Columbia River System Operation Review

Final Environmental Impact Statement

Appendix I

Power

BONNEVILLE POWER ADMINISTRATION

US Army Corps of Engineers
North Pacific Division

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

DOE/EIS-0170

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PUBLIC 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.

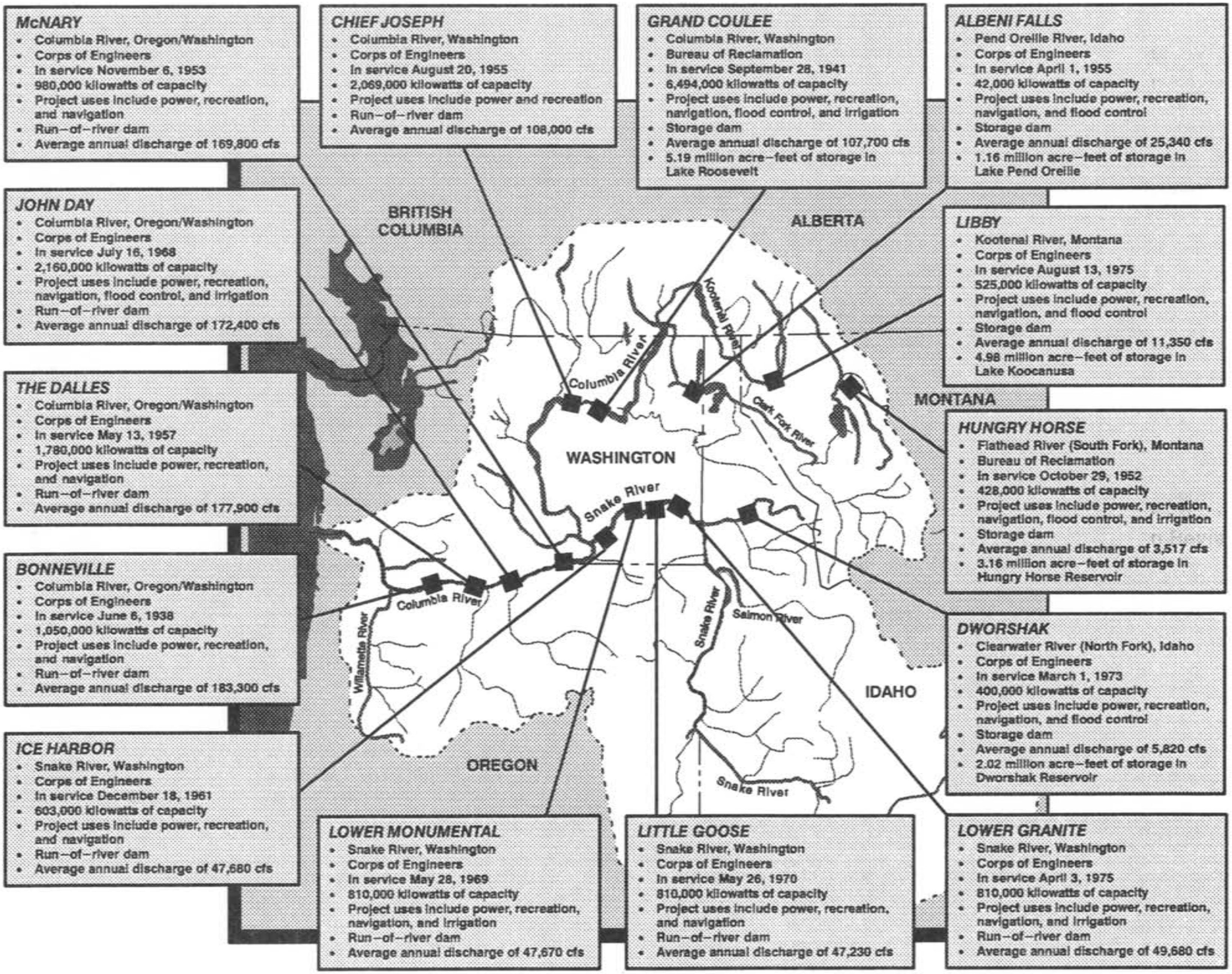
WHAT DO THE TECHNICAL APPENDICES COVER?

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.

There are many interrelationships among the different resources and river uses, and some of the appendices provide supporting data for analyses presented in other appendices. This Power appendix relies on supporting data contained in Appendix A, River Operation Simulation. For complete coverage of all aspects of Power, readers may wish to review these two 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.

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CHAPTER 1

INTRODUCTION: SCOPE AND PROCESS

This appendix discusses the work performed by the SOR Power Work Group. The Power Work Group (PWG) had several major responsibilities: first, to determine the effects of each of the various system operating strategies (SOS) on the Northwest regional power system; second, given these effects, to determine what, if any, actions are required to meet forecasted regional energy consumption; and finally, to estimate the cost for serving the forecasted regional energy consumption. The Northwest regional power system consists of Federal and non–Federal hydroelectric power projects (hydropower or hydro projects) on the main stem of the Columbia and Snake Rivers, numerous smaller hydro projects on other river reaches, and a number of thermal plants (coal, nuclear and combustion turbines).

1.1 SCOPING ISSUES

The SOR began in early 1990 when Reclamation, the Corps, and BPA recognized the need to take a comprehensive view of Columbia River operations and address issues regarding the multiple uses of the system. A scoping process began in August of that year and meetings were held in 14 locations throughout the region to elicit public comment.

Many of the issues that arose during the scoping process formed the basis for the SOR analytical work. A main issue for the PWG was to adequately value the contribution that the hydropower system makes to serving regional loads. For each alternative system operation, the change in that contribution was evaluated. The hydropower system currently provides many products: energy, capacity (both instantaneous and sustained), daily load following capability, etc. The PWG spent much of its time determining how to value these products; this appendix describes that work.

During scoping, a number of other issues were raised regarding the power system. A common theme was the indispensability of hydropower to the regional economy. The economic impact of limiting power production in order to promote other river uses was of concern; many want continued low cost, reliable power.

Another important issue concerned replacement resources. Many commenters stated that if the SOR examines operational alternatives that reduce the power generating capability of the hydroelectric system, the environmental and economic risks and impacts associated with providing replacement power for such reductions must be identified. Other issues suggested in scoping included:

- The use of other resource types (cogeneration, wind, solar, nuclear) to replace hydropower losses.
- Alternative marketing strategies and power exchanges that could be used to replace hydropower losses.
- Investigation of ways to increase generating efficiency and encourage energy conservation to balance the conflicting uses of the system.
- How power sales to the Pacific Southwest are affected by changes in Pacific Northwest system operations.

Other issues not mentioned here are described in a document summarizing public comment entitled "Comment Summary," January, 1991.

Issues raised concerning the Pacific Northwest Coordination Agreement (PNCA) and the Canadian Entitlement Allocation Agreements (CEAA) are treated in the appendices covering those topics.

1.2 WORK GROUP FORMATION AND INVOLVEMENT

The SOR Power Work Group was formed to guide the Federal agencies in determining power system impacts. Hydroelectric projects on the Columbia River system provide approximately 76 percent of the generating capacity in the Pacific Northwest. Every electricity customer in the Northwest is a direct or indirect beneficiary of this hydro resource. There are many interest groups representing consumers of electricity, including the Pacific Northwest Utilities Conference Committee, the Public Power Council, and the Direct Service Industries, Inc. Individual public and private utilities also actively represent their rate payers in the region. Many of these entities are represented on the PWG. A complete list of work group members is shown in a technical exhibit at the end of this appendix.

1.3 THREE–PHASE ANALYSIS

The SOR analytical work was divided into three phases: pilot study, screening analysis, and full–scale analysis.

1.3.1 Pilot Study

The first analytical effort, the pilot study, was a simplified version of the subsequent analysis phases. It was designed to develop methods and procedures that would be used principally in the next phase, the screening analysis. The pilot study had two steps. The first consisted of developing a spreadsheet model to quickly calculate a rough economic impact of changes in operation of the river system. This was expressed as an annual cost in millions of dollars. The second consisted of using this model to show the differences among an initial set of alternatives under conditions of uncertainty (loads, fuel prices, etc.). Three simple alternatives were designed to be representative of alternatives that might be analyzed in the subsequent analysis phases.

1.3.2 Screening Analysis

The next phase, the screening analysis, was designed to analyze a large number of wide–ranging alternatives. Nearly 100 different system operating strategies were evaluated using an improved version of the power spreadsheet model. The screening analysis is more fully described in Chapter 3.2 and also in "Screening Analysis, Volumes 1 and 2."

1.3.3 Full–Scale Analysis

In the full–scale analysis, more detailed models were used to evaluate power system impacts of a final set of system operating strategies. Analytical results in several areas (for example, capacity analysis) were significantly expanded compared to the screening analysis phase. The full–scale analysis forms the basis for conclusions drawn in the Final EIS; therefore, the majority of this appendix will explain the methods used and results from the full–scale analysis.

CHAPTER 2

HYDROELECTRIC POWER IN THE COLUMBIA RIVER BASIN TODAY

2.1 BASIN HYDROLOGIC CONDITIONS

The geography and land use of the affected environment in the Pacific Northwest center on the Columbia River system. The area includes most of Washington, Oregon, and Idaho; Montana west of the Rocky Mountains; small areas of Wyoming, Utah, and Nevada; and southeastern British Columbia. The Columbia River and associated tributaries comprise one of the principal economic and environmental resources in the Pacific Northwest. The Columbia River originates in the Rocky Mountains of British Columbia, Canada and flows south to be joined by two major tributaries, the Kootenai and Pend Oreille Rivers, near the U.S. – Canadian border. Another important tributary, the Snake River, originates in the region of Yellowstone National Park in Wyoming and joins the Columbia River 330 miles (531 km) upstream from the mouth, in southern Washington. The Columbia continues west, forming the border between Oregon and Washington, and eventually reaching the Pacific Ocean. It has traveled a total of 1,214 miles (1,953 km). From the point it passes into Washington to its mouth, it drops steadily for 748 miles (1,203 km).

