was based on overall ratings given during field evaluation work. These figures were annualized for a project life of 50 years, and multiplied by the number of acres of each habitat to be lost or changed. The resulting figures (the total habitat value units) allow relative comparisons between habitat types. The computer program used to analyse the data does not track particular species through the gamut of habitats to determine those best suited for wildlife. Nor does it identify those species for which the habitat had high suitability. It does point out the overall suitability of particular habitat types for meeting habitat requirements of those species for which it was evaluated.

Table 9 summarizes the analysis, showing that mature conifer and mixed mature forests ranked highest in overall suitability for wildlife, followed in order of relative ranking by old growth conifer forest, riparian and mature deciduous. The rankings depend upon the species of wildlife chosen for the evaluation. The consensus of the HEP Team members, however, was that those wildlife selected represented the spectrum of what could reasonably be expected to occur in the respective habitats.

The main purpose of the HEP is to provide numbers of acres which would have to be managed to compensate for the loss of each habitat, either on-site or off-site. The means by which this is done is based upon the assumption that each habitat type can be managed to increase its "value" by X habitat units or a percentage thereof.

One can calculate the area needed for compensation if a value can be established for the habitat type that truly reflects the management potential. As one example, 63 acres of pole stage conifer lost to project has a value of 37.6 habitat units/acre. Perhaps off-site lands in the same habitat category could be enhanced by 33 percent to give a new total of 50 units per acre. The 12.5 units by which the HUV/acre is increased is divided into the total habitat units lost, which gives 189 acres needed for compensation for the 63 on-site acres lost: (63 acres lost x 37.6 HUV/acre) ÷ 12.5 HUV/acre enhancement potential (@ enhancement potential of 33%) = 189 acres of pole stage conifer needed for full compensation.

Appendix C

Economic Methodology

QUANTITATIVE METHODS

Methods of economic analysis (which may be referred to as "investment analysis," "cost-benefit analysis" or life-cycle-costing) are straightforward and simple in concept: all costs and benefits over the life of the project are expressed in terms of their present value (through discounting) and compared--either according to net benefits or some ratio of benefits to costs (or investment cost alone). The important elements are discussed in turn.

Discounting

Values are usually expressed in constant dollars (i.e. net of inflation), but costs or benefits occurring in future years have different values than they would in the present year. This is because of the opportunity cost of foregoing present for future consumption. Opportunity cost may also be thought of as interest which may be earned on invested funds. A public utility uses a social discount rate to account for the public preference for present over future comsumption. It may be measured by the real rate of interest (after inflation adjustment) on low-risk securities.

Real discount rates are usually between three and ten percent (federal water resources are evaluated at seven percent, other federal investments at ten percent, while Seattle City Light presently uses three percent). As an example, a 1981 cost of $100 is converted to $97 in 1980 present value at a three percent rate.

Externalities

Some costs and benefits are an indirect result of project construction. When these can be quantified in terms of dollars, they are "internalized" alongside other directly-related values. For instance, the costs of mitigation of damage to the fisheries by Copper Creek will be added to other construction and operating costs. Most externalities, such as environmental impacts, cannot be quantified, but many can be treated systematically.

Evaluating Energy Output

In economic analysis, value is usually determined by the opportunity cost of replacing the resource. Similarly, energy output must be evaluated by the cost of the next best alternative. It must also be differentiated by time of availability since the cost of purchasing or producing energy varies according to the timing and duration of the need. Firm energy may be required during peak hours, intermediate hours, or off-peak hours (baseload). Non-firm (or secondary) energy is sold outside the service area at a market price, largely determined by Bonneville Power Administration's large sales and control of the regional transmission network.

The value of energy has been determined by a marginal cost study, based on future thermal power costs. Peak load value is provided at the cost of a simple-cycle combustion turbine; intermediate load by a simple cycle turbine; and baseload by a conventional coal plant. Since energy from each of the alternatives is evaluated the same way, and each alternative has been constructed to have similar power characteristics, finding the appropriate alternative cost (i.e., opportunity cost) may not be critical to the economic analysis.

