Columbia River System Operation Review

Final Environmental Impact Statement

Appendix O

Economic and Social Impact

US Army Corps of Engineers
North Pacific Division

DOE/EIS-0170

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INVOLVEMENT IN THE SOR PROCESS

The Bureau of Reclamation, Corps of Engineers, and Bonneville Power Administration wish to thank those who reviewed the Columbia River System Operation Review (SOR) Draft EIS and appendices for their comments. Your comments have provided valuable public, agency, and tribal input to the SOR NEPA process. Throughout the SOR, we have made a continuing effort to keep the public informed and involved.

Fourteen public scoping meetings were held in 1990. A series of public roundtables was conducted in November 1991 to provide an update on the status of SOR studies. The lead agencies went back to most of the 14 communities in 1992 with 10 initial system operating strategies developed from the screening process. From those meetings and other consultations, seven SOS alternatives (with options) were developed and subjected to full-scale analysis. The analysis results were presented in the Draft EIS released in July 1994. The lead agencies also developed alternatives for the other proposed SOR actions, including a Columbia River Regional Forum for assisting in the determination of future SOSs, Pacific Northwest Coordination Agreement alternatives for power coordination, and Canadian Entitlement Allocation Agreements alternatives. A series of nine public meetings was held in September and October 1994 to present the Draft EIS and appendices and solicit public input on the SOR. The lead agencies received 282 formal written comments. Your comments have been used to revise and shape the alternatives presented in the Final EIS.

Regular newsletters on the progress of the SOR have been issued. Since 1990, 20 issues of *Streamline* have been sent to individuals, agencies, organizations, and tribes in the region on a mailing list of over 5,000. Several special publications explaining various aspects of the study have also been prepared and mailed to those on the mailing list. Those include:

The Columbia River: A System Under Stress
The Columbia River System: The Inside Story
Screening Analysis: A Summary
Screening Analysis: Volumes 1 and 2
Power System Coordination: A Guide to the Pacific Northwest Coordination Agreement
Modeling the System: How Computers are Used in Columbia River Planning
Daily/Hourly Hydrosystem Operation: How the Columbia River System Responds to Short-Term Needs

Copies of these documents, the Final EIS, and other appendices can be obtained from any of the lead agencies, or from libraries in your area.

Your questions and comments on these documents should be addressed to:

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PREFACE: SETTING THE STAGE FOR THE SYSTEM OPERATION REVIEW

WHAT IS THE SOR AND WHY IS IT BEING CONDUCTED?

The Columbia River System is a vast and complex combination of Federal and non–Federal facilities used for many purposes including power production, irrigation, navigation, flood control, recreation, fish and wildlife habitat and municipal and industrial water supply. Each river use competes for the limited water resources in the Columbia River Basin.

To date, responsibility for managing these river uses has been shared by a number of Federal, state, and local agencies. Operation of the Federal Columbia River system is the responsibility of the Bureau of Reclamation (Reclamation), Corps of Engineers (Corps) and Bonneville Power Administration (BPA).

The System Operation Review (SOR) is a study and environmental compliance process being used by the three Federal agencies to analyze future operations of the system and river use issues. The goal of the SOR is to achieve a coordinated system operation strategy for the river that better meets the needs of all river users. The SOR began in early 1990, prior to the filing of petitions for endangered status for several salmon species under the Endangered Species Act.

The comprehensive review of Columbia River operations encompassed by the SOR was prompted by the need for Federal decisions to (1) develop a coordinated system operating strategy (SOS) for managing the multiple uses of the system into the 21st century; (2) provide interested parties with a continuing and increased long–term role in system planning (Columbia River Regional Forum); (3) renegotiate and renew the Pacific Northwest Coordination Agreement (PNCA), a contractual arrangement among the region's major hydroelectric–generating utilities and affected Federal agencies to provide for coordinated power generation on the Columbia River system; and (4) renew or develop new Canadian Entitlement Allocation Agreements (contracts that divide Canada's share of Columbia River Treaty downstream power benefits and obligations among three participating public utility districts and BPA). The review provides the environmental analysis required by the National Environmental Policy Act (NEPA).

This technical appendix addresses only the effects of alternative system operating strategies for managing the Columbia River system. The environmental impact statement (EIS) itself and some of the other appendices present analyses of the alternative approaches to the other three decisions considered as part of the SOR.

WHO IS CONDUCTING THE SOR?

The SOR is a joint project of Reclamation, the Corps, and BPA—the three agencies that share responsibility and legal authority for managing the Federal Columbia River System. The National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), and National Park Service (NPS), as agencies with both jurisdiction and expertise with regard to some aspects of the SOR, are cooperating agencies. They contribute information, analysis, and recommendations where appropriate. The U.S. Forest Service (USFS) was also a cooperating agency, but asked to be removed from that role in 1994 after assessing its role and the press of other activities.

HOW IS THE SOR BEING CONDUCTED?

The system operating strategies analyzed in the SOR could have significant environmental impacts. The study team developed a three–stage process—scoping, screening, and full–scale analysis of the strategies—to address the many issues relevant to the SOR.

At the core of the analysis are 10 work groups. The work groups include members of the lead and cooperating agencies, state and local government agencies, representatives of Indian tribes, and members of the public. Each of these work groups has a single river use (resource) to consider.

Early in the process during the screening phase, the 10 work groups were asked to develop an alternative for project and system operations that would provide the greatest benefit to their river use, and one or more alternatives that, while not ideal, would provide an acceptable environment for their river use. Some groups responded with alternatives that were evaluated in this early phase and, to some extent, influenced the alternatives evaluated in the Draft and Final EIS. Additional alternatives came from scoping for the SOR and from other institutional sources within the region. The screening analysis studied 90 system operation alternatives.

Other work groups were subsequently formed to provide projectwide analysis, such as economics, river operation simulation, and public involvement.

The three–phase analysis process is described briefly below.

- **Scoping/Pilot Study**—After holding public meetings in 14 cities around the region, and coordinating with local, state, and Federal agencies and Indian tribes, the lead agencies established the geographic and jurisdictional scope of the study and defined the issues that would drive the EIS. The geographic area for the study is the Columbia River Basin (Figure P–1). The jurisdictional scope of the SOR encompasses the 14 Federal projects on the Columbia and lower Snake Rivers that are operated by the Corps and Reclamation and coordinated for hydropower under the PNCA. BPA markets the power produced at these facilities. A pilot study examining three alternatives in four river resource areas was completed to test the decision analysis method proposed for use in the SOR.
- **Screening**—Work groups, involving regional experts and Federal agency staff, were created for 10 resource areas and several support functions. The work groups developed computer screening models and applied them to the 90 alternatives identified during screening. They compared the impacts to a baseline operating year—1992—and ranked each alternative according to its impact on their resource or river use. The lead agencies reviewed the results with the public in a series of regional meetings in September 1992.
- **Full–Scale Analysis**—Based on public comment received on the screening results, the study team sorted, categorized, and blended the alternatives into seven basic types of operating strategies. These alternative strategies, which have multiple options, were then subjected to detailed impact analysis. Twenty–one possible options were evaluated. Results and tradeoffs for each resource or river use were discussed in separate technical appendices and summarized in the Draft EIS. Public review and comment on the Draft EIS was conducted during the summer and fall of 1994. The lead agencies adjusted the alternatives based on the comments, eliminating a few options and substituting new options, and reevaluated them during the past 8 months. Results are summarized in the Final EIS.

Alternatives for the Pacific Northwest Coordination Agreement (PNCA), the Columbia River Regional Forum (Forum), and the Canadian Entitlement Allocation Agreements (CEAA) did not use the three–stage process described above. The environmental impacts from the PNCA and CEAA were not significant and there were no anticipated impacts from the Regional Forum. The procedures used to analyze alternatives for these actions are described in their respective technical appendices.

For detailed information on alternatives presented in the Draft EIS, refer to that document and its appendices.

WHAT SOS ALTERNATIVES ARE CONSIDERED IN THE FINAL EIS?

Seven alternative System Operating Strategies (SOS) were considered in the Draft EIS. Each of the seven SOSs contained several options bringing the total number of alternatives considered to 21. Based on review of the Draft EIS and corresponding adjustments, the agencies have identified 7 operating strategies that are evaluated in this Final EIS. Accounting for options, a total of 13 alternatives is now under consideration. Six of the alternatives remain unchanged from the specific options considered in the Draft EIS. One is a revision to a previously considered alternative, and the rest represent replacement or new alternatives. The basic categories of SOSs and the numbering convention remains the same as was used in the Draft EIS. However, because some of the alternatives have been dropped, the numbering of the final SOSs are not consecutive. There is one new SOS category, Settlement Discussion Alternatives, which is labeled SOS 9 and replaces the SOS 7 category. This category of alternatives arose as a consequence of litigation on the 1993 Biological Opinion and ESA Consultation for 1995.

The 13 system operating strategies for the Federal Columbia River system that are analyzed for the Final EIS are:

SOS 1a Pre Salmon Summit Operation represents operations as they existed from around 1983 through the 1990–91 operating year, prior to the ESA listing of three species of salmon as endangered or threatened.

SOS 1b Optimum Load–Following Operation represents operations as they existed prior to changes resulting from the Regional Act. It attempts to optimize the load–following capability of the system within certain constraints of reservoir operation.

SOS 2c Current Operation/No–Action Alternative represents an operation consistent with that specified in the Corps of Engineers' 1993 Supplemental EIS. It is similar to system operation that occurred in 1992 after three species of salmon were listed under ESA.

SOS 2d [New] 1994–98 Biological Opinion represents the 1994–98 Biological Opinion operation that includes up to 4 MAF flow augmentation on the Columbia, flow targets at McNary and Lower Granite, specific volume releases from Dworshak, Brownlee, and the Upper Snake, meeting sturgeon flows 3 out of 10 years, and operating lower Snake projects at MOP and John Day at MIP.

SOS 4c [Rev.] Stable Storage Operation with Modified Grand Coulee Flood Control attempts to achieve specific monthly elevation targets year round that improve the environmental conditions at storage projects for recreation, resident fish, and wildlife. Integrated Rules Curves (IRCs) at Libby and Hungry Horse are applied.

SOS 5b Natural River Operation draws down the four lower Snake River projects to near river bed levels for four and one–half months during the spring and summer salmon migration period, by assuming new low level outlets are constructed at each project.

SOS 5c [New] Permanent Natural River Operation operates the four lower Snake River projects to near river bed levels year round.

SOS 6b Fixed Drawdown Operation draws down the four lower Snake River projects to near spillway crest levels for four and one–half months during the spring and summer salmon migration period.

SOS 6d Lower Granite Drawdown Operation draws down Lower Granite project only to near spillway crest level for four and one–half months.

SOS 9a [New] Detailed Fishery Operating Plan includes flow targets at The Dalles based on the previous year's end–of–year storage content, specific volumes of releases for the Snake River, the drawdown of Lower Snake River projects to near spillway crest level for four and one–half months, specified spill percentages, and no fish transportation.

SOS 9b [New] Adaptive Management establishes flow targets at McNary and Lower Granite based on runoff forecasts, with specific volumes of releases to meet Lower Granite flow targets and specific spill percentages at run–of–river projects.

SOS 9c [New] Balanced Impacts Operation draws down the four lower Snake River projects near spillway crest levels for two and one–half months during the spring salmon migration period. Refill begins after July 15. This alternative also provides 1994–98 Biological Opinion flow augmentation, integrated rule curve operation at Libby and Hungry Horse, a reduced flow target at Lower Granite due to drawdown, winter drawup at Albeni Falls, and spill to achieve no higher than 120 percent daily average for total dissolved gas.

SOS PA Preferred Alternative represents the operation proposed by NMFS and USFWS in their Biological Opinions for 1995 and future years; this SOS operates the storage projects to meet flood control rule curves in the fall and winter in order to meet spring and summer flow targets for Lower Granite and McNary, and includes summer draft limits for the storage projects.

WHAT DO THE TECHNICAL APPENDICES COVER?

This technical appendix is 1 of 20 prepared for the SOR. They are:

A. River Operation Simulation

B. Air Quality

C. Anadromous Fish & Juvenile Fish Transportation

D. Cultural Resources

E. Flood Control

F. Irrigation/Municipal and Industrial Water Supply

G. Land Use and Development

H. Navigation

I. Power

J. Recreation

K. Resident Fish

L. Soils, Geology, and Groundwater

M. Water Quality

N. Wildlife

O. Economic and Social Impacts

P. Canadian Entitlement Allocation Agreements

Q. Columbia River Regional Forum

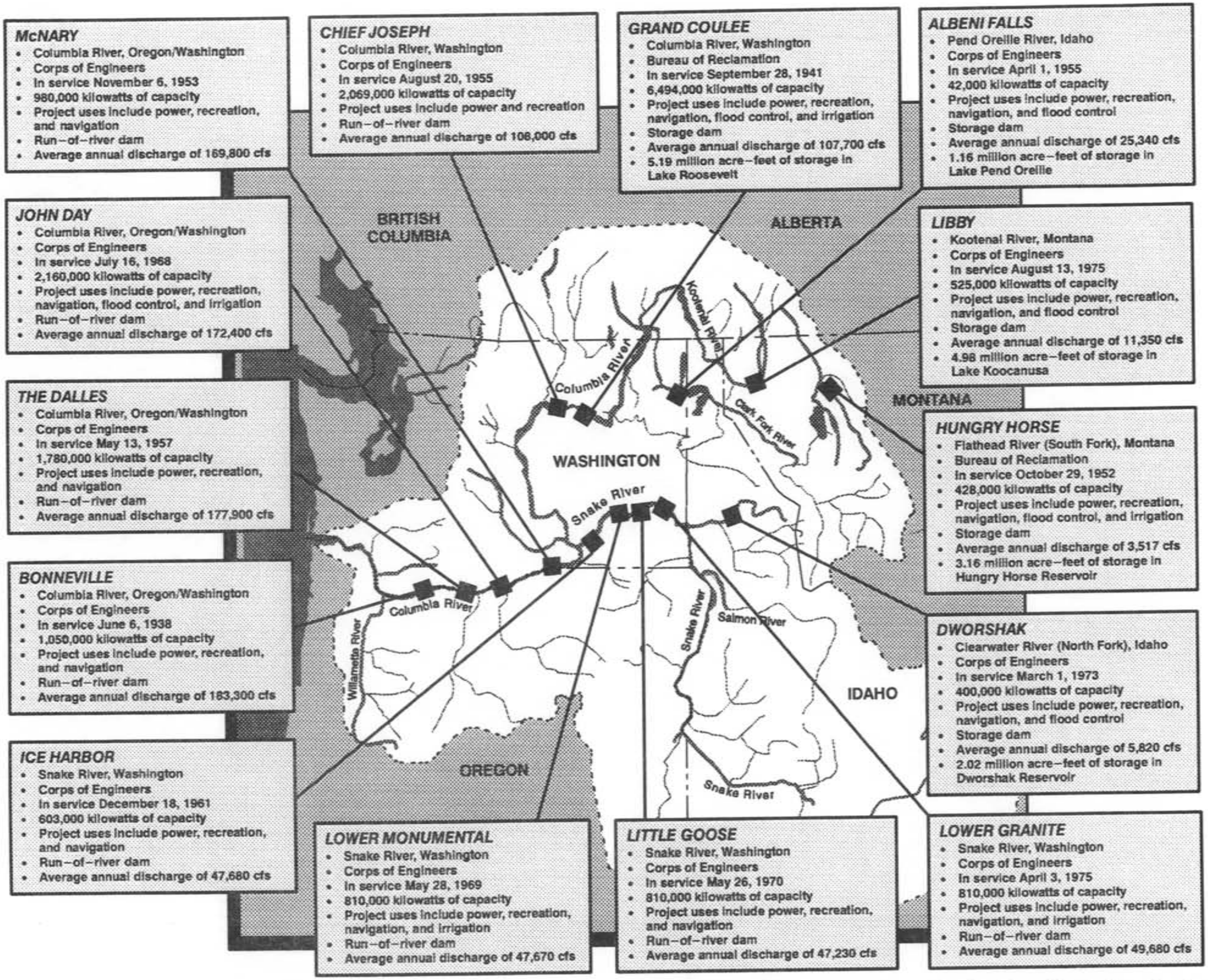
R. Pacific Northwest Coordination Agreement

S. U. S. Fish and Wildlife Service Coordination Act Report

T. Comments and Responses

Each appendix presents a detailed description of the work group's analysis of alternatives, from the scoping process through full–scale analysis. Several appendices address specific SOR functions (e.g., River Operation Simulation), rather than individual resources, or the institutional alternatives (e.g., PNCA) being considered within the SOR. The technical appendices provide the basis for developing and analyzing alternative system operating strategies in the EIS. The EIS presents an integrated review of the vast wealth of information contained in the appendices, with a focus on key issues and impacts. In addition, the three agencies have prepared a brief summary of the EIS to highlight issues critical to decision makers and the public.

In addition to presenting the study results, the appendix includes an overview of the study scope and process, the historic and current social and economic condition in the Columbia River Basin, and the analytical methods used to measure the economic and social impacts. Considerable background and supporting material is presented in the separate resource appendices. The level of detailed background and supporting data presented in this appendix for any river use was gauged by the information provided in the resource appendix for that river use. An effort was made to avoid unnecessary duplication, but sufficient detail is presented to provide the reader with information required to comprehend the data and analyses presented in this appendix without continually having to refer back to the supporting resource appendices. Table P–1 provides the information needed to identify the resource or physical impacts appendix related to each river use. This appendix relies on supporting data contained in the Anadromous Fish, Resident Fish, Wildlife, Flood Control, Irrigation/Municipal and Industrial Water Supply, Navigation, Power, Recreation, and Water Quality appendices. For complete coverage of all aspects of the economic and social analysis, readers may wish to review all ten appendices in concert.



1 million acre feet = 1.234 billion cubic meters
1 cubic foot per second = 0.028 cubic meters per second

Figure P–1. Projects in the System Operation Review.

Table P–1. Summary of River Uses and Associated information Contained in the SOR Technical Appendices

River Use	Economic and Social Impacts	Supporting Resource Technical Appendix
Anadromous Fish	– Economic and social impacts related to commercial, recreational, and tribal harvests	**Anadromous Fish** – Biological impacts to representative stocks
Resident Fish	– Brief discussion related to recreational fishing	**Resident Fish** – Biological impacts
Wildlife	– Brief discussion related to recreational use	**Wildlife** – Biological impacts
Flood Control	– Economic and social impacts related to changes in annual damages from flooding	**Flood Control** – Stage or discharge vs frequency impacts
Irrigation and Water Supply	– Economic and social impacts related to changes in net farm income	**Irrigation and Water Supply** – Changes in water withdrawal costs and net farm income
Navigation	– Economic and social impacis related to changes in the cost of transporting commodities	**Navigation** – Impacts to the congressionally authorized navigation system within the Columbia and Snake River system
Power	– Economic impacts related to changes in rates; impacts of rates on power demand; net system costs; and changes in consumer surplus	**Power** – Annual gross system generation and capacity costs
Recreation	– Economic and social impacts related to the economic value of recreation activity	**Recreation** – Recreation days by type of activity and by site
Water Quality	– Economic and social impacts related to impacts on water	**Water Quality** – Impacts on water quality

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CHAPTER 1

INTRODUCTION: PURPOSE, SCOPE, AND PROCESS

Chapter 1 discusses study scope and processes undertaken to identify and measure economic and social impacts of alternative system operating strategies.

1.1 PURPOSE OF ECONOMIC AND SOCIAL IMPACTS APPENDIX

The purpose of this appendix is to measure the economic and social effects of the alternative system operation strategies. Section 102 of the National Environmental Policy Act (NEPA) and guidelines from the Council on Environmental Quality (CEQ), which interprets NEPA, requires that economic and social impacts be identified. This information is useful to decision makers and others interested in the SOR outcome. Economic measures are used to evaluate efficiency changes in the nation's production of the goods and services and how regional economies are impacted. From the economic assessment, the social analysis identifies the impacts to individuals and groups. Such evaluation identifies the gains and losses to society as a whole and to specific elements of society of implementing a particular alternative.

Typically, the economic effects are stated in monetary terms. Where monetary measures were not readily available, such as with the tribal ceremonial use of anadromous fish, qualitative assessments were used. No attempt was made to monetarily measure non–use values. These principally include existence, option, and bequest values for anadromous fish, resident fish, wildlife and recreation/scenic areas. The concepts of non–use measures are discussed, however, and non–use values from existing studies are presented (see Section 3.3.1.6).

1.2 SCOPE OF ECONOMIC AND SOCIAL IMPACTS ASSESSMENT

The scope of the economic and social analysis has a geographic component and a methodology component.

1.2.1 Geographic Scope

The geographic scope of the economic impacts analysis conducted for the SOR is consistent with the analysis of the physical effects of the SOSs. The SOSs directly influence the operation of the 14 Federal dams on the Columbia and lower Snake Rivers. The operations of other, non–Federal dams in the Columbia River Basin are indirectly affected. In general, the economic impacts were evaluated wherever significant physical impacts were identified. The assessment of social impacts, however, was limited to focus communities considered to be representative of impacted communities in each of eight subregions of the Pacific Northwest. Restriction of the analysis of economic impacts to areas specifically evaluated for physical impacts omits from analysis some important potential impacts. Some of the more important of these are discussed below.

The geographic area for the SOR was the Columbia River Basin, including that portion which lies in Canada, which is influenced by the 14 Federal projects (see Figure P–1). Impacts to Canadian interests, however, were not evaluated, except for potential recreation impacts at Lake Koocanusa (Libby Dam). Some of the SOSs involve changes to power marketing arrangements with other regions, such as the Pacific Southwest, that would impact those regions. Except for consideration the economic value of exporting and importing power to/from outside the region, economic impacts on other regions are not evaluated in this appendix.

The SOR also examined potential flow augmentation benefits to anadromous fish of additional water from the middle and upper Snake River Basins (above Brownlee Reservoir). This water was assumed to be available in varying amounts at different times of the year. Although several potential sources of water have been identified for portions of the water needed, permanent re–direction of this water from Federal storage projects would require Congressional authorization. Rights to use all of the basin's natural flow have been granted to existing water users, under state law. Acquisition of rights to natural flow from individuals or from the State Water Bank would require establishment of a legal process which would allow water rights to be transferred and its use to be changed from existing uses to use for anadromous fish. National and regional economic and social tradeoffs associated with obtaining this water were not addressed in the SOR. Although this issue was not addressed in the SOR, two different estimates of impacts on irrigated land and the cost of obtaining the additional water are available. One estimate was prepared by Economic Research Service, US Department of Agriculture, and the other estimate was submitted as a comment on the Draft Environmental Impact Statement by the state of Idaho. These two estimates are presented in this appendix for the reader's information.

1.2.2 Economic and Social Scope

For each alternative operating strategy, social and economic values were assigned to the primary uses of the Columbia River system. However, not all uses were measured in a direct way. For example, the economic impacts resulting from changes in resident fish populations were measured through the recreation analysis because sport fishing was identified as the primary use of resident fish.

The main uses of the river system evaluated in the SOR analysis were navigation, flood control, irrigation, municipal and industrial water supply, electric power generation, anadromous fish, resident fish, wildlife, recreation, and water quality. For each operating strategy some river uses would be made better off and some would be made worse off. The scope of the analyses presented in this appendix was to measure these tradeoffs from an economic and social viewpoint.

The SOR economic and social analyses measured impacts from three perspectives. The Federal or national view considers the net affects to the nation. The regional economic analyses identified economic gains and losses to specific sub–regions and the social analyses evaluates how selected communities within the sub–regions are affected by the strategies.

1.2.2.1 National Economic Analysis

The first perspective considered the National Economic Development (NED) consequences of alternative system operating strategies. NED analyses are concerned with economic efficiency at the national level. Thus, economic gains (income and/or employment) achieved by one region of the nation at the expense of another region do not represent an increase in the national economy. Generally, NED effects represent the initial or primary response of specific elements of the economy to a change in the operation of the Columbia/Snake River system. For example, an alternative could result in less water being available to generate power. If other resources, such as a combustion turbine plants, are needed to replace the lost hydropower production, the cost of producing power goes up. This increased cost would be a negative NED effect. See Section 3.1 for additional information on NED concepts.

National Economic Development (NED) evaluation procedures (Water Resources Council, 1983) were used as a guide in the derivation of direct impacts. Deviation from NED procedures are identified in the appendix text primarily in chapters 3 and 4.

1.2.2.2 Regional Economic Analysis

The second perspective presents the economic consequences of system operating changes on regional and sub–regional economies. Regional Economic Development (RED) impacts may be the change in the economy of a community or sub–region as a result of improved fishing at a reservoir near the community or within the sub–region. For example, if an SOS improved fishing at a recreation site, the number of visits to that site would likely increase. As the visitors purchase greater amounts of fishing supplies, meals, gas, lodging, etc. in the community or sub–region, the economy is stimulated creating a positive regional impact--an increase in employment and/or income. However, if the improved fishing at the site results in a decrease in fishing and associated expenditures at another site, the gain in one community or sub-region could be offset by a loss in another. For the SOR analysis, regional economic impacts generally are made on the basis of an assumption that economic activity is not transferred among sub-regions in response to the direct impacts of the SOSs, with one exception. The exception is in the case of recreation where the assumption is that residents of a sub-regions will continue to recreate at the same level even if visitation to a specific site is projected to decrease. Thus, the assumption is that these recreators would substitute an alternative site within the same sub-region.

Regional impacts were determined using the IMPLAN input-output model with 1989 datasets, the most recent data available. County data were aggregated into eight subregion models. In addition, models were developed for Oregon, Idaho, Washington, and Montana and the entire four-state region. Table 1-1 shows the sub-regions which were used in the regional impact analysis.

1.2.2.3 Social Analysis

The third perspective presents some of the likely social impacts on selected local communities and individuals because changes in the operation of the system will affect communities differently. One community may lose recreation-related business and suffer an increase in unemployment and decreases in income and tax revenue as a result of a change in reservoir operations. Another community may benefit from increased business, jobs, income, and tax revenue if recreators choose to visit their reservoir instead. Some changes will affect all individuals, but groups of individuals will be affected differently. A change in power rates, for example, will affect everyone, but low income individuals will feel a greater impact, if as a proportion of their budgets, power expenditures are greater than for higher income individuals and if they have fewer substitutes available. Potential social impacts for the selected focus communities were determined through analysis of the indirect economic impacts by the technical staff of the Corps of Engineers, and the Bureau of Reclamation with the assistance of a social impacts assessment consultant.

1.3 PUBLIC INVOLVEMENT AND AGENCY COORDINATION

This section describes the team directly involved in the study effort and the role of the general public and others in shaping the economic and social analysis.

1.3.1 Economic Analysis Group

The team directly responsible for the socio-economic analyses for the SOR is the Economic Analysis Group (EAG). The EAG is one of 16 work groups formed to manage the SOR study and to analyze the environmental, economic, and social impacts of alternative system operating strategies. The EAG had the lead role in managing the evaluation of the social and economic effects. Technical analyses were conducted by the EAG as well as other functional work groups. For example, the Power Work Group estimated the effect of alternatives on regional power system costs.

The EAG consists of 18 core members from the three SOR sponsoring agencies, Bonneville Power Administration (BPA), U.S. Army Corps of Engineers (Corps), and U.S. Bureau of Reclamation (Reclamation) and 38 other interested parties and agency representatives. A list of members of the EAG is included in Chapter 6.

The EAG encouraged anyone interested to participate in work group meetings. Besides official meeting announcements, the work group and the economic analyses conducted for the SOR were discussed in an issue of Streamline, the SOR newsletter.

Typically, three to four individuals outside the core group attended meetings. Representatives from the Northwest Power Planning Council, U.S. Bureau of Mines, Port of Portland, Public Power Council, Pacific Northwest Utilities Conference Committee, and state agencies frequently participated in EAG meetings. About 20 other interested parties received EAG mailings and reviewed work group output, including this appendix.

Table 1–1. Subregions Identified for the SOR Regional Economic Analysis

SubRegion	Counties Included in the SubRegion
1. Puget Sound	Washington: Whatcom, Skagit, Snohomish, King, Pierce, Thurston
2. West Coast	Washington: Clallam, Jefferson, Grays Harbor, Pacific, Wahkiakum, Cowlitz Oregon: Clatsop, Tillamook, Lincoln, Columbia
3. Portland	Oregon: Multnomah, Washington, Clackamas, Yamhill Washington: Clark
4. Mid Columbia	Oregon: Hood River, Wasco, Sherman, Gilliam, Morrow, Umatilla Washington: Skamania, Klickitat, Benton, Franklin, Walla Walla
5. Upper Columbia	Washington: Yakima, Kittitas, Chelan, Okanogan, Douglas, Grant, Lincoln, Adams
6. Lower Snake	Washington: Columbia, Garfield, Asotin, Whitman Oregon: Wallowa Idaho: Latah, Nez Perce, Lewis, Clearwater, Idaho, Custer, Lemhi
7. Northeast	Washington: Pend Orielle, Spokane, Ferry, Stevens Idaho: Boundary, Bonner, Kootenai, Benewah, Shoshone Montana: Lincoln, Flathead, Sanders, Lake, Missoula, Mineral
8. Southern Idaho	Oregon: Malheur Idaho: Adams, Washington, Payette, Gem, Canyon, Ada, lmore, Owyhee, Boise, Valley, Camas Blaine, Gooding, Lincoln, Jerome, Minidoka, Twin Falls, Cassia, Jefferson, Madison, Teton, Clark, Fremont, Butte, Bingham, Bonneville, Power, Bannock, Caribou, Oneida, Franklin, Bear Lake

1.3.2 Public Involvement

Other than the EAG meetings and comments on mailings, the primary opportunities for public involvement came during the scoping meetings, mid–point meetings, meetings on the draft environmental impact statement, and public review of the draft report. The scoping meetings were held in late 1990 and the mid–point meetings were held in 1992. The 14 scoping meetings and the 14 mid–point meetings were held region wide and about 1300 people attended. Economic and social concerns expressed during these meetings are discussed in Section 1.4, Economic and Social Issues Raised During Study. The public input was critical in shaping the scope of the SOR economic and social analyses. For example, the regional and sub–regional impacts analyses were undertaken because of concerns raised during the scoping process.

A draft of the SOR Environmental Impact Statement, including this appendix was completed in July 1994 and was provided to Federal and state agencies, the Tribes, interest groups, and the public for review and comment. In addition, a series of public meetings were held. The public meetings and review resulted in more than 100 comments on the analyses of economic and social impacts. Responses to 100 comments which were logged into the SOR comment tracking database were prepared and are included in Appendix T (Comments and Responses) of the SOR Final Environmental Impact Statement. It was not possible to respond to all of the comments because of time and resource constraints. The most notable of the comments which we were unable to address are contained in a report submitted by the Coeur D'Alene Tribe entitled, "Economic Consequences of Management Strategies for the Columbia and Snake Rivers," July 1995. The report was prepared for the Confederated Tribes of the Umatilla Reservation by ECONorthwest of Eugene, Oregon.

1.3.3 Coordination within SOR Work Groups

The EAG coordinated closely with other SOR work groups. Economic and social effects are dependent on the physical impacts identified by the functional work groups, thus driving the need for close relationships. Coordination was facilitated because several EAG members were representatives on the functional work groups. The dependency of the EAG on the other work groups and their products is shown in Table P–1, located in the Preface.

1.4 ECONOMIC AND SOCIAL ISSUES RAISED DURING STUDY

Numerous economic and social issues were raised during the study. Some were general in nature, while others centered around specific technical measurement concerns. Different analytical requirements of the three lead agencies added to the varied perspectives on the issues. Although measurement of economic activity is relatively well understood theoretically, applying the theory to complex and dynamic conditions, as is the case with this study, can be extremely difficult. The EAG worked toward a goal of reasonably accurate estimates given time and budget constraints. While much long and challenging dialogue took place, consensus was reached on most issues. The results of these discussions were set forth in a requirements and procedures document (Economic Analysis Requirements and Procedures, 1993). The document prescribes the information and tools to be used to measure the impacts analyzed in this study. The issues related to the economic and social analysis are presented in the following paragraphs. In addition, the EAG participated in resolving broader SOR issues such as geographic scope, definition of the no–action alternative, etc. which are discussed in the main EIS document.

1.4.1 General Economic and Social Issues

General economic and social issues mainly came from public comments on the SOR process during the scoping and mid–point meetings. In general, the following types of concerns were expressed.

- Possible negative effects to local economies
- The importance of economic considerations in the decision making process, especially balancing economic and environmental goals
- The need to know the economic assumptions used
- The need for a fair distribution of costs
- The desire to see explicit presentation of economic benefits and costs
- The importance of honoring Tribal and treaty rights
- Concern over possible negative impacts to existing ways of life.

1.4.2 Technical Issues

In addition to general issues, many technical issues were raised in the EAG relating to specific study methods. These are briefly discussed below.

- **Economic value of environmental resources, such as anadromous fish** –– An issue arose over whether non–use values (existence, option, and bequest) of environmental resources should be measured in the SOR analysis. The economic analysis is limited to use values like recreation and commercial fishing. The decision not to estimate and include non–use values in the SOR was a difficult one. The following discussion provides some background on the difficulty and practicality of estimating non–use values in this study. If non–use values are to be used in the evaluation of alternatives, then for a rational assessment they need to be estimated for all river services that have non–use value. For the SOR, this would likely include wild and hatchery anadromous salmon and steelhead, resident fish, wildlife, recreation, cultural resources, water quality, and possibly others. Some of the more important problems arising from existing contingent valuation (CV) studies which are used to measure non–use values include: 1) results that appear inconsistent with the economic assumptions of rational choice; 2) CV responses that sometimes appear implausibly large given the many alternative programs for which individuals might be asked to contribute and the availability of substitutes for the resources being evaluated; 3) inadequate reminders of the respondent's budget constraint; 4) difficulty in communicating clear policy or program information about what the respondents are being asked to value; 5) difficulty in determining the market extent; and 6) separating the "warm glow" of giving from the actual willingness–to–pay for the program in question. A study which fully considers non–use value and addresses measurement issues would be extremely difficult and would clearly exceed the resource constraints for SOR. Despite analytical problems associated with non–use values, these types of studies are routinely estimated. One such study was conducted for the Corps in 1990. This study estimated the existence value of doubling Pacific Northwest salmon and steelhead runs. The draft and final SOR environmental impact statements present the results of the study. A reference to the study is included in Chapter 8.

- **Period of analysis, price level, discount rate, and forecasting --** Considerable discussion took place within EAG meetings regarding these important elements of an economic analysis. They can significantly affect results, especially the ability to compare alternatives across the different river uses and implementation time frames. The EAG adopted the following assumptions. A discussion on how these assumptions are considered in economic evaluations is included Section 3.2 of this appendix, National Economic Analysis Assumptions for SOR.

  – Period of Analysis: 100 years from a base year of 1995.

  – Price Level: October 1992, with a few exceptions which are noted in the text. Updating all costs to a more current price level for the FEIS was not possible due to time and resource constraints.

  – Discount Rate: Two discount rates are used, 7–3/4 percent, the discount rate which Federal water resource agencies are required to use during fiscal year 1995 and 3 percent, the inflation–free interest rate which is used by BPA.