The Snake River, which is 1,038 miles (1,670 km) long, begins in northwestern Wyoming. It flows west and north, forming part of the borders between Oregon and Idaho and between Idaho and Washington. Part of that border is the nation's deepest canyon (Hells Canyon).

The Columbia River Basin is primarily a snow–fed regime in which snow accumulates in the mountains during the winter (November through March), then melts to produce runoff during the spring and summer. A broad–crested flood peak usually occurs in early June, and thereafter the river recedes during the late summer and fall. Tributaries to the Columbia River that lie near the West Coast, such as the Willamette River that flows through Portland, Oregon are dominated by winter rains. This results in high stream flow of short duration throughout the winter and lower flow in the summer.

The Columbia River Basin contains 258,500 square miles (669,515 km^2) of drainage with an average annual runoff at the mouth of the Columbia of about 198 million acre–feet (MAF) (244,332 million m^3). The Canadian portion of the basin on average contributes about 50 MAF (61,700 million m^3) annually, although it represents only about 14 percent of the total drainage area. About 40 percent of the basin lies in the Snake River drainage; however, this relatively arid region contributes only about 18 percent of the total flow during drought years.

The Columbia and the Snake Rivers are very different now from when the region was first settled. The large volume of water and drastic drop in elevation of these rivers once created spectacular falls and annual flooding as snow melted in the mountains. However, the basin has changed dramatically since the 1930's with the construction of the dams. The dams have tamed the annual flooding, have provided inland navigation on the lower Columbia and lower Snake reaches, and have produced hydroelectricity. The hydroelectric projects are operated to accommodate irrigation, fish, wildlife, and recreation needs as well.

Some 255 Federal and non–Federal projects have been constructed in the basin, making it one of the most highly developed basins in the world. Federal agencies have built 30 major multi–purpose projects on the Columbia and its tributaries. The hydropower projects on the Columbia fall into two major categories: storage and run–of–river.

Storage reservoirs are the key to matching the region's plentiful water resources with water needs. The main purpose of storage reservoirs is to adjust the river's natural flow patterns to conform more closely to water uses. Storage dams in the Columbia River Basin store the spring and summer runoff water. In the fall and winter when stream flows would ordinarily be low, water is gradually released from the reservoirs for many river uses. Reservoir levels at storage projects vary greatly during normal river operations.

The total storage capacity of the system is approximately 55 MAF (67,870 million m^3), of which 42 MAF (51,828 million m^3) is usable. The 55 MAF (67,870 million m^3) is approximately 40 percent of the average annual volume runoff for the basin as measured at The Dalles. Approximately half of the 55 MAF (67,870 million m^3) storage capacity is in Canada.

Run–of–river projects have limited storage and were developed primarily for navigation and hydropower generation. These projects pass water at the dam at nearly the same rate it enters the reservoir. Reservoir levels behind these projects vary only a few feet in normal operations.

Stream flows vary from month to month and from year to year according to weather and other natural conditions. In normal years and years of heavy runoff, water is readily available to produce electricity needed in the Pacific Northwest. When stream flows are down, additional water is released to maintain required flows. However, in low runoff years, storage reservoirs may not refill due to multiple stream flow demands.

The amount of runoff in the system is highly variable. For operational purposes, runoff is usually measured at The Dalles, Oregon. Here the average annual runoff is about 134 MAF (165,356 million m^3), but it has varied from about 78 MAF (96,252 million m^3) to 193 MAF (238,162 million m^3). The average monthly natural stream flow at The Dalles ranges from 40,000 cubic feet per second (cfs) (1,133 m^3/s) in winter, to 800,000 cfs (16,992 m^3/s) in the spring. The system's usable storage can accommodate less than one–third of an average year's runoff at The Dalles.

2.2 CHARACTERISTICS OF AFFECTED PROJECTS

2.2.1 Definition of Project Scope

The affected environment includes 14 Federal hydro projects on the Columbia and lower Snake Rivers. These large–scale facilities play a key role in the multi–purpose use of the Columbia River system. They include dams and reservoirs, navigation channels and locks, hydroelectric power plants, high–voltage power lines and substations, fish ladders and bypass facilities, irrigation diversions and pumps, parks and recreation facilities, boat launches, lands that are dedicated to the projects, and areas set aside to replace wildlife habitat. These projects are described below.

2.2.2 Federal Storage Projects

As discussed above, storage is the key to the operation of a multiple–use river system. Of the 14 Federal projects in the affected environment, five are storage reservoirs with a combined storage of 16 MAF (19,744 million m^3). Major Federal storage reservoirs exist behind Libby, Hungry Horse, Albeni Falls, Grand Coulee, and Dworshak Dams.

Grand Coulee and Hungry Horse are managed by Reclamation. The other Federal projects are managed by the Corps. Other characteristics of these Federal reservoirs are shown in Table 2–1.

2.2.3 Federal Run–of–River Projects

The remaining nine Federal projects in the affected environment are run–of–river projects. They are Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. All these are managed by the Corps. Other characteristics of these projects are shown in Table 2–1.

Table 2–1. Hydro Project Characteristics 1/

PROJECT	NO. UNITS	NAME–PLATE RATING (MW)	INSTANTA-NEOUS GENERATING CAPACITY 1/ (PEAK MW)	HYDRAULIC CAPACITY (KCFS)	MANAGER	RIVER
FEDERAL PROJECTS 2/						
Hungry Horse	4	392	428	9	Reclamation	S. Fk. Flathead
Libby	5	525	600	24	Corps	Kootenai
Albeni Falls	3	43	49	33	Corps	Pend Oreille
Grand Coulee	30	6450	6684	291	Reclamation	Columbia
Chief Joseph	27	2069	2614	219	Corps	Columbia
Dworshak	3	400	460	11	Corps	N. Fk. Clearwater
Lower Granite	6	810	932	130	Corps	Snake
Little Goose	6	810	932	130	Corps	Snake
Lower Monumental	6	810	930	130	Corps	Snake
Ice Harbor	6	603	693	106	Corps	Snake
McNary	14	980	1127	232	Corps	Columbia
John Day	16	2160	2484	350	Corps	Columbia
The Dalles	22	1780	2074	375	Corps	Columbia
Bonneville	18	1050	1186	270	Corps	Columbia
NON–FEDERAL PROJECTS 3/						
Brownlee	5	585	675	35	Idaho Power	Snake
Wells	10	774	890	220	Douglas PUD	Columbia
Rocky Reach	11	1213	1346	220	Chelan PUD	Columbia
Rock Island	18	613	662	220	Chelan PUD	Columbia
Wanapum	10	831	956	178	Grant PUD	Columbia
Priest Rapids	10	789	907	187	Grant PUD	Columbia

1/ Maximum generation under optimum conditions
2/ From BPA "1993 Pacific Northwest Loads and Resources Study"
3/ From U.S. Army Corps of Engineers "Columbia River and Tributaries Review Study," July 1989 Book No. 1

2.2.4 Other Federal Projects

Evaluation of reservoir–specific impacts at other Federal projects, such as the Willamette Valley projects, will not be included in the SOR analysis. The operational impacts of these projects on the mainstem Columbia River portion of the system is small, and in some cases, they are already being studied under separate authorities.

Evaluation of reservoir–specific impacts at Federal projects in the Snake River Basin above Brownlee will not be included either. However, the SOR will examine the effect on the downstream system of obtaining more water from the upper and middle Snake River. Studies of the Snake River Basin above Brownlee Reservoir will assume the basin to be a "hypothetical" reservoir that could supply varying amounts of river flow at different times of the year.

2.2.5 Non–Federal Projects

The SOR will evaluate the effects of changing operation of the Federal projects on several non–Federal projects. These include the five mid–Columbia River dams: Wells, Rocky Reach, Rock Island, Wanapum and Priest Rapids. These projects are owned by three public utility districts, Chelan, Douglas and Grant. Also, Idaho Power's Brownlee Dam on the Snake River 4 will be evaluated. Characteristics of these projects are also shown in Table 2–1. Impacts at other non–Federal projects in the system may be included to the extent these projects are significantly affected by any of the alternatives under study in the SOR.

2.3 POWER GENERATION AND SYSTEM OPERATION

The electric generating resources of the Pacific Northwest are capable of producing nearly 43,000 megawatts (MW) of electricity from all sources: hydro, coal, nuclear, combustion turbines, etc. This generating capacity produces over 20,000 average megawatts (aMW) of energy under the worst water conditions, and an additional 4,000 aMW when water conditions are average. Table 2–2 shows the breakdown of Pacific Northwest resources by resource type.

Table 2–2. Pacific Northwest Electric Generating Resources 1/

RESOURCE TYPE	CAPACITY 2/ (MW)	FIRM ENERGY (aMW)
Hydro	31,424	12,739
Coal	4,393	3,796
Nuclear	1,100	715
Imports	2,853	1,926
Combustion turbines	1,666	485
Other	1,184	1,123
Total	42,620	20,784

1/ From BPA "1993 Pacific Northwest Loads and Resources Study"
2/ January peak generating capacity

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 74 percent of the generating capacity in the Pacific Northwest, and approximately 61 percent of the firm energy supply. When in surplus, it is also an export product for the region.

The BPA was created in 1937 to market and transmit the power produced at Bonneville Dam. Today, BPA markets the power from 30 Federal dams and one nuclear plant in the Pacific Northwest and has built one of the largest and most reliable transmission systems in the United States.

BPA's service area includes Oregon, Washington, Idaho, western Montana and small parts of Wyoming, Nevada, Utah, California and eastern Montana. BPA sells wholesale power to public and private utilities, as well as to some large industries. BPA also sells or exchanges power with utilities in California and Canada.

About 85 percent of the firm energy BPA sells is hydroelectric. Table 2–3 shows BPA's resource mix.

Total BPA power sales for fiscal year 1992 amounted to nearly 74 million MWh. Of these, approximately 3 percent were sold to parties outside the region, 34 percent to directly–served industrial customers, 5 percent to investor–owned utilities, and 58 percent to public utility districts, municipalities, co–ops and Federal agencies.

The projects under review in this EIS account for over 95 percent of the Federal system's hydroelectric capability and 65 percent of the region's hydroelectric capability. (Other Federal generation exists on the Upper Snake and in the Willamette River basin.)