Costs used in this report are shown below:

	1979 mills/kwh
Firm energy during peak hours (combustion turbine)	119
Firm energy during intermediate (combustion turbine)	63.6
Firm energy during off-peak hours	21.9
Non-firm energy	12*

*A market price which is assumed to escalate (above inflation) by four percent annually through 1985 and by two percent thereafter.

Summary Statistics

Economic analysis can be summarized according to several commonly-used criteria. Net present value (NPV) is the algebraic sum of all discounted costs and benefits over the life of the project. If it is positive, the investment is feasible (cost-effective). Alternatives with higher NPV's are generally, but not always, given higher ranking. Savings-investment ratio (SIR) is the total of net benefits divided by investment cost. SIR equals one plus (NPV divided by Investment Cost) and, like a benefit-cost ratio, it measures the return on investment. An SIR greater than one is feasible, and greater SIR projects may be preferred when there is a constraint on the capital budget. Levelized cost is calculated by dividing the annualized cost of the facility by its average output. It is a shorthand measure of unit cost, but must be used carefully since generation plants have different output characteristics. Therefore, important benefits may be ignored when comparisons are made on the basis of levelized costs alone.

Summary statistics do not determine the proper investment decision, but they help narrow the information which must be considered. The decision-maker must examine economically feasible alternatives in the light of any associated risk and uncertainty which has not been quantified, budgetary needs and constraints, the relationship to future project development, and the required scale and timing of the investment. Finally, other non-quantitative costs and benefits of the project (and the alternatives, as much as possible) must be considered.

NON-QUANTITATIVE METHODS

Intangible values are often ignored in quantitative studies. Several techniques for processing such information will be briefly identified. These will be applied specifically in a subsequent section.

Imputing a Monetary Value

Various methods have been developed for measuring the value of natural resources and environmental amenities which are not generally productive resources. These are usually based on market value or willingness-to-pay-techniques. Some resources, such as fish, are tangible but difficult to quantify. Others, such as lifestyles or eagle watching, are intangible and, of course, difficult to put a monetary value on. Whichever method is determined to be cogent and useful, the question remains: is it reasonable and justifiable to put a measure on vague human and environmental considerations?

Imputed values enable the decision-maker to incorporate human and natural values into economic and financial analysis. There is, however, a risk that trade-offs with hard economic data may lead to violating a legitimate consensus on an environmental constraint. "Social engineering" is also inappropriate when it falsely suggests that all values, tangible and abstract, can be put in the same hopper.

Side Calculations

The most common way to deal with monetary and non-monetary values together is to condition the results of economic analysis with qualitative statements. Some alternatives may be ruled out on the basis of overriding environmental costs or some other factors. Of the remaining alternatives, some are better economically and others better environmentally. The balance to be struck is a matter of social and political consensus.

Contingency Calculation

In this method, net economic benefits (or NPV) are determined for the proposed action. These are then divided by the number of users of a resource which would be lost. The per capita value of the loss might be so low that it is obviously unrealistic, and therefore the project would not have positive benefits. Similar analysis would then have to be performed on alternatives. Since Copper Creek has a complex of environmental impacts, assigning unit values may be too vague and unwieldy.

Physical Constraints

Environmental concerns can also be expressed as physical limitations on the productive possibilities of a natural resource. These concerns are less yielding as the resource becomes more scarce. In general, though, most parties to an action are willing to recognize some trade-off with productive uses.

This method of processing intangible values starts with a spectrum ranging from absolute physical constraints to completely free, marginal substitutions. As a practical matter, some of the impacts of development can be mitigated in the design stage at minimal economic cost. Others become a tentative physical constraint which determines the configuration and scale of the facility. For example, minimum stream flows for fish maintenance will set an upper limit on the peaking energy potential of a dam. By provisionally raising the minimum to calculate the increased hydropower (and economic benefits), a potential tradeoff is established. This may be resolved through negotiations and political wrangling between the utility and fisheries advocates.