- **Measure of impacts to irrigators --** Three technical economic measurement issues were related to the irrigation analysis. The first and most direct issue involved water availability. That is, can water currently used by irrigators be shifted to other uses? The right to use water from natural flow is granted by the states. For this study these rights were considered an inviolable institutional constraint. The use of water stored in Federal projects is controlled by contracts between water users and the Federal Government. As with state–granted rights to use water from natural flow, existing contractual agreements on the use of stored water were considered to be an inviolable constraint in this study. As a result, the analytical assumption was that current water availability will remain the same under all operating strategies. The second issue addressed whether the alternative operating strategies would cause a change in the crop mix. While measuring crop mix changes is technically correct, it requires dynamic modeling to predict. Because of limited resources and time, the analytical assumption was that no change in crop mix would occur. Given these two assumptions the estimated impact to irrigators was limited to the change in costs associated with pumping water from Federal reservoirs under drawdown conditions. The third issue centered around how to value the energy used to pump water over increased lifts. For this study, electrical energy used by irrigators and other water users is valued at the power rates the users currently pay. This measure of the value of electricity is appropriate because estimated economic impacts are not being used to optimize system operation and because an economic efficiency analysis of irrigated agriculture is a subsidy issue beyond the scope of SOR. Analytical procedures and methods are discussed in Section 3.3.4 of this appendix. Detailed information on the analysis of water use costs can be found in Appendix F (Irrigation/Municipal and Industrial Water Supply).

- **Consistency in measuring impacts among river uses** -- To describe the economic impacts of each SOS, the impacts estimated for each river use were summed to yield the total impacts for the SOS. This summation approach was surfaced as an issue because not all impacts were defined on the same basis or level of detail, and some impacts were not translated into economic terms. The limitations of summing across river uses are documented in this appendix. Alternative approaches of evaluation such as ranking or grouping alternatives by the respective river uses are presented in Chapter 5. It should be noted that the SOR analysis evaluates economic impacts from two perspectives, the Federal or national perspective and the regional perspective. The Federal or national perspective considers the net effects to the national economy. This is the National Economic Development (NED) or direct impact analysis. From this perspective, the general measurement standard for goods and services is the net willingness of users to pay for each increment of output from an alternative. Since it is usually not possible to obtain willingness to pay values, alternative or proxy measures are used. These include actual or simulated market prices, changes in net income, cost of the most likely alternative (e.g., replacement cost of hydropower), and administratively established values. The same type of measure does not have to be used for all goods and services effected by an alternative or across alternatives. The employment of such values is less than ideal, but they are widely used in applied economic analysis. This convention is specified in the US Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, which is the principal guidance for economic analysis conducted by Federal water resource agencies. The SOR analysis uses proxy measures which can be summed and compared from one alternative to another. The analysis is based on existing economic conditions. It would be conjecture to assume current subsidies will no longer exist in the future and an impossible task to identify the economic structure that would exist in the absence of subsidies. The second perspective considers the indirect impacts to the affected regions and subregions. These impacts stem from the initial shocks to the regional economy brought about by the direct impacts and are commonly measured using input-output models which estimate the multiplier effect on a region's economy of specific direct impacts of a project, e.g. an increase in transportation costs due to closure of the Snake River shallow-draft waterway during drawdown. For the SOR 13 regional, state and subregional models were developed using IMPLAN, an input-output modeling system developed by the US Forest Service. The results of the two perspectives can not be compared and were not compared or used interchangeably in the SOR analysis.

- **Positive regional impacts of increased flood damages** -- Increased flooding can result in positive economic benefits to the flooded region in terms of regional income and employment as money flows into the economy for emergency services, cleanup, and rebuilding. Should these regional benefits be measured for SOSs which increase flood damages? The EAG determined that since flooding is never viewed as a positive impact, it would be inappropriate to assess potentially beneficial regional economic impacts of increased flooding associated with some of the SOSs.

- **Gross system generation and capacity cost, net system generation and capacity cost, and consumer surplus in evaluating power impacts --** The gross system cost method is the most commonly used means of evaluating power projects, where the economic feasibility of increasing system generation capability is typically being considered. This method, however, does not account for demand responses to changes in price when low–cost existing generation resources are replaced by new resources which have much higher costs. For this reason, the EAG determined that the net system cost method should be used in the SOR. This method reflects the concept of price elasticity whereby increases in system fixed and variable costs and associated increases in rates to consumers result in decreases in the quantity of electricity consumed (the concept of price elasticity is discussed in Section 3.1.4.2). The analytical approach used for the SOR to estimate system costs is based on balancing resources with loads under each SOS such that system reliability remains the same as it is in the base case. Thus, system reliability requirements define the need for additional resources to meet demand. Costing out these changes gives the change in the gross system costs of meeting Northwest regional loads. These costs are then translated into rate impacts on the major Pacific Northwest customer classes. If the quantity of electricity demanded would change because of the rate impacts, the original estimate of need for additional resources is revised. This process results in net system resource requirements and costs, which takes into account the reduction in the quantity of power demanded in response to a rate increase. Ideally, estimating net system costs is an iterative process which is continued until the supply of electricity is equal to the demand. The difference between system costs for the no action alternative (SOS 2c) and net system costs for a given alternative SOS is the net replacement cost of power. Gross system costs are presented in Appendix I (Power) and Section 4.8.1 of this appendix. Replacement of existing resources with higher cost resources forces rates higher and causes consumers to reduce the quantity of electricity consumed. The increased cost of electricity and the decrease in quantity consumed results in a loss of consumer surplus (decrease in social well–being). The magnitude of the loss in consumer surplus was estimated for the DEIS, but was not estimated for the FEIS.

- **Value of water quality impacts --** Several ways of evaluating water quality economic impacts were considered for the SOR study. The most technically correct way measures the economic value in terms of people's willingness–to–pay either to restore or maintain the quality of water to a specified standard. This method is difficult and expensive to undertake. Given time and budget constraints, the EAG agreed to value water quality changes indirectly through the analysis of water uses. For example, the anadromous fish analysis includes the impact of dissolved gases on fish production. In addition, the EAG agreed that where water quality is degraded to the level that it does not meet legal water quality standards for a specific use, the economic value of the degradation would be measured in terms of the costs which would be incurred to fully restore water quality to meet or exceed the standard. Analyses conducted by the Water Quality Work Group did not show that any of the

SOSs would cause a violation of legally defined water quality standards. Therefore, application of this analytical approach was not required. Details of the effects of the SOSs on water quality are contained in Appendix M (Water Quality).

- **Deep–draft navigation impacts on the lower Columbia River ––** After study scoping, an issue surfaced over the concern that deep–draft navigation in the Columbia River downstream of Vancouver, Washington could be affected by alternative operating strategies. The potential impacts would be associated with alternatives which included drawdown of the lower Snake River projects for extended periods of time. The issue was that late summer refill of the lower Snake River dams could cause a decrease in river stages on the lower Columbia River. Current deep–draft navigation practices maximize the draft of outbound ships based on the actual stage and tidal cycle. Even small changes in available water depth could have economic consequences. To resolve the issue, the SOR study scope was broadened to include navigation on the lower Columbia River. An analysis of the effect of the SOSs on the stage of the Columbia River from Portland to the ocean was conducted by the Navigation Work Group. The results of the study are summarized in Appendix H (Navigation). Analytical procedures and methods used are discussed in Section 3.3.5.2 of this appendix.

- **Temporal shifts in the shipment of grain on the river ––** A key assumption of the SOR navigation analysis is that the flow of grain will continue to move at historical monthly rates for all alternative operating strategies. The issue is whether this is a reasonable assumption. Some transportation analysts believe farmers who now ship from ports on the lower Snake River will likely ship their grain before or after reservoir drawdown and closure of the navigation system rather than use alternative modes of shipment. These analysts believe that farmers who are not affected by closure of the Snake River to navigation would adjust their shipments to facilitate expected changes in shipping patterns of impacted farmers. If this is true the navigation analysis would tend to overstate economic impacts for the drawdown alternatives. Pre–conditions of temporal shifts, however, are that upper and lower river grain types are the same; that farmers have sufficient economic flexibility to make a significant change in their present grain marketing practices; and, that exporters have sufficient flexibility of supply to meet the demands of the export market with a limited geographic supply of grain. Due to resource and time constraints these pre–conditions for temporal shifts were assumed not to occur. This assumption was informally confirmed through discussions with grain exporters who agreed that continued availability of grain from throughout the region would be needed to meet export market demands. Analytical procedures and methods used in the analysis of shallow–draft navigation, including grain transportation, are discussed in Section 3.3.5.2 of this appendix.

- **Input/Output Models and Dynamic Changes ––** Input/output (I/O) models cannot be used to determine the effects of dynamic changes that would result from implementation of the long–term strategies being evaluated in the SOR. The secondary effects of dynamic changes cannot be estimated because coefficients which drive the I/O model are fixed by current economic relationships. Thus, the best that the I/O modeler can do is provide a "snap–shot" estimate of the secondary impacts of a change to a region's economy. Since many of the changes which will result from SOR strategies will change (typically increase) over time, the EAG determined that I/O model studies should be run using average annual estimates of expected changes. Concepts and use of input/output models to evaluate regional economic impacts of the SOSs are discussed in Section 3.5 of this appendix. Results of the analysis are discussed in Chapter 4.

- **Subsidies** -- In general, a subsidy (financial transfer from one individual, economic sector, societal group, etc., to another) occurs whenever goods and services are not priced at marginal cost. In the case where marginal costs are higher than average costs, existing users subsidize new users. On the other hand, where marginal costs are lower than average costs, new users subsidize old users. In the case of the river uses of the Columbia/Snake River system, marginal cost-based prices and average cost-based prices are present. In addition, irrigators served by the Columbia Basin Project pay a contract rate for power used to pump water from Lake Roosevelt (Grand Coulee dam) which is administratively set. At issue is whether existing subsidies should be addressed. That is, should impacts be valued at rates actually paid by users or at the marginal cost to the Nation. The EAG determined that analysis of subsidies was beyond the scope of the SOR. As a result, the analysis reflects a mix of average- and marginal-cost based prices and administratively set prices. The type of prices used for each river use is listed below:

River Use:	Basis for Prices:
Anadromous Fish	Marginal costs
Flood Control	Marginal costs
Irrigation	
Pump Modification	Marginal costs
Power	
Columbia Basin	Administratively set
Other Areas	Average cost
Navigation	Marginal cost
Power	
New Resources	Marginal cost
Rates	Average cost
Recreation	Marginal cost (willingness-to-pay)

- **Allocation of Anadromous Fish to Harvest** -- The fish models used in the analysis fixed the ratio of the number of salmon and steelhead harvested in the numerous fisheries and the fish that escape to spawn. The ratio of harvest to escapement was established based on data through the 1980s. This approach does not reflect fact that fishery management agencies, at least in the short run, will likely reduce the harvest of the fish listed under the ESA and hence increase the escapement amounts. The issue is, should the estimation of salmon harvest and steelhead be adjusted to change the historic harvest to escapement ratios? The harvest allocation issue is very complicated because reducing harvest in one area may only increase harvest in another. The mixed-stock nature of the fisheries would require reduction in harvest of non-targeted species. Some research is ongoing on this issue and fishery management decisions are being made continually. It was decided that it is simply too soon to determine the long range changes in harvest to escapement ratios for all the Columbia River salmon and steelhead. So, the economic analysis of salmon and steelhead harvest is based on historic allocations to the various fisheries. This probably overstates the economic value associated with the fisheries, especially in the short run. But, as ESA stocks recover, historic allocations may be restored. The allocation of fish to harvest is discussed in detail in Section 3.3.1.2 of this appendix.

- **Recreation Demand** - - Several issues were raised in the economic analysis of recreation impacts in the DEIS. It was recognized that the recreation use and value models had numerous limitations, foremost of which were: (1) heavy reliance on professional judgment of expected reaction of recreators to pool level fluctuations and varied flows; (2) application of economic values derived in other studies to the conditions being examined in the SOR; and, (3) inadequate accounting for substitution of lost recreation opportunity at one site to another recreation site. To address these concerns significant modifications were made in the recreation analysis for the FEIS. The analysis presented in this appendix of the FEIS and described in detail in Appendix J (Recreation) used results from an extensive survey of potential recreators throughout the Pacific Northwest and parts of Canada. Approximately 3,000 useable survey responses were utilized to develop information on changes in visitation at Federal projects in the Columbia River Basin with the different system operating strategies. Using this information, regional models were developed to estimate both expected visitation and to monetize the changes in aggregate welfare (direct economic impacts) associated with the impacts to recreation. The models account for substitution among regional waters. Survey responses provided descriptions of actual 1993 recreation behavior, such as trips to Federal water projects and trip expenditures. To help identify the number of recreation trips that would result from changes in operation of Federal projects with the various SOSs, the respondents expressed their intended behavior (contingent behavior) with reservoirs and rivers at various elevations and flows. Respondents indicated whether they would increase or decrease the number of trips to the impacted Federal reservoir, other Federal reservoirs, or other waters in the region. Computer enhanced photos of different reservoir elevations, pool elevations charts, and impacts on recreation facilities were included in the mail–out questionnaires to provide the respondents with the information needed to express their contingent behavior. Since the FEIS includes empirically based and technically valid recreation use and value models, linked directly to the SOR alternatives, the major technical concerns raised in the DEIS have been addressed.

CHAPTER 2

AN ECONOMIC HISTORY OF THE COLUMBIA RIVER BASIN AND ITS USE TODAY

This chapter describes the socio–economic history of the Columbia River Basin. It relates how the Columbia River system influenced development in the Pacific Northwest. Demographic characteristics of the people who live in the region and how the river system is used are also described. In addition, the importance of the Columbia River to Native Americans is briefly discussed.

2.1 THE COLUMBIA RIVER AND SOCIO–ECONOMIC DEVELOPMENT IN THE NORTHWEST

The Pacific Northwest has been characterized as a hinterland to the metropolitan–dominated economic system of Europe and North America. Historical trading patterns suggest that Asia also be included with Europe and North America. In this context, hinterland refers to the economic supporting role of the region in supplying raw materials and semi–finished products– –aluminum, for example– –to national and international markets. The region's economic supporting role began with the emergence of the fur trade in the 1780's and continues today through exports of forest products, agricultural commodities, and semi–finished manufactured products. The purpose of this section is to briefly describe the significance of the Columbia River to Native Americans and the socio–economic development of the region following arrival of the Europeans. The linkage between historical socio–economic development of the region and the development and operation of the Columbia River system of water control projects is also described.

2.1.1 Resource Base

In general, Native American cultures and the economic development of the Pacific Northwest and the Columbia River Basin are closely tied to the region's natural resources. Economic development has progressed in accordance with exploitation of the region's natural resources, largely in response to national and international demand. Among the most significant of the region's natural resources, listed in their general chronological order of exploitation, are: sea and land fur–bearing animals; the land with the region's favorable climate, ranging from cool and wet west of the Cascades to temperate and dry to the east; gold and other minerals; timber; salmon; and, finally, the Columbia River. The region's natural location on the Pacific Rim and its relative nearness to Asian markets provides a locational comparative advantage which has also influenced economic development.

2.1.1.1 Native American Culture and the Columbia River

Within the Pacific Northwest, scholars identify three great Native American cultural areas: Northwest Coast, Plateau, and Great Basin. Each of these areas included a variety of subgroups commonly referred to as tribes that shared traits and life styles, but not necessarily a common language. In all, there were about 125 different tribes speaking more than fifty languages. Although the boundaries of the cultural areas were indistinct, the Plateau cultural area largely consisted of the Columbia River Basin, with the Columbia River as its dominant feature.

The Plateau Native American economy was based on hunting and gathering. Depending on the season, the Plateau people engaged in various types of food–gathering and –preserving activities, but their diet was rich in salmon, which made annual runs up all of the major rivers of the interior. They dried fish for later use and trade. The significance of fish to the Plateau people is illustrated by the fact that until they acquired horses in the early 1700s, fish constituted approximately 80 percent of the Nez Perce diet. Following the acquisition of horses, buffalo, elk, deer, and antelope became increasingly more important in their diet.

The culture and economy of the Plateau people were centered on the region's rivers. When Euro–American fur traders and explorers arrived, in the early years of the nineteenth century, the people lived in small semi–permanent fishing settlements along major streams and tributaries. The Dalles of the Columbia River, home territory to the Wishrams and Wascos was a gathering place for many of the tribes of the Plateau and other cultural areas. Great tribal meetings took place at the Dalles and many tribes traveled to the Dalles to fish for salmon in the spring before the salmon reached their villages. Here was the cosmopolitan center of Northwest Indian life. It was the site of great month–long trade fairs, with dancing, ceremonial displays, games, gambling, and marriages taking place along with the trading. Sometimes the Wishrams and Wascos hosted several thousand visitors who came to trade dried salmon meal, buffalo robes, and slaves from the interior for canoes, marine shell beads, and fish oil from the coast. As testament to the extensive geographical importance of these trading fairs, the goods traded have been found as far away as Alaska, southern California, and Missouri (Schwantes, 1989).

2.1.1.2 The Fur Trade

The fur trade, which exploited coastal and interior fur–bearing animals, rose in the early 1740's, flourished through the early 1800's and ceased to be a significant economic activity by 1850. Initially, the fur trade was centered on sea otters.

By 1829 the sea otter had been all but exterminated. To replace them, the Americans began to bid for inland furs, primarily beaver. British trappers and traders were already well established in the beaver fur trade. With the entry of the Americans, traders and trappers from the two countries engaged in intense competition to dominate the industry. As with the sea otter, competitive exploitation quickly led to the commercial extermination of the resource. The intensity of the competition for the resource is illustrated by the fact that it took just two years to thoroughly despoil the beaver population in the Snake River country. As with sea otter trade, the rewards of the inland trade were spectacular.

During the century–long reign of the fur trade, the Columbia River was used by the British in moving furs up–river to eastern sea ports by way of a route through Canada. The Americans, on the other hand, transported their furs down–river for export to markets in Canton where they were traded for tea. Asian markets were not accessible to British traders because they could trade there only under license from the East India Company, an excessively expensive proposition. The river was also used by both the Americans and British to bring in supplies by way of the ocean and the river, in spite of the fact that entrance to the river was extremely hazardous.

2.1.1.3 Settlement of the Land

From the early days of the fur trade until a boundary was established between Canada and the United States, the Oregon Country was jointly occupied by the British and the Americans. It is of interest to note that the Oregon Country was generally the same geographic region as that which we now consider to be the Pacific Northwest. Louisiana lay to the east, bounded on the west by the Rocky Mountains, and Spanish Territory lay to the south of the Columbia River basin. Oregon Country was formally declared to be a territory of the United States in 1849. Even though it took the United States almost 60 years to take control of the Pacific Northwest, the desire to occupy and control Oregon appears to date from the unveiling of the Columbia River by the American Robert Gray in 1792. An early interest in control is demonstrated by the extension of the Lewis and Clark expedition to the Pacific Ocean, following the purchase of Louisiana in 1803.

The British also wanted at least a portion of the Oregon Country. Their interest was expressed by a recommendation by representatives of the Hudson's Bay Company that the Columbia River be defined as the international boundary. Although the British attempted to support their claim to the territory north of the Columbia River by attracting settlers to occupy it, their efforts were unsuccessful, largely due to the fact that prospective settlers were not to be allowed to own any land. Instead, provisions for settlement offered them long–term leases of land from the Hudson's Bay Company and required them to sell a large portion of their produce to the company. During the first year of the settlement program, not a single prospective settler applied to immigrate. The Americans on the other hand, motivated by what has become known as Manifest Destiny, were successful in attracting settlers to Oregon, both to the south and to the north sides of the Columbia. Settlement efforts by the Americans proceeded, until after Oregon became a Territory, without assistance by the Federal Government. These private efforts to get Americans to migrate to Oregon began as early as 1819, but the first settler, Nathaniel Wyeth did not depart for Oregon until 1831. The first wagon train was organized in 1843, thus establishing the Oregon Trail and initiating the flood of immigrants that would follow.

Although some immigrants traveled on the Columbia River, navigation of the river was expensive, dangerous and required a number of portages. As a result, in 1845 a company of immigrants led by Sam Barlow located an alternate land route which left the river at The Dalles and went around the south side of Mount Hood. This route became known as the Barlow Trail and in 1846 was developed as a toll road.

The issue of control and ownership of the Oregon Country and the international boundary was essentially settled when the British concluded that they should accept a proposal by the United States that the boundary be set at the 49th parallel. Their decision to drop their claim to land north of the Columbia was based on a military intelligence report prepared in 1845. The report noted that, except for Puget Sound, the whole section north of the river was a "pine swamp." The author of the report expressed the view that the Americans were justified in wanting control of the sound because there was no other first–class Pacific harbor. In the author's opinion, the Columbia's bar rendered that river all but unusable. Furthermore, the report indicated that population figures favored the Americans, with an estimated 2110 residents south of the Columbia River and another 3000 immigrants en route on the Oregon Trail. Other than employees of the Hudson's Bay Company, there were no British settlers north of the river. The treaty establishing the international boundary was signed in 1846.

Following formal recognition of the Oregon Country as a territory of the United States in 1849, the Congress, in 1850, passed the Donation Land Law. Under terms of the law any resident who was a citizen of the United States could claim 320 acres (129.5 hectares) in his own name and, if married, another 320 acres (129.5 hectares) in the name of his wife. The Donation Act, although intended to be temporary, was extended to 1855 and was a step toward establishing the nation's unoccupied territory as a free commodity– –a policy that culminated with the Homestead Act of 1862. The promise of free land was a significant factor in attracting new settlers to the territory. However, it is interesting to note that getting to the land was expensive so only people who were already relatively well–to–do could make the trip. Historians generally agree that few, if any, immigrants improved their economic state by trekking the Oregon Trail to the land at "Eden's Gate."

2.1.1.4 Gold

The flood gates of immigration to the Oregon Territory were thrown wide open with the discovery of gold on a tributary to Idaho's Clearwater River in 1859. Ironically, the discovery was made by an Indian who passed the information on to an Indian Trader named Elias Pierce. Access to the area was over land of the Nez Perce reservation. The Tribe protested against prospectors crossing reservation lands, but their protests were ignored and the rush was on. In the spring of 1861, the first steamboat made its way up the Snake River to what is now Lewiston and unloaded its cargo in the midst of farms that the Indians had established. By the time fall came the Indians had been displaced and a shack town of 1200 inhabitants sprawled across the site.

With the discovery of gold, changes to the territory came quickly. New territories were formed: Idaho in 1863– –Washington Territory had been established in 1852– –and Montana in 1864. Also, transportation systems were developed, initially commercial navigation of the river and then roads and railroads. For a time the Columbia River played a vital role.

In 1856 a wagon road was built around Celilo Falls, and portages were built around rapids (The Cascades) near the lower end of the Columbia Gorge. In 1860 various navigation interests combined to form the Oregon Steam Navigation Company (OSN), which began operation in January of 1861. When the company started operations there was little prospect of a profitable business, but then the Idaho gold rush started. By 1865 the OSN fleet consisted of eighteen steamers.

With the OSN charging freight rates based on the concept of "all that the traffic will bear," the door for competition from the railroads was opened. Development of a rail system was further encouraged by the Federal Government's offer of generous land grants, consisting of as much as twenty alternate sections (square miles) of land for each mile of track constructed, the railroads soon captured most of the freight and forced waterborne freight rates to be lowered.

2.1.1.5 Timber

The Pacific Northwest contains the largest softwood forest in the United States. When fur traders of John Astor's Pacific Fur Company arrived at the mouth of the Columbia River in 1810 to construct a fort and trading post, potential sites were all overgrown with gigantic old–growth trees. At that time the trees were more of a nuisance than a resource because they had to be cleared to make room for the fort and they were too big to use either for lumber or for building logs. Some of the trees reached fifty feet in circumference and took four ax–men working simultaneously days to bring one down. After the trees were felled the stumps had to be blown apart with gunpowder so that the pieces could be hauled away.

Commercial exploitation of the region's timber resources remained insignificant until the demand for lumber in California, spurred by the gold rush, caused entrepreneurs to begin commercial harvest of the forest beside Puget Sound. In 1849, the first steam mill was setup to produce lumber for the California trade. With the demand for lumber associated with the Gold Rush and fires which razed San Francisco no less than six times between December 1849 and July 1851, the lumber industry boomed. Attempts to establish the industry south of the Columbia were curtailed by continuing difficulties in navigating the bar at the mouth of the river.

2.1.1.6 Salmon

According to estimates of recent investigators, before 1855 between 10 and 16 million salmon returned to the Columbia River each year. Prehistoric Indians harvested an estimated eighteen million pounds (8 million kilograms) of fish annually. According to the Lewis and Clark Journal of 1805, dried fish took up as much as one–half the space inside the homes of Indians. The Columbia was the hub of a trading place where as many as 5,000 tribal people gathered during the fishing season. Goods to trade came from all over the Northwest, the Great Plains, the Great Basin, and as from as far away as the Great Lakes.

The first recorded attempt to commercialize the harvest of salmon apparently occurred in 1832 when Nathaniel Wyeth arrived on the Columbia River from Boston to "ascertain if possible to make a business of curing Salmon in this River. . ." The enterprise was apparently not immediately successful because commercial salmon fishing on the Columbia did not reach its peak until the 1880s and 1890s. During those decades canneries packed as many as 630,000 cases of forty–eight one–pound (.4536 kilogram) tins during the annual runs. In 1906, fish wheels were taking more than a million fish each year and, in Oregon alone, there were 55 canneries. The intense harvest effort soon led to declines in the annual catch. In order to halt the declining harvest, toward the end of the nineteenth century, Oregon and Washington began to impose restrictions on harvest and to establish closed seasons. However, the laws were haphazard; until 1909, for instance, there was no uniformity of closed seasons.

Today only about two and one–half million fish return to the Columbia River. A number of stocks are extinct; Snake River sockeye are endangered; and, Snake River spring/summer and fall Chinook are listed as threatened under the Endangered Species Act. The depressed size of salmon runs has considerably reduced the economic significance of the fishing industry from its heyday in the late 1800's.

2.1.1.7 The Columbia River

The bar at the mouth of the Columbia River made entrance to the river hazardous. And between the time of its discovery until jetties were constructed at its mouth in the late 1880s, numerous ships were lost attempting to cross the bar. In spite of the hazards, the discovery of gold in California induced more than fifty ships to push their way across the bar and into the river in 1849. Construction of the jetties, however, tamed the river's fearsome bar. With safe passage over the bar assured, the river was established as a major waterway and Portland was assured a role as sea port. Later, construction of locks at Willamette Falls extended navigation up the Willamette River.

Navigation on the Columbia River upstream from Portland required portages until canals and locks were built past Cascades Rapids in 1896 and Celilo Falls in 1915. In 1893 when the Corps of Engineers recommended construction of the canal and locks around Celilo Falls, there was no commerce on the river above the falls. In spite of this, the Board of Engineers stated they had no doubt that "... when the obstructions to navigation near The Dalles shall be removed there will be commerce, although the extent of its development cannot be foreseen." When the project was completed in May of 1915, six steamboats passed through the newly opened canal. As speculated, waterborne commerce developed and the canal helped keep rail rates below monopoly levels, but until the multi–purpose dams were constructed on the Columbia and Snake Rivers beginning in 1938, commerce on the river remained light.

Impetus to continue development of the water resources of the Columbia River basin came from the need for water to irrigate land which was given to settlers under various laws, including the Desert Land Act of 1877. Under this Act, a settler was allowed 640 acres (259 hectares) if he undertook to irrigate eighty acres (32.4 hectares). Although a number of attempts were made to comply with the law, projects large enough to irrigate eighty acres (32.4 hectares) were generally beyond the capability of individual farmers. To remedy the problem, Congress passed the Carey Act in 1894 under which, upon application, one million acres (404,700 hectares) of Federal land would be transferred to a state if the state would undertake reclamation (irrigation) of those acres. Except for Idaho, where 868,000 acres (351,280 hectares) were eventually put under irrigation, relatively little land was brought into production under the Act.

The general failure of provisions of the Carey Act to result in irrigation projects and continued difficulties of private interests to bring water to the free land, eventually led Congress to pass the Newlands Act of 1902. Under this Act, the Reclamation Service (since 1923 the Bureau of Reclamation) was created. By 1918, Reclamation was busy studying a proposal for a dam at Grand Coulee. The proposal was originally made in 1892 by a Big Bend real estate agent who envisioned use of Grand Coulee not only for irrigation, but also as "a first–class ship canal." At the same time, the Corps of Engineers and the Federal Power Commission had been authorized to conduct a nationwide survey of the irrigation, navigation, flood control, and power potential of all major rivers of the United States. The study was completed in 1931 and, regarding a dam at Grand Coulee, concluded that the project could be largely paid for by selling surplus power. In all, construction of ten dams on the Columbia and Snake Rivers was recommended.

At the time the Corps' study was completed, the country was gripped by the depression of the 1930s. Private interests and public officials agreed that construction of multiple purpose dams on the Columbia would put people to work; would generate power; would provide for improved navigation; and, would irrigate farms. Accordingly, construction of dams at Cascades Rapids and Grand Coulee was authorized in 1933, with the former––to be known as Bonneville––to be constructed by the Corps of Engineers and the latter to be constructed by Reclamation. Thus, the construction of the Columbia River system was initiated. The decision to proceed was not justified based on economic analyses which are now required under Principles and Guidelines (Water Resource Council, 1983), but on the basis of the judgment of the nation's leaders that development of the nation's rivers was in the nation's best interest. This judgment was expressed by President Franklin D. Roosevelt in 1934, as follows:

> "There is another reason for the expenditures of the taxpayers money in very large amounts on the Columbia . . . we are creating power, more power—and I always believe in the old saying, 'more power to you.' I don't believe you can have enough power for a long time to come, and the power we are developing here is going to be power which for all time is going to be controlled by the government."

Although the decision to construct the dams was not based on an analysis of potential economic benefits, as with the locks and canal at Celilo Falls, economic benefits sufficient to more than justify their construction occurred. Almost immediately following completion of the first projects, World War II broke out and created a demand for large amounts of electricity. The "pump–priming" effects that construction of the dams and World War II had on the region's economy did not end with the war. Today more than 700,000 acres (283,300 hectares) of irrigated land along the Columbia and Snake Rivers benefit directly from projects on the Columbia and lower Snake Rivers. Federal and non–federal hydropower projects in the region supply approximately 75 percent of the electricity used in the Northwest and provide the region with the lowest power rates in the nation. The Columbia–Snake waterway extends navigation to Lewiston, Idaho, 465 miles (750 kilometers) from the ocean, and provides for low–cost transportation of farm commodities to ports on the lower Columbia River's deep–draft navigation channel for export to international markets. In addition, storage projects in the basin prevent flooding of rural communities, agricultural lands, and major metropolitan centers like Portland. The contribution of the existing system of water control facilities to each of the various beneficiaries of a regulated Columbia River are described in greater detail later in this appendix and in appendices on each river use.

2.1.2 Population and Current Economic Development

This section presents a brief overview of the region's current and projected population and economic development. The information presented in this section was taken from the Bonneville Power Administration 1993 Resource Programs EIS.

2.1.2.1 Current and Projected Population

In the Pacific Northwest, population centers around Seattle/Tacoma (WA), Portland/Vancouver (OR/WA), Eugene/Springfield (OR), Spokane (WA), and Boise/Nampa/Caldwell (ID). Based on the 1990 Census of Population, the population in Washington grew from about 4.13 million in 1980 to about 4.87 million in 1990, an 18 percent net increase and an annual rate of growth of 1.8 percent. The population of Oregon increased from about 2.63 million in 1980 to about 2.84 million in 1990, an 8.1 percent net increase and an annual growth rate of 0.8 percent. The population in Idaho grew from 947,000 to about 1 million, a 6.6 percent net increase and an annual growth of 0.6 percent. The population of western Montana increased from 294,500 in 1980 to 303,300 in 1990, a 3.0 percent net increase and an annual growth rate of 0.3 percent. Table 2–1 shows population projections for the four state area through 2015.

Approximately eight million people lived in the region (Idaho, Oregon, and Washington) in 1980, and by 2015 this figure is expected to grow to about 12 million. Population growth is expected to be higher than the average growth rate for the Nation. While the recession during the 1980's contributed to outward migration, the enhanced prospects for the region have reversed this trend. The regional economy is expected to foster increased inward migration during the forecast period. Comparatively stronger economic growth and increases in retirement and recreation help foster population growth above U.S. averages.

2.1.2.2 Economic Development

Over the past 10 years, the economy of the Pacific Northwest has evolved from resource–based to more diversity, with growing trade and service sectors. In 1980, resource–based industries accounted for 30.9 percent of manufacturing employment; by 1990, their share had fallen to 27.2 percent. High technology industries (aerospace, electronic, and scientific instruments), have grown in share over the last decade from 30.3 to 42.0 percent of total manufacturing. Overall, the manufacturing share of the regional economy was 19.4 percent in 1980 and fell to 17.7 percent by 1990.

The lumber and wood products industry still plays an important role in the region's economy, with 3.4 percent of the total regional employment, but this sector has declined from a decade ago, when it accounted for 4.4 percent of total employment. Food processing has fallen from 2.5 percent of total employment in 1980 to 2.1 percent in 1990. This loss of employment share has been due to an increase in the relative size of the employment base and productivity gains brought on by plant upgrades and other efficiencies. Transportation equipment, primarily Boeing, has remained at nearly 4 percent of total employment over the last decade, and the electronics and scientific instruments industries have grown from 13.4 percent of manufacturing employment to 17.7 percent. Energy–intensive aluminum production is economically important to the region, but the level of employment in this sector is relatively small (0.7 percent of total employment in 1990).

While the manufacturing share fell over the decade, the non–manufacturing share of total employment rose from 80.6 to 82.3 percent. A rise in wholesale and retail trade and services accounts for most of the gain. Employment in trade grew from 24.1 percent of total employment in 1980 to 25.0 percent in 1990. The services sector grew from 18.8 percent of total employment in 1980 to 22.9 percent in 1990. The region's growing trade with California and the Far East also broadens the economic base.

Twenty–five percent of U.S. exports to Asia and 30 percent of all U.S. exported goods are handled through Pacific Northwest ports.

The advantage of low–cost energy relative to other areas has strengthened the region's economic base. Due to the availability of natural gas from Canada and the region's hydro base for electricity, the Pacific Northwest has a long–term energy advantage. Recently, the region's electricity prices ran 40 percent lower on average than the nation and natural gas prices were 16 percent less.

The region still can be hard–hit by high interest rates and their dampening effect on housing, which is the biggest source of demand for the region's lumber and wood products. However, more diversity and efficiency in industries in the region means more resistance to severe fluctuations now than in the past. Continued high levels of international trade should help offset the negative impact of periodic national business cycles, and the non–manufacturing service sector of the region's economy is expected to continue to grow faster than total employment.