Power production on the Columbia River system traditionally has involved three primary objectives within a variety of system and project constraints:

- Meeting the region's firm energy commitments
- Optimizing future energy production through refill of storage reservoirs
- Maximizing nonfirm energy production to keep regional power rates as low as possible.

2.3.1 Firm Energy

Firm energy is the amount of energy that can be produced on a guaranteed basis, given the region's worst historical water conditions. Firm energy load–carrying capability (FELCC) is the amount of energy the region's generating system can be called on to produce on a firm basis during actual operations. FELCC is made up of both hydro and non–hydro resources, including power purchases.

Table 2–3. BPA Electric Generating Resources 1/

RESOURCE TYPE	CAPACITY 2/ (MW)	FIRM ENERGY (aMW)
Hydro	20,095	7,443
Nuclear	1,100	715
Firm Contracts	434	627
Total	21,629	8,785

1/ From BPA "1993 Pacific Northwest Loads and Resources Study"
2/ January peak generating capacity

The critical period refers to the portion of the historical stream flow record in which the hydro system would generate the least amount of energy, given the load shape, with all reservoirs drafted from full to "empty". (Empty means drawn down to the lowest operating level.) Each year, planners analyze the 50–year historical stream flow record and determine the critical period. Reservoirs are assumed to be full at the beginning of the critical period and drawn down to "empty" at the end.

The critical period has been based in recent years on the 42–month interval from September 1, 1928, through February 29, 1932. This is often referred to as the 4–year critical period. There are other periods in the 50–year stream flow record that have a volume runoff significantly below normal, but 1928–1932 yields the least amount of firm energy for the present system configuration and load shape. In the critical period, the hydro system produces about 12,700 aMW of FELCC.

2.3.2 Refill

The reservoirs of the hydropower system are used for many purposes. They are used to store water for power needs, for fish migration, for recreation, for irrigation and for other uses too numerous to mention. As planners begin to allocate volumes of water for various uses, consideration must be given to how far down to draft the reservoirs. Refilling the reservoirs is an important objective to ensure a full allocation of water for future uses. Given the uncertainty of the year's runoff, enough water must be retained in storage to provide flows necessary for spring fish migration and to ensure a high likelihood of reservoir refill by summer to fulfill recreational needs and provide water for next year's power generation.

2.3.3 Nonfirm Energy

Nonfirm energy is energy in excess of that needed to meet Pacific Northwest firm power requirements and which cannot be stored for future use. In most water years, stream flows are high enough to produce at least some nonfirm energy. This is particularly true after January 1, when initial runoff forecasts make it possible to estimate how much water will be available from snow pack runoff. In an average year, nonfirm generation may add over 30 percent to the hydro system's generating output. Nonfirm energy is generally sold with no guarantee of continuous availability and with the ability to terminate delivery on very short notice.

2.4 TRANSMISSION SYSTEM

The transmission grid in the Northwest is interconnected with Canada to the north, with California to the south, and with Utah and other states to the east. BPA's transmission system consists of over 14,500 circuit miles (23,200 km) of transmission lines. BPA's grid provides about three–fourths of the region's transmission capacity. Power produced at dams in the Northwest serves customers locally and thousands of miles away.

2.4.1 Pacific Northwest/Pacific Southwest Intertie

The Pacific Northwest/Pacific Southwest Intertie exists to transport power between the Pacific Northwest and California. The Intertie currently consists of three high–voltage transmission lines: two 500–kilovolt (kV) alternating current (AC) lines and one 1000–kV direct current (DC) line. The AC lines extend about 945 miles (1,521 km) from John Day Substation near John Day Dam on the Columbia River in Oregon to the Lugo Substation near Los Angeles. They interconnect with other transmission lines at eight points. The 846–mile (1,361–km) DC line runs from the Celilo Station near The Dalles Dam in Oregon to the Sylmar Station near Los Angeles. The line transmits power directly between the Pacific Northwest and Southern California.

Currently, the physical capability of the three Intertie lines is approximately 7900 MW––about 4800 MW on the two AC lines and 3100 MW on the DC line.

2.4.2 British Columbia Hydro Interconnections

Power from Canada is carried over B.C. Hydro's grid to one of two links between British Columbia and the Pacific Northwest: a pair of 500–kV lines near Blaine, Washington, and another pair of 230–kV lines north of Spokane. Total nonfirm transfer capability between the B.C. Hydro and BPA systems is currently 2300 MW.

From the Canadian border, power from British Columbia can be transmitted over the Pacific Northwest transmission grid to The Dalles area, where it can feed into the Intertie.

2.4.3 Sales Outside the Region

In some years, the region sells large quantities of power to customers outside the Pacific Northwest, principally to utilities in California and Canada. In other years, the region sells very little power outside of the Pacific Northwest. This variation is due to the nature of the hydroelectric system. In good water conditions, available power generation exceeds energy consumption within the region. This power is often sold outside the region on a nonfirm basis.

In addition, the differences in seasonal peaks between the Pacific Southwest and the Pacific Northwest provide an opportunity for sales and purchases of power. Since Pacific Northwest loads peak in the winter, and the Pacific Southwest in the summer, various arrangements for transfers of power at those times of year can be made.

In FY 1992, BPA sold over 2 million MWh of energy outside the Pacific Northwest, along with 1,500 MW of capacity.

CHAPTER 3

STUDY METHODS AND SCREENING RESULTS

The objective of this section is to describe the analytical methods used to estimate the effects of changes in Columbia River Basin system operations on the regional power system's ability to serve regional loads and the costs of serving that load. The SOR had two major analytical phases: screening analysis and full–scale analysis. Both will be described in this section; however, since the screening analysis has been previously documented, its description will be brief.

The full–scale analysis has been modified substantially for this Final EIS. These modifications will be described here. A comprehensive description of the full–scale analysis performed for the Draft EIS can be found in that document.

3.1 GENERAL DESCRIPTION OF STUDY METHODS

3.1.1 Screening Analysis

The purpose of the screening analysis was to quickly analyze 90 alternative system operating strategies and determine their impact on power system costs. The screening analysis consisted of two steps: first, to develop a spreadsheet model to quickly calculate changes in system costs given changes in the operation of the river system; and second, to determine the impact on power system costs of the ninety proposed system operating strategies under conditions of uncertainty.

3.1.2 Full–Scale Analysis

The purpose of the full–scale analysis for the Final EIS was to refine the work done during the screening phase and for the Draft EIS. The full–scale analysis evaluated a smaller number of alternatives in more detail, using a variety of methods. Impacts were determined for the entire Pacific Northwest region. Impacts were calculated for energy, sustained capacity and instantaneous capacity. Energy impacts were determined with a modified version of the spreadsheet model developed for screening and for the full–scale analysis in the Draft EIS. Capacity impacts were calculated with several spreadsheet models.

3.2 SCREENING ANALYSIS

3.2.1 Description of the Spreadsheet Model

The Power Work Group spreadsheet model for the screening phase was designed to quickly calculate the total system costs for alternative system operating strategies. To do this, a number of simplifying assumptions were made regarding resource acquisition, resource dispatch, resource operating costs, power purchase costs, etc. These simplifications allowed the spreadsheet model to quickly assess a wide range of inputs, thereby dealing with uncertainty and its impact on power system costs. The simplifying assumptions, however, made the model less useful for predicting exact changes in power system costs, and more useful for ranking alternative system operating strategies.

Model inputs consisted of total generation from the hydro and thermal systems, total loads, new resource costs, etc. Each of the 90 system operating strategies resulted in different monthly amounts of hydro system generation. These amounts were provided by a hydroregulation model, HYDROSIM, and were input to the spreadsheet model. Using these and other inputs, the model determined monthly loads, acquired new resources if needed, and operated the system by displacing regional thermal plants and selling excess power outside the region when possible. The output of the model was the total annual cost for the entire Pacific Northwest power system in millions of 1993 dollars. This cost consists of new resource capital costs, plus operating costs for all resources, plus costs for curtailment of service, less revenues from extraregional sales.

3.2.2 New Resource Acquisition Philosophy

One of the more difficult questions in determining power system costs is determining the amount of resources needed to replace potential losses in the hydropower system's capability. This question was especially difficult given the wide range of system operating strategies that were examined in the screening analysis. Traditionally the region has relied on the hydro system's flexibility to shape new resources to meet regional loads. In other words, resource needs could be determined on an "average annual" basis, and the hydro system could "fill in" monthly deficits resulting from the fact that the new resource's generation shape did not exactly match the system's needs.

These traditional methods were called into question under many of the alternatives analyzed in screening. The hydro system's flexibility was often severely restricted by the constraints imposed by many of the alternatives. The ability to cover monthly deficits given average annual energy acquisitions was not possible. Hence, the screening model assumed that the hydro system could not shape average annual energy acquisitions to cover monthly deficits. Given this assumption, the model incorporated three different philosophies regarding resource acquisitions. The philosophies ranged from building non-displaceable base load resources, to building no resources and buying spot-market energy. These methods are described in more detail in "Screening Analysis, Volume 1."

3.2.3 Input Uncertainty

The screening analysis allowed a number of input variables to vary: amount of nonfirm hydro generation, loads, fuel prices, nonfirm energy prices on the spot market, and new resource costs. Through use of decision analysis techniques, this uncertainty was incorporated into the screening analysis results. Again, this is described in "Screening Analysis, Volume 1."

3.2.4 Screening Results

The quantitative results developed from the screening model are presented in "Screening Analysis, Volume 2." These results showed that the power system cost impacts from the system operating strategies varied over a wide range. Some alternatives showed small decreases in yearly costs over the base case; others showed increases as high as $2 billion. The screening analysis primarily measured the effects of changes in Columbia River Basin system operations on the ability of the Northwest regional power system to serve regional *energy* loads. However, the Northwest regional power system also delivers another product--capacity. The limited scope of the screening analysis prevented a rigorous treatment of the effects of changes in river operations on the ability to deliver capacity. However, this is handled in more detail in the full-scale analysis.

3.3 FULL-SCALE STUDY METHODS

3.3.1 Overview of Analysis

The full-scale analysis looked at a smaller number of system operating strategies. This allowed for a greater level of sophistication in determining the impact of these strategies on the Northwest power system. To this end, the full-scale analysis employed a wider variety of models and techniques than was used in screening. These techniques will be described in this section.