As long as all property rights are fairly represented and information is widely distributed, this method should lead to an optimal use of resources. It can be argued, on the other hand, that it has taken years to institutionalize and protect certain environmental values (which are usually external to the production decision) through statutory and administrative law. To yield to tradeoffs now may open the door to stronger economic forces.

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1. Engineering Liaison
2. Public Involvement
3. Permits, Legislation, and Public Policy
4. Archaeology and History
5. Local Communities
6. Public Facilities and Services
7. Scenic Environment
8. Recreation
9. Land Use and Housing
10. Economics and Labor
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Personal Communications, Appendix B

Roderick, B., Wildlife Biologist, Washington Department of Game, July, 1980.

GLOSSARY

ACRE-FOOT - A volume of water one foot deep and one acre in area, or 43,560 cubic feet.

ALPINE GLACIERS - Ice masses flowing in mountain valleys.

"AMENITY RIGHTS"- The intangible values of the human environment.

ANADROMOUS FISH - Those species of fish which mature in the sea and migrate into streams to spawn. Salmon and steelhead are examples.

ANNUAL AVERAGE ENERGY - The total energy produced by a generating plant in an average year.

AVERAGE LOAD - The amount of energy supplied during a specified period of time; expressed in kwh, but sometimes divided by 8760 (hours in a year) to be expressed in kw.

BASE FLOWS - The usual ongoing flow in a stream between storms.

BASELOAD - The minimum load on a power system extended over a given period of time, usually a year.

BEDROCK - Unbroken solid rock.

BENTHIC - Organisms living on the bottom of the stream.

BIG GAME - Large animals hunted for sport and for use as food; e.g., elk, deer, bear.

BIOTIC - Life or the act of living.

BORROW SITE - Location from which soil or rock is removed for use in construction.

BTU - British thermal unit. The amount of heat required to raise temperature of 1 lb. of water 1°F.

CAPACITY - Maximum power output, expressed in kilowatts or megawatts. Equivalent terms: peak capability, peak generation, carrying capability. In transmission, the maximum load a transmission line is capable of carrying.

CEREMONIAL USE - Use of a food or object required as part of a religious or traditional activity.

CFS - Cubic feet per second; a volume flow rate measure for water or air.

COMMERCIAL FISHERY - The sum of salmon caught by commercial (nontreaty) fishermen for sale and the salmon and steelhead caught by Indians for sale or subsistence. Includes both fresh and saltwater fishing.

COMPENSATION - Actions balancing the loss of an environmental value with the improvement of environmental or monetary values of another type or in another area.

CONTINENTAL ICE SHEET - A large ice mass covering a whole region.

CORE - A stone tool from which pieces, called flakes, have been removed by chipping.

CRITICAL PERIOD OF RECORD - A period of time during which rivers used for hydroelectric power had the lowest recorded water flow.

DEGREE DAY - An expression of a climatic heating or cooling requirement expressed by the difference in degrees F. above or below the average outdoor temperature for each day and an established indoor temperature base of 65 F.

DEMAND - In an economic context, the quantity of a product that will be purchased at a given price at a particular point in time. In a public utility context, the rate at which electric energy is delivered to or by a system, expressed in kilowatts or megawatts.

DISCOUNT RATE - The discount rate is used to convert benefits and costs occurring at different times to a common time base, their present value. The rate is equivalent to the time value of money. It is generally in real terms--that is, exclusive of inflation. City Light used a real discount rate of 3 percent, which is an average real rate of return on borrowed funds over an historical time period.

DIVERSION TUNNEL - The conduct which contains the river flow during construction in the stream bed.

ECOSYSTEM - The complex of a community and its environmental functioning as an ecological unit in nature.

EIS - Environmental Impact Statement

ENERGY - The average power production over a stated interval of time; expressed in kilowatt-hours, megawatt-hours, average kilowatts, or average megawatts. Equivalent terms: energy capability, average generation, firm energy load carrying capability.

ENHANCEMENT - Actions improving the environmental values of an area above and beyond those existing under the natural condition.

EPA - United States Environmental Protection Agency.