Table 2–1. Population Projections through 2015 (millions)

	1980	1990	1995	2000	2005	2010	2015
Washington	4.13	4.87	5.31	5.62	5.91	6.21	6.52
Oregon	2.63	2.84	3.17	3.38	3.57	3.76	3.96
Idaho	.95	1.0	1.11	1.18	1.24	1.29	1.35
Western Montana	.29	.30	.32	.34	.36	.38	.40
Regional Totals	8.00	9.01	9.91	10.52	11.08	11.64	12.10

California, with over 29 million people (more than 10 percent of the nation's total population) represents an important market for the Pacific Northwest. The tourism industry, fueled by the scenic coast, Columbia River Gorge, and Hells Canyon, provides economic stimulus in less populated regions and helps stimulate activity in the service and trade sectors. Agriculture also is a substantial industry in the region, employing about 275,000 in 1990, down from about 285,000 in 1980. the decline in agriculture employment is part of the shift toward a less resource–dependent economy and also is due to growing productivity in the farm sector.

For the forecast period 1990 to 2010, overall growth for major sectors of the regional economy in each state is expected to be moderate. Manufacturing employment is forecasted to be generally stagnant while non–manufacturing employment is expected to be relatively robust. Growth in the electronics industries is expected to be strong but the natural resource industries are expected to suffer declining employment levels. Embedded into the declining lumber and wood products forecast is the assumption of supply constraints due to the implementation of the spotted owl recovery plan. This forecast also assumes there are no military base closures although it does anticipate gradual reduction of military in the Region of about .7 percent per year. There are no assumptions of impacts from listing species of Columbia and Snake Rivers salmon and steelhead as endangered.

Manufacturing is forecast to drop from about 17 to around 13 percent of total employment. The actual level of employment in manufacturing will grow slightly over the forecast, but due to the rapid growth in non–manufacturing, the share will be declining.

Employment in the finance, trade, and service sectors is expected to remain strong as the economic base shifts toward a service economy and reflects continuing shifts in national demographics. Increased foreign trade and current management trends also suggest growth in business services. Non–manufacturing employment is projected to grow faster than the national average for the same sector.

2.2 MAJOR USES OF THE RIVER SYSTEM

The Columbia River and its tributaries touch the lives of nearly every resident of the Northwest–– from providing the world–famous Pacific salmon to supplying the clean natural fuel for over 75 percent of the region's electrical generation. This section introduces the major uses of the river system. The Final Environmental Impact Statement (FEIS) has an appendix for each one of the primary uses. The focus here is on an economic perspective. References to the other appendices where additional detail can be found are made throughout this section.

2.2.1 Anadromous Fish

The harvest of Columbia River anadromous fish has been a major activity of man throughout history in the Pacific Northwest. Anadromous fish have been an important food source for indigenous people for centuries and remain an important part of the cultural heritage of Native Americans. In more modern times, harvest rates by the 50,000 to 60,000 Native Americans who lived in the Columbia Basin in the early 1880's was estimated to have been about five to six million adult salmonids per year (NPPC, 1986). Non–native commercial harvest has occurred in the Lower Columbia River since the 1860's and peaked for the different runs in the late 1880's and 1890's with the harvest of Chinook at 43 million pounds (19 million kilograms), sockeye at 45 million pounds (20 million kilograms), coho at seven million pounds (3.2 million kilograms), and chum at over eight million pounds (3.6 million kilograms). Through the 1920's essentially all Columbia River salmon were commercially harvested in the river with gillnets and fish wheels. Historically, local processors canned most of the salmon for national and international markets. Over time, the market for Columbia River canned salmon has been replaced to a large extent by the frozen and fresh salmon market.

In the 1930's, the ocean troll fishery began, and over the years moved from the mouth of the Columbia River to further out in the ocean to the salmon feeding grounds, roughly a band from ocean beaches to about 25 miles to sea. The ocean troll industry resulted in harvest of anadromous fish from other river basins and spread the harvest of Columbia River fish up and down the West Coast of the US and Canada.

Like the non–native commercial fisheries, sport fishing for anadromous fish began in the late 1800's, but catch statistics are sparse until the 1950's. Sport fishing occurs in the ocean, the lower river, the mainstem, and the spawning tributaries.

The Native American fishery has continued to exist and is protected through treaty rights that assure that the four Columbia River treaty tribes can continue to fish from Bonneville Dam to McNary Dam. A major dip net native fishery was located at Celilo Falls until 1957 when the rising pool behind The Dalles Dam inundated the falls. The Columbia River Native American fishery consists primarily of set gillnets, but dip net fishing still occurs at several locations.

All three Columbia River anadromous fisheries––non–native commercial, sport, and Native American––have experienced immense declines in harvest from before the turn of the century. In recent years, the Columbia River salmon runs have displayed substantial variations. For example, the Columbia River sockeye runs had a low in 1978 of 18,400 fish and a high in 1985 of about 200,000 fish. The upriver fall Chinook run size has fluctuated greatly over the last decade. In 1983, the run size was about 175,000 fish as compared to about 540,000 fish in 1987 (ODFW, 1991). With the variations in run sizes and changing market conditions, the income generated by salmon harvest has also varied greatly, but this income continues to be a strong element in the local economies of Oregon, Washington, and the four treaty tribes. The total gross annual value of the commercial harvest of the fishery in the Columbia River (excluding ocean and sport harvest) averages about $15,200,000 (1990 dollars based on a weighted average value for 1986 to 1990) (Olsen, 1992). The economies of coastal and lower river communities include significant amounts of employment in fish harvesting, fish processing, boat services, recreational charters, and tourist related industries. The commercial fishery and charter fishing industries tend to be labor intensive, so much of the revenue generated goes directly to households. Therefore, consumer supported businesses like retail, housing, restaurants, etc. are indirectly effected if income from fishing declines substantially.

The treaty tribes rely on the fishing industry to help maintain economic viability and economic diversity of the Indian communities. The cultural, historical and spiritual values of salmon runs continue to be of extremely high value to the tribes.

2.2.2 Resident Fish and Wildlife

The economic importance of resident fish and wildlife is tied directly to the recreation use at the reservoirs and river reaches of the Columbia River Basin. The abundance of fish and wildlife resources influences recreation activity and the economic value recreators place on fishing, hunting, and other recreation experiences. Accordingly, to the extent that changes in the operation of the hydropower system impact fish and wildlife resources at the reservoirs and river reaches are affected by the system, these changes could influence the amount of recreation activity and quality of the recreation experience. For example, when the number and size of resident fish in a reservoir increases or decreases, the number of recreational fishing days could change along with the angler's willingness–to–pay for the recreation experience. Similarly, site–seeing, boating, and hunting activities can all be influenced by the condition and quantity of fish or wildlife. However, the economic impacts of changes in resident fish and wildlife are not directly reflected in the SOR recreation economic analysis, because data required to establish a statistically valid relationship between fish and wildlife abundance and economic values (willingness–to–pay) were not available. While it was not possible to specifically asses economic effects of changes in fish populations, etc., respondents to the recreation survey which was conducted for the SOR by the Recreation Work Group based their perceived value of their expected fishing experience under river and reservoir conditions associated with the alternative SOSs on their perception of their expectations regarding the abundance and quality of the fishery. Therefore, potential changes in resident fish populations, etc., are embedded in the values obtained through the survey. The appendices for resident fish (Appendix K) and wildlife (Appendix N) present details on specific fish stocks and wildlife populations and details on the recreation survey are presented in the recreation appendix (Appendix J).

2.2.3 Flood Control

Because the Columbia River's flow varies so widely, the river was subject to severe floods prior to construction of major reservoirs in the US and Canada and levees at a number of damage centers throughout the region. Controlling damaging flood waters was one of the original purposes of many of the dams on the river. And flood control remains a high priority for system operations today. Due the high priority placed on controlling floods through operation of the system's major storage projects, the potential impact of the alternative SOSs on the system's ability to control floods was evaluated. The economic effects of existing and changed flood control operations are measured in terms of expected annual flood damages at damage centers throughout the basin. These damage centers are grouped into three study areas as shown in Table 2–2 and displayed in Figure 2–1. The Flood Control Exhibit (Exhibit B) to this appendix provides additional details on the Columbia River flood control system and the derivation of average annual damages.

Table 2–2. Flood Control Study Areas

Study Area	Damage Center
Upper Columbia River	Libby Dam to Kootenay Lake Albeni Falls to Cusick Pend Oreille Lake Columbia Falls to Flathead Lake Flathead Lake Kerr Dam to Thompson Falls
Clearwater River	Dworshak Dam to Lewiston Levees Lewiston Levees to Snake River
Lower Columbia River 1/	Washougal Drainage District – near Vancouver, WA Sandy Drainage District – at Portland, OR Multnomah Drainage District Peninsula Drainage District No. 1 – at Portland, OR Peninsula Drainage District No. 2 – at Portland, OR Cowlitz I at Longview Drainage District – at Longview, WA

1/ There are a total of 53 flood protection levee systems (drainage districts) along the lower Columbia River. Of these, 29 are above RM40 and are included in the study area for the SOR.

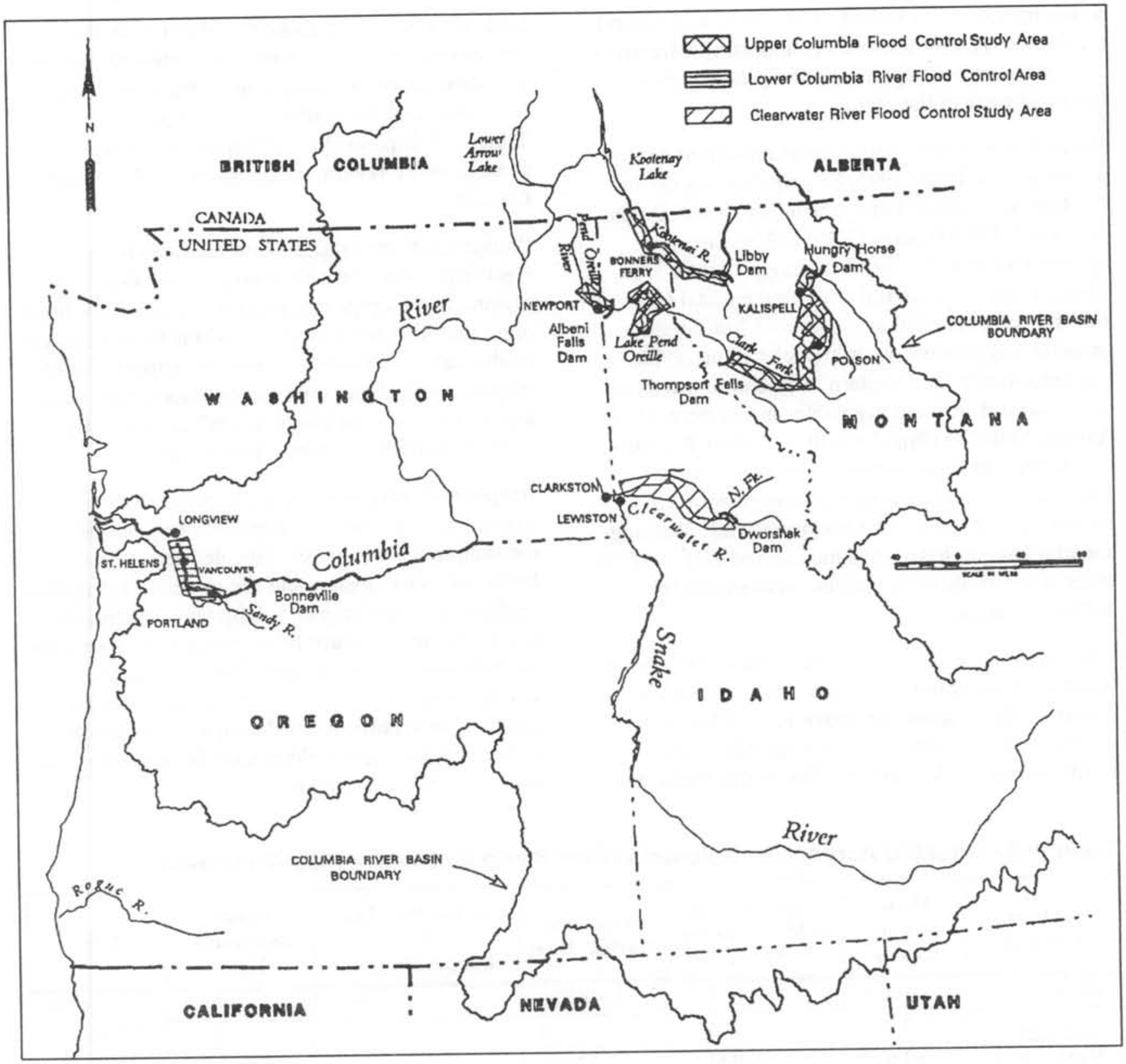

Figure 2–1. Map of Flood Control Study Areas

2.2.4 Irrigation and Municipal and Industrial Water Supply

2.2.4.1 Irrigation

Agriculture, including the production from irrigated lands, is an important industry to the economy of the Columbia River Basin. In 1991, crop and livestock sales amounted to $9.7 billion in the region, excluding British Columbia. In addition to the direct effect of these sales on the region's employment and income, the region's economic base is enhanced by the induced and stemming impacts generated by the processing, shipping and handling, and transportation of agricultural products, as well as the provision of production inputs to agricultural producers. A vast network of supporting infrastructure has been built up around the production of food and fiber in the region.

Water is one of the region's most important natural resources. In 1989–1990 the irrigated acreage for the Columbia River Basin (including British Columbia) was 7,324,300 acres (2,964,049 hectares), or approximately 4 percent of the region's total area. This acreage includes full and supplemental irrigation service to lands that range from low intensive meadow hay production at high elevations in Idaho, eastern Oregon, and western Montana to intensive irrigation of fruits and vegetables in southern Idaho, Yakima Valley, Willamette Valley, central Washington, Columbia River corridor, and other areas. Idaho has the largest irrigated acreage with 3.3 million acres (1.33 million hectares), while Washington and Oregon have 1.878 million and 1.317 million acres respectively (0.76 million hectares and 0.53 million hectares).

The major blocks of concentrated irrigation development are located in the Yakima Valley, Boise and Payette Valleys, along the Snake River Plain in southern and eastern Idaho, central Washington, north central Washington, the Deschutes basin, and lands adjacent to the Columbia River near the Tri–cities area. There have been extensive private irrigation developments pumping from the McNary, John Day, and Ice Harbor reservoir pools. Table 2–3 displays the distribution of irrigated acreage in the region, including British Columbia, Canada.

Production from irrigated land accounts for a substantial portion of the total crop production in the region. Some crops like potatoes, sugar beets, hops, mint, and fruit are almost exclusively from irrigated lands. Table 2–4 demonstrates the importance of irrigation and shows total crop production in Washington, Oregon, and Idaho in 1987 as well as the portion estimated to come from irrigation.

Irrigation diversions from the region's streams, rivers, and reservoirs is a function of the crops' consumptive use requirements, delivery system losses, on–farm losses, and the method of irrigation application. Net irrigation depletions, essentially diversions minus return flows, is the more meaningful indicator to system operations because the residual water is the actual amount available for instream flow purposes, including running the hydropower system. Return flows must be accounted for in flood control operations.

Table 2–3. Irrigated Acreage in Columbia River Basin by State – 1989–90 (acres)

State or Province	Above Grand Coulee	Grand Coulee to Mouth of the Snake	Above Ice Harbor Dam	Ice Harbor Dam to Bonneville Dam	Below Bonneville Dam	Total
Idaho	25,800	0	3,306,400	0	0	3,332,200
Montana	433,700	0	0	0	0	433,700
Washington	60,600	1,509,800	77,300	207,900	23,300	1,878,900
Oregon	0	0	502,000	531,500	283,100	1,316,600
British Columbia	89,700	103,100	0	0	0	192,800
Wyoming	0	0	94,100	0	0	94,100
Utah	0	0	5,600	0	0	5,600
Nevada	0	0	70,400	0	0	70,400
Total Acres	609,800	1,612,900	4,055,900	739,400	306,400	7,324,300

Source: 1990 level modified streamflow,Columbia River and Coastal Basin, A.G. Crook Company, April 1993.

Table 2–4. Crop Production in Washington, Oregon, and Idaho

Crop	Selected Major Commodities: Total Production For 3 States[1/]		Portion From Irrigated Lands[2/]
	Units	Production	Percent of Total
Corn for grain	Bu.	14,134,000	86.9
Wheat	Bu.	249,907,000	31.0
Potatoes	Cwt	178,452,000	99.0
Hops	Lbs	14,457,000	100.0
Mint, Oil	Lbs	5,748,000	100.0
Hay, alfalfa & mix	Tons	8,480,000	63.7
Vegetables	Acres	331,000	73.2
Orchards	Acres	46,000	85.0
Sugar Beets	Tons	4,710,000	100.0

1/ Source: 1987 Census of Agriculture data for Idaho, Oregon and Washington. Data excludes western Montana and portions of the basin in Wyoming, Utah and Nevada.
2/ Source: Percentages are estimates utilizing 1987 Census of Agriculture including the 1988 irrigation supplement with 1988 data.

Total irrigation diversions in the region were 32.56 million acre–feet (40,179 million cubic meters) for the 1990–1991 base level of development, with a net depletion of 13.73 million acre–feet (16.94 million cubic meters). Table 2–5 summarizes irrigation diversions and depletions for the hydrologic basins in the region for the 1990–1991 period (base level of development).

2.2.4.2 Municipal and Industrial (M&I) Water Supply

The current level of M&I depletions were not considered to be significant in the measurement of impacts under SOR alternative operating strategies.

Approximately 90 percent of the total water withdrawn in the Pacific Northwest is for irrigation (BPA, 1993). Public water supply and domestic use account for about 4 percent, commercial use about 2 percent, and industrial use about 2 percent. The remaining amount is shared by livestock, mining, and thermoelectric. Water withdrawn for non–agricultural use has a higher return rate than for agricultural uses. Accordingly, total depletion for the M&I uses is estimated at less than 2 percent.

2.2.5 Navigation

Columbia River Basin economic growth has been closely associated with water transportation. The history of the basin records a program of continuing improvements to increase the serviceability of the deep–draft and inland waterway systems and to keep them adapted to the changing needs of navigation. Four river segments have had improvements: (1) the deep–draft channel which serves ocean–going commerce and extends from the Pacific Ocean to Vancouver, Washington and to Portland on the Willamette River; (2) the Columbia–Snake River

Table 2–5. Irrigation Diversions and Net Depletions by Basin

Hydrologic Basin	Irrigation Diversion (Acre–Feet)	Net Irrigation Depletion (Acre–Feet)
Upper Columbia & Kootenai	179,256	113,576
Clark Fork–Pend Oreille & Spokane	1,287,004	768,602
Columbia Plateau, East Cascade, & Yakima	5,632,369	3,425,053
Upper Snake River	14,365,500	4,661,060
Central Snake River	7,545,580	2,623,520
Lower Snake River	849,012	533,494
Mid Columbia	2,352,607	1,334,923
Lower Columbia	59,020	22,300
Willamette	290,668	231,874
Total	32,561,057	13,734,403

Source: Draft USBR/BPA, Columbia River Basin System Operating Review Irrigation Delpetion estimate, September 10,1993, prepared for Bonneville Power Administration by A.G. Crook Company

shallow–draft navigation channel which extends from Portland, Oregon/Vancouver, Washington into the interior of the Columbia Basin all the way to Lewiston, Idaho, on the Snake River; (3) the Willamette River shallow–draft channel which extends from Portland, Oregon up the Willamette River to Eugene, Oregon; and, (4) the Yamhill River shallow–draft channel which extends from the confluence of the Willamette and Yamhill Rivers to McMinnville, Oregon. In addition, ferry service is provided on Lake Roosevelt (Grand Coulee Dam) in Washington and logs are transported on Dworshak reservoir in Idaho. The only improved systems which would be potentially affected by the alternatives SOSs are the deep–draft channel, the Columbia–Snake River shallow–draft channel, and ferry service on Lake Roosevelt.

The Columbia River navigation channel services an enormous area that covers much of the western United States. The region produces a variety of commodities, foodstuffs, and other products. Agriculture dominates the regional industries associated with waterborne commerce. Trade revolves around grains (such as wheat, alfalfa, corn, grass seed), fruits, and vegetables, with wheat being the largest export item. Other regional industries that use water transport include aluminum, pulp and paper, petroleum, logs, lumber, and beef. Products shipped on the shallow–draft channel are comprised mainly of wheat, grain, wood products, logs, petroleum, chemicals, and other agricultural products. Containerized commodities are also transported via the waterway. Containers are typically loaded at Lewiston Idaho, Pasco Washington and Boardman and Umatilla Oregon, with approximately 97 percent of these shipments destined for Portland, Oregon and the remainder going to Vancouver, Washington. Petroleum products have historically made up the bulk of upriver barge shipments on the waterway. The following paragraphs in this section contain relatively brief descriptions of the waterways and associated commerce. Additional information is contained in Appendix H (Navigation).

2.2.5.1 Deep–Draft Navigation

The Federal deep–draft navigation channel begins at the Columbia River entrance channel and extends inland to Portland–Vancouver (Oregon and Washington, respectively). The entrance channel extends two miles (3.2 km) seaward and three miles (4.8 km) landward from the outer ends of the Columbia River jetties at the Pacific Ocean. In 1957, the entrance was deepened to 48 feet (14.6 m) and maintained at that depth until 1984 when it was deepened to 55 feet (16.8 m) to provide improved navigability of the bar. The 40–foot (12.2 m) deep–draft channel extends inland from the Pacific Ocean 106 river miles (170.6 km) to Vancouver, Washington, and also up Willamette River from its confluence with the Columbia River to the Broadway Bridge at Portland, Oregon. In addition to channels and turning basins, there are numerous small harbors along the river. Deep–draft anchorage sites have been designated by the US Coast Guard at Astoria, Longview, Kalama, Woodland, Henrici Bar, Willow Bar, Kelley Point and Hayden Island. The deep–draft channel is used extensively by oceangoing vessels transporting products and commodities to and from national and international markets.

Port Facilities

Import–export terminals are located adjacent to the 40–foot (12.2 m) channel between its upstream terminus at Vancouver and the river's entrance. The Port of Vancouver exports wheat, barley, lumber, paper/newsprint, and linerboard, and imports such products as alumina, cement, iron and steel products and fertilizers. The Port of Portland exports wheat, barley, logs, lumber, soda ash, and metal scraps, and imports autos and auto parts, iron and steel products, limestone, salt (crude), and alumina. Port Longview exports logs, soda ash, coke, wood chips and paper products, and imports alumina, salt (crude), coal tar pitch, fertilizers, sand, and zircon. The Port of Kalama specializes in the export of grains such as corn, sorghum, wheat, and barley, and imports toluene and chemicals.

With the exception of Longview, all the major ports with deep water access off–load and reload grain for shipment to export markets. A tabulation of major lower Columbia/Willamette River grain elevators and their respective capacities is shown in Table 2–6.

Fleet Composition

Approximately 90 percent of oceangoing cargo ships calling at lower Columbia River ports operate under

Table 2–6. Columbia/Williamette River Grain Elevators

	Location	Storage Receiving Facilities	Loading Capacity (bushels)	Capacity (Tons/Hr)
United Grain Corp	Vancouver, WA	barge, rail	5,000,000	2,400
Louis Dreyfus	Portland, OR	barge, raill, truck	1,500,000	1,200
Bunge Corp	Portland, OR	barge, rail, truck	1,500,000	1,200
Columbia Grain	Portland, OR	barge, rail	4,000,000	1,800
Cargill Inc. Terminal 4	Portland, OR	barge, rail, truck	8,000,000	2,400
Harvest States Co–op	Kalama, WA	barge, rail, truck	6,400,000	1,500
Peavey Grain	Kalama, WA	barge, rail	2,000,000	3,000
Port Longview	Longview, WA	barge, rail, truck	5,000,000	800

foreign flag. These include liquid and dry bulk carriers, container ships, auto carriers, tankers, and general–cargo ships. General cargo, tanker, and container ships that use the lower Columbia River range in size from 15,000 to 50,000 deadweight tons (15,240 to 50,800 metric tons) and draft 25 to 40 feet (7.6 to 12.2 m) loaded. Dry bulk carriers are designed to carry non–containerized, non–liquid products such as corn, wheat, logs, lumber, and wood chips. Many of the ships used to transport corn and wheat to export markets are panamax–class vessels ranging up to 60–80,000 deadweight tons, (60,960– 81,280 metric tons) with design drafts of 37 to 44 feet (11.4 to 14.4 m) and lengths exceeding 700 feet (213 m). Since the initiation of midwest corn exports from Kalama in 1983 and the deepening of the river entrance in 1984, the number of deep–draft vessel transits of the lower Columbia River has increased significantly. Approximately 12.5 percent of the grain vessel fleet calling at lower Columbia River ports are panamax–sized vessels, with the remainder ranging in length from 450 to 650 feet (137 to 198 m).

Waterborne Commerce

Major commodities transported on the deep–draft portion of the Columbia River navigation channel are wheat, grain, and corn. Other products include autos, containerized products, logs, petroleum, chemicals, and other miscellaneous products. Most of the commerce on the river is associated with the export/import trade with other countries. Major countries involved in the region's export trade are Japan, Korea, and Taiwan, as well as other Pacific Rim countries. Total tonnage of Columbia River export products to the top five countries for 1990 are shown in Table 2–7.

Import trade is conducted worldwide with countries such as Australia, Japan, Canada and Mexico. The lower Columbia River is one of the largest auto import areas on the west coast. In 1992, Portland was the largest automobile port on the west coast and the fourth largest auto port overall in the United States. The top five import partners for products and commodities are listed in Table 2–8.

Table 2–7. Top Five Export Countries – 1990, Columbia River Deep–Draft Channel

Country	Commodity	Total Short Tons
Japan	Wheat, Corn, Logs, Other	12,264,209
Korea	Corn, Wheat, Logs, Other	5,116,483
Taiwan	Corn, Wheat, Soda Ash, Other	3,202,711
Philippines	Wheat, Soda Ash, Peas, Other	1,413,535
Pakistan	Wheat, Machinery, Household, Other	1,075,883
Source:	Waterborne Commerce Statistics, U.S. Army Corps of Engineers.	

Table 2–8. Top Five Import Countries – 1989, Columbia River Deep–Draft Channel

Rank	Import Country	Commodity
1	Australia	Alumina
2	Japan	Autos & Vans
3	Mexico	Salt, Crude Oil
4	Canada	Limestone
5	Korea	Cement
Source: The Great Waterway, 1989.		

Major Columbia River export items are ranked in Table 2–9 by tonnage. Nearly all of these commodities rely on barge transport through the inland system of locks for delivery to export terminals and ultimately, to markets worldwide.

2.2.5.2 Shallow–Draft Navigation

The Columbia–Snake River shallow–draft waterway is a Federally–maintained channel and system of locks between Portland–Vancouver and Lewiston, Idaho. The waterway is used by commercial tug and barge companies to move products and commodities to and from upstream origin and destination points. Access to the inland areas by barge traffic is made possible by a system of locks, which allow passage through the Federal dams on the river. Within the Columbia/Snake Federal navigation system there are four dams and locks on the Columbia River: Bonneville, The Dalles, John Day and McNary; and four on the Snake River: Ice Harbor, Little Goose, Lower Monumental, and Lower Granite.

The authorized navigation channel (27–foot deep (8.2 m) by 300–foot (91.4 m) wide) extends from Vancouver, Washington, to The Dalles, Oregon (RM 191.5) (km 308.1). From The Dalles to Lewiston, Idaho, the channel is 14 feet (4.3 m) deep and 250 feet (76.2 m) in width. The authorized minimum depth of the channel is 14 feet (4.3 m) at minimum operating pool (MOP) elevations at each of the dams. Lock sills are at –15 feet (–4.6 m) MOP but the rest of the channel is maintained to –14 feet (–4.3 m) MOP. Under normal operation of the system, pool elevations generally fluctuate between full pool and two feet (.6 m) below full pool, providing channel operating depths of about 18 feet. (5.5 m)

Table 2–9. Major Export Items from the Columbia River (short–tons)

Export	1990	1989	1988
Wheat	11,569,427	11,350,330	15,073,585
Corn	6,968,267	7,048,202	5,797,559
Logs	3,155,651	3,805,574	3,719,711
Soda Ash	1,464,768	1,136,370	1,044,776
Wood chips	898,804	1,160,367	1,030,573
Barley	715,265	492,613	856,919
Lumber	513,361	898,999	620,372
Sorghum	498,374	409,010	199,709
Beet Pulp Pellets	405,532	202,712	182,083
Coke	332,416	445,917	500,684
Total	26,521,865	26,950,094	29,025,971
% of Columbia River exports	92%	92%	92%
Total – Columbia River	28,763,587	29,437,819	31,397,753

Source: The Great Waterway, 1989.

Port Facilities

Riverside facilities managed by port districts or other public or private entities are located on each of the pools created by the locks and dams in the system. There are 54 port and other shipping operations that provide transportation for agricultural, timber, and other products. On the shallow–draft segment there are 20 ports that have grain handling capability out of a total of 22 ports. These are listed in Table 2–10, below:

Table 2–10. Location of Elevators with Grain Handling Capability, Columbia/Snake Shallow–Draft Navigation Channel

Pool	Port	River Mile	Major Commodities
Lower Granite	Lewiston	2 (Clearwater R)	Grain, pulses, logs, containers
	Clarkston	138 (Snake R)	Grain, containers, logs
	Wilma	135 (Snake R)	Grain, wood concrete, petroleum
Little Goose	Almota	104 (Snake R)	Grain
	Central Ferry	83 (Snake R)	Grain fertilizer
	Garfield	83 (Snake R)	Grain
Lower Monumental	Lyons Ferry	61 (Snake R)	Grain
Ice Harbor	Windust	38 (Snake R)	Grain
	Sheffler	29 (Snake R)	Grain
McNary	Burbank	2 (Snake R)	Grain
	Pasco	328 (Col. R)	Petroleum, chemicals, fertilizer, plate glass
	Kennewick	328 (Col. R)	Grain, fertilizer
	Wallula	314 (Col. R)	Grain
	Port Kelley	312 (Col. R)	Grain
	Umatilla	293 (Col. R)	Containers, logs, woodchips, general cargo
John Day	Hogue Warner, Port of Morrow	278 (Col. R	Grain
	Morrow	275 (Col. R)	Grain, containers, logs, wood chips
	Roosevelt	240 (Col. R)	Grain
	Arlington	240 (Col. R)	Grain
The Dalles	Biggs	208 (Col. R)	Grain
Bonneville	The Dalles	190 (Col. R)	Wood chips, grain
	Klickitat	170 (Col. R)	Lumber, grain, aggregate

Fleet Composition

The existing towboat and barge fleet consists of approximately 40 tow boats and 175 barges operated by six barge companies. These are used principally on the shallow–raft segment of the river. Commodities are transported through the inland waterway system on non–powered barges propelled by tow boats. The barges are rectangular, with flat bottomed hulls, and vary in size and design depending on the type of cargo they are intended to carry (open deck, tank, bin, etc.). Barges draft between 11 (3.4 m) and 14 feet (4.3 m) loaded. The size and weight of the tow determines the size or horsepower of the towboat required to move it. To facilitate efficient movement through the system of locks on the Columbia and Snake Rivers, barges are assembled together in tows of one to six barges. The optimum tow is made up of barges that can pass through the upstream locks as a unit. A typical tow configuration consists of five barges and a towboat in the configuration of two sets of barges side by side, with one barge and the tow boat side by side in the rear. The data below describe the types of barges used to transport various commodities.

Standard and Jumbo Combination Barge: Grain and petroleum products, alfalfa, potatoes, paper.

Standard & Jumbo Covered Bin: Dry bulk cargo such as grain under protective cover (30 percent of the total barge traffic).

Open Bin: Dry bulk commodities such as wood chips and sawmill scrap.

Flat Deck: Logs, construction equipment and materials, containers.

Tank Barges: Bulk liquid commodities, petroleum products, anhydrous ammonia (fertilizer).

Log Rafts: The standard log raft is 455 feet (138.7 m) long by 65 feet (19.8 m) wide and contains 250,000 board–feet net Scribner Scale, (590 m3) or 937 tons. (952 metric tons)

Tow boats operating on the waterway vary in size and horsepower. About 60 percent of the barge movements passing through Bonneville Lock use tow boats having from 250 to 1,840 horsepower. These tow boats range in length from 42 to 108 feet (12.8 to 32.9 m), in width from 13 to 34 feet (4 to 10.4 m), and draft from 6 to 11 feet (1.8 to 3.4 m). The remaining movements require tow boats with 2,000 to 3,600 rated horsepower. The largest vessels in this group are 127 feet (38.7 m) long, 35 feet (10.7 m) wide, and draft up to 12 feet (3.7 m).

Alternate Transportation Modes

Alternative or complementary modes of commodity transport are rail and truck. Union Pacific and Burlington Northern Railroads are the predominant rail companies which operate in the region. There is relatively little grain traffic from Oregon, Washington, or Idaho that is moved by rail to Pacific Northwest ports. Most of the region's grain production is transported by water. Of the total volume of annual rail–grain carloads unloaded at Pacific Northwest export elevators, including Seattle and Tacoma, wheat makes up about 25 percent. More than half of the rail traffic is corn, most of which originates from Nebraska, Minnesota and South Dakota. Shown in Table 2–11, below, is the volume of grain moved by rail to Pacific Northwest Ports over a five year period, 1986 to 1990.

Trucks are used for commodity transport, particularly for upriver movement of petroleum and chemical products. Trucks are also used almost exclusively in moving grain from the farm to country or river elevators, and also to transport products arriving at river terminals to their final destinations. Shown in Table 2–12, below, are comparative data on shipments of wheat and barley to export houses by various mode for the years 1987 to 1991.

Waterborne Commerce

The Columbia/Snake River waterway services an enormous area that covers much of the western United States. Agriculture dominates the regional industries associated with waterborne commerce. Trade revolves around grains, such as wheat, alfalfa, corn, grass seed, fruits, and vegetables, with wheat being the largest export item. Other regional industries that use water transport include aluminum, pulp and paper, petroleum, logs, lumber, and beef.

Table 2–11. Annual U.S. Rail–to–Port Grain Traffic Pacific Northwest Ports, 1986–90 (Short–Tons)

Port	1986	1987	1988	1989	1990	Average
Portland	31,940	39,037	43,536	36,543	39,411	38,093
Vancouver	13,482	14,520	21,281	13,957	17,732	16,194
Kalama	32,015	50,254	61,274	85,398	77,299	61,248
Longview	0	487	594	301	0	276
Tacoma	21,618	23,109	44,918	46,206	48,203	36,811
Seattle	4,486	13,439	15,171	24,252	15,900	14,650
Source: The Grain Book, 1991.						

Table 2–12. Receipts of Wheat and Barley at Columbia River Export Houses by Mode of Transportation for Crop year 1987–88 to 1990–91 (in thousands of bushels)

Transport Mode	1987–88	1988–89	1989–90	1990–91
Barge	199,855	198,185	165,197	179,528
% of total	40.6	43.0	40.9	40.4
Rail	274,825	247,441	226,714	254,514
% of total	55.9	53.8	56.2	57.2
Truck	17,032	14,707	11,798	10,505
% of total	3.5	3.2	.9	2.4
Source: The Great Waterway, 1991.				