It is important to remember the purpose of this analytical work--to compare the effects on the regional power system of the different SOSs being analyzed. The purpose of this analysis is not to predict exactly what would happen to power system costs if one of these SOSs were implemented. Hence, the methods employed in this analysis are appropriate for comparing alternatives, but not for predicting actual system costs or implementation strategies. This distinction will be pointed out in the description of methodology.

3.3.2 Overall Analytical Approach

Changing the hydropower system operating strategy affects the capability of the regional power system in a number of ways. The first is in its ability to generate energy, and the costs of generating that energy. The second is in its ability to generate capacity, and the costs of generating that capacity. The capacity question is more complex than the energy question because capacity can take many different forms: instantaneous ability to meet a peak load, sustained ability to meet a long–term capacity sale, etc. Changes in the regional power system's ability to provide these products, and the costs of providing these products, are the core of the power system impact analysis.

Power system impacts were examined across a range of hydrologic conditions. The hydroregulation model, HYDROSIM, provided information showing total monthly hydro generation for 50 years of historic water conditions, from September 1928 through August 1978. This was the entire hydrologic record available for this analysis. For more detailed information on hydroregulation modeling, please refer to Appendix A, River Operation Simulation.

The cost of the system's ability to provide energy was measured by calculating the total annual cost for operating the entire Pacific Northwest power system for each of these water conditions. This cost consisted of new resource capital costs plus operating costs for all resources, less revenues from extraregional sales. The result for each water condition was summed, and the average was the total *expected* annual cost, calculated across the range of hydrologic conditions. By averaging the results, each water condition was given equal weight.

The cost of the system's ability to provide sustained capacity was measured by evaluating the impact on the system's ability to produce 50 hour per week sustained capacity under critical water conditions. This capacity product is the ability to deliver energy during the daytime heavy load hours (10 hours a day for 5 weekdays) and have an equal amount of energy returned at night and on weekends. This capacity does not impact the monthly or annual average energy in the system since the amount of energy being delivered during the day is equal to the amount of energy returned off peak.

The cost of the system's ability to provide instantaneous capacity was measured by evaluating the impact on the system's ability to meet a one–hour peak load under critical water and extreme weather conditions.

The sum of the costs of the system's ability to provide energy, sustained capacity and instantaneous capacity give the power system costs for each of the SOSs. Deltas in these costs give the changes in power system costs due to changes in system operation.

Annual energy and capacity costs were calculated both for the loads and resources that existed in the 1995–96 operating year (OY 1996) and for the loads and resources that existed for the 2003–04 operating year (OY 2004). Results for intermediate years were determined by interpolation, and results for years past OY 2004 were assumed to stay constant. Since the economic analysis covers the years OY 1995–OY 2094 (see Appendix O), results for OY 1996 were assumed also for OY 1995 and results for OY 2004 were assumed for OY 2005–OY 2094.

3.3.3 Determination of Hydro System Capability

One of the most important aspects of the power system impact analysis was determining the ability of the regional hydro system to generate power——both capacity and energy. Under each SOS, the amount and pattern of hydro system generation can be quite different. These differences are described in more detail in Chapters 4 and 5.

3.3.3.1 Energy Production

Traditional methods have long described the hydro system's generating potential in terms of two different kinds of energy——firm and nonfirm. Firm energy is defined as the amount of guaranteed energy that can be generated by the hydro system if the hydro system were to experience its worst historical water conditions. Guaranteed in this context means energy usable by Northwest electric customers— —energy in the shape of the Northwest's load requirements. Worst historical water is often referred to as "critical water." Firm Energy Load Carrying Capability (FELCC) is the amount of energy the region's generating system can be called on to produce on a firm basis during actual operations. Regional hydro FELCC has been around 12,700 aMW in the past.

All energy generated in excess of firm energy is referred to as nonfirm energy; nonfirm because the system can only count on this energy if water conditions are better than the worst historical stream flows. In an "average" water year, the system can produce around 4,000 aMW of nonfirm energy.

The ability of the hydro system to produce firm energy is driven primarily by the hydropower system's ability to store water for later release. In other words, the hydro system can "move" water into times of the year when electricity is most needed by Northwest customers. This is commonly referred to as "flexibility." This implies an operation which stores water during spring and summer runoff periods for use in the winter when the Northwest experiences its greatest loads. In the past, the hydro system has had a significant amount of flexibility in its ability to move water around primarily to serve the needs of the power system.

This hydro system flexibility is severely restricted in some of the SOSs studied in the full—scale analysis. In some of these alternatives, the hydro system has little ability to move water into times of power need. It must generate power when the water is coming down the river, usually in response to a requirement from some other use area. This severely restricts the ability of the system to generate firm, useful energy and calls into question some of the traditional concepts and terms that have long been used to describe the hydro system's capabilities.

For example, in the past, energy deficits have been determined on an annual basis. Traditional Pacific Northwest resource planning methods have relied on the hydro system's flexibility to shape new resources into the power system. In other words, resource needs could be determined on an annual basis, and the hydro system could be counted on to fill in monthly energy deficits resulting from the fact that the new resource's monthly shape did not exactly match the system's monthly needs. However, given the restrictions imposed by many of the SOSs, the ability of the hydro system to cover monthly energy deficits given acquisitions that replace average annual deficits may no longer be possible.

It is not the intent of the energy impact analysis to reinvent terms or concepts for defining hydro system capability. But the issues raised here will be important in determining the amount and types of resources to be used to replace hydro system energy losses.

3.3.3.2 Capacity Production

The ability of the hydro system to generate capacity is also affected by changes in the timing of storing and releasing water. In the case of capacity, no clear standard (such as critical water) exists for determining the amount of firm capacity available from the hydro system. Also, capacity cannot be shifted easily from one period to another. Two notions of capacity exist, instantaneous and sustained. Historically, meeting the instantaneous peak load has not been a problem in the Northwest, but sustaining high loads for several hours per day for weeks at a time has been a problem.

Under the Pacific Northwest Coordination Agreement (PNCA) planning process, PNCA participants calculate a firm peak load carrying capability. This instantaneous peak measurement of the capacity on the system is the ability to meet an instantaneous or one—hour peak load. This type of capacity is primarily affected by the availability of generators and their maximum capability. It is generally evaluated by looking at generator maximum capability, maintenance schedules and forced outage rates. In the past, on a planning basis, the instantaneous capacity of the system has exceeded the peak load forecast by large margins. Currently, these margins are diminishing and the system may require resource additions to meet instantaneous peak loads in the future. This is discussed in section 3.3.7.

Sustained capacity is the ability of the hydro system to meet several hours of peak loads within a specific period of time day after day. This type of capacity is calculated by measuring both the amount of water (fuel) that can be released through the hydro project turbines during this time period, and the instantaneous capability. In addition, reservoir levels must be returned to their previous levels by reducing generation at later times. Generally water is drafted out of the reservoir for several hours to meet high loads and then generation is reduced so that inflows will replenish the reservoir. This process is limited by the rate at which water may be drafted and the rate at which reservoirs refill. During times of year when inflows are low, the rate at which a reservoir may be replenished becomes the constraining factor.

When marketed, sustained capacity usually meets a high load for eight to 12 hours per day, with an equivalent amount of energy returned at night. Sustained capacity may also be viewed as the ability to meet high loads for a cold week by drafting the system harder than average, with water re–stored in a lower load warm week.

The calculated sustained capacity value for the region is less than the calculated instantaneous capacity value. It is constrained by the instantaneous capacity and restricted by the ability to draft and store water and the rates at which this takes place. It should be viewed as a water management problem, with restrictions on hydro project operations as the constraints. Both sustained and instantaneous capacity are discussed in this Final EIS.

3.3.4 Resource Acquisition Philosophy

Determining power system costs for each SOS necessitates making assumptions about what types and quantities of resources will be needed to replace losses in the hydro system's capability. A new resource acquisition philosophy was adopted for the Final EIS for the energy portion of the full–scale analysis. This resource philosophy will be described here. For a description of the concepts used in the Draft EIS, see that document.

Reliability–Based Resource Acquisition

In past years, Northwest utilities acquired resources sufficient to maintain a "load/resource balance." This balance entailed comparing projected firm loads to anticipated firm resources on an annual basis, with firm hydro resources determined using worst or critical water. If resources exceeded loads, the system was said to be surplus. If loads exceeded resources, the system was considered deficit and utilities would acquire resources sufficient to eliminate the deficit.

Traditional "firm planning" methods for determining the need for new resources resulted in a highly reliable power supply, guaranteed by acquiring firm resources within the control of the region's utilities. Competition is forcing utilities to lower prices at the expense of this high level of reliability. Few, if any, Northwest utilities can afford to maintain the level of reliability suggested by the strictest interpretation of firm planning.

At present, utilities are relying on spot market purchases to meet indigenous loads to an unprecedented extent. This will continue until one of two things happens: either reliability will decline to a point where utilities decide acquisitions of firm resources in the Pacific Northwest are needed, or resource acquisitions will become competitive with the purchase market. How far utilities are willing to allow reliability levels to drop is unclear. No clear enforceable standards exist, and methods for assessing system reliability are in their infancy in the Northwest.

Therefore, a number of assumptions were needed in order to determine the regional resource acquisition plan for each SOS. For the purpose of comparing SOS alternatives, and determining the types of resources that would be acquired to meet changes in hydro output, analysts assumed that, at a minimum, regional utilities would strive to maintain a probability of failing to meet load equivalent to one day in twenty years. This level of reliability is enunciated as a target in the Pacific Northwest Coordination Agreement, though it is by no means binding on signatory utilities with regard to resource acquisition decisions.

A probabilistic analysis was performed on each SOS to determine if new resources were required to bring the regional power system into conformance with expected energy outages of 24 hours at average load service in 20 years (or 1.2 hours per year). For example, if average regional loads were 20,000 MW, acquisitions were made so that annual outages did not exceed 24,000 MW–hr (20,000 X 1.2).