ESCAPEMENT - The number of mature fish returning to spawn that escape harvest by fishers.

ESCAPEMENT GOAL - The number of fish that a resource agency wants to reach the spawning grounds. The escapement goal might or might not be the optimum escapement.

FAUNA - The various animal populations of a particular area.

FERC - Federal Energy Regulatory Commission.

FLAKE - A piece which has been removed from a stone tool or core by chipping.

FLORA - The various plant populations of a particular area.

FLOW FLUCTUATION - The variation in amount of water passing through a channel.

FORCED OUTAGE RESERVE - A planning reserve held for emergency shutdowns of generating equipment.

FOSSIL FUELS - Coal, oil, natural gas and other fuels originating from fossilized geologic deposits and depending on oxidation for release of energy.

FRY - The stage in the life of a fish between the hatching of the egg and the absorption of the yolk sac. From this stage until they attain a length of one inch, the young fish are considered advanced fry.

GRUBBING - Removing the upper soil layer as well as tree stumps.

HABITAT - The place or type of site where a plant or animal naturally or normally lives and grows.

HEAD - Head is the vertical distance from the surface of the reservoir or from the point of diversion on a stream or river to the blades of the turbines. This value is one of the factors that determines how much power can be generated.

IMMATURE - The stage at which a tree or other plant has become established and yet have not attained full development.

INSOLATION - The total amount of solar radiation, direct, diffuse and reflected, striking a surface.

INTRUDED - The forcing of molten rock into a crack or space below the surface of the earth.

INUNDATION - Covering with water.

JUVENILE - A physiologically immature or undeveloped fish.

KILOVOLTS (kv) - A unit of electric power equal to one thousand volts.

KILOWATT (kw) - A unit of electric power equal to one thousand watts. One kilowatt produces 3,413 Btu and is equal to about 1-1/3 horsepower.

KILOWATTHOUR(kwh) - A basic unit of electric energy which equals one kilowatt of power applied for one hour.

LEVELIZED COST - The present value of all costs over the life of the project is converted to a constant annual equivalent (annualized) using an appropriate discount rate, and the annualized amount is divided by average annual output. Expressed in mills/kwh (i.e. $/1000 kwh).

LITHIC SITE - An archaeological site consisting primarily of stone tools.

LOAD - The amount of electric power delivered to a given point on a system.

LOAD CYCLING - A method of reducing peak demand by shutting off electricity to various end uses during peak operating hours.

LOAD FACTOR - The ratio of the average load supplied during a designated period to the peak or maximum load during the same period.

LOAD MANAGEMENT - Influencing the level and state of the demand for electric energy so that demand conforms to individual existing supply situations and long-run objectives and constraints.

MATURE - The stage at which a tree or other plant has attained full development and is in full seed production.

MAXIMUM POOL ELEVATION - The highest water level measured in feet above sea level that is maintained in a reservoir during normal operating conditions.

MEGAWATT (mw) - One million watts or one thousand kilowatts, about 1,300 horsepower.

MEGAWATT-HOUR (mwh) - A basic unit of electric energy which equals one megawatt of power applied for one hour.

MINIMUM FLOW - The lowest allowable flow discharging from the dam reservoir or the powerhouse.

MITIGATION - Actions which may avoid or reduce the risk of adverse environmental impacts.

MORPHOLOGY - A branch of biology dealing with the form and structure of organisms.

NEPA - National Environmental Protection Act.

NET PRESENT VALUE(NPV) - All discounted benefits less all discounted costs over the life of the project. Costs include initial capital costs as well as recurring costs for operation, maintenance, replacements, fuel and other expenses. They may also include the costs of mitigation for environmental damages, to the extend such costs can be quantified.

NPDES - National Pollutant Discharge Elimination System Permit.

NRA - National Recreation Area.

OFF-PEAK - A period of relatively low system demand for electric energy as specified by the supplier, such as in the middle of the night.

OLD GROWTH - A tree that is past full maturity; the last stage in forest succession.

PEAKING - Operation of generating facilities to meet maximum instantaneous electrical demands.