Products shipped on the shallow draft channel are comprised mainly of wheat, grain, wood products, logs, petroleum, chemicals, and other agricultural products. Containerized commodities are also transported via the waterway. Containers are typically loaded at Lewiston, Pasco, Boardman, and Umatilla, with approximately 97 percent of these shipments destined for Portland and the remainder going to Vancouver. Petroleum products have historically made up the bulk of upriver barge shipments on the waterway.

Projected Commerce

A review was made of projected growth in tonnage for the Columbia–Snake Rivers' segment of the Nation's inland waterways (IWR 1992). Over a 10–year period, (1990–2000) the projected change in total volume of goods shipped on the Columbia–Snake inland waterway is low to moderate. This growth could have a long–term impact on system transportation, handling and storage requirements. However, due to constraints on time and resources to conduct analyses for the SOR, the navigation analysis was based on existing commodity volumes.

2.2.5.3 Dworshak Reservoir

Commercial navigation on project waters includes transporting logs on Dworshak reservoir. Logs from harvest operations in the North Fork Clearwater River drainage above the reservoir are hauled to staging areas at various points along the reservoir and are rafted to log dumps near the dam. They are then collected at the dumps and transferred to trucks for transport to mills. Use of the reservoir for this purpose saves time and cost when compared to trucking logs the entire distance. Dworshak Reservoir is thus used on a seasonal basis to transport approximately 20 million board–feet (47,195 m3) of logs annually. About 90 percent of this commercial operation occurs during the months of June, July, and August. The recent history of log handling on Dworshak Reservoir is shown below. Although log handling facilities continue to be maintained, currently logs are not being transported on the reservoir because the pool elevation is unreliable.

Year	Volume (million board–feet)
1988	25
1989	14
1990	22
1991	20
Source: U.S. Army Corps of Engineers, Walla Walla District.	

2.2.6 Power

The electric generating resources of the Pacific Northwest are capable of producing nearly 44,000 megawatts of electricity from all sources: hydro, coal, nuclear, combustion turbines, etc. This generating capacity produces nearly 20,000 average megawatts (aMW) of energy under the worst water conditions, and an additional 5,000 aMW when water conditions are average.

The hydroelectric dams on the Columbia and Snake Rivers are the foundation of the Northwest's power supply. Falling water provides the energy to turn power–generating turbines at the dams. Hydropower supplies approximately 76 percent of the generating capacity in the Pacific Northwest, and approximately 62 percent of the firm energy supply. When in surplus, it is also an export product for the region. A more detailed description of the hydropower system can be found in Appendix I (Power).

The Bonneville Power Administration was created in 1937 to market and transmit the power produced at Bonneville Dam. Today, BPA markets the power from 30 Federal dams in the Pacific Northwest operateded by the Corps and Reclamation and has built one of the largest transmission systems in the United States.

The Federal generating and transmission system serves an area that includes Oregon, Washington, Idaho, western Montana and small parts of Wyoming, Nevada, Utah, California and eastern Montana. Public and private utilities, as well as some large industries, buy power from these federal facilities. Utilities in California and Canada also buy and exchange power with the Pacific Northwest.

About 86 percent of the firm energy BPA sells is hydroelectric. The projects under review in this FEIS account for 88 percent of the Federal system's hydroelectric capability and 57 percent of the region's hydroelectric capability.

Because hydropower is a relatively inexpensive source of electricity, electricity rates in the Northwest are among the lowest in the nation. This benefits Northwest rate payers, and explains why many energy–intensive industries, such as aluminum manufacturers, have located in the Northwest. For fiscal year 1992, approximately one–third of the power BPA sold went to industries it directly served. These direct service industries include 15 industrial firms operating 19 plants in the Pacific Northwest, producing products such as aluminum and other primary metals, pulp and paper, ferroalloys and chlor–alkalies.

Hydropower's relative cost advantage also explains the intensity of residential electric use in the Pacific

Northwest. The average Pacific Northwest residential consumer uses over 50 percent more electricity than an average homeowner in the rest of the nation.

Many of the alternative SOSs evaluated in the FEIS will reduce the ability of the Federal dams to generate electricity. This electricity will need to be replaced by higher cost resources, which will lead to rate increases for Northwest consumers. This may affect the viability of Northwest industry, and will increase the electric bills of residential and commercial consumers of electricity. The methodology used to evaluate these effects is described in Chapter 3 (Section 3.3.6) and the effects are explained in Chapter 4 (Section 4.8) of this appendix.

2.2.7 Recreation

2.2.7.1 Introduction

The economic impacts of changes in recreation activity can be separated into direct and indirect impacts, which are described in more detail in Chapter 3 (Section 3.3.7). The direct impacts are the change in visitation and the change in willingness–to–pay values. The associated indirect or secondary impacts, are the change in recreation expenditures and are of interest to the general public and many communities in the region. The economies of communities located near recreation use areas depend directly on the number of visitors and the amount of money they spend in the area. For example, if operation of a reservoir like Lake Koocanusa is changed in a way that limits the use of boat ramps during the major recreation season, then fewer visitors will come to the area and purchase supplies like gasoline, food, and lodging in Libby, Montana. Businesses will suffer and possibly close resulting in reduced employment, regional income, and tax revenues. However, some recreators that did not visit Lake Koocanusa may visit Pend Oreille Lake instead, boosting the economy in the Sandpoint, Idaho area. The indirect impact analysis will identify these tradeoffs on local economies using regional input–output models. The extent of impacts can be substantial as indicated by a few Pacific Northwest studies that have estimated expenditures by recreators. For example, a study of lake and river fishermen in Montana showed that, on average, a Montana resident fishermen expended about $48 per lake fishing trip, and those traveling from outside Montana spent about $360 in Montana on each lake fishing trip (Duffield, 1987). The results from a survey of northwest recreators by the SOR Recreation Work Group were used to define the direct and indirect values associated with recreation at the impacted rivers and reservoirs. Detailed information on historic recreation activity and recreation facilities which could be impacted by the alternatives is contained in Appendix J (Recreation).

2.2.7.2 Recreation Visitor Days

Recreation visitor days at the reservoirs and river reaches within the geographic scope of the SOR were over 20 million in 1991 and have averaged over 18 million for the past five years. Recreation visitors participate in numerous activities. Generally, these recreation activities can be separated into water–dependent (swimming, fishing and boating) and water–related (picnicking, hiking and camping) activities. The water–related activities rely on water as an aesthetic complement that enhances the activity.

2.2.7.3 Occurrence of Recreation Activity

Recreation activity occurs throughout the study area. However, the analysis of recreation impacts associated with alternative SOSs included in the SOR was limited to just those areas where recreation use of affected lakes and streams could be significantly impacted by a change in the operation of the system. The projects and associated stream–reach areas for which use estimates and economic values were developed are shown in Table 2–13. Also shown in the same table are the types of recreation activity of concern and the occurrence of those activities at projects or stream–reach areas.

Table 2–13. Recreation Areas and Recreation Activities

		Recreation Activities				
Project or Area	**Type of Project or Area**	**Boating**	**Fishing**	**Camping**	**Picnicking & Other Day Use**	**Swimming**
Hungry Horse	Lake	Yes	Yes	Yes	Yes	Yes
Grand Coulee	Lake	Yes	Yes	Yes	Yes	Yes
Libby	Lake	Yes	Yes	Yes	Yes	Yes
Below Libby	Stream	No	Yes	No	No	No
Albeni Falls	Lake	Yes	Yes	Yes	Yes	Yes
Chief Joseph	Lake	Yes	Yes	Yes	Yes	Yes
Dworshak	Lake	Yes	Yes	Yes	Yes	Yes
Below Dworshak	Stream	No	Yes	No	No	No
Lower Granite	Lake	Yes	Yes	Yes	Yes	Yes
Little Goose	Lake	Yes	Yes	Yes	Yes	Yes
Lower Monumental	Lake	Yes	Yes	Yes	Yes	Yes
Ice Harbor	Lake	Yes	Yes	Yes	Yes	Yes
McNary	Lake	Yes	Yes	Yes	Yes	Yes
John Day	Lake	Yes	Yes	Yes	Yes	Yes
The Dalles	Lake	Yes 1/	Yes	Yes	Yes	Yes
Bonneville	Lake	Yes 1/	Yes	Yes	Yes	Yes

1/ Includes windsurfing

Other impact areas were examined by the Recreation Work Group (RWG) and the results are presented in Appendix J. Recreation impacts in some areas were not assessed in quantitative terms or used a different assessment model, and therefore, were not included in the economic impact analysis. For example, the RWG made recreation use estimates for the Columbia River reach above Lake Roosevelt and below Arrow, in Canada. However, this Canadian reach was not included in this appendix for the following reasons: (1) the reach was assessed with a different recreation model that did not separate impacts into the different activities; and, (2) the EAG was not comfortable in using recreation value estimates from United States studies for the Canadian impacts.

In addition to the recreation activities shown in Table 2–13, sport fishing for anadromous fish is also a significant recreation activity that could be impacted by the alternative operating strategies. A description of this activity is include in section 2.2.1, above.

2.2.8 Water Quality

The Pacific Northwest region has an abundant water supply, and water quality has generally been maintained at a high level. Water quality in the Columbia River Basin is important to fish and wildlife, recreation, aquatic environment, and the economy. Many activities influence water quality including, dam operations, agriculture, navigation, mining, timber and wood products, and urban development. From the SOR perspective, the study focus is on water quality affects from the operation of Columbia River system Federal dams.

Dams impound water and can sharply reduce river velocity. As a result, sediment will either settle on the bottom of the reservoir or become suspended in the reservoir's water column, potentially increasing turbidity and concentrations of contaminants in the reservoir or downstream. Spilling or increased discharge below dams can also increase gas levels which can cause gas bubble disease in fish. Gas bubble disease can kill fish or cause behavioral disorders. Water temperature is also affected by dams. Creation of large deep reservoirs normally causes stratification or layers of water with different physical and chemical properties. Dams can also change the temperature of the water released from the reservoirs, causing impacts to the aquatic ecosystem. The SOR water quality analysis is limited to the primary affects of sedimentation, dissolved gas saturation, and water temperature.

The economic value of water quality changes are measured indirectly through the analysis of water uses, such as fish production and recreation. Appendix M (Water Quality) provides detailed information on water quality in the Columbia River basin.

CHAPTER 3

ANALYSIS PROCEDURES AND METHODOLOGIES

Chapter 3 describes how the economic and social effects were measured. It begins with an introduction to basic NED concepts. Then general study assumptions and definitions are discussed, followed by specific discussions on how the NED impacts were measured. The remainder of the chapter concentrates on conceptual and SOR specific discussions regarding input–output analysis and social impact assessments.

3.1 NATIONAL ECONOMIC EVALUATION, THE CONCEPTS

This section provides the reader with a brief overview of some of the concepts used in NED economic evaluation. Many of the topics introduced are the subject of entire courses and texts in the field of economics. The goal here is to strive for an intuitive understanding of the basic economic principles involved, not a rigorous treatment of the issues. Much of this section is excerpted directly from the Overview Manual for Conducting National Economic Development Analysis (Institute for Water Resources, 1991).

3.1.1 Scarcity

A general definition of economics, is that it is "a study of mankind in the ordinary business of life." This general definition, however, is a bit too broad for the purpose of this study. For the SOR we will confine our interest in the science of economics to theroy of economic analysis. In this more narrow context, economics can be defined as the study of the processes by which scarce resources are or might be allocated toward the achievement of competing objectives. The scarce resource being considered within the SOR is the Columbia River system and the competing objectives are the interests of the various users of the the system.

Consider a single stretch of river. It can be preserved in its natural state with restricted access. Or, it can be moderately developed for recreational uses, such as hiking, fishing, hunting, and canoeing. Or, the banks could be cleared and developed for industrial, commercial, and residential usage. Yet another alternative would be to dam the lower end of the reach and flood the entire stretch of river to provide flood protection, hydropower, water supply, and general recreation to thousands of people. The reach can't be used for all these purposes, so the fundamental problem becomes how, and on what basis, to decide among these competing choices. This is the exact problem facing users of the Columbia River system as they increasingly compete for the limited water resources in the basin. One purpose of SOR is to decide how the Columbia's water should be allocated among the river uses.

All resources are scarce. Choosing to use a resource one way means choosing not to use it another way. Potential benefits foregone by the choice to use a resource in one way rather than another, are referred to as opportunity costs. Thus, every choice made by mankind costs something, even if the best choice is made. In the case of the operation of the Columbia River system, choices must be made from among the system operation alternatives, at a minimum the cost of the choice that is made will be the foregone benefits of uses of the system that are not complementary to the objective which is maximized by the selected operation.

The opportunity cost of resources changes over time as supply and demand for goods and services change. If storage area of a reservoir has been allocated to flood control, leaving it dedicated to flood control precludes the opportunity to use that same storage for water supply or recreation. If the value of water supply or recreation is now valued more highly than flood control, society would be better off by reallocating the reservoir storage area to the higher valued use.

The process of developing a plan for the use of a water resource, such as the Columbia River, is an exercise in the fundamental economic problem of scarcity. The fundamental problem of scarcity is not confined to such broad issues as what to do with a unique reach of river. The concrete and steel used in a fish bypass structure could be used in many other ways as well. Using these resources for fish bypass means they will not be available for alternative use elsewhere in, for example, an office building. Thus, the fish bypass structure costs the nation an opportunity to do something else with the resources. In essence, the NED principle is intended to ensure that the benefits to the nation of the use of these resources in a project exceed the costs of the project to the nation. In other words, the NED principle ensures that concrete and steel will be used in a bypass structure only if the benefit to the nation exceeds the cost. Non–economists might be inclined to argue that concrete and steel are not "scarce" in the common usage of the word, that is precisely the point. All resources are scarce, their prices are an indication of their relative scarcity. Thus, concrete and steel, though easy to obtain are indeed scarce.

3.1.2 Optimal Use of Scarce Resources

To understand the NED objective requires some understanding of a field of economics known as welfare economics. Welfare economics focuses on using resources optimally so as to achieve the maximum well–being for the individuals in society.

Evaluating projects is complicated by the fact that "welfare" is not an observable variable like bushels of wheat, kilowatts of energy, or pounds of fish. The economic welfare of an individual is formally given by his or her utility level. Utility is a term that is generally synonymous with happiness or satisfaction. Thus, project outputs have value because they make people happy or provide them with satisfaction.

It is commonly accepted among economists that the only objective basis under which one can say that society is better off with a water resource project than without it, is when some people are made better off and no one is made worse off by the project. This adaptation of what has come to be known as the *Pareto principle* is not experienced in the realm of practice. Project benefits are generally localized, while the Federal share of costs come from taxpayers across the country. Thus, though the residents of a protected flood plain are made better off, some taxpayers are made worse off because they receive no benefits from the project and must pay some of the costs. If even one person is made worse off, there are no objective grounds to support the project on the basis of increased utility because it is impossible to objectively compare the increased happiness of the protected beneficiaries with the decreased happiness of the taxpayers.

If economic theory stopped here, there would be no such thing as economically justified public works projects. In an effort to extend the class of issues that can be addressed by welfare economics, the *compensation principle* was developed in 1939. Again adapting the principle to water resource development, it says a project should be undertaken if potential "with–project" gains are sufficiently large that everyone could be made better off by some redistribution of goods or income following implementation of the project.

The significant difference is that the compensation principle recognizes the existence of "winners" and "losers". It goes on to allow that if the winners gain enough from the project that they could, hypothetically, reimburse the losers, then the project is worth undertaking whether there is reimbursement or not. Society as a whole is better off, even if some of its members are worse off.

For example, if a project costs one million people $1 each and 100,000 people realize $20 in benefits each, there are clearly winners (the 100,000) and losers (the 1,000,000). However, the $2,000,000 in benefits could be redistributed in such a way that each of the 1,000,000 gets his $1 back so no one is made worse off and each of the 100,000 could still have $10 each. This compensation principle provides the theoretical basis for undertaking water resource projects––society can, hypothetically, be better off.

To decide whether to build a project, benefit–cost analysis is often used to determine if the total and incremental benefits produced by the project exceed the total and incremental costs of the project. The optimum level of development or scope of a project is achieved when incremental benefits are just equal to incremental costs. When this condition exists, net benefits—–the difference between total benefits and total costs—–are maximized. Benefits are measured as the willingness–to–pay for project outputs, and costs are the necessary opportunity costs of the project. Usually, willingness–to–pay is measured indirectly through the use of proxies such as the least–cost alternative for power and navigation and the value of damages prevented for flood control. In addition to economic measures, however, non–economic factors such as public acceptability; technical feasibility; and, environmental impacts, including impacts on threatened or endangered species are considered. Generally, if economic benefits exceed costs, net benefits have been maximized, and non–economic criteria are met, the project is recommended for implementation.

In the case of SOR, the question is not whether to build a project, but rather, would society be better off if the Columbia River system were operated differently. Using economics in making this decision is complicated by the fact that the river system produces outputs which are difficult to accurately measure in economic terms. Examples include the biological outputs such as anadromous fish, resident fish, and wildlife. While economic principles are important to the SOR decision process, they are not the only criteria being used.

3.1.3 Willingness–to–Pay

Willingness–to–pay can be measured in one of two ways. One method involves estimating the amount of money an individual would be willing to pay for the output of a project (level of output associated with an operating strategy in SOR). The other method involves estimating the money an individual would require to willingly forego the output of a project and be as satisfied as in each case.

These willingness to pay concepts are applicable for firms as well. On the producer side of economy, however, more measurable quantities, such as profits, substitute for utility.

Economists generally measure these willingness–to–pay values as the areas under curves. Consumer surplus is defined as the area below the demand curve and above the price line. Producer surplus is defined as the area above the marginal cost curve (supply curve for a competitive firm) and below the price line. Both of these concepts are discussed in greater detail in the next section.

3.1.4 Prices and the NED Principle

All the techniques used to estimate NED benefits and costs rely on the availability of prices or the ability to reasonably estimate prices if they are unavailable. Since prices are so important to NED, it is important to understand a little bit about them.

In the following sections, supply and demand curves are introduced separately. The combination of the forces of supply and demand to produce prices is then examined. Finally, the equilibrium price as determined by supply and demand is considered as a societal optimum. However, it should be noted that when a resource has a clear owner then the price of the resource will measure the value of its next best use because that is at least what must be "bid" to obtain its use from competitors. When no clear owner can exercise property rights to a resource then economic markets will not determine a price or opportunity cost because there is no single owner to insist on payment for the value of lost opportunities. Such "unowned" resources will tend to be underpriced and overused.

3.1.4.1 Demand Curve

Demand represents the maximum quantity of a good or service people are willing and able to purchase at various prices. The "Law of Demand" states that, all other things equal, if the price of a good goes up, the quantity purchased will go down, and vice versa.

The demand curve is sometimes referred to as a willingness–to–pay curve because it measures how much people are willing to pay for each additional unit of the good or service. People buy additional amounts of a good until the last unit is worth exactly what it costs.

Figure 3–1 shows a hypothetical consumer's demand curve for recreation days at a specific project. If a $5 user fee is in effect, the consumer will purchase 10 recreation days. The 10th recreation day is worth exactly five dollars to the consumer.

Each of the first nine recreation days is worth more than $5 to the consumer. S/he would have purchased them if the price were higher than $5. In fact, the figure shows that the consumer would still have purchased 8 of the 10 recreation days at a price of $6. Even though the price of each day is $5 s/he was willing to pay more than that for them. Willingness–to–pay should not be confused with price.

The area under the demand curve is an approximation of the total benefit a person derives from being able to consume a certain amount of a good. It is the person's total willingness–to–pay for the good. In Figure 3–1, total willingness–to–pay is $100 (areas a+b+c), i.e., 20 days of recreation at this site is worth a maximum of $100 to our consumer. How many days our consumer will actually buy depends on the price.

For example, our consumer won't use the site at all if the fee is $10. S/he is willing to pay a maximum of $9.50 for the first recreation day because the utility s/he gets from this one day is worth $9.50 to her. Because the price is only $5, and the day is worth $9.50, s/he'll surely purchase it. The utility of the second day is worth $9 to her, and it costs only $5, so s/he'll clearly purchase it, and so it goes until the 10th recreation day, which is worth $5 and costs $5. Though s/he will purchase the 10th day, the 11th day is worth only $4.50 to her and it costs $5. S/he will not buy it. Her purchase rule is, like your own, if you are willing to pay an amount equal to or greater than the price, you buy. If you aren't, you pass.

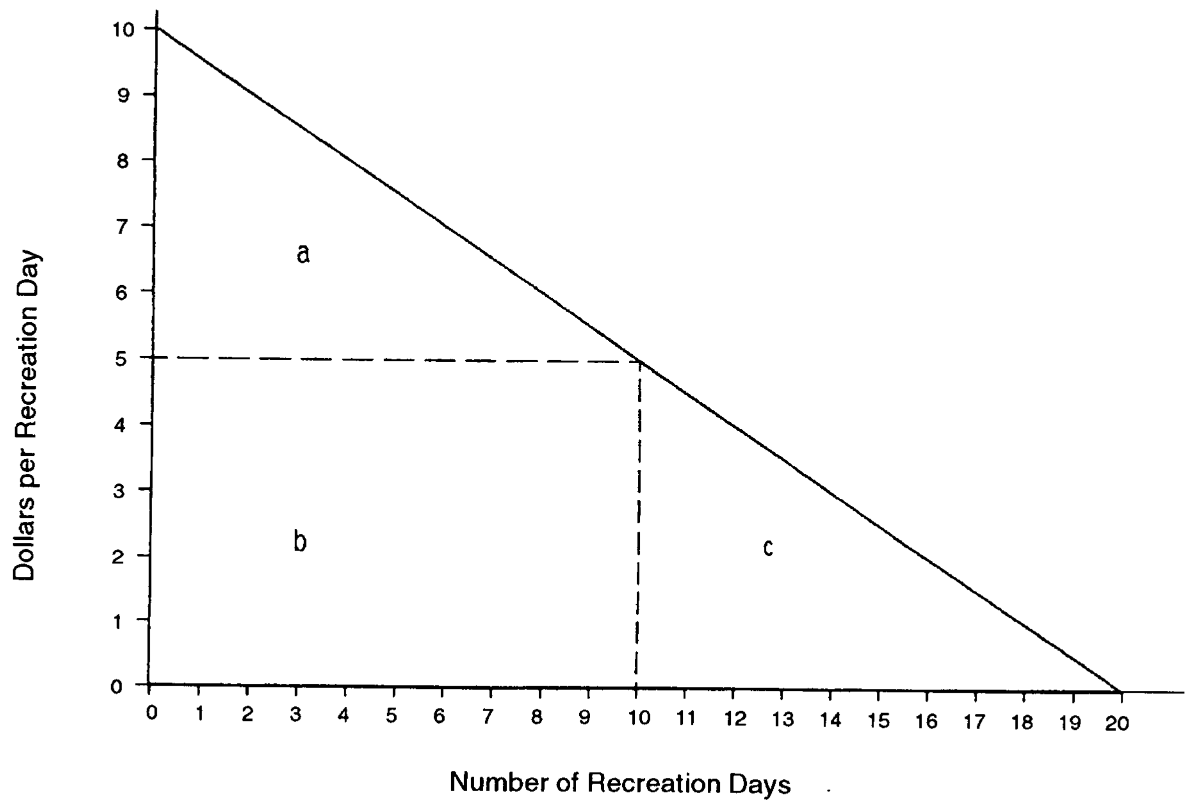

Figure 3–1. Individual Demand Curve

3.1.4.2 Price Elasticity of Demand

As explained above, the demand (quantity consumed) of a good is related to the price of the good. The amount by which demand changes in response to a change in price is referred to as the price elasticity of demand. Formally, this relationship (elasticity) is defined as the ratio of the percentage change in quantity demanded to the percentage change in price. This relationship can be either zero, inelastic, or elastic. Elasticity is zero if there is no change in quantity demanded when price changes. The relationship is inelastic when the percentage change in the quantity demanded is less than the percentage change in price. When the percentage change in the quantity demanded is greater than the percentage change in price, the demand is said to elastic. For most goods, the demand curve (the quantity demanded at varying prices) slopes downward to the right as is shown in Figure 3–1. This type of demand curve includes elasticies ranging from elastic to inelastic, with the left portion of the curve being elastic and the right portion being inelastic.

It is important that readers understand that a rise in price results in a decrease in the quantity demanded (not demand), all else being equal, regardless of the elasticity. Elasticity is the measure of the degree of consumer response to the change in price. In the case of the effects of the SOSs on the supply of electricity from the Columbia River system, the higher the price elasticity of demand for electricity, the less concerned the region needs to be about potential losses of generation, because the percentage decrease in quantity demanded will be greater for any rise in price. Thus, rising prices decrease the quantity demanded and reduce the need to replace lost hydro system generation with higher cost thermal or other resouces. The effect of price elasticity on the quantity of electricity demanded is explained in Section 3.3.6 (methodology) and Sections 4.8.5 and 4.8.6 (results).

3.1.4.2.1 Consumer Surplus

The willingness–to–pay interpretation of the demand curve allows us to measure how much better (worse) off a person is when the price decreases (increases). At a price of $9.50, our consumer buys one day of recreation use. To induce the purchase of a second day, the price must be reduced to $9. At a price of $9, s/he pays $9 for each of the two recreation days s/he buys even though s/he would have paid $9.50 for the first day. The area under the demand curve and above the price (area a in Figure 3–1) represents the surplus the consumer realizes from having the lower price. This consumer surplus is only an approximation of the value of the increased utility to the consumer, but it is sufficient for this demonstration. The area under the demand curve to the left of a quantity of 10 is $75 (areas a+b in Figure 3–1). This represents the total benefit of 10 recreation days to our consumer; hence, it also represents her total willingness–to–pay for 10 days of recreation at this site. At a price of $5, s/he pays only $50 (area b in Figure 3–1) for 10 recreation days though s/he was willing to pay $75. S/he realizes a consumer surplus of $25, i.e., the difference between her total willingness–to–pay and what s/he actually pays or the area below the demand curve and above the price line.

If we add all the individual demand curves to get the market demand curve, we can obtain a measure of consumer surplus for all consumers by taking the area under the demand curve and above the price line. Figure 3–2 shows the consumer surplus for a consumer. Consumer surplus for the entire market would be measured in the same way, but the quantities of recreation days would reflect the quantity demanded by all users of this site, as shown in Figure 3–3.

Relating this to consumer benefits is a simple matter. The area under the individual's demand curve ($75 in the Figure 3–2 example) is a measure of total benefits for the quantity of output (10 in the example). The cost of these benefits is the area below the demand curve and the price line ($50). The consumer surplus of $25 is, analogously, the consumer's net benefits.

Because certain resources have unique characteristics, some economists question whether standard demand analysis incorporates all of the resource's value. Consumer surplus is an area under a demand curve. Demand curves reflect the willingness and ability of people to buy a resource. Not everyone who values a resource is both willing and able to pay for it at a given point in time.

Individuals, who are not consuming the good or service, may be willing to pay some amount of money to preserve their option to consume the service at some later date. This value, called "option value" is a value over and above the consumer surplus because these people are not included in the market demand curve. This option is important if there is some possibility that the resource, such as an endangered species, will not be available at some time in the future.

Considerable controversy has developed among economists over the sign of this option value. In other words, option value may increase or decrease benefits depending on what are, for purposes of this chapter, rather esoteric arguments. The empirical evidence has not been conclusive.

The economics literature broadens this option value concept to include "existence value" and "bequest value". Some individuals who are not consuming the resource might be willing to pay some amount of money just to know the resource exists, though they have no intention of ever using it. Voluntary organizations, such as the one organized to preserve the Statue of Liberty, provide evidence of existence value. People who will never visit the site contributed to its preservation. A more esoteric extension of this idea is that some people may be willing to pay some amount of money to be able to pass a unique resource on to future generations. These people affix some value to a resource because of what it might mean to future generations, bequest value.

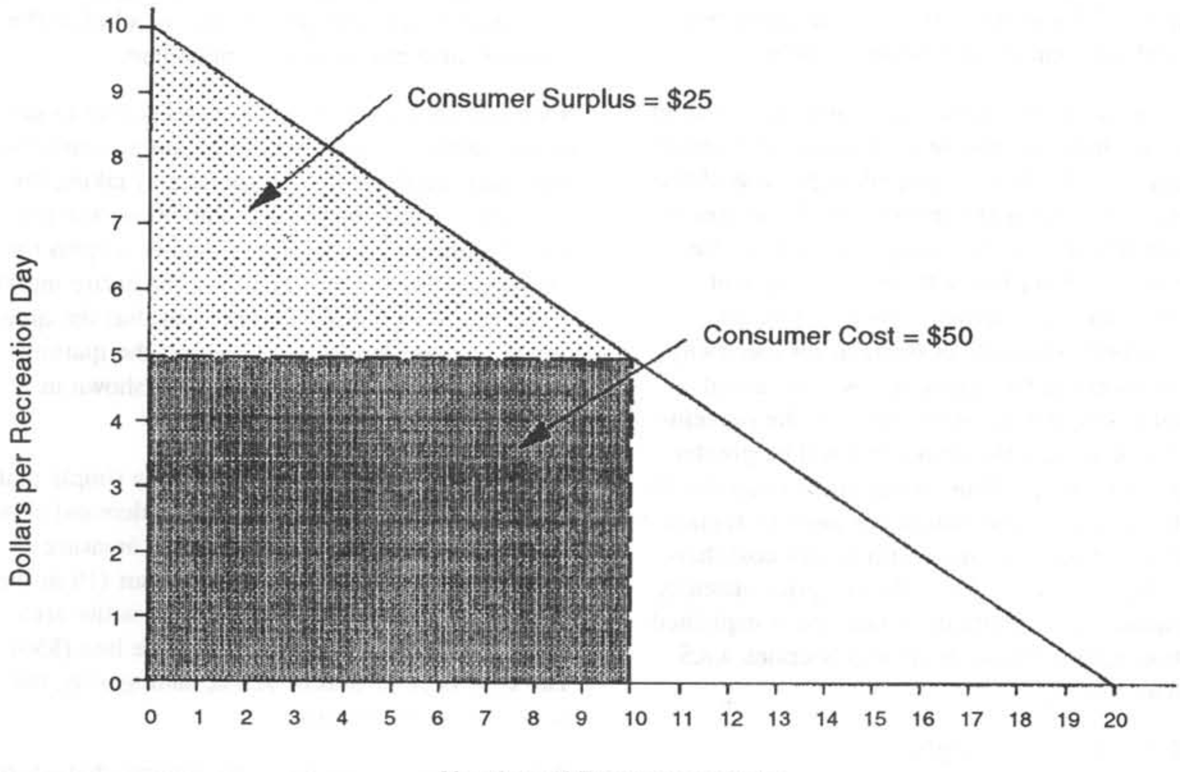

Figure 3–2. Consumer Surplus

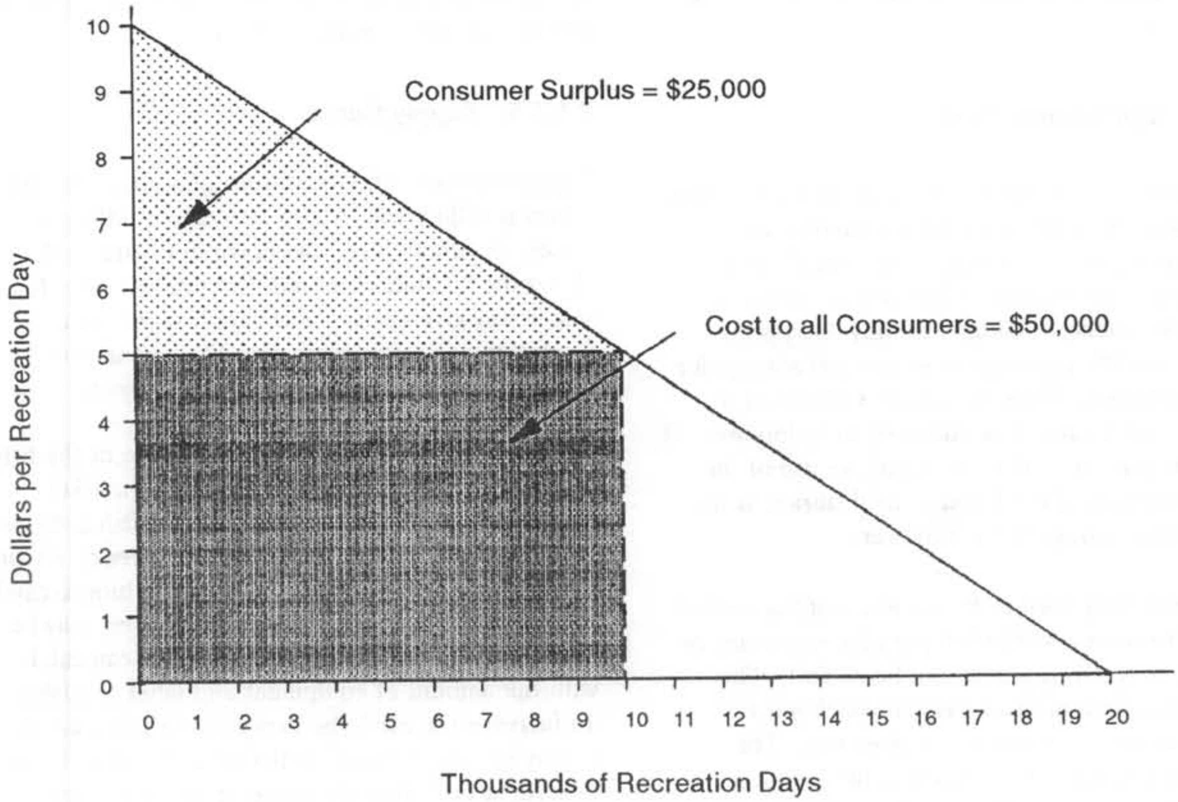

Figure 3–3. Market Demand and Consumer Surplus

The SOR economic analysis recognizes that these values may exist for resident fish and wildlife, and for wild anadromous fish. Due to measurement difficulties and the controversy surrounding these values, no measurement of them was used in estimating the economic effects.

3.1.4.3 Profit Maximization

Economic analysis requires the assumption that people act rationally to maximize their utility subject to their available budgets. This same assumption of rational behavior to maximize utility is applied when people organize as firms. Firms are assumed to be profit maximizers. If profit is defined as total revenues (TR) minus total costs (TC), it is impossible to maximize profits unless costs are minimized. If total revenues are fixed at any level, profit will not be as large as possible unless costs are as small as possible. Thus, profit maximization implies cost minimization.

It is a simple matter to make the jump from profit maximization to net benefit maximization. Total revenues become total benefits (TB), total costs remain total costs. The water resources agency becomes the rational firm and the difference between TB and TC represents net benefits.

In some instances actual benefits are not known and are not estimated. For example, environmental mitigation and restoration is often based on the assumption that the benefits of providing some fixed level of output (TB) exceed the costs (TC) of doing so. Rational economic behavior requires the analyst to minimize the costs of providing these benefits.