Inability to model probabilities associated with hourly operations limited analysts to looking at the problem on a monthly basis. The standard was tightened from 1.2 to .83 hours per year to account for undetected outages occurring on an hourly basis. In the example above, acquisitions were made so that outages did not exceed 16,600 MW–hr (20,000 X .83).

Purchases from outside the Pacific Northwest were assumed up to the limits of the available intertie capability. Intertie availability was modeled as a random variable based on historical experience with intertie outages. Load levels were represented as random variables as was thermal plant performance. Hydro system generation was taken from a HYDROSIM run using historical water conditions as the random variable.

Thousands of scenarios were run, each with a different set of numbers for load levels, thermal unit performance, intertie availability and hydro generation. When available resources and spot market purchases were not sufficient to meet loads, a failure to meet load was tallied. Resources were added until annual load failures, averaged over all scenarios, were no greater than 16,600 MW–hr.

Two separate operating years were analyzed, September 1995–August 1996 (referred to as OY 1996) and September 2003–August 2004 (referred to as OY 2004). Regional loads and resources for these years were taken from BPA's 1994 Pacific Northwest Loads and Resources Study (also known as the White Book). For each SOS, the number of MWs of resources necessary to maintain the above reliability standards was determined for both OY 1996 and OY 2004.

Economic–Based Resource Acquisition

The reliability analysis determined the amount of resource acquisition that would be needed to maintain system reliability after supplies of spot market purchases were exhausted. A subsequent economic analysis determined that the most cost–effective resource to acquire to meet this need would be combined cycle combustion turbines.

Since the Draft EIS, costs of combined cycle combustion turbines have fallen dramatically. In that document, it was assumed that combined cycle combustion turbines cost an average of 37 mills/kWh to build and operate. However, costs for these CTs have dropped precipitously in the intervening years, more than 10 mills from the prices used in the Draft (see Chapter 4). This is due primarily to three factors: historically low natural gas prices, decreases in hardware costs, and increases in CT operating efficiency.

The new CT costs, plus the characteristics of CT resources (ability to operate when needed and be displaced in times of excess hydro generation) make combined cycle turbines appropriate resources for meeting the region's power reliability needs. In fact, studies for this Final EIS suggest that acquisition of combined cycle CTs becomes competitive with spot market purchases at about the same time they are needed to meet the 1 day in 20 years reliability standard. In some cases, CTs appear to become economic prior to the turbines being needed for reliability purposes on a monthly energy basis. The result of this is that the economic analysis comparing SOS alternatives is relatively insensitive to the timing and type of resource acquisitions.

Therefore, several assumptions were made. First, it was assumed that it would be impossible to site, license and construct CTs by OY 1996, so the analysis for that operating year assumed that all energy needs would be met by spot market purchases.

For OY 2004, an attempt was made to optimize the choice of combined cycle CTs versus purchases, after sufficient CTs were constructed to meet the reliability standard set above. Many combinations of purchases and CT acquisitions in OY 2004 yielded nearly identical results. In fact, replacement of combined cycle CTs with single cycle CTs also affected the results only negligibly. Even though costs in OY 2004 were very insensitive to the choice of purchases or CTs, the amount of combined cycle CTs was chosen to minimize total system costs in OY 2004. These results are presented in Chapter 4.

3.3.5 Treatment of Uncertainty

As mentioned above, the screening analysis treated a number of input variables as uncertain: amount of nonfirm hydropower generation (water), loads, fuel prices, nonfirm hydropower generation sale prices, and new resource costs. However, the screening analysis revealed that the variability associated with hydropower generation due to differing water conditions made the uncertainty associated with other input variables insignificant. Hence, the full–scale analysis looked only at the uncertainty surrounding water. Power system impacts were examined across a range of hydrologic conditions. Fifty years of historic water conditions were analyzed, from September 1928 through August 1978. This was the entire hydrologic record available for this analysis.

3.3.6 Energy Analysis

A number of different analytical methods were used to determine the power system impacts of the various SOSs. The energy analysis is discussed in this section, with the capacity analysis following.

A modified version of the spreadsheet model used both in the screening analysis and the full–scale analysis for the Draft EIS was the primary tool for determining energy system impacts. The spreadsheet model is briefly described above in Section 3.2.1. To reiterate, the model is designed to quickly calculate the total system costs of a given operation of the Pacific Northwest regional power system. Model inputs consist of information on total generation from the existing hydro and thermal system (with hydro generation coming from HYDROSIM), maintenance schedules for existing thermal resources, monthly loads, new resource costs, operating costs for existing thermal resources, prices for sales of energy to outside the region, and prices for purchases of energy from outside the region. Using these inputs, the model acquires new resources or makes purchases, and operates the system by displacing regional thermal plants if possible and selling power outside the region if excess generation is available. The output of the model is the total annual cost for the entire Pacific Northwest power system in millions of 1996 dollars. This cost consists of new resource capital costs plus operating costs for all resources, less revenues from extraregional sales. Costs were calculated for OY 1996 and OY 2004.

Major improvements in the model since the draft include: purchase power and nonfirm prices specified by month rather than annually; old, more expensive thermal plants displaced prior to new, efficient CTs; new data for purchase power costs and nonfirm prices, CT costs, loads and resources, etc. Data will be discussed in more detail in Chapter 4.

In addition, nonfirm prices were estimated slightly differently for the Final EIS. In the draft EIS, nonfirm prices were based on revenues that the Pacific Northwest could expect to receive from the sale of excess hydro generation to the Pacific Southwest. This recognized the fact that in the past, the Pacific Southwest has not necessarily paid for the true value of excess hydro generation. However, this meant that the Pacific Southwest would realize benefits (or costs) from changes in Pacific Northwest hydro generation that were not being captured in the analysis. To remedy this, nonfirm prices in the final EIS were based instead on the cost of the thermal resources displaced in the Pacific Southwest. These cost savings would accrue to the Pacific Southwest, but are now captured in the accounting. Hence the notion of "regional" costs has really been expanded to include the Pacific Southwest as well as the Pacific Northwest.

3.3.7 Capacity Analysis

3.3.7.1 Determination of Changes in Capacity

Measuring changes in the system's ability to generate capacity is a difficult exercise. Much of the capacity analysis depended on numerous assumptions, made on the basis of best judgement. In order to keep all of the alternatives on a "level playing field," the same assumptions were used for all alternatives, except where the specifications of a particular alternative called for restrictions. For each SOS, the loss or gain in capacity for each month was determined as compared to SOS 2c, the no–action alternative. The capacity analysis was done with a spreadsheet model and is intended to provide a relative ranking among the various alternatives.

As noted earlier, the term capacity itself can be defined in a number of ways. Instantaneous capacity is the amount of peak load that could be served at any instant. Fifty–hour sustained capacity is the amount of peak load that could be served 10 hours per day over a 5 day week assuming that the run–of–river projects can be refilled at night and over the weekend. Critical water conditions were used to determine capacity impacts.

Sustained Capacity

The analysis to determine changes in sustained capacity was done by taking the week's inflow at run–of–river plants, and shaping as much of the generation as possible into the 10 peak hours each day. For Grand Coulee, Chief Joseph, the mid–Columbias, and the lower Columbia, an additional 4 peak hours were included. This was done to represent ramping up to serve loads immediately before and ramping down after the 10 peak hours. This left the system at minimum generation for the remaining 10 hours. For the four lower Snake River plants, a simple 10–hour peak was used with no ramping. This is because there is a lot of peaking capability on the Snake compared to the normal flow, so under extreme conditions, the lower Snake River projects may be saved for peaking, while the reservoirs and remaining run–of–river projects serve more of the baseload.

Inflow was shaped at the run–of–river projects using the available forebay, and requiring the run–of–river projects to be back to their initial elevations by the beginning of the next week. This requirement was not applied to the reservoirs, since they would normally not be required to refill each week.

A difficult problem was whether or not the upstream projects would release additional water which could then be shaped by downstream run–of–river plants. In the winter, in a cold snap, a weekly average discharge from a plant might be much higher than the month average outflow. It was finally assumed that in the winter Grand Coulee would draft up to its maximum limit of 1.5 foot/day, while in the spring, no additional drafting would be done for capacity. In the summer only very limited amounts of drafting were allowed. Dworshak was allowed to generate full load in the winter with no extra draft in spring and small drafts in summer. It was assumed that the plants would not spill to move water downstream for peaking purposes.

For the reservoirs, maximum capacity was determined by either full load, or the maximum amount that could reasonably be generated given the non–power requirements on the project. A head loss check was also done. Ten percent of the generators were considered to be out–of–service at each plant, except Grand Coulee, which used 20 percent. This was done because the large third powerhouse units have historically been somewhat less reliable than the smaller units.

Some alternatives have flow targets and also specify the weekend flow be at least 80 percent of the previous five weekdays' average flows. However, no alternative has specified how much load factoring can be done at run–of–river plants on an average weekday. For the purposes of this analysis, it was assumed that there were no restrictions other than minimum flow, turbine capacity, and forebay range. For alternatives which specified spill at night, nighttime flows at spilling projects were assumed to be at least 50 percent of the daytime flows. If higher minimum flows were instituted at night, or the nighttime minimums were a larger percentage of the daytime flow levels, the capacity losses shown here would be even greater, since water released at night would not be available to generate during peak hours.

Operating the turbines within 1 percent of peak efficiency also limits the capacity of a system, both raising minimum flows, and limiting maximum generation. The effects of operating within 1 percent of peak efficiency were not examined in this analysis. It is not expected that including this effect would change the ranking of any of the alternatives.

For each SOS, the total change in capacity available on the system was a simple summation of the change in capacity from the run–of–river projects plus the reservoirs.

Instantaneous Capacity

An instantaneous capacity analysis was also performed for the Final EIS. The same spreadsheet model used to determine 50–hour sustained capacity was used to determine the change in one–hour peaking capability for each SOS as compared to SOS 2c. This was accomplished by setting the spreadsheet to only one peak hour per day, thereby providing the one hour peak capability that could be served in any day. This is a reasonable approximation for the peak capacity. It does not include tailwater rate of change constraints, and thus may somewhat over or understate the amount of instantaneous capacity for a particular alternative. However, it does clearly show the capacity effects of the drawdown alternatives, which were expected to have large capacity impacts. It was also effective at picking up the head differences at the reservoirs due to some hydro operations.