PEAKING CAPABILITY - The maximum peakload that can be supplied by a generating unit, station, or system in a stated time period. It may be the maximum instantaneous load or the maximum average load over a designed interval of time.

PEAKING CAPACITY - Generating units or stations which are available to assist in meeting that portion of peakload which is above the baseload.

PEAKLOAD - The maximum electrical load in a stated period of time. It may be the maximum instantaneous load or the maximum average load over a designated interval of time.

PH - A measure of the acidity of a substance. A low PH is acid, a high PH is basic, a moderate PH is neutral.

PENSTOCK - The pipeline or conduit that carries water under pressure to the turbines.

PERIPHYTON - Small plant growth adhering to the stream bottom.

PLANKTON - Aquatic organisms which float passively or exhibit limited locomotor activity.

POLE STAGE CONIFEROUS - The successional stage of the coniferous forests in which the young tree begins to loose its lower branches until the time the rate of crown growth begins to slow and crown, and expansion is noticeable.

POWER - The time rate of transferring or transforming energy, for electricity, expressed in watts. Power, in contrast to energy, always designates a definite quantity at a given time.

POWERHOUSE - The structure that houses the turbines and generators.

RAMPING RATE - The rate at which discharge flows from a hydroelectric, or other impoundment is released to the river downstream.

RAPTOR - Birds of prey, including hawks, owls, eagles, etc.

RECURRENCE INTERVAL - The average time between infrequent events.

REDD - Area of stream or lake bottom excavated by a female salmonid during spawning.

REGENERATING CONIFEROUS - Coniferous trees which recently have become established either through natural or critical means or both.

RENEWABLE RESOURCES - Those resources which are not finite in their availability, if managed properly.

RESIDENT FISH - Fish presently living in the reservoir, river and streams within the study area.

SALMONID - Belonging or pertaining to the suborder salmonoidea, to which the salmon family belongs.

SAVINGS-INVESTMENT RATIO - The total of net benefits divided by investment cost.

SCL - Seattle City Light.

SCRUBBING - Removing pollutants, such as sulfur oxides or particulate matter, from stack gas emissions usually by means of a liquid sorbent.

SEISMIC - Related to earthquakes.

SECOND GROWTH TIMBER - Consists of trees that occupy the growing site after the old growth (first growth) has been removed.

SEDIMENTATION - The action or process of depositing solid material, both mineral and organic.

SEPA - State of Washington, Environmental Protection Act.

SLURRY - A mixture of a liquid and a solid.

SPAWNING - The production or deposition of eggs by an aquatic animal.

SPIRITUAL USE - Use, usually non-consumptive, involving the role an object (e.g. animal, plant, sun) or natural phenomenon (e.g. lightening, rain) plays in the spiritual or mythological traditions of an individual or group of people.

SPORT FISHERY - Salmon and steelhead caught for private use under sport regulations. Includes both fresh and saltwater fishing.

STRANDING - Removal of habitat requirements (such as water from redds) caused by flow fluctuation or dam operations.

SUPERSATURATION - A condition in which more than a normal amount of gas (atmospheric air) is dissolved in the water.

TAILRACE - The channel conveying water away from the powerhouse.

TOPOGRAPHY - The configuration of a surface, including its relief, elevation, and the position of its natural and man-made features.

TORPOR - Physiologic adaptation involving reduced metabolic activity allowing some mammals to survive periods of low food availability and reduced temperatures, as in the winter season.

TURBIDITY - The capacity of materials suspended in water to scatter light. Highly turbid water is often called "muddy", although all manner of suspended particles contribute to turbidity.

TURBIDITY UNITS (TU) - A quantity of measure used to express the "cloudiness" of water. The maximum U.S. Environmental Protection Agency recommended level for drinking water is 5 TU. It is desirable to maintain the level below 1 TU.

UPLAND GAME BIRDS - Such as pheasant, quail, partridge, grouse, and wild turkey species.

VOLCANISM - Volcanic activity.

WAC - Washington Administration Code.