Thus, cost minimizing behavior is an important subcategory of profit maximizing behavior used when the level of benefits is unknown but assumed to exceed costs.

3.1.4.4 Opportunity Cost

As discussed above, because of scarcity, choices have to be made. Whenever a choice is made there is a corresponding cost. A choice to do one thing is a choice not to do another. Choosing to use a resource, say reservoir storage, for any one purpose costs at least the opportunity to use that storage for another purpose. Thus, if storage is allocated to flood control it cannot be allocated to hydopower. If hydropower is the next best alternative use of the storage, the cost of the flood control storage is the value of that storage as hydropower.

Price is routinely used as the measure of the cost of a good or service. While $50 per acre–foot may be the price of water, that may not be its cost. The economic definition of cost is *that which must be foregone to use the resource in a given way*. The opportunity cost of any decision is the foregone value of the next best alternative not chosen. Fortunately, for most goods purchased in a competitive market, price includes opportunity cost. Unfortunately for water resource planners, there are many goods and services used and produced by water resource projects that are not produced in competitive markets, for which price does not exist nor does price equal opportunity cost.

The SOR study provides an excellent example of opportunity costs at work. The storage and operation of Columbia River projects built long ago were allocated for a specific mix of purposes. Presumably that mix of purposes was optimal at the time the projects were constructed. The projects are being studied now to determine if the existing storage and operations should be reallocated for a different mix of purposes. Why? Changing opportunity cost is the answer. Since costs of the Federal system are borne by the various river uses as prescribed by Federal law, if, as a result of the analysis of the SOR alternatives, decision makers determine that the operation of the system should be changed from the present operation, it may be necessary to reallocate project and system costs among river uses.

3.1.4.5 Supply Curve

Supply represents the quantities of a good or service a firm is willing and able to produce at different prices. A supply curve, as shown in Figure 3–4, shows the amount of output the firm will offer for sale at any given price. The supply curve for a competitive industry represents the cost to that industry of providing the last unit of output.

Figure 3–4 shows how the output choice of the firm, in this case a fisherman, will respond to market price. Let's assume that if the price of fish is $3 per pound, he will harvest 800 pounds per week. At any harvest beyond this amount, the cost to him to catch the fish is greater than $3 per pound. This may be because 800 pounds is the maximum he can catch with the amount of equipment and labor available. To increase the catch, he may have to add a laborer or buy new equipment. If the price rises to $4, the fisherman finds that the higher price covers the higher cost (i.e., the extra wages or the cost of new equipment) of catching more fish, and at the new price he would be willing to provide 1,200 pounds of catch.

The cost of the 1,200th pound of fish is $4. The fisherman won't harvest more because he would incur costs greater than the $4 per pound he receives. A rational fisherman would not incur costs to catch fish that would exceed the value of the fish.

Just as the area under the demand curve shows total willingness–to–pay, areas under the supply curve show total costs of harvesting a given level of output. The total cost of harvesting 800 pounds of fish is $1600 (area b in Figure 3–4).

Deriving the market supply curve can be more complicated than simply adding the output that each fisherman would produce at each possible price. Nonetheless, the intuition developed from thinking of market supply in this way best suits this section's purposes.

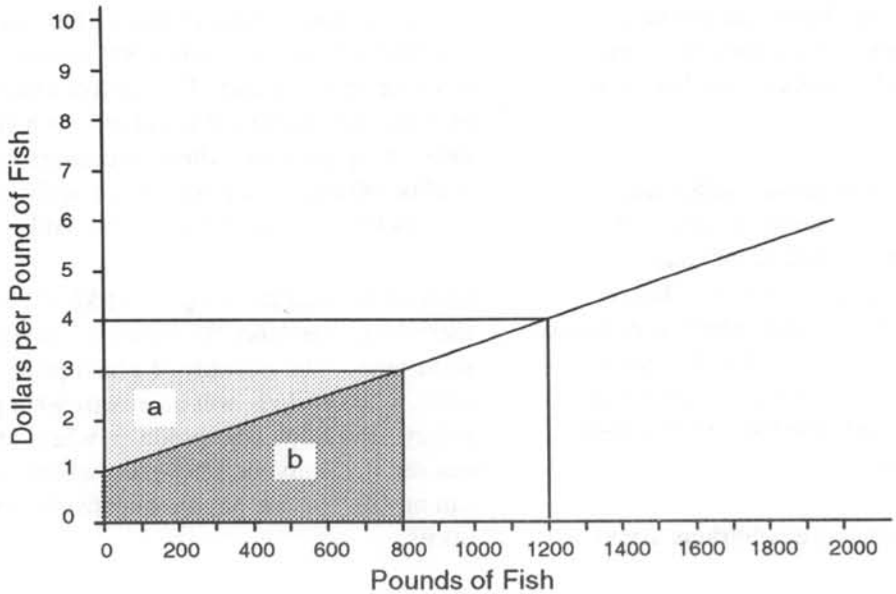

Figure 3–4. Supply Curve

3.1.4.6 Producer Surplus

The points on the supply curve can be interpreted as the producers "willingness to pay the cost of production" at each level of production. Producer surplus, represented by the area below the price and above the supply curve, identifies what the producers are willing to pay (but don't have to) and allows us to measure how much better (worse) off a producer is when the price increases (decreases). Interpretation of the supply curve in a willingness–to–pay concept is just a little bit trickier than is the case for the demand curve.

At a price of $4 per pound, our fisherman is willing to harvest 1,200 pounds of fish. His total revenue is $4,800. Therefore, maximum amount the producer would be willing to pay (or, if you find it more intuitive, the maximum cost he would be willing to incur) to catch the 1,200 pounds of fish is $4,800. Revenues at the margin would exactly cover his marginal costs, which include a fair return on his capital.

The shaded rectangle in Figure 3–5 represents the fisherman's total revenues, $4,800. The triangle beneath the supply curve (darker shade), represents the producers total costs of $3,000 for catching these fish. The area above the supply curve and below the price line (lighter shade) represents producer surplus of $1,800.

3.1.4.7 Markets and Prices

A competitive market equilibrium allocates resources efficiently. The intent of the NED principle is, likewise, to allocate resources efficiently. Thus, it is useful to consider market equilibrium.

The self–interests of the consumers and producers are fundamentally in conflict. One seeks the lowest price possible, the other the highest price possible. Consider the market for wheat. "If wheat costs $2 per bushel, I'll buy so much; if it's $1.75 I'll buy more," the consumer plans. This is the basis of the demand relationship described above. "If wheat sells for $2, I'll produce so much; if it sells for $2.50, I'll produce even more," the producer plans. This is the basis of the supply relationship. These independent plans are coordinated and the players' actions are influenced by the market.

Figure 3–6 shows hypothetical supply and demand for the wheat market. Each good is assumed to provide benefits only to the person who consumes it. Each seller is assumed to pay all the costs of producing the output. The intersection of supply and demand represents the market's equilibrium position. Equilibrium is essentially a state of balance between consumers and producers who have conflicting interests.

When the price of wheat is above equilibrium, say at $3.00, consumers want only 4,000 bushels, while producers are willing to provide 12,000 bushels. There is a surplus of wheat at this price. Everyone who is willing to buy wheat at this price has done so, so the only way to sell the surplus wheat is to drop the price. Thus, if price is above the equilibrium there will be forces at work, the "force" of self–interest, that will drive prices lower.

If the price of wheat is below equilibrium, say at $1.00, consumers want 12,000 bushels but producers are willing to provide only 4,000 bushels. Now, there is a shortage of wheat. Consumers who want wheat and fear they won't get it will offer a higher price to assure they get some wheat, producers in search of profits will raise the price. Once again, self–interest assures that a price that is too low will rise.

Only at the equilibrium price of $2.00 per bushel will there be no tendency for prices to change in the short term. The quantity of wheat produced at this price, 8,000 bushels, will be exactly what people want to buy. Everyone who produces wheat at that price can sell it. Everyone who wants wheat at that price can buy it. No one has an incentive to lower or raise prices.

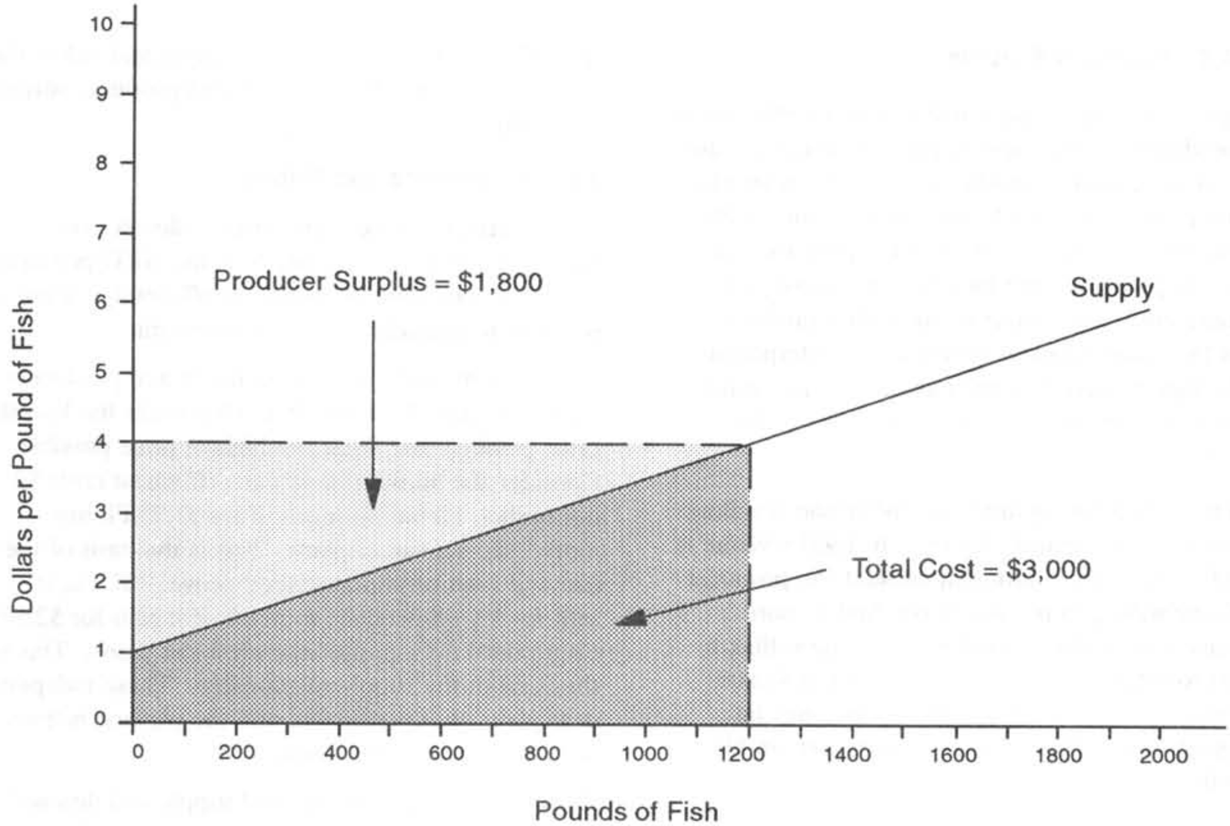

Figure 3–5. Producer Surplus and Opportunity Cost

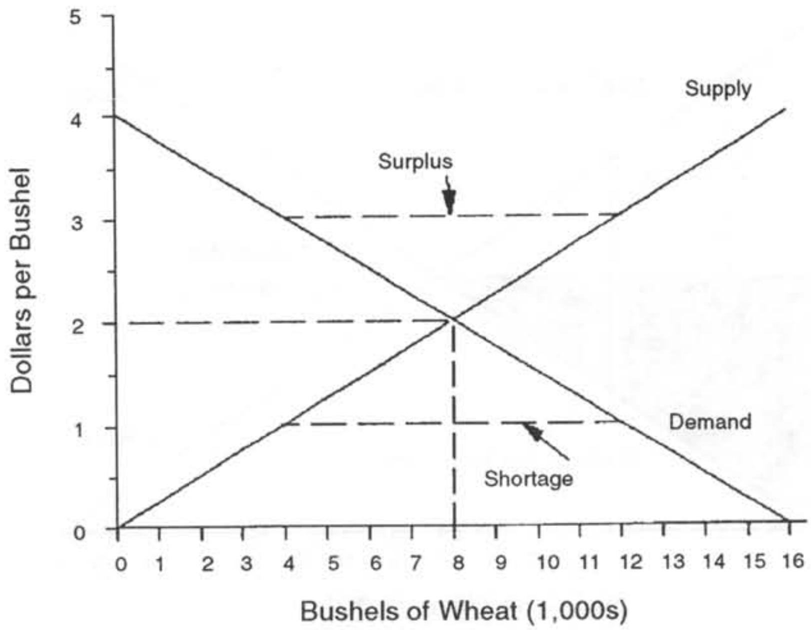

Figure 3–6. Market Supply and Demand

Prices are the result of a dynamic balance of the self–interests of buyers and sellers as they meet in the marketplace.

3.1.4.8 Supply, Demand, and Social Welfare

Social welfare is maximized at the equilibrium price. The demand curve represents the consumers' willingness to pay for additional output, and the supply curve represents the producers' cost of producing additional output. At equilibrium, society's opportunity cost and its willingness to pay for additional output (the last unit produced) are exactly equal. Also at equilibrium, all of the wheat produced will just clear the market, i.e., there is neither a market surplus or shortage.

Consider the market for wheat again. Total benefits, consumers' total willingness–to–pay, are shown as the area under the demand curve. Producers total costs are shown as the area under the supply curve. Maximization of net benefits (total benefits minus total costs) occurs at an output of 8,000 bushels of wheat and is represented by the shaded areas of Figure 3–7. Net benefits are defined as consumer surplus plus producer surplus at any level of output.

Any increase in quantity beyond 8,000 bushels would reduce net benefits because the cost of producing the wheat, read from the supply curve at that quantity, exceeds consumers willingness to pay for it, read from the demand curve at that quantity.

It would be possible to increase net benefits reduced by overproduction (past equilibrium) by dropping the last additional unit of wheat. For example, the opportunity cost of the 10,000th bushel of wheat is $2.50, while consumers are only willing to pay $1.50 for it. Net benefits are therefore diminished by $1.00 for the 10,000th bushel produced. Figure 3–8 shows that at an output of 10,000 bushels net benefits would be $15,000, reduced by the shaded triangle which represents an excess of costs over benefits.

In Figure 3–9, net benefits are shy of their maximum value by the shaded triangle. At any quantity below the equilibrium, the benefits of an additional bushel would exceed the costs of producing it so it would be impossible for a quantity in this range of output to be optimal.

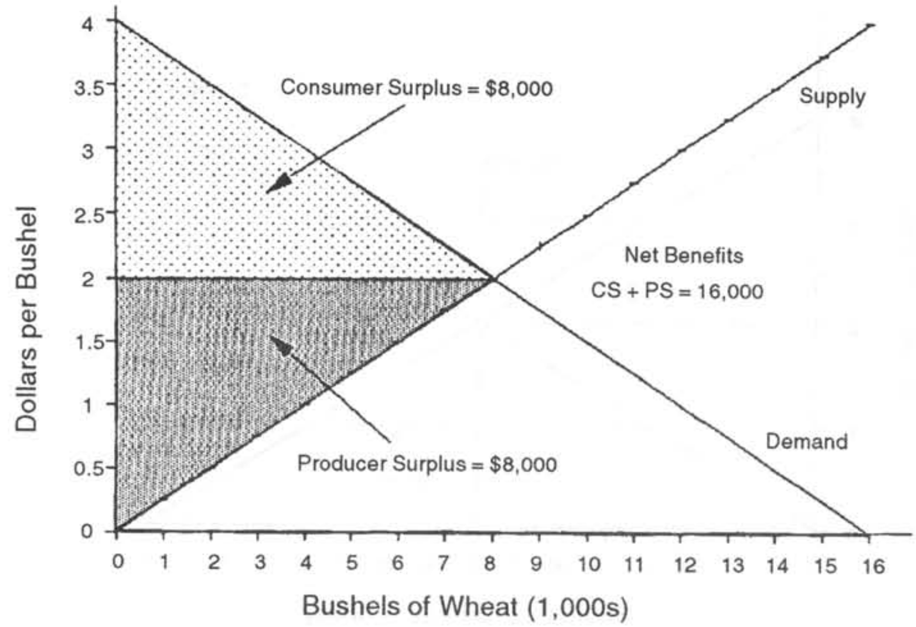

Figure 3–7. Maximum Net Benefits

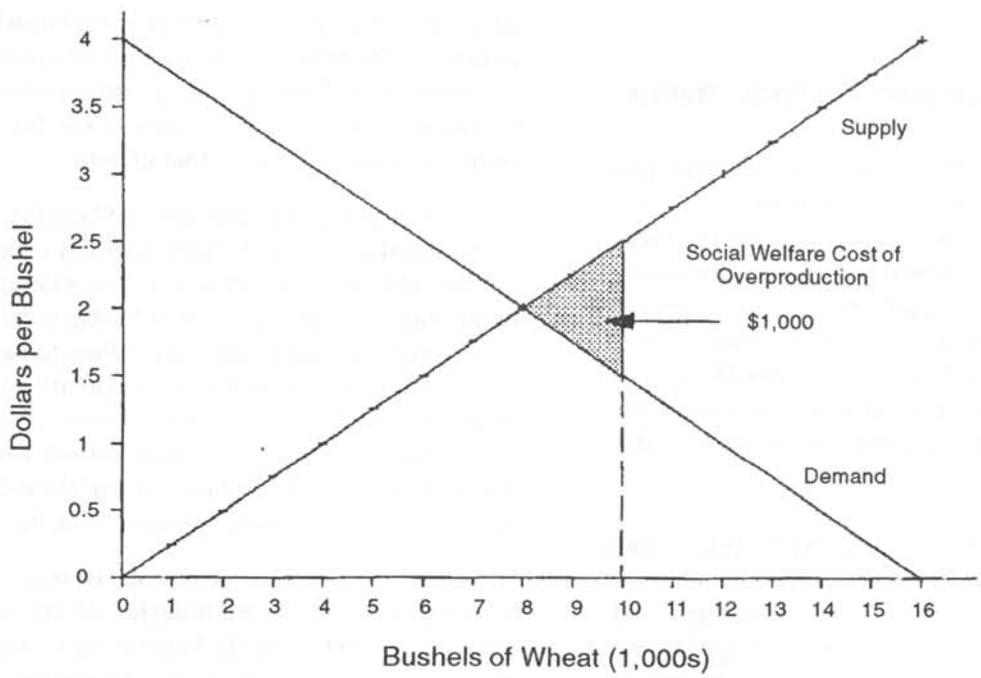

Figure 3–8. Overproduction

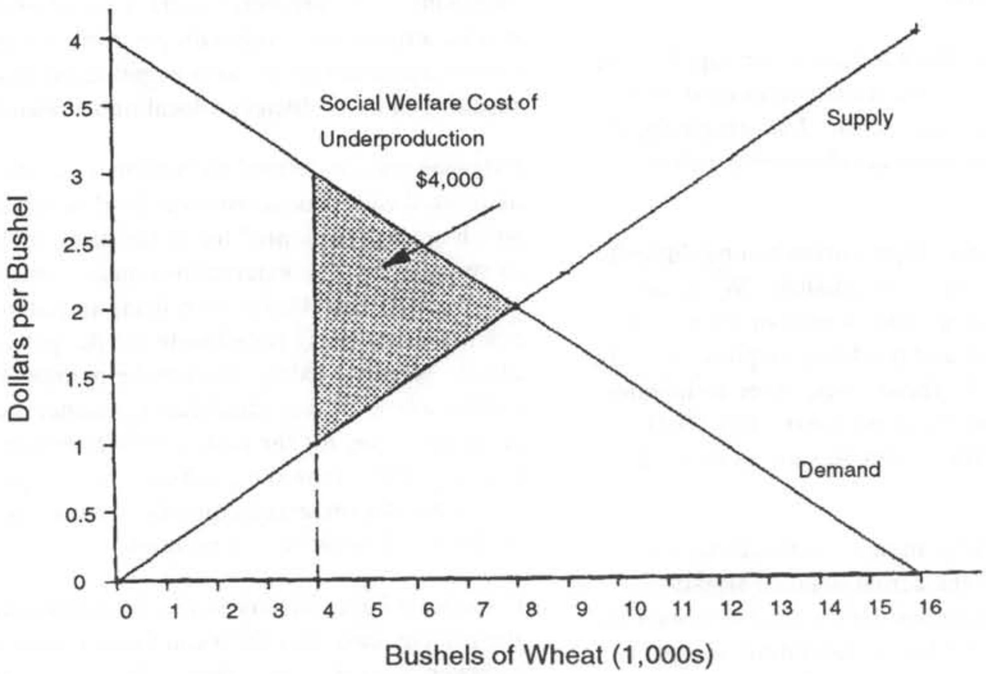

Figure 3–9. Underproduction

Underproduction makes consumers worse off than they could be because at equilibrium they could get more wheat at a cheaper unit price, increasing their consumer surplus, from $2,000 to $8,000 in Figure 3–9

Producers are selling wheat for $3/bu which is $2 per bushel more than it costs them to produce it. Their total revenue ($12,000) at 4,000 bushels could be greater ($16,000) if they sold more wheat (satisfied demand) at equilibrium price but producer surplus would decline from $10,000 to $8,000.

The net loss to society (social welfare cost of underproduction) is the potential net benefit not realized at underproduction. At an output of 4,000 bushels, the net loss is $4,000 ($6,000 consumer surplus loss plus $2,000 producer surplus gain).

Over production would never be voluntarily arrived at. Buyers do not value the additional wheat enough to even pay the equilibrium price. Producers must pay more than the equilibrium price to produce the additional wheat. If this quantity of wheat is produced there would be a lost opportunity to make better use of the resources used in the extra production. This lost opportunity is an efficiency loss to society.

When all conditions for a competitive market are met, competitive market prices are a measure of the true opportunity costs of the marginal resource. Given these conditions, it is impossible for society to improve over the market equilibrium output. Thus, in estimating NED benefits and costs it is important that opportunity costs be used or very closely approximated when valuing resources, because otherwise resources will be misallocated and society is not as well off as it could be.

The value of the increased wheat output from a water resource project would be obtained by comparing net benefits with the project to net benefits without the project.

3.1.4.9 When Demand and Supply Curves Don't Exist

Estimating the area under a demand or supply curve can be a simple matter when the curves exist and prices and quantities are known. Unfortunately, in the case of water resource development, such is rarely the case.

Deriving demand and supply curves can be difficult, costly, time consuming, or impossible. When demand and supply curves do not exist or cannot be estimated, consumer and producer surpluses can't be directly measured. In these cases, other techniques are used to approximate these areas. The NED evaluation procedures (Water Resources Council, 1983) state:

"Since it is not possible in most instances for the planner to measure the actual demand situation, four alternative techniques can be used to obtain an estimate of the total value of the output of a plan: Willingness to pay based on actual or simulated market price; change in net income; cost of the most likely alternative; and administratively established values."

Similar techniques are used when supply curves are unavailable. The most important thing to remember at this point is that all benefit measurement techniques estimate the willingness to pay for the output of a project. In the case of the SOR, a number of different techniques are used to estimate the willingness to pay for changes in the way the PNW hydropower system is currently operated.

3.1.5 Market Failure

Situations that prevent efficient market–determined allocations of resources are called market failures. There are many reasons for market failure. Externalities and public goods, two of the best known examples, are briefly described below.

3.1.5.1 Externalities

Many economic activities provide incidental benefits to people for whom they were not intended. Other activities indiscriminately impose incidental costs on others. These effects are called externalities. When externalities are present, a market based economy will underproduce goods with positive externalities and overproduce goods with negative externalities resulting in an inefficient allocation of resources.

Externalities are defined as benefits or costs associated with production of a good or service which are not accounted for in the price of the good or service. Positive externalities make someone better off without that person being required to reimburse the party responsible for the positive effect. Negative externalities make members of society worse off, but individual consumers are not required to pay for the cost of mitigating the externality at the time the good or service is produced. Flood control projects frequently generate both positive and negative externalities.

Consider a large cannery in the flood plain that is the primary customer for a can factory several miles removed from the flood plain. Flood control protects the cannery and in so doing incidentally benefits the can factory as well. The can factory realizes a positive externality for which it does not have to pay.

Negative externalities make someone worse off without that person being compensated for the negative effect. Floodwalls and levees can produce higher flood stages or more frequent flooding at downstream locations. The residents of communities affected by this induced flooding suffer and are not compensated for a negative externality.

The NED principle requires that externalities be accounted for in order to assure efficient allocation of resources. Figure 3–10 shows how failure to account for the positive externalities of a flood control project can result in underproduction of flood protection.

Demand D_1 in the figure, consists of benefits to flood plain occupants only. Maximizing net benefits to flood plain occupants only leads to an output of Q_1 which falls short of the efficient output Q_2. D_2 includes the benefits of D_1 plus positive externalities to beneficiaries like the can factory.

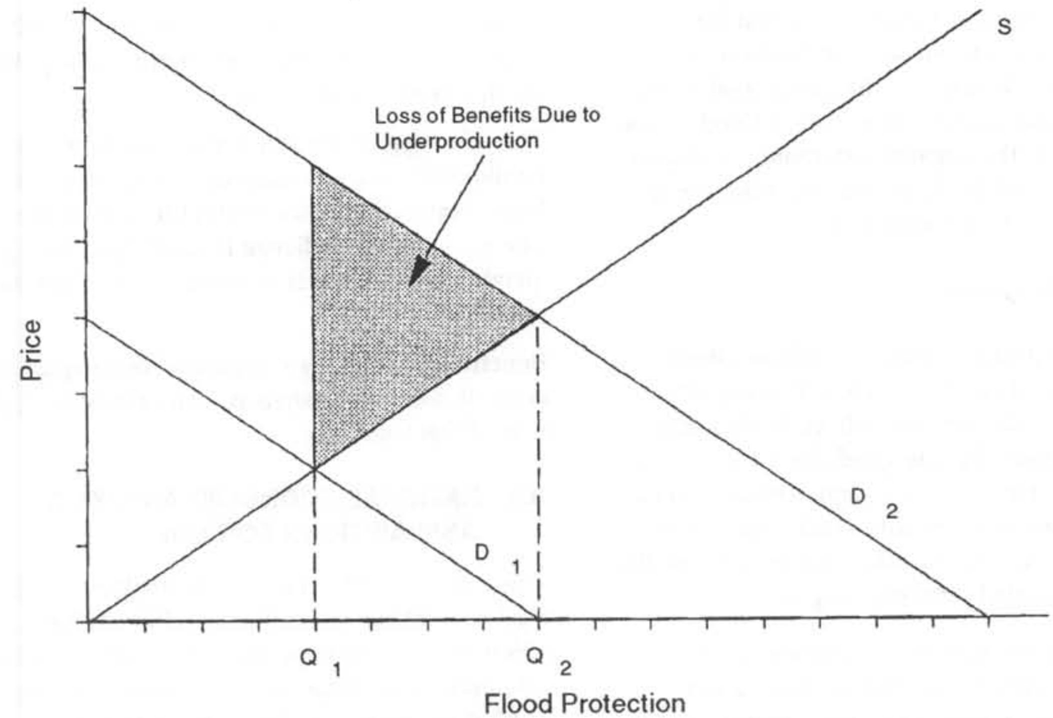

Figure 3–10. Underproduction of Flood Control

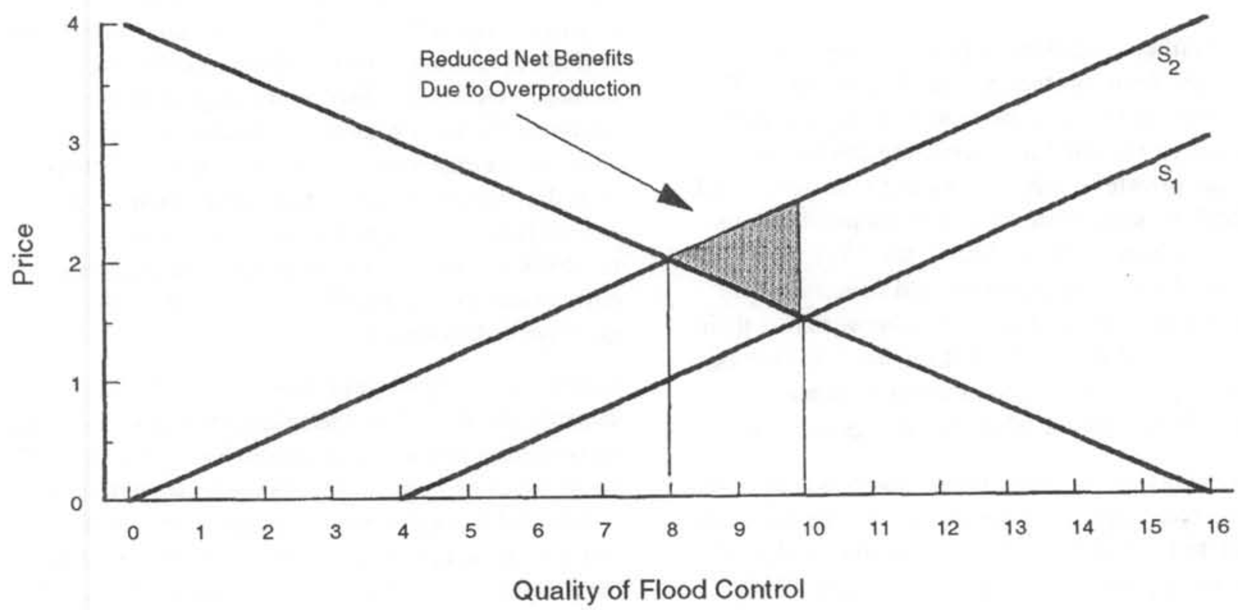

Figure 3–11. Overproduction of Flood Control

Figure 3–11 shows how failure to account for negative externalities can result in over production of flood protection. When only the direct costs of the project are considered (S_1), the level of flood protection is 10. When the negative externality of induced flooding is included (S_2) becomes the true supply curve and the efficient output is 8.

3.1.5.2 Public Goods

Another area in which the market fails to allocate resources efficiently is in the production of public goods. Public goods are best defined by first considering private goods. Private goods have two important attributes. First, they are depletable, i.e., they are used up when they are consumed. Second, they are excludable, i.e., anyone who does not pay for the good can be excluded from enjoying it.

Public goods do not have these attributes. For example flood control is neither depletable nor excludable. Once a local flood protection project is built, anyone in the protected floodplain enjoys flood protection, no one can be excluded. Nor does one person's consumption of flood control use it up (deplete it) and make it unavailable to another. Everyone living in the protected area can essentially consume the same level of protection.

Under market conditions, a private party would provide the flood protection and then try to "sell" it to residents of the area, but since nonpaying users could not be excluded from enjoying the public good, the private suppliers of such goods would find it difficult or impossible to collect for providing the benefits of such services. This is the "free rider" problem. How many people would voluntarily pay $5,000 for flood protection if they know that if their neighbors buy it they will get it for free? Such goods cannot be provided by free enterprise because people will not pay for what they can get for free.

A more subtle point about public goods is that if one person's consumption of the good does not use it up or deplete it, then the additional, or marginal, cost of one more person using the good is zero. With zero marginal cost, efficient resource allocation requires that anyone who wants the good or service be provided it at no cost. So, not only is it often impossible to collect for consumption of a public good, it is also undesirable.

There is a legitimate role for government to provide public goods and to create conditions (e.g., taxes or local cooperation agreements) for cost recovery. The economists' challenge is identifying the optimal quantity of such goods in the absence of market prices.

Benefit–cost analysis is a general technique for doing this. NED analysis is a more specific application of this technique.

3.2 NATIONAL ECONOMIC ANALYSIS ASSUMPTIONS FOR SOR

This study, as with all economic analyses, begins with a set of working assumptions and definitions on which the analysis depends. These definitions and assumptions are important to a clear understanding of what the results of the study represent.

3.2.1 Discounting and Discount Rates

The process of equating money values across time is to equate future sums of money with their present equivalent value. This process is known as discounting. The discount rate is society's opportunity cost of current consumption. That is, it's the rate society uses to equate amounts of money at different points in time. Generally, discounting applies to the economic value of something. Such that the present value or average annual economic value of fisherman days would be calculated, rather than average annual fisherman days, for example. However, the results are same, regardless of whether fisherman days, in our example is discounted or the value of the days is discounted.

Economic theory suggests that the social rate of discount should reflect the return that can be earned on resources employed in alternative private use. To avoid losses of well–being, resources should not be transferred from the private sector to the public sector if those resources can earn a higher return in the private sector. Setting the discount rate equal to the social opportunity cost of funds ensures an efficient allocation of resources across time. There are, of course, certain complications that prevent economists from identifying and even agreeing on what the social opportunity cost of funds should be.

The issue has been resolved for the Corps and Reclamation through Section 80 of PL93–251, which bases the interest rate used in the analysis of water resources investment analysis on the cost of government borrowing. For fiscal year (FY) 1995, the federal discount rate is 7.75 percent.

BPA uses a discount rate of 3.0 percent. This rate specifically excludes an allowance for future inflation and is considered to be an estimate of the real rate of return; i.e., the rate of return on all types of investments after the return has been adjusted to remove the effects of inflation. By virtue of the fact that the Federal discount rate is based on the cost of long–term borrowing by the Federal Government, it contains an inflation premium component. For example, comparing the real rate of 3.0 percent used by BPA with the Federal discount rate of 7.75 percent would suggest that the latter has an inflation premium of about 4.75 percent. This premium is a function of the expectations of investors regarding the future rate of inflation. Thus, if rate of inflation is expected to increase in the future, investors will ask a high inflation premium and interest rates will rise.

To accommodate the analytical requirements of all three agencies, both the 3.0 percent and 7.75 percent rates of interest have been used in measuring the NED economic impacts. It is noted, however, that no attempt was made to include inflation in the estimates of implementation costs or benefits. Because future inflation has not been incorporated in the analysis, the 3.0 percent inflation – free discount rate is the appropriate rate to use for making comparisons of the alternative SOSs considered in the SOR.

3.2.2 Expected and Equivalent Annual Values

Economic impacts are expressed as average annual dollars. For a hypothetical example, alternative "X" will result in expected average annual flood damages of $100,000. The annual estimates generally represent either an expected value or equivalent value or a combination of the two.

Expected annual values are stochastically determined from observations over many years. Expected values are typically seen in flood control studies where the expected annual damage is the average damage which can be expected to result from many years of flow experiences with conditions remaining unchanged. It is computed by weighing each damage value according to its probability of exceedance. Graphically, it represents the area under the damage–frequency curve.

Equivalent annual values take into account conditions that change over time. Economic impacts are estimated for future years over the period of analysis. The estimates are then discounted to a base year and amortized over the life of the project. Amortization is equivalent to calculating a loan payment that repays principal and interest. This process takes into account the social discount rate and allows impacts that occur at different points in time to be directly compared.

3.2.3 Price Level and Inflation

With a few exceptions which are noted in the text, constant prices expressed at a mid–1992 price level were used in the SOR economic analysis. No adjustment for future inflation was made, even though several of the alternatives would require several years (up to 15 years) to implement. Under this frequently used and simplifying assumption of a constant price level over the life of a project, prices do not change relative to one another and inflation has no bearing on the results.