3.3.7.2 Determination of the Value of Capacity

Sustained capacity

For each SOS, the above analysis determined the change in the ability to produce sustained capacity as compared to SOS 2c. This sustained capacity change was given a particular value in each month, regardless of whether there was an increase or decrease in the amount of sustained capacity available (see Chapter 4). Since there is a West Coast market for sustained capacity, it was determined that its value would be determined by that market, and not by whether or not the Pacific Northwest itself was capacity surplus or deficit. Each monthly value approximated the market value of delivering energy on peak and included the cost differential between on peak and off peak energy.

The CTs added above for monthly energy reliability and economic purposes also provide value in delivering sustained capacity. These CTs were credited with the values shown in Chapter 4.

This methodology is significantly different from the methodology employed in the Draft EIS. In addition, the market for sustained capacity has also changed radically since the Draft was published, and this change is reflected in the much lower prices shown in Chapter 4.

Instantaneous capacity

Unlike in the sustained capacity analysis, instantaneous capacity changes were not valued at a market–based price. Instantaneous capacity is not normally a commodity that is bought and sold as is sustained capacity. Rather it is a reliability notion– –will there be enough generation to meet peak loads under worst case conditions?

Hence a load resource balance for instantaneous capacity was determined. This was developed by taking the instantaneous capacity load/resource balance in the 1994 White Book under extreme weather conditions, adjusting it for the addition of the CTs acquired above for monthly energy reliability, and then applying the changes in instantaneous capacity determined by the capacity spreadsheet model. This was done for OY 1996 and OY 2004 (OY 2005 was used as a proxy for OY 2004 since data for OY 2004 was not available).

At that point, all months showing continued deficits were charged with the costs of acquiring additional reserves. The price of reserves was determined by looking at the price BPA proposed to charge for reserves in its initial rate case proposal for 1995. These rates are documented in Chapter 4. Hence the costs of instantaneous capacity deficits were added to the costs of energy deficits and the costs of changes in sustained capacity in order to calculate the power impact cost of each SOS.

CHAPTER 4

ALTERNATIVES AND THEIR IMPACTS

4.1 GENERAL DESCRIPTION OF ALTERNATIVES

Seven alternative System Operating Strategies (SOS) were considered in the Draft EIS. Each of the 7 SOSs contained several options, bringing the total number of alternatives considered to 21. This Final EIS also evaluates 7 operating strategies, with a total of 13 alternatives now under consideration when accounting for options. Section 4.1 of this chapter describes the 13 alternatives and provides the rationale for including these alternatives in the Final EIS. Operating elements for each alternative are summarized in Table 4–1. Later sections of this chapter describe the effects of these alternatives on power.

The 13 final alternatives represent the results of the third analysis and review phase completed since SOR began. In 1992, the agencies completed an initial effort, known as "Screening" which identified 90 possible alternatives. Simulated operation for each alternative was completed for five water year conditions ranging from dry to wet years, impacts to each river use area were estimated using simplified analysis techniques, and the results were compared to develop 10 "candidate SOSs." The candidate SOSs were the subject of a series of public meetings held throughout the Pacific Northwest in September 1992. After reviewing public comment on the candidate strategies, the SOR agencies further reduced the number of SOSs to seven. These seven SOSs were evaluated in more detail by performing 50–year hydroregulation model simulations and by determining river use impacts. The impact analysis was completed by the SOR workgroups. Each SOS had several options so, in total, 21 alternatives were evaluated and compared. The results were presented in the Draft EIS, published in July, 1994. As was done after Screening, broad public review and comment was sought on the Draft EIS. A series of nine public meetings was held in September and October 1994, and a formal comment period on the Draft EIS was held open for over 4 1/2 months. Following this last process, the SOR agencies have again reviewed the list of alternatives and have selected 13 alternatives for consideration and presentation in the Final EIS.

Six options for the alternatives remain unchanged from the specific options considered in the Draft EIS. One option (SOS 4c) 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 final SOSs are not numbered consecutively. There is one new SOS category, Settlement Discussion Alternatives, which is labeled SOS 9 (see Section 4.1.6 for discussion).

The 13 alternatives have been evaluated through the use of a computerized model known as HYDROSIM. Developed by BPA, HYDROSIM is a hydroregulation model that simulates the coordinated operation of all projects in the Columbia River system. It is a monthly model with 14 total time periods. April and August are split into two periods each, because major changes can occur in streamflows in the first and second half of each of these months. The model is based on hydrologic data for a 50–year period of record from 1928 through 1978. For a given set of operating rule inputs and other project operating requirements, HYDROSIM will simulate elevations, flows, spill, storage content and power generation for each project or river control point for the 50–year period. For more detailed information, please refer to Appendix A, River Operation Simulation.

The following section describes the final alternatives and reviews the rationale for their inclusion in the Final EIS.

Table 4–1. SOS Alternative–1

Summary of SOS

SOS 1 Pre-ESA Operation	SOS 2 Current Operations	SOS 4 Stable Storage Project Operation
SOS 1 represents system operations before changes were made as a result of the ESA listing of three Snake River salmon stocks. SOS 1a represents operations from 1983 through the 1990–91 operating year, influenced by Northwest Power Act; SOS 1b represents how the system would operate without the Water Budget and related operations to benefit anadromous fish. Short-term operations would be conducted to meet power demands while satisfying nonpower requirements.	SOS 2 reflects operation of the system with interim flow improvement measures in response to the ESA salmon listings. It is consistent with the 1992–93 operations described in the Corps' 1993 Interim Columbia and Snake River Flow Improvement Measures Supplemental EIS. SOS 2c represents the operating decision made as a result of the 1993 Supplemental EIS and is the no action alternative for the SOS. Relative to SOS 1a, primary changes are additional flow augmentation in the Columbia and Snake Rivers and modified pool levels at lower Snake and John Day reservoirs during juvenile salmon migration. SOS 2d represents operations of the 1994-98 Biological Opinion issued by NMFS, with additional flow aumentation measures compared to SOS 2c.	SOS 4 would coordinate operation of storage reservoirs to benefit recreation, resident fish, wildlife, and anadromous fish, while minimizing impacts to power and flood control. Reservoirs would be managed to specific elevations on a monthly basis; they would be kept full longer, while still providing spring flows for fish and space for flood control. The goal is to minimize reservoir fluctuations while moving closer to natural flow conditions. SOS 4c attempts to accommodate anadromous fish needs by shaping mainstem flows to benefit migrations and would modify the flood control operations at Grand Coulee.

Actions by Project

	SOS 1	SOS 2	SOS 4
LIBBY	**SOS 1a** Normal 1983–1991 storage project operations **SOS 1b** • Minimum project flow 3 kcfs • No refill targets • Summer draft limit of 5–10 feet	**SOS 2c** Operate on system proportional draft as in SOS 1a **SOS 2d** • Provide flow augmentation for salmon and sturgeon when Jan. to July forecast is greater than 6.5 MAF • Meet sturgeon flows of 15, 20, and 12.5 kcfs in May, June, and July, respectively, in at least 3 out of 10 years	**SOS 4c** • Meet specific elevation targets as indicated by Integrated Rule Curves (IRCs); IRCs are based on storage content at the end of the previous year, determination of the appropriate year within the critical period, and runoff forecasts beginning in January • IRCs seek to keep reservoir full (2,459 feet) June-Sept; minimum annual elevation ranges from 2,399 to 2,327 feet, depending on critical year determination • Meet variable sturgeon flow targets at Bonners Ferry during May 25-August 16 period; flow targets peak as high as 35 kcfs in the wettest years

KAF = 1.234 million cubic meters

MAF = 1.234 billion cubic meters

Table 4–1. SOS Alternative–1

SOS 5 Natural River Operation	SOS 6 Fixed Drawdown	SOS 9 Settlement Discussion Alternatives	SOS PA
SOS 5 would aid juvenile salmon by increasing river velocity. The four lower Snake River projects would have new outlets installed, allowing the reservoirs to be drawn down to near the original river elevation. The "natural river" operation would be done for 4 1/2 months in SOS 5b and year-round in SOS 5c. John Day would also be operated at MOP for 4 months, and flow augmentation measures on the Columbia River portion of the basin would continue as in SOS 2c.	SOS 6 involves drawing down lower Snake River projects to fixed elevations below MOP to aid anadromous fish. SOS 6b provides for fixed drawdowns for all four lower Snake projects for 4 1/2 months; SOS 6d draws down Lower Granite only for 4 1/2 months. John Day would also be operated at MOP for 4 months, and flow augmentation measures on the Columbia River portion of the basin would continue as in SOS 2c.	SOS 9 represents operations suggested by the USFWS, NMFS, the state fisheries agencies, Native American tribes, and the Federal operating agencies during the settlement discussions in response to the *IDFG v. NMFS* court proceedings. This alternative has three options, SOSs 9a, 9b, and 9c, that represent different scenarios to provide increased river velocities for anadromous fish by establishing flow targets during migration and to carry out other actions to benefit ESA-listed species. The three options are termed the Detailed Fishery Operating Plan (9a), Adaptive Management (9b), and the Balanced Impacts Operation (9c).	SOS PA represents the operation recommended by NMFS and the USFWS Biological Opinions issued March 1, 1995. This SOS supports recovery of ESA-listed species by storing water during the fall and winter to meet spring and summer flow targets, and protects other resources by setting summer draft limits to manage negative effects, by providing flood protection, and by providing for reasonable power generation.