3.2.4 Period of Analysis

The NED impacts were evaluated over a 100 year planning horizon. The base year or beginning of the analysis period is 1995. This represents the first year in which an alternative could be implemented. A 100–year planning horizon was selected to minimize the effect of the discounting process on the present and average annual values of system costs and benefits associated with the various SOSs. This is a significant factor because some of the alternatives cannot be implemented before 2010, 15 years from the beginning of the period of analysis. In addition, anadromous fish models use a 40–year period to estimate an equilibrium level of production. That is to say, impacts of an alternative on anadromous fish production are not fully realized until 40 years after an alternative is implemented. Thus, with an alternative which takes 15 years to implement, full production of anadromous fish would not be reached until 55 years after the beginning of the period of analysis (1995).

Due to time and resource constraints, forecasts of changes in socio–economic factors which could affect the value of an alternative over time, such as population growth, new construction in flood plains, and demand for electricity, were not made. As a result, the analysis tends to understate impacts associated with river uses where the use would be expected to increase in the future. Annual values are shown both in terms of "undiscounted" and "discounted" amounts to allow for comparison among alternatives. Average annual values represent the amortization of costs over a 100–year period of analysis which begins when the alternative is implemented. Equivalent annual values are the average annual values discounted back to the beginning of the SOR period of analysis– –1995.

3.2.5 Implementation Timing

The timing of implementation of alternative investments has an effect on the annual cost of the alternative because of the time value of money, as indicated by the discount (interest) rate. Thus, alternatives which cannot be implemented for several years into the future have lower annual costs than those which can be implemented sooner, when the alternatives are compared at a common point in time. The effects of implementation timing on the annual costs of alternative operations of the Columbia–Snake system are accounted for in the cost analysis by present valuing implementation costs to the base year of the period of analysis for the SOR– –1995, as explained in Section 3.2.4 of this chapter. The analysis of implementation costs of the alternatives is presented in Chapter 4 (Section 4.2) of this appendix to the FEIS.

3.2.6 Full Employment

National economic development analyses assume a full employment economy. If all resources are fully employed, this means that all resources have alternative uses, i.e., all resources have opportunity costs. The significance of this assumption is that it provides the planner with a rationale for using market prices.

"Full employment" of labor resources does not mean the absence of unemployment. It is generally recognized that there is some normal level of unemployment in our economy. Even when the economy is strong, with plentiful jobs, there are people who are unemployed because they are changing careers, moving to another part of the country, graduating from school, entering the work force for the first time, or reentering the work force after some absence.

In recent years, mobility in the United States has resulted in a general consensus that a natural rate of unemployment is about three to six percent. Thus, the assumption of full employment is that over the planning horizon the economy will generally have an unemployment rate within this range.

3.3 NATIONAL ECONOMIC ANALYSIS FOR SPECIFIC RIVER USES

Presenting the information and methods used to measure the national economic development affects is the purpose of this section. The procedures used in this study are imperfect. As usual the effort was constrained by time and money. Moreover the data required for such a complex undertaking were lacking and in some cases unknowable. Nonetheless, the procedures used were formulated to reasonably approximate the willingness to pay or opportunity costs given the study constraints and realizing that rational decisions regarding the operation of the 14 Federal projects may depend on the resulting estimates.

3.3.1 Anadromous Fish

The anadromous fish of the Columbia River represent a very valuable resource of both regional and national interest. The economic value of the fish runs can be broken into the value to users and the non–users of the resource. Users consist of the commercial fishermen, sport fishermen, and the Native American fishermen who harvest the fish for commercial, sport, subsistence, and ceremonial purposes. Examples of non–users are the public that perceive a value knowing that anadromous fish runs exist or will exist for future generations. These values are referred to as existence and bequest values. Defining these values in monetary terms is not easy because neither the users nor non–users "purchase" or sell their existence and bequest values. Therefore, a market price, i.e. economic value, cannot be accurately defined.

Many approaches have been developed by economists to assign monetary values for environmental resources like fish, but these approaches are not widely accepted. Due to the controversy surrounding monetizing the existence and bequest value of an anadromous fish, no assignment of a dollar value per fish is made. The analysis, however, provides estimates of the economic values of the fish which are harvested and sold in the commercial market. In addition, the recreation or sport value in terms of consumer surplus for fishing for the Columbia River salmon and steelhead runs is estimated. Since different system operation alternatives will impact the size of fish runs, the economic activity surrounding the fish runs will change. This appendix provides descriptions of this economic activity both from an NED standpoint and a regional economy standpoint. However, it should be made clear that economic estimates provided here do not represent the full value of the fish runs and should not be manipulated to define a "value per fish."

3.3.1.1 Resource Assessment

For each SOS, estimates of expected fish runs are presented in Chapter 4. These estimates were developed by the Anadromous Fish Work Group (AFW) and are presented in Appendix C (Anadromous Fish). Anadromous fish of the Columbia River consist of several species of salmon, steelhead trout, shad, smelt, etc. The species of primary interest from an economic standpoint are salmon and steelhead and these are the only species examined here.

Fish Models

Appendix C provides an assessment of historic and current runs of Columbia River salmon and steelhead. For evaluation of alternative SOSs the AFW utilized three computer models to simulate the life cycles of salmon and steelhead. Appendix C describes these computer models in considerable detail. Two in–river survival models were utilized to estimate survival of juvenile fish on their downstream migration. The two juvenile passage models were the Columbia River Salmon Passage model (CRiSP) used primarily by BPA and the Passage Analysis Model (PAM) developed and used by the Power Council. In addition a life–cycle model, entitled Stochastic Life Cycle Model (SLCM), was used to estimate survival through the entire egg–to–adult spawning life cycle. SLCM was designed to mimic the basic mechanisms regulating populations of Pacific salmon and steelhead. In addition, SLCM attempts to capture some of the intra–annual and inter–annual variation inherent in these populations by incorporating stochastic variation into each step in the life cycle. This enables SLCM to reflect some of the variability inherent in nature. The economic analysis used the life cycle model SLCM to describe the economic activity associated with the catch of adult salmon and steelhead.

The results of the life–cycle model provides long term trends in fish survival for each of the alternatives. Because fish survival through one life cycle influences the number of fish in the following life cycle, the long–term trends are the most descriptive output. The AFW used the life cycle results for year 40 of each of the SOSs to describe fish survival. The variability in possible fish runs were also modeled by AFW, and results are presented in Appendix C for the median estimate of fish survival and expected confidence intervals from 10 percentile to 90 percentile for all the SOSs. This appendix presents fish survival information for the median values estimated for each SOS.

Indicator Stocks

The fish life–cycle models did not estimate changes to the entire Columbia River salmon and steelhead runs, even though it was recognized that the SOSs have the potential to impact every fish run in the system. To model all species was simply too large of a task and all the necessary data were not available. The AFW identified a group of indicator stocks to model that, in their judgment, sufficiently describe the impacts of each SOS on salmon and steelhead in the different geographic regions in the Columbia basin. The spring chinook indicator stocks were Methow and Snake River stocks. Summer chinook indicators included the Methow and Snake River stocks and fall runs of chinook were modeled with the Hanford Reach and Snake River stocks. Steelhead were modeled with Dworshak hatchery steelhead.

The limitation of the analysis to indicator stocks is a practical reality that somewhat complicated the presentation of economic information. This appendix is intended to present the commercial and sport economic impacts to the impacted Columbia River runs and hence some assumptions had to be made to extrapolate the partial estimates of fish runs to the entire Columbia River fishery. To test how well the indicator stocks represented the total runs of the various species a simple bivariate Pearson correlation study was done. The correlation between indicator stocks and the dam counts at six mainstem Columbia and Snake River dams were examined. The data used for the correlations were the spawning escapement of the indicator stocks and dam counts from the mid–70s through the late 1980's. The correlation studies are shown in Appendix C, and the general conclusions are summarized by stock below.

For spring chinook, at least one indicator stock was highly correlated with each of the dam counts. For summer chinook, the results were less encouraging. McNary, Priest Rapids and Wells summer chinook counts were highly correlated with the Methow summer chinook counts. However, Ice Harbor and Lower Granite counts were not correlated with either of the indicator stocks. Dam counts for fall chinook at Bonneville, Ice Harbor, McNary, and Priest Rapids were strongly correlated with the Hanford Reach indicator stock, while Lower Granite fall chinook counts were strongly correlated with the Snake River indicator stock. Steelhead dam counts did not correlate well with the Dworshak indicator stock..

Given the results of the correlation studies the following general caveats are made concerning the description of the economic activity associated with each SOS. The anadromous fish indicator stocks modeled in the SOR process are good indicators of spring and fall chinook runs of the Columbia River. The indicator stocks are only fair indicators of the summer chinook run and poor indicators of the steelhead run. For these reasons a high degree of error of estimate is assumed for the summer chinook and steelhead estimates.

The Columbia River coho runs comprise a significant component of the ocean and lower Columbia River commercial and sport fisheries. However, as explained in the Appendix C, the Columbia River coho run consists almost exclusively of fish produced at lower river hatcheries. Wild coho salmon are now considered to be extinct in the Snake and upper Columbia River sub–basins. The SOSs investigated in SOR will not have any appreciable impact on the Columbia River coho runs. For this reason, this major economic component of the Columbia River fisheries was excluded from the SOR analysis.

The AFW determined that sockeye would not be modeled because measures of migrational characteristics (e.g., dam passage parameters, travel time, and survival) are not available. Therefore, the impacts on sockeye for the various SOSs are not reported. Some economic information is provided below for sockeye, but the size of the sockeye run and its economic value is relatively low. As a result, including or excluding sockeye from the analysis of economic impacts does not present a significant problem.

3.3.1.2 Fish Harvest Analysis

A description of the harvest of Columbia River salmon and steelhead runs impacted by the alternative SOSs is a critical element of this economic analysis. The economic information provided here is only that associated with harvesting of salmon and steelhead for the commercial market and the economic values associated with harvesting salmon and steelhead in the sport fishery. In addition a description of the fish catch by Native Americans for ceremonial and subsistence purposes is presented. The number of fish that escape harvest and become the spawners necessary to perpetuate the run are not shown here, but they comprise a large portion of the entire fish run. For example, the escapement amounts for the Columbia upriver bright chinook from 1987 to 1991 represented 35 to 50 percent of the in–river run.

The SLCM model provided estimates of the number of fish harvested for the indicator stocks, but the indicator stocks comprised only a small component of the total Columbia River runs influenced by SOR alternatives. The impacts on the indicator stocks were used to define impacts of each SOS in relative terms to a base case. That is, if the model results for the indicator stocks for fall chinook had an estimated 10 percent reduction in harvest from the base case condition, then a 10 percent reduction was assumed for the entire Columbia River fall chinook run.

Considerable data exist on the harvest of salmon and steelhead in both the ocean and in–river fisheries. The historic catch information provided the basis for most of the analysis. Since the SLCM model was calibrated on information from the mid–1980s to early 1990s, historic information is compiled for this same time frame. As described in Section 2.2.1, Columbia River salmon are harvested in four major fisheries: (1) ocean troll commercial fishery in waters off the coast of Alaska, Canada, Washington, Oregon, and California, (2) sport fishery in the ocean, at Buoy 10, and the main stem and tributaries of the Columbia River, (3) non–Native American gill–net commercial fishery in the Columbia River below Bonneville Dam, referred to as Zone 1 to Zone 5 fishery, and (4) Native American fishery from Bonneville Dam to McNary Dam which includes harvest for the commercial market and ceremonial and subsistence purposes. The management zone for the Native American fishery is entitled Zone 6.

Ocean Harvest

Ocean harvest of Columbia River stocks of salmon and steelhead by fishery can only be defined with a relatively high degree of uncertainty. Most ocean harvest data is compiled for the states in which the fish are landed. This ocean harvest data are not easily disaggregated into particular stocks of fish because the migratory nature of salmon in the eastern Pacific Ocean creates a mixed stock of fish from a multitude of home streams ranging from California to Alaska. Identification of the home stream of any salmon caught in the ocean can only be done for those fish that are marked with tags such as the coded wire tags (CWT). Data bases are maintained for recoveries of CWT from the various fisheries. These data have limitations because only a small sample of fish are marked with CWT, not all recoveries are reported, and typically only hatchery fish are marked.

The CWT data have been used extensively by several researchers and agencies. The Pacific Salmon Commission (PSC) used CWTs to produce their PSC Chinook Model to evaluate alternative fishery management regimes in conjunction with international treaties between Canada and the US The PSC Chinook Model incorporates nearly all stocks originating from the Columbia River northward for which adequate CWT recovery data are available for estimation of fishery impacts. The 1993 calibration of the PSC Chinook Model was employed to describe the historic harvest by fishery (Morishima, 1993). The general findings of CWT studies by Columbia River species are: (1) steelhead are not a target species for harvest in the US or Canadian ocean commercial or sport fisheries, however, some small percentage of steelhead have been caught in nets targeting non–salmon and non–steelhead species, (2) ocean harvest of Columbia River sockeye has been minimal, and (3) ocean harvest of Columbia River fall chinook runs has been significant and occurs from Alaska to Northern California. Given these general findings, the harvest description for the ocean fisheries provided here is limited to the harvest of chinook. Steelhead and sockeye ocean harvests were not quantified because CWT data showed ocean harvest to be minimal.

Table 3–1 provides the estimated breakdown of fish catch for the Columbia River stocks of salmon and steelhead investigated in the SOR for the period of 1987 to 1991. The stocks presented represent those in which significant CWT data existed. Therefore, smaller runs from tributaries of the Columbia River are not included. For this reason the estimates somewhat understate the catch of Columbia River salmon and steelhead. Ocean catch is shown for commercial and sport fisheries for Alaska,, Canada, and the US.

The fall chinook run is presented in two columns. The first column, entitled total Columbia River Fall Chinook, includes information on catch of falls from the major tributaries in the lower Columbia River such as the Cowlitz and Lewis rivers. The SOSs are unlikely to impact these lower river runs, so the second column, entitled SOR Fall Chinook includes an estimate of the runs likely to be impacted by the SOSs. The SOR fall chinook catch estimates presented consist of Columbia River upriver brights, Spring Creek tules, Lower Bonneville tules, and Snake River falls. A similar approach was taken for the spring and summer chinook runs. The Total Columbia River column includes the large Willamette and Cowlitz Rivers spring chinook runs which will not be impacted by the SOSs. As explained above, no significant ocean catch has been identified for steelhead and sockeye. Some of these species are caught in the ocean. While the extent of the catch is not known, it is believed to be relatively small.

In–River Harvest

The in–river harvest is shown in Table 3–1 in two rows: In–River Commercial and In–River Sport. The in–river commercial consists of gillnet commercial fishing in Zones 1 to 5, and the Native American harvest in Zone 6. The largest component of the in–river sport fishery for fall chinook occurs in the Buoy 10 fishery at the mouth of the Columbia River. The steelhead sport fishery occurs throughout the Columbia River basin, but the largest concentrated steelhead sport fishery occurs in the Clearwater River. The sockeye catch is harvested in the Native American fishery, but since the listing of sockeye as endangered under the Endangered Species Act, there has not been a tribal commercial harvest of this species.

Native American (Tribal) Fishery

The Native American fishery is a special subset of the in–river fishery and is described briefly in this section. Treaty fishing rights are established for the Treaty Tribes of the Nez Perce Tribe, the Confederated Tribes of the Umatilla, the Confederate Tribes of the Warm Springs Reservation of Oregon, and the Confederated Tribes and Bands of the Yakima Indian Nation. The Treaty Tribes have rights to fish in their usual and accustomed fishing places from Bonneville Dam upstream to McNary Dam. The treaty Indian fishing can be divided into three functional categories; tribal commercial fishing, tribal subsistence fishing, and tribal ceremonial fishing. All these fishing activities are managed according to the Columbia River Fish Management Plan (CRFMP, 1988).

For the most part, the tribal commercial fishery provides their commercial catch to the wholesale buyers as whole fish, delivered "in the round." The wholesale fish dealer is licensed by the state of operation.

Tribal subsistence fishery refers to those fish caught by enrolled members of treaty tribes for personal consumption of the tribal member or immediate family, or for trade, sale or barter, or to give to other Native Americans for their consumption. Salmon and steelhead that are taken for subsistence purposes during the commercial fishing season are treated as commercial fish by fishery agencies. However, since these fish are generally not sold, they are not tracked by the fish ticket method; so, landings of tribal subsistence and ceremonial fish are estimated by the tribes. Tribal ceremonial fish are those fish caught and used pursuant to tribal authorization for religious or other traditional Native American cultural purposes. Ceremonial fish may not be sold, bartered or offered for sale. At least two days notice must be given to the Directors of Fish and Wildlife before ceremonial fishing may occur on the Columbia River.

Table 3–1. Columbia River Salmon Catch Estimates, Averages for the 1987 to 1991 Period (1,000 Fish).

AVERAGES FOR THE 1987 TO 1991 PERIOD (1,000 FISH)						
	Total Col Riv Fall Chinook 1/	SOR Fall Chinook 2/	Total Col Riv Sp/Sum Chinook 3/	SOR Sp/Sum Chinook 4/	Steelhead	Sockeye
COMMERCIAL CATCH: 5/						
ALASKA	52.0	48.7	11.2	0.1	0.0	0.0
CANADA	176.1	162.8	40.9	10.9	0.0	0.0
U.S. OCEAN	46.0	39.0	13.0	0.3	0.0	0.0
IN–RIVER	213.2	213.0	18.0	0.7	64.9	23.7
TOTAL COMMERCIAL	**487.3**	**463.5**	**83.1**	**12.0**	**64.9**	**23.7**
SPORT CATCH:						
ALASKA	3.0	2.8	0.7	0.0	0.0	0.0
CANADA	12.5	12.0	1.9	0.0	0.0	0.0
U.S. OCEAN	31.9	28.8	9.8	0.1	0.0	0.0
IN–RIVER	27.3	14.4	101.9	0.1	50.9	0.0
TOTAL SPORT	74.7	58.0	114.3	0.2	50.9	0.0
TOTAL CATCH	562.0	521.5	197.4	12.2	115.8	23.7

1/ Includes Cowlitz & Other lower river tributaries.
2/ Fall chinook impacted by SOSs. Upriver brights, lower Bonneville, Spring Creek, and Snake River.
3/ Includes Willamette & other lower river tributaries.
4/ Columbia upriver spring and summer chinook.
5/ Includes Native American harvest for commercial, ceremonial, and subsistence.

SOURCES: Morishima, Gary S. "Distribution of Columbia River, Washington Coastal, & Puget Sound Salmon Stocks." Presented to PUD#1 Clark Co., Wa. Feb. 1993.
ODF&W and WDF. "Status Report: Columbia River Fish Runs & Fisheries, 1960–1990."

3.3.1.3 Fish Allocation

In order to define the economic activity associated with salmon and steelhead, the adjusted survival estimates from the fish models must be allocated to the different fisheries and to escapement for spawning. A key assumption for the analysis is that the historic allocation rate of fish to the harvest and escapement will continue into the future, regardless of change in production. This assumption is embedded in the fish survival models and in the analysis of economic impacts. With the ESA stocks in particular, this may be a weak assumption, but any other distribution assumption would be purely arbitrary because of the total absence of supporting data.

3.3.1.4 Commercial and Sport Fish Values

As described above, values are not assigned to the salmon and steelhead on a per fish basis because of the inadequacies of economic valuation techniques for all benefits to society, and not accounting for all fish (e.g., spawners and non–CWT stocks). What is presented is limited to the values associated with the harvest of salmon and steelhead by the commercial and sport fishery. These estimates are presented for informational purposes and are not meant to be compared to other economic values in a "trade–off" analysis.

Commercial Values

One measure of the direct economic value of the fish harvested for commercial purpose is the ex–vessel value which is the price received by the harvesters from fish buyers. The ex–vessel value may not always be the net economic (NED) value because it represents the gross income which has not been reduced to net income by subtracting the cost of harvesting. However, the ex–vessel value is the most appropriate economic value for decision making when only small marginal changes in fish catch are involved and where the small change in the supply of fish would not measurably change the incremental cost of harvesting. In this case, the ex–vessel value reasonably estimates the net economic value. This condition does not hold for large changes in fish catch and in situations where the total net economic value of the commercial fishery are being estimated. Since the SOR is examining large and small changes in fish supply, both the full ex–vessel value and an estimated net economic value are presented to cover the range of economic output.

Numerous researchers have attempted to define net income by identifying a variable harvesting cost to define a net–to–gross ratio that could be applied to the ex–vessel values received by the commercial fish harvester. No consensus has been reached on the net–to–gross ratio. Hanemann (1986) and Meyer (1988) adopted a ten percent of ex–vessel revenues for short–run incremental costs (a 90% net–to–gross ratio). In an economic study of the Sacramento River chinook salmon, Hydrosphere Resource Consultants (1991) suggested a variable cost of 11 to 21 percent of ex–vessel value assuming no change in fishing effort. If a change in fishing effort occurs, a variable cost range of 26 to 50 percent was recommended. To demonstrate a range of possible values for the commercially caught salmon and steelhead, net–to–gross ratios of 50 and 100 percent, representing "low" and "high" values, are presented for the current catch (see Tables 3–5 and 3–6, respectively) and for catch with alternative operations of the Columbia River system (see Chapter 4, Section 4.3). The net income derived by these net–to–gross ratios is meant to estimate the return for the operator's labor, management, and capital.

The average ex–vessel prices for salmon and steelhead for the years of 1987 to 1991 are shown in Table 3–2, on a per species basis. These average ex–vessel values were based on price leveling the prices received over this time frame to 1992 price levels using the gross domestic product price deflator. The price per pound varies by location of catch to reflect the difference in quality and size of the fish and market conditions. The size of fish caught also varies geographically. For example, ocean troll harvest provides a relatively high quality of salmon compared to the same species of salmon that is caught in–river. The in–river fish is nearing the spawning stage and the physiological changes associated with spawning deteriorates the marketability of the fish. Alternatively, the in–river fish are at their peak growth age and hence may be larger than ocean

Table 3–2. Columbia River Salmon Ex–Vessel Average Values per Fish for the 1987 to 1991 Period

	SOR Fall Chinook 1/	SOR Sprg/Summ Chinook 2/	SOR Steelhead	SOR Sockeye
	Ex–Vessel $/Fish	Ex–Vessel $/Fish	Ex–Vessel $/Fish	Ex–Vessel $ /Fish
COMMERCIAL: 3/				
Alaska 4/	26.3	26.3	0.0	0.
Canada 4/	26.3	26.3	0.0	0.
U.S. Ocean 4/	26.3	26.3	0.0	0.
In–River 5/	17.6	63.0	11.0	8.

1/ Fall chinook impacted by SOSs. includes: upriver brights, Bonneville and Spring Creek, and Snake River.
2/ Columbia upriver spring and summer chinook.
3/ Includes Native American harvest for commercial, ceremonial, and subsistence.
4/ Used Oregon and Washington average ex–vessel value.
5/ Used weighted average for Zones 1–6 for falls. Only spring values used for spring/summer chinook.

caught fish. The values shown here simplify this variability by averaging over several catch locations, size of fish, and the five year period.

Sport Values

Table 3–3 shows the estimated annual number of angler trips experienced over the 1987 to 1991 period for the specific stocks of salmon and steelhead. These estimates were derived from the ODFW & WDF (1991) data, and IDF&W steelhead creel census.

The two most widely used methods to derive demand curves for recreation activity are the travel cost method (TCM) and the contingent valuation method (CVM). Section 3.3.7 describes these two procedures. Studies utilizing these accepted evaluation procedures were examined to determine their suitability for use in valuing salmon and steelhead sport fishing in this FEIS. All available TCM and CVM studies of salmon and/or steelhead fishing were screened by the EAG to identify those thought to be must suitable for this study. Hence, the values used here represent a transfer of findings from other studies. There are numerous conceptual and empirical issues surrounding the transfer of recreation value estimates from one site or study to another. This issue of "benefit transfer" is discussed extensively in Section 3.3.7.2, and the interested reader is directed to that section.

Several researchers have compiled and/or compared recreation studies in which either the TCM or CVM approaches were used to estimate the consumer surplus. The most thorough comparative studies are (Walsh, Johnson and McKean, 1992), (Walsh, 1986) and (Sorg and Loomis, 1984). Since Richard Walsh's work is more recent than Sorg and Loomis (1984), it includes several additional studies and is used as the major reference for compilation of values for this FEIS. Additional literature searches were done for the SOR and additional benefit studies were added to the list if the study team judged them to meet the screening criteria.

Table 3–3. Columbia River Salmon Angler Trips from 1987 to 1991

Area	Recreational Trips			
	Fall Chinook 1/	Sprg/Sum Chinook 2/	Steelhead	Sockeye
	(1000 Trips)	(1000 Trips)	(1000 Trips)	(1000 Trips)
SPORT:				
Alaska 3/	2.2	0.0	0.0	0.
Canada 3/	9.6	0.0	0.0	0.
U.S. OCEAN 3/	23.0	0.1	0.0	0.
In–River 4/	23.2	0.2	127.3	0.
TOTAL TRIPS	**58.1**	**0.2**	**127.3**	**0.**

1/ Fall chinook impacted by SOSs. includes: upriver brights, Bonneville and Spring Creek, and Snake River.
2/ Columbia upriver spring and summer chinook.
3/ Based on trips per fish for WA and OR at 0.8 trips/fish.
4/ For chinook used bouy 10 data of 1.61 trips/fish. for steelhead. Used 2.5 trips/fish for salmon.

The studies compiled in Walsh, et al. (1992) were stratified into the most recent studies and those that were conducted in the states of Washington, Idaho, Oregon, and Montana. In addition, any British Columbia, Canada studies were included. This stratification was done to meet the screening criteria of: (1) age of studies, (2) the need to meet similar population characteristics, and (3) similar market conditions. The Walsh, et al. (1992) literature search included nine anadromous fishing value studies which utilized acceptable TCM or CVM study procedures. The study team was aware of additional studies that met the screening criteria and added these to the list (see table footnote). Table 3–4 summarizes the 12 acceptable studies that were considered for the SOR analysis. The values presented in Table 3–4 are the average of the studies shown in each category with the values price indexed to the mid–1992 dollars with the consumer price index.

Because of the uncertainty associated with the valuation approach described above, the analysis utilized a range of values. The recommended "low" consumer surplus value for an angler day of anadromous fishing was $50.50, and the "high" value was $63.50.

3.3.1.5 Computation of Direct Impacts

Tables 3–5 and 3–6 present the ranges of the average annual direct economic value of the Columbia River anadromous fish stocks over the period of 1987 to 1991. "Low" and "high" ranges were developed by varying two key parameters. The "low" values shown in Table 3–5 are based on a 50 percent net–to–gross ratio to compute net income for fish caught in the commercial fishery, and a recreation day value for salmon and steelhead fishing of $50.50. The "high" values shown in Table 3–6 are based on full ex–vessel value for fish caught in the commercial fishery, and a recreation day value of $63.50. The information shown in these two tables was computed by combining catch information in Table 3–1 with value information in Tables 3–3 to 3–4 and adjusting commercial values by the net–to–gross ratios.

The information provided in Tables 3–1 to 3–5 above are based on historic averages of the actual catch, commercial price, and recreational consumer surplus. The catch and price information were compiled from the five–year period of 1987 to 1991. The size of the Columbia River salmon and steel

Table 3–4. Recreation Values for SOR Analysis—Based on National Studies from 1983 to 1992 and/or Regional Studies for OR, WA, ID, and MT (Consumer Surplus Values, Mid–1993 Dollars per Recreation Day).

Area	Average Low Value 1/	Average High Value 2/	# Of Studies	Average of All Studies 3/
Anadromous Fishing	50.50	63.50	12	62.90

1/ Values are the lowest of average values computed for the regional studies, or the studies done from 1983 to 1992.

2/ Values are the highest of average values computed for the regional studies, or the studies done from 1983 to 1992.

3/ Values are the average of all the studies which are either regional, or done from 1983 to 1992.

SOURCES: Richard G. Walsh, Donn M. Johnson, John R. McKean, "Benefit Transfer of Outdoor Recreation Demand Studies, 1968–1988," Water Resources Research, Vol. 28, No. 3, March 1992. Supplemented by Wandschneider, et al. (1993), Olsen, et al. (1990), Cameron and James (1986), and Crutchfield and Schelle (1979).

head runs in this period was influenced by the operation of the Columbia System through that period and several years before because of the two– to five–year life cycles of salmon and steelhead. This information serves as the basis for computing the impacts associated with the different SOSs in Chapter 4 of this appendix. The SLCM results estimated the harvest numbers for year 1995 which is used as the initial year of project evaluation.

3.3.1.6 Existence Value

The computation of economic values for the salmon and steelhead fisheries do not include estimates of existence values. The existence value, as discussed here, is the value to the region's non–users of anadromous fish of knowing that Columbia Basin salmon and steelhead runs exist. Several reasons precluded using an estimate of existence value in the SOR economic analysis. Within the economic profession there is considerable debate concerning the theory which supports existence values. Of those economists who accept the theory, there is no agreement on the proper way to measure existence values. For these reasons, existence values were left out of the economic valuation of Columbia river anadromous fish.

Though these existence values were not used in the SOR analysis, a study done in the Pacific Northwest that defined existence values for Columbia River salmon and steelhead is discussed here to give the reader a general feeling for the possible magnitude of benefits that are not included in this appendix.

The study entitled "A Study of Existence and Sport Values for Doubling the Size of the Columbia River Basin Salmon and Steelhead Runs," (Olsen, Richards, and Scott, 1990) presented results of a household survey of Pacific Northwest ratepayers. The study estimated what the ratepayers would be willing to pay to double the Columbia basin salmon and steelhead runs. The doubling of runs is a general goal of the Council.

Approximately 2,900 Northwest households participated in the study by answering contingent value questions. The individuals that do not participate in either the commercial or sport fishery were considered as expressing an almost "pure" form of existence value because they were considered as resource non−users. Approximately 54 percent of the resource non−users indicated a willingness−to−pay to double the size of the fish runs. The non−users responded that they would pay an additional $26.42 per year (mean value 1990$) on their power utility bills to double the fish runs. When this number is extrapolated to the appropriate number of households in the Pacific Northwest, the annual willingness−to−pay value is over $42 million.

This study was done before the listing of several stocks under the Endangered Species Act, and hence the values are probably not valid for current conditions. The SOR alternatives will not double the fish runs so the values are not directly applicable to this analysis. Furthermore, there is no supportable way to apply the results of this study to the individual SOSs.

3.3.2 Resident Fish and Wildlife

From an economic standpoint, the impacts of the different SOS on resident fish and wildlife will be reflected in the impact on recreation. The abundance of fish and wildlife resources at the impacted reservoirs and river reaches can influence the amount of recreation activity and quality of the recreation experience. For example, when the number and size of resident fish in a reservoir increases or decreases, the number of recreational fishing days will likely change along with the angler's willingness to pay for the recreation experience. The national economic development values are represented by the recreator's willingness to pay for the recreation activity, while the regional economic impacts are associated with the expenditures that recreators make and who will receive income and jobs from these expenditures.

Relative changes in resident fish and wildlife which are estimated for each of the SOSs are discussed in Appendix K (Resident Fish) and Appendix N (Wildlife), respectively. Section 3.3.7 of this appendix describes how estimated recreation use and values were derived for this draft EIS. It is important to note, however, that the recreation use estimates were based primarily on the ability to use the recreation facilities at different pool elevations or flow levels. This access−based recreation use estimate did not account for impacts on recreation use associated with changes in the abundance of fish and wildlife resources. The study team was unable to find any acceptable methodology to modify the recreation use estimates to reflect the different levels of resident fish and wildlife associated with the different SOS. Ideally, this would require an econometric model that relates recreation use and values to changes in fish and wildlife abundance. Some recreation value studies have identified possible "fish or wildlife abundance" explanatory variables, such as number of fish caught, to define the economic value of recreation. But, it was the study team's opinion that these studies were not directly applicable to the SOR projects. No quantitative adjustments are made for this draft EIS.

The impacts on recreation from changes in resident fish and wildlife are, therefore, discussed in a qualitative manner in Appendix J (Recreation). A similar approach was used to reflect possible changes in economic impacts with the different SOSs. For those SOSs with the largest impacts, either positive or negative, on the resident fish and wildlife resources, the possible economic impacts are discussed in a qualitative fashion. The ongoing Pacific Northwest recreation survey will attempt to identify the effects of fish and wildlife abundance on recreation use and values. For the final EIS the results of the recreation survey will be utilized to make adjustments in the recreation use, the willingness to pay values, and expenditures for recreation.

Table 3–5. "Low" Value Estimates of Columbia River Salmon and Steelhead Catch — Annual Averages for the 1987 to 1991 Period. 1/

	VALUE OF CATCH 1/				
	Fall Chinook 2/ Annual Value ($1000)	**Sprg/Sum Chinook 3/ Annual Value ($1000)**	**Steelhead Annual Value ($1000)**	**Sockeye Annual Value ($1000)**	**Totals of 4 Species Annual Value ($1000)**
COMMERCIAL: 4/					
Alaska 5/	640	0	0	0	640
Canada 5/	2,140	140	0	0	2,280
U.S. Ocean 5/	510	0	0	0	510
In–River	1,870	20	360	100	2,350
SPORT:					
Alaska	110	0	0	0	110
Canada	480	0	0	0	480
U.S. Ocean	1,160	0	0	0	1,160
In–River	1,170	10	6,430	0	7,610
TOTAL COMMERCIAL	5,160	160	360	100	5,780
TOTAL SPORT	2,920	10	6,430	0	9,360
TOTAL COMM + SPORT	8,080	170	6,430	100	15,140

1/ Recreation day value = $50.50 Commercial net–to–gross = 50 percent
2/ Fall chinook impacted by SOSs. Includes: upriver brights, Bonneville and Spring Creek, and Snake River.
3/ Columbia upriver spring and summer chinook.
4/ Includes Native American harvest for commercial, ceremonial, & subsistence.
5/ Used Oregon & Washington average ex–vessel value.

Table 3-6. Columbia River Salmon Catch and "High" Value Estimates — Annual Averages for the 1987 to 1991 Period. 1/

	Fall Chinook 2/ Annual Value ($1000)	Sprg/Sum Chinook 3/ Annual Value ($1000)	Steelhead Annual Value ($1000)	Sockeye Annual Value ($1000)	Totals of 4 Species Annual Value ($1000)
COMMERCIAL: 4/					
ALASKA 5/	1,280	0	0	0	1,280
CANADA 5/	4,280	290	0	0	4,570
U.S. OCEAN 5/	1,030	10	0	0	1,040
IN-RIVER	3,750	40	710	200	4,700
SPORT:					
ALASKA	140	0	0	0	140
CANADA	610	0	0	0	610
U.S. OCEAN	1,460	10	0	0	1,470
IN-RIVER	1,470	10	8,080	0	7,940
TOTAL COMMERCIAL	10,340	340	710	200	11,590
TOTAL SPORT	3,680	20	8,080	0	10,160
TOTAL COMM + SPORT	14,020	360	8,790	200	21,750

1/ Recreation day value = $63.50. Commercial net-to-gross = 100 percent
2/ Fall chinook impacted by SOSs. Includes: upriver brights, Bonneville and Spring Creek, and Snake River.
3/ Columbia upriver spring and summer chinook.
4/ Includes Native American harvest for commercial, ceremonial, & subsistence.
5/ Used Oregon & Washington average ex-vessel value.