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b Operate on system proportional draft as in SOS 1a **SOS 5c** Operate on system proportional draft as in SOS 1a	**SOS 6b** Operate on system proportional draft as in SOS 1a **SOS 6d** Operate on system proportional draft as in SOS 1a	**SOS 9a** • Operate on minimum flow up to flood control rule curves year-round, except during flow augmentation period • Provide sturgeon flow releases April-Aug. to achieve up to 35 kcfs at Bonner's Ferry with appropriate ramp up and ramp down rates **SOS 9b** • Operate on minimum flow up to flood control rule curves year-round, except during flow augmentation • Provide sturgeon flow releases similar to SOS 2d • Can draft to elevation 2,435 by end of July to meet flow targets **SOS 9c** • Operate to the Integrated Rule Curves and provide sturgeon flow releases as in SOS 4c	**SOS PA** • Operate on minimum flow up to flood control rule curves beginning in Jan., except during flow augmentation period • Strive to achieve flood control elevations in Dec. in all years and by April 15 in 75 percent of years • Provide sturgeon flows of 25 kcfs 42 days in June and July • Provide sufficient flows to achieve 11 kcfs flow at Bonner's Ferry for 21 days after maximum flow period • Draft to meet flow targets, to a minimum end of Aug. elevation of 2,439 feet, unless deeper drafts needed to meet sturgeon flows

1 kcfs = 28 cms   1 ft = 0.3048 meter

Table 4–1. SOS Alternative–2
Actions by Project

	SOS 1	SOS 2	SOS 4
HUNGRY HORSE	**SOS 1a** Normal 1983–1991 storage project operations	**SOS 2c** Operate on system proportional draft as in SOS 1a	**SOS 4c** • Meet specific elevation targets as indicated by Integrated Rule Curves (IRCs), similar to operation for Libby • IRCs seek to keep reservoir full (3,560 feet) June-Sept.; minimum annual elevation ranges from 3,520 to 3,450 feet, depending on critical year
	SOS 1b • No maximum flow restriction from mid-Oct. to mid-Nov. • No draft limit; no refill target	**SOS 2d** Operate on system proportional draft as in SOS 1a	

	SOS 1	SOS 2	SOS 4
ALBENI FALLS	**SOS 1a** Normal 1983–1991 storage project operations	**SOS 2c** Operate on system proportional draft as in SOS 1a	**SOS 4c** Elevation targets established for each month, generally 2,056 feet Oct.–March, 2,058 to 2,062.5 feet April–May, 2,062.5 feet (full) June, 2,060 feet July–Sept. (but higher if runoff high); Oct.–March drawdown to 2,051 feet every 6th year
	SOS 1b No refill target	**SOS 2d** Operate on system proportional draft as in SOS 1a	

KAF = 1.234 million cubic meters MAF = 1.234 billion cubic meters

Table 4–1. SOS Alternative–2

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b Operate on system proportional draft as in SOS 1a **SOS 5c** Operate on system proportional draft as in SOS 1a	**SOS 6b** Operate on system proportional draft as in SOS 1a **SOS 6d** Operate on system proportional draft as in SOS 1a	**SOS 9a** • Operate on minimum flow up to flood control rule curves year-round, except during flow augmentation period **SOS 9b** • Operate on minimum flow up to flood control rule curves year-round, except during flow augmentation • Can draft to meet flow targets, to a minimum end-of-July elevation of 3,535 feet **SOS 9c** • Operate to the Integrated Rule Curves as in SOS 4c	**SOS PA** • Operate on minimum flow up to flood control rule curves year-round, except during flow augmentation period • Strive to achieve flood control elevations by April 15 in 75 percent of the years • Draft to meet flow targets, to a minimum end-of-August elevation of 3,540 feet

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b Operate on system proportional draft as in SOS 1a **SOS 5c** Operate on system proportional draft as in SOS 1a	**SOS 6b** Operate on system proportional draft as in SOS 1a **SOS 6d** Operate on system proportional draft as in SOS 1a	**SOS 9a** Operate on minimum flow up to flood control rule curves year-round, except during flow augmentation period **SOS 9b** • Operate on minimum flow up to flood control rule curves year-round, except during flow augmentation period • Can draft to meet target flows, to a minimum end-of-July elevation of 2,060 feet **SOS 9c** • Elevation targets established for each month, generally no lower than 2,056 feet Dec.—April, no lower than 2,057 feet end of May, full (2,062.5 feet) June—Aug., 2,056 feet Sept.—Nov.	**SOS PA** • Operate to flood control elevations by April 15 in 90 percent of the years • Operate to help meet flow targets, but do not draft below full pool through Aug.

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4–1. SOS Alternative–3
Actions by Project

	SOS 1	SOS 2	SOS 4
GRAND COULEE	**SOS 1a** • Operate to meet Water Budget target flows of 134 kcfs at Priest Rapids in May 1/ • Meet minimum elevation of 1,240 feet in May **SOS 1b** • No refill target of 1,240 feet in May • Maintain 1,285 feet June–Sept.; minimum 1,220 feet rest of year • No May–June flow target	**SOS 2c** • Storage of water for flow augmentation from January through April • Supplemental releases (in conjunction with upstream projects) to provide up to 3 MAF additional (above Water Budget) flow augmentation in May and June, based on sliding scale for runoff forecasts • System flood control space shifted from Brownlee, Dworshak **SOS 2d** • Contribute, in conjunction with upstream storage projects, up to 4 MAF for additional flow augmentation • Operate in summer to provide flow augmentation water and meet downstream flow targets, but draft no lower than 1,280 feet	**SOS 4c** • Operate to end-of-month elevation targets, as follows: 1,288 Sept.-Nov 1,287 Dec. 1,270 Jan. 1,260 Feb. 1,270 Mar. 1,272 Apr. 15 1,275 Apr. 30 1,280 May 1,288 Jun.-Aug. • Meet flood control rule curves only when Jan.-June runoff forecast exceeds 68 MAF
PRIEST RAPIDS	**SOS 1a** • Meet May-June flow targets 1/ • Maintain minimum flows to meet Vernita Bar Agreement 2/ **SOS 1b** • No May flow target • Meet Vernita Bar Agreement	**SOS 2c** Operate as in SOS 1a **SOS 2d** Operate as in SOS 1a	**SOS 4c** Operate as in SOS 1a

1/ Flow targets are weekly averages with weekend and holiday flows no less than 80 percent of flows over previous 5 days.
2/ 55 kcfs during heavy load hours October 15 to November 30; minimum instantaneous flow 70 kcfs December to April
KAF = 1.234 million cubic meters MAF = 1.234 billion cubic meters

Table 4–1. SOS Alternative–3

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b	**SOS 6b**	**SOS 9a**	**SOS PA**
Operate on system proportional draft and provide flow augmentation as in SOS 2c	Operate on system proportional draft and provide flow augmentation as in SOS 2c	• Operate to meet flood control requirements and Vernita Bar agreement • Provide flow augmentation releases to help meet targets at The Dalles of 220-300 kcfs April 16-June 15, 200 kcfs June 16-July 31, and 160 kcfs Aug. 1-Aug.31, based on appropriate critical year determination • In above average runoff years, provide 40% of the additional runoff volume as flow augmentation	• Operate to achieve flood control elevations by April 15 in 85% of years • Draft to meet flow targets, down to minimum end-of-Aug. elevation of 1,280 feet • Provide flow augmentation releases to meet Columbia River flow targets at McNary of 220-260 kcfs April 20-June 30, based on runoff forecast, and 200 kcfs July-Aug.
SOS 5c	**SOS 6d**	**SOS 9b**	
Operate on system proportional draft and provide flow augmentation as in SOS 2c	Operate on system proportional draft and provide flow augmentation as in SOS 2c	• Operate on minimum flow up to flood control rule curves year-round, except during flow augmentation period • Can draft to meet flow targets, bounded by SOS 9a and 9c targets, to a minimum end-of-July elevation of 1,265 feet	
		SOS 9c	
		• Operate to meet McNary flow targets of 200 kcfs April 16-June 30 and 160 kcfs in July • Can draft to meet flow targets, to a minimum end-of-July elevation of 1,280 feet • Contribute up to 4 MAF for additional flow augmentation, based on sliding scale for runoff forecasts, in conjunction with other upstream projects • System flood control shifted to this project	

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b	**SOS 6b**	**SOS 9a**	**SOS PA**
Operate as in SOS 1a	Operate as in SOS 1a	Operate as in SOS 1a	Operate as in SOS 1a
SOS 5c	**SOS 6d**	**SOS 9b**	
Operate as in SOS 1a	Operate as in SOS 1a	Operate as in SOS 1a	
		SOS 9c	
		Operate as in SOS 1a	

1 kcfs = 28 cms   1 ft = 0.3048 meter

Table 4–1. SOS Alternative–4

Actions by Project

	SOS 1	SOS 2	SOS 4
SNAKE RIVER ABOVE BROWNLEE	**SOS 1a** Normal 1990—91 operations; no Water Budget flows	**SOS 2c** Release up to 427 KAF (190 KAF April 16—June 15; 137 KAF Aug.; 100 KAF Sept.) for flow augmentation	**SOS 4c** Same as SOS 1a
	SOS 1b Same as SOS 1a	**SOS 2d** • Release up to 427 KAF, as in SOS 2c • Release additional water obtained by purchase or other means and shaped per Reclamation releases and Brownlee draft requirements; simulation assumed 927 KAF available	

	SOS 1	SOS 2	SOS 4
BROWNLEE	**SOS 1a** • Draft as needed (up to 110 KAF in May) for Water Budget, based on target flows of 85 kcfs at Lower Granite • Operate per FERC license • Provide system flood control storage space	**SOS 2c** Same as SOS 1a except for additional flow augmentation as follows: • Draft up to 137 KAF in July, but not drafting below 2,067 feet; refill from the Snake River above Brownlee in August • Draft up to 100 KAF in Sept. • Shift system flood control to Grand Coulee • Provide 9 kcfs or less in November; fill project by end of month • Maintain November monthly average flow December through April	**SOS 4c** Same as SOS 1a except slightly different flood control rule curves
	SOS 1b • No maximum flow restriction from mid-Oct. to mid-Nov. • No draft limit; no refill target	**SOS 2d** Same as SOS 2c, plus pass additional flow augmentation releases from upstream projects	

KAF = 1.234 million cubic meters

MAF = 1.234 billion cubic meters

Table 4–1. SOS Alternative–4

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b Same as SOS 1a **SOS 5c** Same as SOS 1a	**SOS 6b** Same as SOS 1a **SOS 6d** Same as SOS 1a	**SOS 9a** Provide up to 1.927 MAF through Brownlee for flow augmentation, as determined by Reclamation **SOS 9b** Provide up to 927 KAF through Brownlee as determined by Reclamation **SOS 9c** Provide up to 927 KAF through Brownlee as determined by Reclamation	**SOS PA** Provide 427 KAF through Brownlee for flow augmentation, as determined by Reclamation