3.3.3 Flood Control

Flood control is an important use of the regulated Columbia River system. Several locations within the Columbia River basin in Idaho, Montana, Washington, and Oregon are particularly vulnerable to flooding. These damage centers are the focus of the SOR flood control analysis. Some proposed operating strategies could increase the flood risk to these communities. Physical aspects of the flood control system and analysis of the stage/frequency relationship can be found in the Appendix E (Flood Control). Detailed economic analysis of flood control for each Damage Center can be found in Technical Exhibit B of this appendix. The basic concepts used to evaluate the flood control effects of the SOSs are discussed below.

Stage-Damage Estimates

As flood waters exceed the river banks and flow onto nearby developed properties, damages occur. Generally, the deeper and longer water stands on structures, the greater the damage. Likewise, greater damage is caused by larger floods which inundate more structures This stage–damage relationship is used to predict the amount of damage that could occur at various depths of flooding at each damage center.

Discharge–Stage Relationship

Discharge is the measure of water moving across a given point. Generally discharge is expressed in cubic feet per second. For any given geographic area to be flooded to a certain depth requires a sufficient quantity of water. This relationship between discharge and stage is called the rating curve. The rating curve is integrated with the stage–damage curve to yield the discharge–damage curve.

Discharge–Frequency Relationship

The discharge–frequency relationship describes the probability of exceeding a given discharge in any year. The discharge frequency curve is integrated with the discharge–damage curve to yield the frequency–damage curve.

Expected Annual Damages

Expected annual damages are equal to the area under the frequency–damage curve. This area is normally estimated by mathematical approximation. Computer programs, such as the Corps's Hydrologic Engineering Center program, Expected Annual Damage (EAD), are frequently used to estimate expected annual flood damages. Flood control/economic impacts are presented in detail for each Damage Center in Exhibit B, and in summary detail in Chapter 4.

Flood damages were collected and analyzed for the following categories of damages. All damage reaches will not contain all categories.

Residential – Residential damages include inundation losses to residential structures and contents, appurtenant buildings, and grounds. Damage to structures and contents was estimated by combining water depths and depth damage functions for various structure types. Average content value was estimated to be 40 percent of the structure value. Flood losses include damage to floors, walls, heating equipment, furniture, appliances, personal property, and damages to grounds such as yards and fences.

Commercial – Commercial damages include inundation losses to all properties used in commerce, business, wholesale and retail trade, services, and entertainment. Physical flood damages to commercial property and facilities included damages to land, buildings, equipment, supplies, inventory, and other items used to conduct business.

Industrial – Industrial damages represent inundation losses to properties and facilities used in manufacturing and food processing and include physical damage to buildings, raw materials, equipment, finished products, and overhead expenses.

Agricultural – Agricultural damages include loss and destruction of growing crops, land, barns, and other appurtenant buildings and their contents. Losses to equipment, stored crops and feed, livestock, fences, and other farm facilities are also included in this category. Siltation, loss of soil fertility, and cost of removal of debris and weed seed are also analyzed.

Public – Public damages include inundation losses to schools, parks, and other facilities, including equipment and furnishings owned or operated by Federal, State, county, or local government units. Utility damages include losses to electric, water, telephone plants, transmission lines, and similar facilities. This category also includes inundation and destruction losses to roads, streets, pavement, sidewalks, bridges, and other highway structures, supplies, and equipment.

Emergency Aid – Emergency aid includes expenditures essential to the preservation of life and property, such as clearance of debris and wreckage, emergency repair or temporary replacement of private and public facilities, evacuation assistance, Federal aid for flood fighting, flood emergency preparation, rescue operations, police protection, and repair and restoration of damaged flood control works. Also included is Federal assistance to State and local governments to accomplish channel clearing, debris removal, and other emergency channel work on unimproved streams.

Other – Other damages include losses to railroad property, vehicles and mobile equipment. Railroad losses include damage to tracks, roadbed rights–of–way, supplies and equipment directly attributable to flooding. Vehicle damage include buses, trucks, automobiles, and mobile equipment.

3.3.4 Irrigation and Municipal and Industrial Water Supply

3.3.4.1 Overview

The analysis of economic impacts of SOR alternative operating strategies on entities who pump from reservoir pools on the Columbia and Lower Snake rivers is divided into two components: (1) the irrigation pumping associated with commercial agriculture termed "commercial irrigation," and (2) M&I users, which includes pumpers who utilize reservoir water for municipal and industrial purposes (M&I), Corps of Engineers pumping for recreation areas and wildlife habitat, irrigation of state parks, irrigation of golf courses, and other consumptive uses. Additional information on the analysis of economic impacts to irrigation and M&I water pumpers is contained in Appendix F (Irrigation and M&I Water Supply).

Because the alternative SOSs have different implementation dates, it was necessary to discount the pumping costs associated with each alternative plan to year zero of the analysis (1995). This procedure, consistent with standard time value of money evaluation concepts, is necessary to insure that the comparison among SOR alternatives is on an equal basis. Interest rates of 7.75 percent and 3.0 percent were used to compute the present value of future capital expenditures as well as average annual equivalent values over a 100–year period of analysis. To reflect the present value of capital expenditures, costs were discounted from future implementation dates to 1995, the base year used for the SOR. To estimate the annual costs of pump modifications, capital costs were amortized over the estimated life of the modification (20 years).

3.3.4.2 Irrigation

Analysis of the alternative SOSs indicates that up to six reservoirs would experience lowered reservoir pools under at least one of the SOSs which include drawdown of lower Snake River projects and John Day. These reservoirs by name of dam are: (1) Grand Coulee (Columbia River), (2) Lower Granite (Snake River), (3) Little Goose (Snake River), (4) Lower Monumental (Snake River), (5) Ice Harbor (Snake River), and (6) John Day (Columbia River). Grand Coulee would experience drawdown to supply additional water to the lower Columbia River during the juvenile fish migration. The four Snake River projects and John Day would be drawn down in SOSs 5, 6, and 9c to increase water velocity through the pools, also during the juvenile migration. However, of the Snake River projects only Lower Granite would be drawn down for SOS 6d. In addition, the John Day pool alone is draw down to MOP in the Preferred Alternative.

Irrigation water is pumped from Grand Coulee, Ice Harbor, and John Day reservoirs. Irrigation pumpers at these reservoirs will be impacted by those SOR operating strategies which propose a drawdown of the pool during the pumping season. It is currently estimated that pumpers on the John Day and Ice Harbor pools irrigate about 175,000 acres. In addition, for those alternative system operating strategies that lower the level of Franklin D. Roosevelt Lake (FDR) at Grand Coulee Dam, the increased pumping costs to irrigators who receive water from the Federal Columbia Basin Project were identified. Over 655,000 acres are irrigated from this project.

The pumping plants on John Day and Ice Harbor reservoirs are operated and maintained by individual owners. Under reservoir drawdown these pumping plants would have to be modified in order to continue operation. The Grand Coulee pumping plant is owned, operated, and maintained by Reclamation. The assumption of the Irrigation/M&I Work Group was that irrigated land would not go out of production because of alternative operating strategies.

Pump modification costs were estimated by the Corps of Engineers and private engineering consultants. Modification of John Day and Ice Harbor facilities are necessary, in general, to lower the intake structure, extend the intake lines further into the reservoir pool, to dredge a channel to the intake line, or some combination of all three remedies.

In addition to pump modification, additional operating and power costs are incurred due to the increased lift with drawdown. The pump modification costs along with the increased operating and pumping costs were included in the analysis. The increased costs are essentially mitigation costs associated with those particular SOSs.

Because pump modification costs are not necessary at FDR Lake, only the cost of the increased electrical consumption under drawdown conditions was used to measure impacts at Grand Coulee.

The major input components to the pumping cost analysis include the following items, with the identified data source.

- Reservoir pumpers on John Day and Ice Harbor pools−−the only irrigation pumpers identified as being affected by the drawdown alternatives (Corps).

- Quantity of water pumped for each reservoir pool (Corps).

- The cost of existing pumping stations, including O,M,R&P. Normalized to current prices −−October 1992 price level−− (Corps and Reclamation data).

- Current electrical rates for irrigation & M&I pumping.

- The cost of modifying the pumping stations to insure their continued operation under alternative proposals with drawdown, including the increased annual pumping cost and ownership cost (Corps and Reclamation).

- Estimation of increased pumping costs to irrigators receiving water from FDR Reservoir −−Federal Columbia Basin Project (Reclamation).

The pumping cost analysis is a static−equilibrium analysis of the current farm practices of reservoir pumpers. That is, current representative yields, crop distribution, prices received and paid, and the general agronomic conditions in the area were held constant. Electrical power rates used in the analysis of each SOS are the rates currently in affect (1993). The power rates used in the analysis are shown in Table 3−7. Although cost estimates for pump modifications were estimated for each pump station, the analysis is not intended to be a micro−feasibility analysis of modifying the pumping plants for each reservoir pumper.

3.3.4.3 Municipal and Industrial Water Supply

In addition to commercial irrigation, other reservoir water users have been identified who would be impacted by drawdown of the six reservoirs. These users include M&I water users, fish hatcheries, water for parks, and irrigation of wildlife habitat. Impacts to all of these water users were evaluated under the category of M&I water supply. Although M&I water users would be impacted at all six projects, impacts were evaluated for only John Day, Ice Harbor, Lower Monumental, Little Goose and Lower Granite. Impacts at Grand Coulee were not evaluated because they were judged to be relatively insignificant.

As with irrigation water users, potential impacts on M&I pumpers was measured by determining the pumping plant modification costs and the increased pumping cost for those installations to obtain a total annual cost. This analysis is based on the same general assumptions as were used for the analysis of impacts to irrigation pumpers.

Table 3-7. Electrical Power Rates used in the Analysis of Pumping Costs Power Rate (mills/kwh)

Project/State	Irrigation	M&I Water
Grand Coulee Washington	0.95	na
Lower Granite Washington	29.0	29.0
Little Goose Washington	29.0	29.0
Lower Monumental Washington	29.0	29.0
Ice Harbor Washington	29.0	29.0
John Day Oregon Washington	 33.5 25.0	 35.0 25.0
na = not applicable		

3.3.5 Navigation

3.3.5.1 Introduction

The measure of direct economic impacts to navigation was defined as the change in total system-related transportation costs resulting from each alternative compared to existing system transportation costs. The analysis of indirect economic impacts, meanwhile, measures secondary impacts, or ripple effects, that will occur within the regional economy as a result of changes or disruption within the existing transportation network.

Realization of this overall objective requires determining the physical impacts of each system operating plan on commercial navigation use of the waterway, assessing alternative shipping modes and costs; and determining the least-cost combination or combinations of storage, handling, and transport modes given different operating scenarios. Identifying the least-costly alternative mode involves an analysis of existing commodity storage facilities, regional rail and truck capacity, handling rates, and numerous other related factors.

3.3.5.2 Analysis of Impacts

Deep Draft Navigation

An analysis was performed to determine the extent to which deep draft commercial navigation would be impacted during the refill of Snake River reservoirs and pools that would be drawn down annually under certain scenarios. This was done to determine whether ocean going vessels which presently utilize the 40-foot navigation channel between Vancouver, Washington and the Columbia River entrance would incur significant delays or other problems due to reduced flows in the river during refilling operations.

A comparison of the stage available at key points in the lower Columbia River with varying discharges from Bonneville Dam was combined with the probability of occurrence of those discharges for plans requiring drawdown of the lower Snake River dams during March and/or April and refill during the months of August, September, and October. The greatest potential for navigation impacts from refill operations would be present during this period. The analysis identified the actual stage at several locations on the lower Columbia River for a range of discharges from Bonneville during those months. These locations include Wauna at river mile 41.6 (66.9 km), Kalama at river mile 75.0 (120.7 km), and Vancouver at river mile 106.5 (171.4 km). The port locations of Kalama and Portland/Vancouver are reported to be the most depth sensitive locations on the river, while Wauna is recognized as a critical passage location for loaded outbound vessels.

A family of tidal curves was developed for the Lower Columbia River coincidental with a range of discharges from Bonneville Dam. Using hydraulic modeling software, (DWOPR) data for the months of August, September, and October were sorted for each year of a 50–year period of record to determine the distribution of daily flows on an annual basis. Inflows from the Willamette River and other significant Columbia River tributaries were included based upon mean flows during August, September, and October, as was 1985 hourly tidal data recorded at Tongue Point for those same months. Outflows from Bonneville were varied in increments of 2500 cfs (70.8 m3/s) between 70,000 cfs and 80,000 cfs, (2,264.8 m3/s) and by 5,000 cfs (141.6 m3/s) between 80,000 cfs and 100,000 cfs (2,831 m3/s). The probability of occurrence was then determined for significant flows; 70,000 cfs (1,981.7 m3/s) occurrences, the maximum flow, and a value that represents the mid–range between those two flows). The relationship between flow occurrence and the availability of stage on the lower Columbia River during the three month period was thus established at the three key locations.

Stage availability is defined as feet relative to Columbia River Datum (CRD), in one–foot (.3 m) increments through the range of data. From this, stage loss that would result from the drawdown strategies was determined for each SOS, as was the total time in hours for each foot of stage loss at each location. The results of this analysis are presented in Chapter 4.

Dworshak Log Transport

Analysis of potential impacts related to the use of Dworshak Reservoir for transporting raw logs identifies the additional costs of log shipment to Lewiston, Idaho when pool elevations are reduced to levels that restrict access to log dumps. System operating strategies that cause significant changes in pool elevations during the conservation season will affect access to dump sites located on the reservoir, such that log rafting operations would be restricted or curtailed whenever the pool elevation drops below the level of a dump site. Where dump sites become inaccessible, logs must then be transported by truck to other available sites on the reservoir or to their final destination at Lewiston.

The analysis of potential impacts in this appendix used 50 years of simulated data. A model which measures the added cost of transporting logs to Lewiston by truck was utilized to assess the monetary impacts of restricted log rafting activity. Basic elements of the model include the monthly volume of shipments, road miles and trucking costs, log quantities per site, and consideration of the minimum pool elevation required to use each site. Impacts are expressed as the alternative cost of truck transport of logs that would normally be rafted via the reservoir.

Based upon historical data, annual log quantities were divided between three main dump sites on Dworshak pool as follows:

Dump Site	Percent of Total	Minimum Operating Elevation (Feet)
Little North Fork	56%	1,575
Benton Creek	34%	1,570
Milk Creek	10%	1,585

Until the pool elevation drops below 1570 feet (478.5 m), logs would be transported by truck to the nearest usable site on the pool. When the pool elevation drops below 1570 feet, all logs would be moved by truck to Lewiston. Detailed information on the model is contained in Appendix H (Navigation). The results of the analysis are presented in Chapter 4 of this appendix.

Shallow Draft Navigation

A transportation model (SOR Transportation Model) was prepared by contract to analyze the direct economic impacts of various operating strategies. It was designed to measure the costs of commodity shipments under existing and alternative operating conditions and allow NED impacts to be quantified. The model simulates transportation responses to different river conditions associated with salmon mitigation measures (water flow) on the Columbia/ Snake waterway. It computes transportation, handling, and storage costs and capacity utilization of nodes and links for the status quo, (base case) and for changes in project operations that affect the utilization of barge transportation. It thus captures the changes in costs (transportation, storage and handling) that users of the Columbia/Snake River system would incur as a result of navigation impairment. The model consists of separate modules for analysis of grain and non–grain commodities. A description of methodology and data employed is set forth in the report "System Operation Review Transportation Model, Final Report", prepared by Transportation Research and Analysis Center, Inc., 1993. The report is available from the US Army Corps of Engineers, Portland District, upon request.

The model traces commodity movements on a monthly basis from origin to destination, including the seasonal movement of grain from farm to elevator to river port. Changes can be made with respect to input data and assumptions about the monthly flow of grain from origin to destination, handling and storage costs, and alternative transport modes. This capability allows users to model effects of seasonal shifts of shipments between upper river and lower river origins and destinations.

The level of commerce on the waterway is represented by the volume of waterborne shipments via the river system for 1992–93. Data have been compiled for the system of locks, using Waterborne Commerce Statistics and the Lock Performance Monitoring System (LPMS) of the Corps of Engineers. These data were then compared to the volume of products arriving by water at deep–water terminals and were correlated with seasonal volumes shipped from upstream river elevators.

For purposes of modeling, major commodities presently shipped on the Columbia–Snake River were grouped as follows: grain, petroleum products, wood chips and logs, wood products, and all other (primarily export products shipped via containers such as peas, beans and lentils, lumber, and wood pulp, and also fertilizer). Although a variety of commodities benefit from the inland navigation system, wheat and other grain are the products predominantly shipped using this mode of transportation. Wheat and other grains grown throughout the Columbia River Basin , Montana and North Dakota that are destined for export markets typically move from farms to country elevators, to river elevators, and then to export elevators downstream where oceangoing vessels can use deep water. Grain shipped to export elevators via rail is normally delivered by truck to the country elevators where it is loaded on rail cars.

Waterborne movements from upstream to deep–draft destination ports are thus traced from their points of origin. In the case of grain, volume moving from farm through country elevators to river elevators, passing through Columbia/Snake River shallow–draft waterway, and arriving at export ports were identified. Costs of transport for these shipments are aggregated and include handling and storage costs incurred at interim destinations. This procedure has also been used for other commodities shipped by water, upstream as well as downstream.

Regionally, grain makes up the overwhelming majority of tonnage moved by water. This is reflected in the model, which contains 900 flow links (movement from one point to the next) for grain and 120 flow links for other commodities. For grain, transportation costs are an aggregation of costs associated with movement from farm to country elevator, to river elevator, to deep–draft export elevator. Origins include growing areas within Oregon, Washington, Idaho, Montana and portions of North Dakota. A survey was made of those country elevators which serve as interim destinations for down bound grain. River elevators along the Columbia and Snake

Rivers were likewise identified. The number of elevators surveyed for this purpose is shown below by state.

State	No. of County Elevators	No. of River Ports
Washington	313	14
Oregon	46	6
Idaho	111	1
Montana	N.A.	N.A.
North Dakota	N.A.	N.A.

(N.A. = Not Available)

For other commodities moved downstream by water, origins are considered river ports (loading points) and destinations are locations of off–loading. For upstream movements, costs reflect transport by water from point of entry to the waterway to the location where commodities are off–loaded.

Major criteria which govern the modeling process are as follows: The model is demand driven, such that the existing level of monthly exports from the region will be maintained. Where a particular SOS places constraints upon the navigation system, the monthly volume of shipments and the total amount exported from lower Columbia River and Puget Sound elevators would continue to be maintained from within the region.

For grain flows, the model contains seasonal parameters to reflect seasonal variations in flows. These seasonal indices were derived from historical data (1986–1991) using Waterborne Commerce Statistics data. For all non–grain commodities, the monthly (seasonal) indices are assumed to be 1 (equal monthly shipments throughout any given month of the year). Therefore, for each non–grain commodity, the monthly transportation costs were determined and calculated for the applicable duration of each respective SOS that involved drawdown. For the remaining portion of the year when the locks would be accessible, the monthly costs associated with normal shipping conditions would remain unchanged. Drawdown of the Snake River pools prevents use of the locks for varying periods of time and precludes light–loading of barges as a mitigation measure. Also, since historical export volume is assumed to be maintained, temporary storage would be viable only on a limited basis.

The analysis defines the transportation system in terms of long–run equilibrium. Potential changes in the operation of the system are assumed to be long–term. On this basis, replacing the tug and barge fleet with shallower draft equipment would be possible, but of no practical value since the locks would be closed during drawdown because the water level in the pools would be below the elevation of the lock sills. Also, the supply of railroad cars could be increased should commodities switch from the waterway to rail transport. Although a number of types of wheat are blended for export, the specific makeup of export grain commodity is not a consideration in the analysis. However, because of the necessity to mix or blend the various types of wheat for the export market, the analysis assumes that grain supplies are not subject to temporal shifts among regions.

All model outputs are adjusted to reflect the date of implementation of each particular SOS. All values are expressed in 1992 dollars and reflect 1995 conditions. System transportation costs associated with each SOS are expressed as average annual amounts at both 3 percent and 7.75 percent over a 100–year period of analysis.

3.3.6 Power

This section discusses the approach and methodology used to measure and compare the economic impacts to power resulting from the alternative system operating strategies (SOS). The analysis of hydropower system generation and total regional system power costs for each SOS are described in Appendix I (Power). The rest of the analysis of power system impacts, including a summary of gross system generation and capacity costs, net system costs, and rates is described in this appendix. Consumer surplus effects of changes in system power costs with representative SOSs was discussed and estimated for the DEIS. However, it was not possible to assess these effects for the FEIS, because of time and resource constraints.

3.3.6.1 Overview of Analysis

The gross system cost method described in Appendix I (Power) is the traditional method used to evaluate the economic feasibility of the addition of alternative generation and conservation resources to the system to meet increasing demand for electricity. This method, however, does not account for demand responses to changes in price when low–cost existing generating resources are replaced by new resources with much higher costs. The net system cost method used in this appendix reflects the concept of price elasticity, whereby rate changes can result in changes in the demand for electricity. These changes in demand lead to a revised (lower) estimate of the amount of additional resources to meet projected loads, resulting in net system costs. The net system costs reflect the costs for additional resources *after* accounting for the reduction in the demand for electricity due to rate increases.

For each SOS, the cost of meeting regional demand assuming *no* changes in demand due to elasticities was estimated in Appendix I and will be referred to in this appendix as "gross system generation and capacity costs" or simply "gross system costs." The rate impacts from the SOSs, the subsequent elasticity effects, and the resulting net system costs are estimated and described in this appendix.

3.3.6.2 Implementation Costs

Changes in the operation of the Columbia–Snake hydropower system as specified by the alternative SOSs result in changes in system power generation and, for some SOSs, costs incurred to implement the strategy. Specifically, implementation costs would be required for those SOSs which include physical modification of projects to permit drawdown of reservoirs below current minimum operating pool elevations. SOSs which will require modifications to the existing projects are: SOSs 5b and 5c; SOSs 6b and 6d; SOSs 9a and 9c; and the Preferred Alternative (PA).

Implementation costs were developed by the Corps of Engineers for its Columbia River Salmon Mitigation Analysis System Configuration Study, Phase I. Except for costs for SOS 5c, cost data presented in this appendix are from Appendices A and B of the report, Columbia River Salmon Mitigation Analysis, System Configuration Study, Phase I, US Army Corps of Engineers, April 1994. Costs for SOS 5c were prepared by the Walla Walla District of the Corps during continuing studies of projects modifications and operations addressed in Phase I of the System Configuration Study. Costs are reconnaissance–level and would be expected to change as more detailed site–specific data are obtained during feasibility studies. Implementation costs are allocated to project purposes (e.g., power, navigation, flood control, etc.) in accordance with their share of total benefits. Since the dominate project beneficiary of each of the affected projects (Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and John Day) is power, most of the implementation costs are allocated to power. These costs are included with system generation costs to obtain estimates of total system costs and power rates. The allocation of implementation costs is discussed in Chapter 4 (Section 4.8.3) of this appendix.

3.3.6.3 Gross System Generation and Capacity Costs

Much of the analysis of potential impacts on the Pacific Northwest region's electrical power system was done by the Power Work Group. The methodology employed and the results of their analyses are presented in Appendix I of this FEIS. The analysis presented in Appendix I had three major purposes: first, to determine the effects of each of the SOSs on power generation from the Northwest regional power system; second, given these effects, to determine what, if any, actions would be required to meet forecast regional energy demand; and finally, to estimate the cost for serving the forecast regional energy demand. The analysis was based on costs associated with an assumption that losses in hydropower system generation for each SOS would be replaced, in total, without regard to the effect that higher cost replacement power would have on the demand for power.

The analysis was based on the regional electrical energy demand forecast for the 1995–96 and

2003–04 operating years. The analysis estimated both the capacity and energy (system generation) costs of operating the Pacific Northwest power system to meet this regional demand under hydropower system conditions described by each SOS. Changes in gross system costs for each SOS were calculated as compared to SOS 2c, the no–action alternative. These changes are shown in Table 5–5 of Appendix I (Power).

3.3.6.4 Rate Impact Analysis Methodology

Gross system generation and capacity costs are the starting point for the rate impact analysis. These costs are calculated in Appendix I, Power, where they are referred to as total regional costs. For each SOS, these are the costs of replacing losses in hydropower generation, assuming demand stays constant. Accounting for differences in implementation timing of each SOS gives equivalent annual power system impacts. The effects of demand reductions due to increases in rates and implementation costs were not considered in Appendix I (Power) but will be addressed in this appendix.

3.3.6.4.1 Changes in the Pacific Northwest Electric Utility Industry since DEIS

The rate impact analysis in this FEIS is substantially different from the methodology used for the DEIS. This is primarily due to recent changes in the Pacific Northwest utility industry. Several events have contributed to a significantly different wholesale electric market than was present even just a few years ago.

Competition has increased considerably in the electricity industry in general and in the Pacific Northwest in particular. This increase in competition is due to a number of factors, including: deregulation as outlined in the Energy Policy Act of 1992 (EPAct); prolonged low natural gas prices combined with an increase in supply; increases in combustion turbine efficiency combined with reductions in their capital costs; and additional competition in the market from power marketers and brokers.

Two provisions of the EPAct will have profound effects on BPA. One allows for the formation of "exempt wholesale generators," also referred to as independent power producers (IPPs), that are exempt from certain restrictions in the Public Utility Regulatory Policies Act of 1978 (PURPA). IPPs are now able to build generating plants and sell the power to any wholesale customer rather than only to utilities, as was the case under PURPA. The other provision of the EPAct allows greater access to transmission grids by competing wholesale electricity sellers, including these IPPs. This access is known as "wholesale wheeling." Both of these changes provide utilities with more alternatives for purchasing wholesale power at competitive prices.

In addition, the Federal Energy Regulatory Commission has recently proposed rules that will order utilities to unbundle their transmission and generation and open their grids for comparable service to all users.

The EPAct provisions and the proposed FERC rules are based on FERC's previous experience with deregulating the natural gas industry. Removal of regulation initially increased the price of natural gas and provided an economic incentive for increasing gas supply. In response to this price signal the supply of gas increased significantly. This over capacity of gas in turn led to a dramatic reduction in natural gas prices. Thus the acquisition of new gas resources is now a function of the competitive gas market with the market price acting as a signal to determine the need for new gas supply. A gas futures market developed which allows gas users to hedge against uncertain future gas prices. The wholesale electricity market is now evolving in a similar fashion.

During the 1990's, the wholesale market for electricity has broadened to become much more of a West Coast rather than a Pacific Northwest regional market. Completion of the third AC intertie increased the capability of the interconnected system. The supply of natural gas in California increased significantly as a result of major expansions of pipeline capacity encouraged by deregulation from Canadian, Rocky Mountain, and Gulf Coast production areas. At the same time, the demand for electricity in California declined. Prices of natural gas reached remarkably low levels during 1994 and 1995, with the November 1994 spot price of natural gas down by 65 percent compared to the price in October 1993. BPA estimates that natural gas prices to electric utilities in California will decline in 1995. In addition, the efficiency of combustion turbines has increased (in part as a result of deregulation in the airline industry that required more efficient turbine engines), such that the fully allocated cost of output from a new CT can be as low as 24 mills per kilowatt–hour in the first year of operation, depending on fuel arrangements. Even more efficient combined cycle combustion turbines will be available in the next few years. In addition, at current gas prices the variable cost for some older less efficient gas fired plants whose fixed costs have been fully amortized can be lower than 20 mills per kilowatt–hour.

Marketers and brokers are new participants in the electricity market, making the market picture more competitive. These companies are willing to take risks in order to gain market share. In addition, some have access to capital and to financial instruments that allow them to buy and sell power on the open market as if it were a commodity. Neither marketers nor brokers own the generation equipment that produces the electricity, so they have very low fixed costs. Brokers merely match up buyers and sellers, for a fee, and never own the electricity themselves. With the advent of wholesale wheeling, these types of businesses have increased dramatically.

Hence competition has increased significantly in the electricity industry in the Pacific Northwest.

3.3.6.4.2 Consequences for BPA

The above factors have a number of consequences for BPA. BPA is facing increasing competition which threatens its once–stable customer base. Long–term customer load placement on BPA is no longer assured. New market participants can now easily generate or purchase low–cost electricity and get it to a variety of markets. Other suppliers can effectively compete for the business that BPA has always expected to serve.

BPA is now a price–taker in a competitive wholesale market. BPA rates are no longer necessarily lower than alternative sources of power. If BPA's costs result in rates higher than the market, BPA will need to reduce costs or find other sources of revenues. BPA cannot raise rates and expect to keep all of its current customers.

In addition, BPA is changing some of its contract provisions to allow previously captive wholesale customers to buy power elsewhere.

3.3.6.4.3 Rate Impact Analysis Methodology in DEIS

The rate impact analysis in the DEIS assumed that all increases in costs due to changes in hydropower operations in each SOS would be paid by BPA and lead to increases in BPA rates. It also assumed that these rate increases would cause end–use consumers (the consumers who purchase electricity from BPA customers) to use less electricity due to the economic price elasticity of demand, leading to the need to acquire fewer replacement resources.

The reality is that BPA has determined it cannot raise its rates past the competitive market rate, or it will lose load to competition. Hence it cannot necessarily expect to raise rates to cover the cost of changes in operation of the hydropower system.

For example, current cost increases due to implementation of the National Marine Fisheries Service's 1995 Biological Opinion are being absorbed by BPA in at least three ways: 1) significant agency–wide cost cutting; 2) credits from the federal government under the Regional Power Act section 4(h)(10)(C) for the river system's non–power users' share of these cost increases; and, 3) reduced probability of repaying the US Treasury the yearly payment required for amortization of the cost of the dams and BPA's transmission system.

It is currently assumed that if the above cost increases were included in BPA rates, BPA would lose customers to other regional utilities, IPP's, brokers, etc. End–use demand for electricity would likely not change.

3.3.6.4.4 Implication for Rate Impact Analysis Methodology in FEIS

Consequently, the rate impact analysis methodology presented in the DEIS is irrelevant given the situation in which BPA currently finds itself. However, analysts felt that it was important to include some type of rate impact analysis to give the reader a basis for comparison across SOSs in terms that were understandable.

Therefore, a number of simplifying assumptions were made in order to do the rate impact analysis for this FEIS. First of all it was assumed that all equivalent annual power system impacts plus equivalent annual implementation costs (referred to as total equivalent annual gross costs in this appendix) would be initially recovered through rates by spreading the increased costs among all Pacific Northwest regional rate payers in proportion to the revenues they generate. The total equivalent annual gross cost increases were divided among utility ratepayers and DSI ratepayers in proportion to their calendar year 1994 revenues. It was assumed that end–use consumers would react to these rate increases by reducing demand, causing a reduction in costs due to the need for fewer replacement resources. This would result in an estimate of equivalent annual net replacement costs and an eventual final rate impact. This impact would be an average change in regional retail rates, assuming all net replacement costs were covered by changes in regional retail rates.

This will give an adequate representation of how regional retail rates might change if all the power impact costs were recovered through rates. It will give the reader a useful method for comparing SOSs using rate impacts. However, due to all the conditions mentioned above, it is unlikely that rates will increase due to these changes. So the reader must understand the limited value and use of this analysis.

3.3.7 Recreation

An important aspect of the SOR analysis is the evaluation of the outdoor recreation associated with the operation of the Columbia River system. The economic values associated with recreation can be separated into direct and indirect economic values. The direct values represent the recreator's willingness to pay for the recreation activity which includes two components: (1) the costs to participate (e.g., the entrance fee); and, (2) the dollar amount the recreator is willing to pay above the out of pocket costs (entitled the consumer surplus). The indirect impacts are the effects on local economies, in terms of income and jobs, associated with the expenditures that recreators make to participate in recreation activities, including expenditures for lodging, food, auto, boat, fishing and hunting supplies, etc.. This section presents the methodologies used to estimate the direct economic impacts for each System Operation Strategy (SOS) in terms of expected recreation activities and the economic value of those activities. Procedures for estimating indirect economic impacts are explained in Sections 3.5 and 3.6 of this appendix.

3.3.7.1 Individual Willingness–To–Pay for Recreation

A measure of the direct economic value of goods and services, including recreation activity, is the willingness–to–pay (WTP) of the users. For goods that are sold in a market the WTP is the amount actually paid to obtain the good plus an additional amount an individual would have been willing to pay for the chosen quantity of the good. This latter monetary amount is generally referred to as the consumer surplus and represents the value of the quantity of the good purchased by the consumer, over and above the amount actually paid. Increases in consumer surplus are considered as welfare gains to the consumer because this extra value is obtained without charge. Total consumer welfare to society is measured by summing the consumer surplus across all participants. In the case of valuing recreation, the amount charged for the activity is generally very small or non–existent. This presents a problem to the economist in trying to estimate the demand curve for recreation activities and the related consumer surplus. Since there is no well established market for which recreation goods are exchanged, the economist must utilize non–market approaches to develop demand curves for the estimation of consumer surplus.

The two most widely used methods to derive demand curves for recreation activity are the travel cost method (TCM) and the contingent valuation method (CVM). The TCM uses indirect means to determine the demand curve. The TCM relies on variations in travel cost (of recreators) and their visitation rates to trace out the demand curve. The basic premise of the approach is that the number of trips to a recreation site will decrease as the direct out–of–pocket and time costs of travel increase, other things remaining equal (Walsh, 1986). Examples of out–of–pockets costs are vehicle operation costs, opportunity costs of time, and lodging costs which all vary with the distance traveled. By observing participation rates from different locations (distances) from a recreation site, the associated travel costs are used to impute the amount individuals are willing to pay for the use of the site. A demand curve for a site is derived from this information to show the number of trips at various travel costs (out–of–pocket costs.) The area under the estimated demand curve, but above actual costs, is the measure of the net WTP and is defined as the consumer surplus.

The CVM is a direct approach to determine the demand for and value of recreation. The object of the CVM approach is to use surveys to determine the individual's net WTP to recreate. In this approach, a sample of the affected population is asked to report their maximum willingness–to–pay, contingent on hypothetical changes in recreation opportunities or resources (Walsh, 1986). CVM can be implemented using several different questioning approaches. The bidding game approach uses an iterative questioning technique which involves repeatedly asking the person if he/she would pay successively higher and higher amounts of money. Once the person reaches the maximum amount he/she would pay, this final value is recorded (Donnelly, Loomis, Sorg, and Nelson, 1985). Another approach is open–ended questions where the respondent is asked to state the amount he/she would pay for the described good. The close–ended approach uses questions that require the respondent to answer a single willingness–to–pay question with a "yes" or "no". For example, "Would you pay $20 for the described recreation experience?" Each of these approaches have their advantages and disadvantages which influences a study's sample size, sample design (in–person, phone, or mail–out questionnaires), and data manipulation requirements.

A variation on the CVM is the contingent behavior approach. This approach is similar to CVM because the individual is asked to report changes in behavior based on hypothetical changes in recreation opportunities or resources. The individual is asked to report behavioral changes, such as changes in recreation trips or activities, rather than the willingness–to–pay values asked for in CVM. The contingent behavior approach can complement other approaches such as TCM to reduce uncertainty in projections of recreator's reactions to changes in recreation opportunities or resources.

3.3.7.2 Recreation Use and Value Estimation Procedures

The DEIS used a facilities–based recreation model to estimate recreation demand with the different SOSs, in terms of recreation days. This recreation impact assessment model related pool elevations and stream flows to the level of recreation activity. To assign values to the recreation day estimates, the DEIS relied on a literature search of economic evaluation studies. The averages of numerous recreation values developed in other studies were applied to the recreation day estimates, by activity, to determine the economic impacts of each SOS. Several issues were raised in the economic analysis of recreation impacts in the DEIS. The RWG and EAG recognized that the recreation use and value models used for the DEIS had numerous limitations, foremost of which were (1) heavy reliance on professional judgment of expected reaction of recreators to pool level fluctuations and varied flows, (2) application of economic values derived in other studies to the conditions being examined in the SOR, and (3) inadequate accounting for substitution of lost recreation opportunity at one site to another recreation site.

The procedures used in this FEIS to estimate recreational use and values are based on the results of a Pacific Northwest–wide survey of recreators to develop models that define trips to Federal reservoirs and the associated consumer surplus. A detailed description of the recreation survey approach and the development of regional recreation models is included in Technical Appendix J1 to Appendix J (Recreation), entitled, "Columbia River System Operation Review Recreation Impacts: Demand Model and Simulation Results" (RCG/Hagler Bailly). Following is a description of the basic elements of the survey and modeling process as presented in the RCG/Hagler Bailly report. Use and valuation results for each of the SOSs are presented in Chapter 4 of this appendix.

The objectives of the recreation survey and subsequent modeling were to develop and apply the capability to predict (1) the number of trips individuals in the PNW will take to selected Federal projects and other areas in the Columbia River Basin under existing hydrologic conditions and those characterized in the SOSs and (2) the economic value of these trips, as measured by consumer surplus. Accomplishment of these objectives would then allow us to calculate changes in those values across the different SOSs.

The recreation survey and demand studies were undertaken to meet the following criteria:

- Ability to model the behavior of recreators and nonrecreators;
- Ability to adjust for nonresponse of recreators and nonrecreators;
- Ability to take into account the fact that more avid recreators may live in the least densely populated counties, many of them close to the project;
- Ability to forecast changes in welfare and trip–taking in response to changes in monthly site characteristics affected by reservoir operation;
- Inclusion of multiple recreation types;
- Inclusion of multiple recreation sites with substitution/complementary relationships between them;
- Inclusion of numerous zero trip possibilities;
- Ability to predict changes in welfare and trip–taking in response to hydrologic conditions that are systematically beyond the range of observation; and
- Ability to model impacts on all SOR Federal reservoirs.

The development and application of a PNW recreation survey and associated demand models were able to address the above criteria with varying degrees of success. The survey design and process, and development and application of the recreation demand and value models are described in the following paragraphs.

The Recreation Survey

The recreation survey instrument was developed in an iterative process that involved a panel of experts and pretesting by a focus group. Participants in the pretest were asked to complete both the survey instrument and an accompanying assessment questionnaire. The assessment questionnaire elicited opinions regarding the clarity and complexity of the survey's questions and instructions. The opinions of the focus group participants were used to guide development of the final questionnaire.

The final survey instrument was a 12 page mail–out questionnaire, in the form of a small booklet. In addition to the survey questions, the questionnaire included a cover page and two pages showing maps. Four versions of the survey were prepared, one for each of the four geographic subregions. The subregions were based on project visitation results obtained from a survey done for the DEIS. Each version of the survey included three or four Federal projects or river reaches which were determined to be likely substitutes. Time and funding constraints of the study required a reduction in the number of recreation sites that could be studied. Since the focus of the SOR is the operation of the Federal Columbia River system, nine areas directly affected by Federal projects were included in the four different survey versions: seven reservoirs (Dworshak, Hungry Horse, Pend Oreille, Libby, Grand Coulee, Lower Granite, and John Day) and two river locations (Kootenai and Clearwater Rivers). All 14 Federal reservoirs included in the SOR were not included because of the extreme data requirements. For modeling purposes the RWG, EAG, and the contractor judged that Lower Granite results could be utilized for Ice Harbor, Lower Monumental, and Little Goose because of the project similarities. Impacts from alternative SOSs were judged to be minimal for Chief Joseph, McNary, The Dalles, and Bonneville and were not modeled. The Clearwater River below Dworshak and the Kootenai River below Libby were selected for modeling because they were judged to have relatively high use and to be subjected to the most direct impact from the alternative SOSs.

The sampling strategy combined random general population surveys with surveys of recreators at Federal projects. The recreation model was designed to predict how changes in the operation of the Federal projects would effect recreation behavior in the general population. Consequently, the model had to be estimated from a random sample of the general population in the Pacific Northwest. However, the sample also had to obtain enough trip information from the respondents to estimate the model parameters. This latter requirement was met by sampling individuals who visited Federal projects and those who live close to the projects. The sampling was stratified as follows: (1) 3,000 random sample directory–listed individuals (including 150 from southern British Columbia and southwestern Alberta, Canada); (2) 3064 individuals from counties adjacent to the Federal projects; (3) 500 individuals who were surveyed in the previous stage of study (Phase 1A) of which 388 were water–based recreators; and, (4) 577 individuals who returned post cards that were distributed at the Federal projects in August and September of 1993 (2,000 postcards were distributed with 577 useable responses). The initial mailing and two follow–up mailings took place in October and November 1993. The entire sample of 7,030 was used in the survey response modeling process, as described later. The non–responses were used to help define the total demand, by being the basis for defining the probability that any individual will recreate. Response rates are presented in Table 3–8. After "data cleaning" there were 2,795 useable survey responses.

The 2,795 useable survey responses were separated into two groups: (1) 1,620 "recreators" who reported taking at least one trip in the survey region in the past 12 months, and (2) 1,175 "nonrecreators" who reported taking no trips in the past 12 months. Summary information for the recreator's responses on travel costs per trip and the number of annual trips is shown in Table 3–9. See Technical Appendix (J1) to Appendix J (Recreation) for a more detailed discussion of survey responses.

Table 3–8. Recreation Survey Response Rate Summary by Population Strata

	POPULATION				
	PNW	Adjacent County	Post Card	Phase 1A	Canada
Sample Size	2,850	3,064	577	389	150
Return–to–Sender	334	604	12	21	44
Return–to–Sender Rate	12%	20%	2%	5%	29%
Other Ineligible	38	47	0	0	2
Potential Respondents	2,478	2,413	565	368	104
Completed Questionnaires	1,054	1,218	410	172	31
Raw Response Rate	37%	40%	71%	44%	21%
Completion Rate	43%	50%	73%	47%	30%

Table 3–9. Selected Recreation Survey Response Data by Survey Version

Survey Version and Area	Mean Travel Costs/Trip ($)	Annual Trips
Version 1:		
Hungry Horse	118	2.9
Pend Oreille	147	5.9
Libby	142	7.5
Kootenai River	131	9.2
Version 2:		
Dworshak	120	7.9
Clearwater River	111	6.9
Lower Granite	93	9.3
Pend Oreille	157	6.2
Version 3:		
Grand Coulee	198	4.2
John Day	117	6.3
Lower Granite	182	4.1
Version 4:		
Grand Coulee	126	6.3
Dworshak	190	4.0
Lower Granite	154	7.0
Pend Oreille	174	13.3

Survey Response Models

The modeling of expected recreation use (demand) and economic value (consumer surplus) was a multiple–step process. The starting point of the analysis was the survey of recreators. Since this survey was a mail–out survey it was the survey recipient's choice whether to respond or not. This self–selection nature of the mail–out survey could introduce bias in the results. To correct for this bias, Survey Response Models were developed. These models estimated the propensity of an individual in a sample to respond to the survey, as a function of numerous explanatory variables. The explanatory variables included socioeconomic characteristics, distances to regional waters, and population strata. The parameter estimates from the Survey Response Models were used to calculate a variable entitled the inverse Mill's ratio (IMR) which was incorporated into the demand models. The IMRs corrected for potential bias that differences in the propensity to respond with useable recreation data might have on the recreation demand model parameters. With this approach all 7,030 mail–out surveys were utilized to estimate the general populations' recreation demand at the Federal projects.

Recreation Demand Models

A two stage recreation demand model for each of the nine survey areas (seven reservoirs and two river reaches) was estimated. To do this nine distinct estimation samples from the data were developed. The first stage of the model answers the question of whether an individual recreates at a specific project. If he/she does, then the next step is to estimate the determining factors. This first stage of modeling, called monthly trip demand, defines the number of summer trips an individual will take to a project during a specified time frame––in this case the summer months. The number of trips is a function of (1) price from the individual's home to the specific recreation project and other recreation destinations (travel costs), (2) water levels at the project, (3) water levels at alternative projects, (4) socio–economic characteristics, and (5) a time variable. Nearly 50 independent variables were tested to determine significance in estimating the dependent variable of the number of trips from an individual to a project. Development of the model was based on the trips defined in the survey responses. The questionnaires included contingent behavior questions in which expected trips to areas were related to water levels. These contingent behavior responses were treated as actual trips, and consequently expanded the data source significantly. The econometric process of model development was extremely complicated and the interested reader is referred to the Appendix J−1 for a more complete explanation.

The monthly trip demand models are models of recreation area demand, which varies for the four summer months, across areas and also differs across the types of recreation activities in which individuals engage. The model equations were aggregated so that all individuals are assumed to have behaved identically in response to explanatory variables if they visited a particular project and engaged in the same activity. The result is that for each recreation area, a demand equation was estimated using observed trips and characteristics of those who visited the area, correcting for possible bias caused by excluding those who could have, but did not visit the area.

Simulation Models

To evaluate the impacts of each alternative SOS, a PC−based computer model was developed which estimates the number of trips and total summer consumer surplus for each of the nine recreation areas based on changes in water level conditions.

The simulation model contains nine distinct sub−models which operate independently during a simulation. To estimate the expected demand of a single individual, the model requires three types of information: personal characteristics, water levels, and the model parameters from the Recreation Demand Models. The model uses standard procedures for the Travel Cost Method to construct a demand curve for each individual by varying the travel cost variable. The resulting demand curve is used to compute the consumer surplus for the individual, by project, and by the summer month time period, consisting of four summer months.

Given a set of water levels the simulation sub−model for a recreation area calculates values for expected monthly demand for each of the four summer months over 50 water years and expected monthly consumer surplus for every individual in the sub−model's sample. Averages over the sample are saved. Then the water levels are set equal to the next set of monthly values for the next water year, and new expected demand and consumer surplus values are computed. At the completion of the analysis of all 50 water years, the model has saved 200 monthly average values for each individual. These interim results become inputs for a calibration process that uses actual 1993 visitation data to convert average expected monthly trips and consumer surplus per person to aggregate visitation and consumer surplus measures.

The model outputs provide estimates of average annual recreation days by area, by activity, for the 50−year time period, and the low and high water years of 1941 and 1976, respectively. The models also provide the summer consumer surplus for each recreation area for the average of the 50−year time period, and the 1941 and 1976 water years. To provide this information for all the areas several adjustments were made. Only nine recreation areas were modeled, and Lower Granite was the only project modeled on the lower Snake River. The simulation model allows estimates to be created for Ice Harbor, Lower Monumental and Little Goose, based on the demand model results for Lower Granite. This was judged to be a suitable approach for most of the SOSs for three reasons: First, Lower Granite receives more than 64 percent of the total recreation at the four lower Snake River projects. Second, the operating scenarios are very similar for all four projects. And, third, project characteristics of the four projects are very similar.

The survey obtained the number of trips to recreation areas, but the RWG wanted the impacts associated with each SOS to be based on the number of recreation days. Therefore, it was assumed for this study that the number of trips and recreation days were the same. This is somewhat of an under−estimation because some trips result in more than one recreation day, especially for camping trips. This approach, however, does not bias the consumer surplus estimates because the number of trips is the major variable for the travel cost computations. There also was a need to estimate annual recreation days from the models which included only the four summer months. This was done by simply adding a fixed non−summer visitation amount to the summer month estimates. Actual non−summer month visitation for each project for the November 1992 through October 1993 was used to correspond with the recreation survey period. Since the non–summer months are fixed between alternative SOSs, any comparison of the SOSs will net out the non–summer visitation. The simulation results are also available by recreation activity. The demand models were not broken down into individual recreation activity models, but did include some dummy variables to account for different recreation demand for boaters and fishers. However, the activity breakdown in the model results was fixed based on survey results. Thus, total visitation results from the simulation models were multiplied by a fixed percentage for each activity to provide the activity–by–activity estimates.

3.4 WATER QUALITY

The economic value of water quality changes are measured indirectly through analysis of water uses, such as fish production and recreation.

3.5 REGIONAL ECONOMIC EVALUATION, THE CONCEPTS

Regional economic activity is measured using input–output analysis which is a method to estimate the size of economic impacts to regions and communities. Many of the operating strategies evaluated would affect local economies. Strategies that increase anadromous fish runs near certain communities may result in more tourists and fishermen spending money in that region. Conversely, strategies that decrease opportunities to recreate, say through lowering pool elevations, may result in less recreators spending money in that region. Regional economic analysis was done for the System Operation Review using the input–output model IMPLAN. All input–output (I–O) models begin with the construction of a set of accounts which describe the transactions between industries, their purchases of primary inputs, and their sales to final demand. The following paragraphs explain the transaction, direct requirements, and total requirements tables and how they are used to estimate regional economic impacts in a simplified example.

A complete set of documentation for the thirteen regional, state, and subregional models developed for the SOR has been made available to the SOR Economic Analysis Group. The fully adjusted models are available on 3.5" diskettes, stored using the DOS 5.0 Backup utility. Documentation is available for all price, employment, RPC, and production function adjustments made to the input–output models.

A more detailed discussion of the model construction is included in an earlier report, *System Operation Review: Framework for Indirect Impacts Analysis*, prepared by Northwest Economic Associates. Exhibit E provides further description and results of the regional analysis.

3.5.1 Validating the Basic Data

The basic data for the IMPLAN system was developed by the University of Minnesota for the USDA Forest Service. The most recent data available at the time of model construction was for the base year 1985. In developing models for the Columbia River System Operation Review (SOR), it was necessary to review this data and evaluate changes in economic activity and adjustments in relative prices that may have occurred since 1985. After researching data availability, it was decided that 1989 was the latest year for which consistent data were available for all model regions.

3.5.2 Adjusting the Trade Relationships and Production Functions

After evaluating and adjusting the basic data, the initial social accounts were developed. An important step in the development of the social accounts is the evaluation of the regional purchase coefficients (RPC's). A regional purchase coefficient is the fraction of locally produced goods and services that is used to meet local demand. These values are initially set the first time the social accounts are constructed using a combination of predictive equations and observed values from multi–regional input–output models. Reports displaying the supply/demand pool ratio and the initial RPC for each commodity were prepared for each sub–regional, state, and regional model. This information was put in spreadsheets and consistency across models was checked.

After the RPC's were set, the social accounts were developed again, and production function reports for selected industries were obtained. These reports were checked to ensure that regional economic structures were reasonably represented by the model production functions.

3.5.3 Construction of the Models

After changes to the price relationships, employment levels, trade relationships, and production functions have been made, the social accounts are constructed. While the social accounts themselves are very useful as an aid to understanding economic structure, they have even more power in understanding economic structure and analyzing economic change when transformed into an I−O model. Two matrices are involved, the "make" matrix and the "use" matrix for each industry. The make matrix lists the quantity of each commodity produced by each industry, the use matrix lists the quantity of each commodity it uses to produce its output. Transformation of the social accounts into the input−output accounts begins with converting the make and use matrices into technical coefficient matrices. The normalized regional use matrix is called the regional absorption matrix. It shows the proportion of each industry's total outlay spent on locally produced commodities. The normalized regional make matrix is called the regional market shares matrix. It shows a given industry's proportion of a region's total commodity production.

The regional direct requirements matrix is derived by multiplying the regional market shares matrix by the regional absorption matrix. The result is an industry by industry direct requirements matrix that establishes interindustry purchases per dollar of industry output by tracing the use of a commodity by an industry to the industries that produce the commodity. The data has at this point been transformed from a commodity and industry basis to an industry basis. In the IMPLAN system terminology, this step is called developing the input−output accounts, or squaring the matrix.

The next step is to transform the direct requirements matrix into a direct plus indirect requirements matrix. Matrix algebra methods are used to develop a table of these direct plus indirect requirements. Any standard text on I−O methods provides for the details of this operation.

At the completion of this step, the social accounts have been transformed into an input−output model. The resultant matrix is referred to as the direct and indirect requirements matrix or the inverse matrix. Column sums of this matrix are the so called output multipliers. Additional multipliers are constructed by incorporating the direct relationships between output, employment, income, and value added.

3.5.3.1 Transaction Tables

An input−output model can be used to approximate the local economy by expressing economic relationships among economic sectors. Any developed economy, whether national, regional, or local, is characterized by a high degree of interdependence among industries of the economy. Each economic industry not only produces goods or services, but is also a consumer itself, purchasing other goods and services for use in the production process. Economic relationships are measured by dollar values of purchases or sales among economic sectors. The key to input−output analysis is the construction of the input−output or transactions table, which shows the flow of commodities from each of a number of producing industries to all consuming industries and final demand. A transactions table portrays the dollar flows of goods and services among industries in an economy for a given accounting period. From transaction tables, information about total sales, sectorial input requirements, possible input substitutions, etc., can be estimated. From these flows between economic industries, two other structural tables can be developed: (1) a table of direct requirements and (2) a table of total requirements.

In the transaction table, Table 3−10 sales and purchase transactions within the economy are set forth in a matrix of rows and columns. Each row shows the output sold by each industry shown along the left−hand side of the table to each industry shown across the top of the table. Each column shows the purchases made by each industry shown along the top of the table from the industries along the left−hand side. Because this is a square table, one row corresponds to each column. The entry in each cell represents a purchase for the column industry and a sale for the row industry.

Table 3–10. Hypothetical Transaction Table

Producing Industries	Purchasing Industries			Final Demand	Total Output
	Agriculture	Manufacturing	Services		
Agriculture	10	6	2	18	36
Manufacturing	4	4	3	26	37
Services	6	2	1	35	44
Primary Inputs	16	25	38	0	79
Total Outlay	36	37	44	79	196

Thus, the entries in the first column show agriculture purchasing $10 worth of output from itself, $4 worth of output from manufacturing, $6 from services, and $16 from primary inputs (e.g. labor), summing to a total outlay of $36. Reading along the row, agriculture sells $10 worth of output to itself, $6 to manufacturing, $2 to services, and $18 to final demand. Summing the sales results in a total output value of $36.

3.5.3.2 Direct Requirements Table

Table 3–11 is a direct requirements table for the preceding transaction table. The entries in this table are to be interpreted as the minimal requirements from each of the producing industries at the left of the table in order for each industry at the top to produce one dollar's worth of output.

These direct requirements are determined by dividing the column entries for agriculture, manufacturing, and services in the transaction table by the outlay of the respective column. In this example, the manufacturing industry requires 16.2 cents worth of input from agriculture ($6/$37), 10.8 cents from manufacturing industries, and 5.4 cents from services in order to produce one dollar of output. In other words, the 16.2 cents would be interpreted as the "dollar's worth of inputs from agriculture per dollar's worth of output from manufacturing." The remaining inputs to the manufacturing industry come from the primary inputs part of the model.

3.5.3.3 Total Requirements Table

One of the most important applications of the input–output model is to calculate the equilibrium output levels in each industry of the economy. Output is in equilibrium if it is just equal to the quantity demanded for all purposes, such as inputs for production, consumption, investment, and exports. Once the transactions table is balanced and aggregate final demand equals aggregate primary inputs, an equilibrium exists.

Now suppose that someone, probably in a final demand institution, would like to buy more. This starts a chain reaction of increasing production everywhere. Using the direct requirements table, it is possible to calculate by hand the reaction as it ripples through all industries in the economy.

For example, suppose a foreign country would like to purchase $1 more from the agriculture industry. Using the direct requirements table one can trace the results. In order to sell an additional dollar's worth of output to final demand (in this case, exports), the agriculture industry must purchase 27.8 cents of output from itself, 11.1 cents of output from the manufacturing industry, and 16.7 cents of output from the services industry. This is the first round. Now for agriculture to sell 27.8 cents to itself, it must again purchase 7.7 cents more output ($.278 times .278) cents to itself and 3.1 cents ($.278 times $.111) from manufacturing and 4.6 cents ($.278 times $.167) from services. The second round

Table 3–11. Hypothetical Direct Requirements Table

Producing Industries	Purchasing Industries		
	Agriculture	Manufacturing	Services
Agriculture	.278	.162	.045
Manufacturing	.111	.108	.068
Services	.167	.054	.023
Primary Inputs	.444	.676	.864

is not finished, because for manufacturing to sell 11.1 cents to agriculture, it must buy 1.8 cents ($.111 times $.054) from services. Services must also purchase 0.8 cents (16.7 cents times .045) from agriculture, 1.1 cents (16.7 cents times .068) from manufacturing, and 0.4 cents (16.7 cents times .023) from itself to sell 16.7 cents to agriculture. In just the first two rounds, agriculture has produced $1 for export, 27.8 cents plus 7.7 cents for itself, 1.8 cents for manufacturing, and 0.8 cents for services, totaling $1.38. Now if one were to follow this procedure ad infinitum, the total amount each industry would be required to produce could be calculated.

Another mathematical procedure called "inverting the matrix" can also be used to estimate the continuous effect of any change in one of the sectors in the model. This can be done using the information on final demands and total outputs using the transactions table combined with the information contained in the direct requirements table and some matrix algebra. From this information, the following system of equations can be developed.

$$X_1 = .278\,X_1 + .162\,X_2 + .045\,X_3 + Y_1$$
$$X_2 = .111\,X_1 + .108\,X_2 + .068\,X_3 + Y_2$$
$$X_3 = .167\,X_1 + .054\,X_2 + .023\,X_3 + Y_3$$

where X_1, X_2, and X_3 are the total outputs of the three endogenous industries, While Y_1, Y_2, and Y_3 are the respective processing industries' sales to final demand, and the coefficients are the entries in the direct requirements table. In matrix notation, the system becomes:

$$\begin{vmatrix} X_1 \\ X_2 \\ X_3 \end{vmatrix} = \begin{vmatrix} .278 & .162 & .045 \\ .111 & .108 & .068 \\ .167 & .054 & .023 \end{vmatrix} \times \begin{vmatrix} X_1 \\ X_2 \\ X_3 \end{vmatrix} + \begin{vmatrix} Y_1 \\ Y_2 \\ Y_3 \end{vmatrix}$$

Or more simply stated:

$$X = AX + Y$$

Where vector X is the vector of total outputs, A is the matrix of direct coefficients, and Y is the vector of final demands. The above may also be written as

$$(1 - .278)\,X_1 - .162\,X_2 - .045\,X_3 = Y_1$$
$$-.111\,X_1 + (1 - .108)\,X_2 - .068\,X_3 = Y_2$$
$$-.167\,X_1 - .054\,X_2 + (1 - .023)\,X_3 = Y_3$$

Which may also be written in matrix notation as:

$$\begin{vmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{vmatrix} - \begin{vmatrix} .278 & .162 & .045 \\ .111 & .108 & .068 \\ .167 & .054 & .023 \end{vmatrix} \times \begin{vmatrix} X_1 \\ X_2 \\ X_3 \end{vmatrix} = \begin{vmatrix} Y_1 \\ Y_2 \\ Y_3 \end{vmatrix}$$

and may be reduced to:

Where I is the identity matrix, $(I - A)$ is called the Leontief matrix, and A, X, Y are as previously defined.

The coefficients are now in the proper form to solve the system and find the vector of outputs required to sustain a given vector of final demands. The mechanical process is to find the Leontief inverse or the inverse of the Leontief $(I-A)$ matrix. The Leontief inverse $(I-A)^{-1}$ is defined as the total requirements matrix and is presented in Table 3–12.

Table 3–12. Hypothetical Total Requirements Table

Producing Industries	Purchasing Industries		
	Agriculture	Manufacturing	Services
Agriculture	1.4459	0.2678	0.0852
Manufacturing	0.1996	1.1628	0.0901
Services	0.2582	0.1100	1.0431
Total or Output Multiplier	1.91	1.54	1.22

To develop a solution, both sides of the above equation must be premultiplied by the Leontief inverse, as follows:

$$(I - A) X = Y$$

which reduces to:

$$X = (I-A)^{-1} Y$$

Using the information in the table form and the above matrix, we can develop the following system equations:

$$X_1 = 1.4459\ Y_1 + 0.2678\ Y_2 + .00852\ Y_3$$
$$X_2 = 0.1996\ Y_1 + 1.1628\ Y_2 + .0901\ Y_3$$
$$X_3 = 0.2582\ Y_1 + 0.1100\ Y_2 + 1.0431\ Y_3$$

Returning to our example, when a foreign country (or final demand institution outside of the model "region") wants to purchase $1 more from the agriculture industry, we would like to determine the total increase in output resulting from this $1 increase in final demand.

Using the above system of equations and looking at the $1 increase only, agriculture sales to final demand (Y_1) would equal 1 and manufacturing (Y_2) and services (Y_3) sales to final demand would be zero. After multiplying through, agriculture total output (X_1) equals $1.4459 (1 times the coefficient associated with Y_1), manufacturing output (X_2) equals $.1996, and services output (X_3) equals $.2582. Summing the three outputs, we find the total increase in output resulting from a $1 increase in final demand of the agriculture industry to be $1.91. We have found the total output, both direct and indirect, that this hypothetical economy is required to produce in order for the agriculture industry to sell one more dollar of output to a final demand industry. The total output requirement divided by the output sold to the final demand industry is designated as the "output multiplier." The output multiplier is calculated by summing the appropriate column of the Leontief inverse. As presented in the total requirements table by summing each column the output multipliers are 1.91, 1.54, and 1.22 for the agriculture, manufacturing, and service industries, respectively.

3.5.3.4 Multipliers

As an initial amount of income earned in a community is spent and re–spent to purchase goods and services produced within that community, the total amount of income generated within the community because of the initial expenditure becomes substantially larger than the initial amount. This is referred to as the mulitplier effect. To illustrate how it works, consider the following example. An industry in a community exports goods outside the local area and receives money for those goods. The industry spends part of this money on goods and services in the local community. Expenditures that are for inputs and labor in the local economy are part of the multiplier process. Expenditures that are for imports (goods and services outside the local economy) are not spent in the local community and are called "leakages". For example the industry may receive $1 and spend $0.60 of this dollar paying for local labor and inputs. The other $0.40 is a leakage as it goes to buy imports. Of the $0.60 used to pay laborers and inputs, $0.30 could be re–spent in the community, while the rest leaks out. This process continues

until the amount remaining in the local economy is negligible. In order to determine the multiplier value, the initial dollar is added to the sum of the local re–spending. In the above example, $1.00 (initial change) + $0.60 (labor and inputs) + $0.30 (re–spent in community) +... and so on. For example, a multiplier of $2.49 indicates that for each dollar that enters the local economy $2.49 worth of local business activity will be generated.

3.6 REGIONAL ECONOMIC ANALYSIS IN SOR

The regional economic analysis examines how regional and local economies are affected by the SOR operating strategies described in Chapter 4. The direct economic impacts associated with the SOR alternatives are measured on a national basis. However, the actual incidence of these impacts are distributed across various locations within the Columbia River basin region. Consequently, the secondary (or regional) impacts of these changes would occur in some parts of the region and not in others.

3.6.1 Study Areas

In total, thirteen study areas are recognized as locations of potential SOR–related economic impacts. Five of these study areas are defined for the Pacific Northwest and the four states which comprise the region. The remaining eight study areas are referred to as subregions and are made up of multi–county groupings, six of which cross state boundaries. The primary objective in specifying the regions and subregions was to identify areas that could potentially be directly and indirectly affected by changes in system operations. Specification of the subregions was an iterative process that involved Northwest Economic Associates (NEA) and the SOR Economics Work Group. The final set of subregions, presented at the May 1992 Economics Work Group meeting and accepted by the work group, is shown in Table 3–13. Input–output models are built for each of the subregions, or study areas, identified. The IMPLAN regional economic model used is discussed in detail in Exhibit E.

3.6.2 Linking the Direct and Indirect Economic Impacts

The first step of the regional analysis is to translate the direct economic impacts into measures of economic change that can be incorporated into the indirect impact analysis. For some of the resource uses the NED benefit and cost values can be included in the regional analysis without any modification. In other cases, only the direct measure of physical change is carried over and alternative values are developed to describe the direct impact. For example, since recreation occurs in a non–market environment, the NED value of recreation benefits is willingness to pay, but the regional analysis is driven by actual expenditures. Therefore, recreation expenditure data are used in the regional analysis rather than NED benefits. Once the appropriate measure of the value of direct economic impacts has been determined, the direct impacts are allocated to the various regions and the IMPLAN models are executed to determine the indirect impacts. The determination of indirect impacts from the direct impacts is discussed in Chapter 4 (Section 4.11) and Exhibit E of this appendix to the SOR FEIS.

3.7 SOCIAL IMPACT EVALUATION

The social impact analysis is a representative assessment of potential socio–economic impacts of changes in the operation of the Columbia River system on specific local communities. The analysis is considered to be representative because it was not possible to assess potential impacts to all communities, subregions, states, the region in general, and areas outside the Pacific Northwest. This section describes the social impact analysis process.

Table 3–13. PNW Subregions for Analysis of Indirect Economic Impacts

SubRegion	Counties Included in the Subregion
1. Puget Sound	Washington: Whatcom, Skagit, Snohomish, King, Pierce, Thurston
2. West Coast	Washington: Clallam, Jefferson, Grays Harbor, Pacific, Wahkiakum, Cowlitz Oregon: Clatsop, Tillamook, Lincoln, Columbia
3. Portland	Oregon: Multnomah, Washington, Clackamas, Yamhill Washington: Clark
4. Mid Columbia	Oregon: Hood River, Wasco, Sherman, Gilliam, Morrow, Umatilla. Washington: Skamania, Klickitat, Benton, Franklin, Walla Walla
5. Upper Columbia	Washington: Yakima, Kittitas, Chelan, Okanogan, Douglas, Grant, Lincoln, Adams
6. Lower Snake	Washington: Columbia, Garfield, Asotin, Whitman Oregon: Wallowa Idaho: Latah, Nez Perce, Lewis, Clearwater, Idaho, Custer, Lemhi
7. Northeast	Washington: Pend Orielle, Spokane, Ferry, Stevens Idaho: Boundary, Bonner, Kootenai, Benewah, Shoshone Montana: Lincoln, Flathead, Sanders, Lake, Missoula, Mineral
8. Southern Idaho	Oregon: Malheur Idaho: Adams, Washington, Payette, Gem, Canyon, Ada, Elmore, Owyhee, Boise, Valley, Camas Blaine, Gooding, Lincoln, Jerome, Minidoka, Twin Falls, Cassia, Jefferson, Madison, Teton, Clark, Fremont, Butte, Bingham, Bonneville, Power, Bannock, Caribou, Oneida, Franklin, Bear Lake

3.7.1 Focus Communities

Communities and Indian Tribes within each sub–region would be impacted by varying degrees from changes in the operation of the Columbia River System. Since it was not possible to provide an analysis of all of these, focal points for the analysis were identified. The focus communities selected for the assessment are shown in Table 3–14. The focus communities were selected to represent the extreme, or maximum, expected extent of potential impacts on communities within the Pacific Northwest. In addition to the focus communities, however, it is recognized that a number of other geographical areas would also be impacted to varying degrees. Areas identified which would be directly impacted by changes in the operation of the Columbia River System are as follows:

- The Pacific Northwest (OR, ID, WA, and Western Montana)
- Individual states of the Pacific Northwest
- Subregions of the Pacific Northwest, as defined for the SOR regional economic analysis (see Section 3.6)
- Non–PNW Areas: Areas outside the Pacific Northwest which would be impacted include the Pacific Southwest, primarily California; Montana east of the Continental Divide; North Dakota; and, portions of British Columbia, Canada.

3.7.2 Basis for Social Impacts

The basis for estimating social impacts was the analysis of indirect economic impacts which would accrue to communities and Tribes within each subregion. Expert judgment was used to allocate subregional indirect economic impacts and to estimate the significance and probable incidence of impacts to specific communities within each of the subregions

Table 3–14. Focus Communities for Social Impact Analysis, by Subregion

SOR Subregion	Focus Communities for Social Impacts
1. Puget Sound	None
2. West Coast	Oregon: Astoria
3. Portland	Oregon: Portland
4. Mid Columbia	Oregon: Umatilla/Morrow
	Washington: Tri–cities
5. Upper Columbia	Washington: Colville Reservation, Grand Coulee/Coulee Dam
6. Lower Snake	Idaho: Orofino, Lewiston, Nez Perce Reservation
	Washington: Clarkston
7. Northeast	Montana: Libby, Columbia Falls, Flathead Lake, Flathead Reservation
	Idaho: Bonners Ferry, Kootenai Reservation
	Washington: Spokane Reservation
8. Southern Idaho	None

modeled in IMPLAN. The analysis includes allocating employment, income, and population changes to focus communities and Tribes. IMPLAN model output was analyzed to estimate significance of impacts. The list of focus communities was reviewed and revised to verify that the identified communities and tribes would experience significant impacts. Communities and tribes without significant impacts were not included.

3.7.3 Social Impacts Assessment Process

The social impacts assessment process consisted of the following activities:

- Focus communities were selected. The selection criteria were designed to (1) include communities with potential significant impacts; (2) include representative communities from all of the subregions for which direct and indirect economic impacts were estimated; and, (3) to include some Native American communities.

- Current socio–economic profiles of the focus communities were prepared (see Exhibit F).

- Indirect economic impacts from the regional economic impacts analysis were allocated to the focus communities as the basis for determining the significance of the impacts.

- Allocated indirect economic impacts were compared with the current level of economic activity of each community to obtain an estimate of the significance of the impacts.

- Finally, potential responses of the communities to the impacts were estimated and indicators of significance for each river use and alternative system operating strategy were developed. This assessment consisted of estimating and describing the significance of indirect economic impacts to specific communities and the response of the communities, groups, and individuals to the impacts. The analysis was completed in a workshop by key individuals from the EAG and representatives of a contractor (Northwest Economic Associates). The analysis included estimating the significance of indirect impacts to the communities/tribes, translation of indirect impacts by industry code into specific economic activities/entities in the community, assessment of likely community response to these changes, assessment of impacts to groups and individuals including changes in their way of life and values. Results of the assessment are presented in Chapter 5 and Exhibit F of this appendix to the SOR FEIS.