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b Same as SOS 4c **SOS 5c** Same as SOS 4c	**SOS 6b** Same as SOS 4c **SOS 6d** Same as SOS 4c	**SOS 9a** • Draft up to 110 KAF in May, 137 KAF in July, 140 KAF in Aug., 100 KAF in Sept. for flow augmentation • Shift system flood control to Grand Coulee **SOS 9b** • Draft up to 190 KAF April-May, 137 KAF in July, 100 KAF in Sept. for flow augmentation • Shift system flood control to Grand Coulee • Provide an additional 110 KAF in May if elevation is above 2,068 feet and 110 KAF in Sept. if elevation is above 2,043.3 feet **SOS 9c** Same as SOS 9b	**SOS PA** Draft to elevation 2,069 feet in May, 2,067 feet in July, and 2,059 feet in Sept., passing inflow after May and July drafts

1 kcfs = 28 cms   1 ft = 0.3048 meter

Table 4–1. SOS Alternative–5

Actions by Project

	SOS 1	SOS 2	SOS 4
DWORSHAK	**SOS 1a** • Draft up to 600 KAF in May to meet Water Budget target flows of 85 kcfs at Lower Granite • Provide system flood control storage space **SOS 1b** • Meet minimum project flows (2 kcfs, except for 1 kcfs in August); summer draft limits; maximum discharge requirement Oct. to Nov. (1.3 kcfs plus inflow) • No Water Budget releases	**SOS 2c** Same as SOS 1a, plus the following supplemental releases: • 900 KAF or more from April 16 to June 15, depending on runoff forecast at Lower Granite • Up to 470 KAF above 1.2 kcfs minimum release from June 16 to Aug. 31 • Maintain 1.2 kcfs discharge from Oct. through April, unless higher required • Shift system flood control to Grand Coulee April–July if runoff forecasts at Dworshak are 3.0 MAF or less **SOS 2d** • Operate on 1.2 kcfs minimum discharge up to flood control rule curve, except when providing flow augmentation (April 10 to July 31) • Provide flow augmentation of 1.0 MAF plus 1.2 kcfs minimum discharge, or 927 KAF and 1.2 kcfs, from April 10-June 20, based on runoff forecasts, to meet Lower Granite flow target of 85 kcfs • Provide 470 KAF from June 21 to July 31 to meet Lower Granite flow target of 50 kcfs • Draft to 1,520 feet after volume is expended, if Lower Granite flow target is not met; if volume is not expended, draft below 1,520 feet until volume is expended	**SOS 4c** Elevation targets established for each month: 1,599 feet Sept.-Oct.; flood control rule curves Nov.-April; 1,595 feet May; 1,599 feet June-Aug.;

KAF = 1.234 million cubic meters MAF = 1.234 billion cubic meters

Table 4–1. SOS Alternative–5

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b • Operate to local flood control rule curve • No proportional draft for power • Shift system flood control to lower Snake projects • Provide Water Budget flow augmentation as in SOS 1a • Draft to refill lower Snake projects if natural inflow is inadequate	**SOS 6b** Same as SOS 5b	**SOS 9a** • Remove from proportional draft for power • Operate to local flood control rule curves, with system flood control shifted to Grand Coulee • Maintain flow at 1.2 kcfs minimum discharge, except for flood control or flow augmentation discharges • Operate to meet Lower Granite flow targets (at spillway crest) of 74 kcfs April 16-June 30, 45 kcfs July, 32 kcfs August	**SOS PA** • Operate on minimum flow-up to flood control rule curve year-round, except during flow augmentation period • Draft to meet flow targets, down to min. end-of-Aug. elevation of 1,520 feet • Sliding-scale Snake River flow targets at Lower Granite of 85 to 100 kcfs April 10-June 20 and 50 to 55 kcfs June 21-Aug. 31, based on runoff forecasts
SOS 5c • Operate to flood control during spring • Refill in June or July and maintain through August • Draft for power production during fall	**SOS 6d** Same as SOS 5b	**SOS 9b** • Similar to SOS 9a, except operate to meet flow targets at Lower Granite ranging from 85 to 140 kcfs April 16-June 30 and 50-55 kcfs in July • Can draft to meet flow targets to a min. end-of-July elevation of 1,490 feet	
		SOS 9c • Similar to SOS 9a, except operate to meet Lower Granite flow target (at spillway crest) of 63 kcfs April-June • Can draft to meet flow targets to a min. end-of-July elevation of 1,520 feet	

1 kcfs = 28 cms 1 ft = 0.3048 meter

Table 4–1. SOS Alternative–6

Actions by Project

	SOS 1	SOS 2	SOS 4
LOWER SNAKE	**SOS 1a** • Normal operations at 4 lower Snake River projects (within 3 to 5 feet of full pool, daily and weekly fluctuations) • Provide maximum peaking capacity of 20 kcfs over daily average flow in May **SOS 1b** Same as 1a, except: • No minimum flow limit (11,500 cfs) during fall and winter • No fish-related rate of change in flows in May	**SOS 2c** • Operate reservoirs within 1 foot above MOP from April 16 to July 31 • Same as SOS 1a for rest of year **SOS 2d** Same as SOS 2c	**SOS 4c** Same as SOS 2c

	SOS 1	SOS 2	SOS 4
LOWER COLUMBIA	**SOS 1a** • Normal operations at 4 lower Columbia projects (generally within 3 to 5 feet of full pool, daily and weekly fluctuations) • Restricted operation of Bonneville second powerhouse **SOS 1b** Same as 1a, except no restrictions on Bonneville second powerhouse	**SOS 2c** Same as SOS 1a except: lower John Day to minimum irrigation pool (approx. 262.5 feet) from April 15 to Aug. 31; operate within 1.5 feet of forebay range, unless need to raise to avoid irrigation impacts **SOS 2d** Same as SOS 2c	**SOS 4c** Same as SOS 2c, except operate John Day within 2 feet of elevation 263.5 feet Nov. 1 through June 30

KAF = 1.234 million cubic meters MAF = 1.234 billion cubic meters

Table 4–1. SOS Alternative–6

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b • Draft 2 feet per day starting Feb. 18 • Operate at natural river level, approx. 95 to 115 ft below full pool, April 16-Aug. 31; drawdown levels by project as follows, in feet: Lower Granite 623 Little Goose 524 L. Monumental 432 Ice Harbor 343 • Operate within 3 to 5 ft of full pool rest of year • Refill from natural flows and storage releases **SOS 5c** Same as SOS 5b, except drawdowns are permanent once natural river levels reached; no refill	**SOS 6b** • Draft 2 feet per day starting April 1 • Operate 33 feet below full pool April 16-Aug. 31; drawdown levels by project as follows, in feet: Lower Granite 705 Little Goose 605 L. Monumental 507 Ice Harbor 407 • Operate over 5-foot forebay range once drawdown elevation reached • Refill from natural flows and storage releases • Same as SOS 1a rest of year **SOS 6d** • Draft Lower Granite 2 feet per day starting April 1 • Operate Lower Granite near 705 ft for 4 1/2 months, April 16-Aug. 31	**SOS 9a** • Operate 33 feet below full pool (see SOS 6b) April 1-Aug. 31 to meet L. Granite flow targets (see Dworshak); same as SOS 1a rest of year • Spill to achieve 80/80 FPE up to total dissolved gas cap of 120% daily average; spill cap 60 kcfs at all projects **SOS 9b** • Operate at MOP, with 1 foot flexibility April 1-Aug. 31; same as SOS 1a rest of year • Spill to achieve 80/80 FPE up to total dissolved gas cap of 120% daily average; spill caps range from 18 kcfs at L. Monumental to 30 kcfs at L. Granite **SOS 9c** • Operate 35 to 45 feet below full pool April 1-June 15 to meet L. Granite flow targets (see Dworshak), refill by June 30; same as SOS 1a rest of year • Spill to achieve 80/80 FPE, as in SOS 9b	**SOS PA** • Operate at MOP with 1 foot flexibility between April 10 - Aug. 31 • Refill three lower Snake River pools after Aug. 31, Lower Granite after Nov. 15 • Spill to achieve 80% FPE up to total dissolved gas cap of 115% 12-hour average; spill caps range from 7.5 kcfs at L. Monumental to 25 kcfs at Ice Harbor

SOS 5	SOS 6	SOS 9	SOS PA
SOS 5b Same as SOS 2, except operate John Day within 1.5 feet above elevation 257 feet (MOP) from May 1 through Aug. 31; same as SOS 2c rest of year **SOS 5c** Same as SOS 5b	**SOS 6b** Same as SOS 5 **SOS 6d** Same as SOS 5	**SOS 9a** • Same as SOS 5, except operate John Day within 1 foot above elevation 257 feet April 15-Aug. 31 • McNary flow targets as described for Grand Coulee • Spill to achieve 80/80 FPE, up to total dissolved gas cap of 120% daily average, as derived by agencies **SOS 9b** • Same as SOS 2, except operate John Day at minimum irrigation pool or 262.5 feet with 1 foot of flexibility from April 16-Aug. 31 • McNary flow targets as described for Grand Coulee • Spill to achieve 80/80 FPE, up to total dissolved gas cap of 120% daily average, as derived by Corps **SOS 9c** Same as SOS 9b, except operate John Day at minimum operating pool	**SOS PA** • Pool operations same as SOS 2c, except operate John Day at 257 feet (MOP) year-round, with 3 feet of flexibility March-Oct. and 5 feet of flexibility Nov.-Feb. • Spill to achieve 80% FPE up to total dissolved gas cap of 115% 12-hour average; spill caps range from 9 kcfs at John Day to 90 kcfs at The Dalles

1 kcfs = 28 cms 1 ft = 0.3048 meter

4.1.1 SOS 1-Pre–ESA Operation

This alternative represents one end of the range of the SOR strategies in terms of their similarity to historical system operations. This strategy reflects Columbia River system operations before changes were made as a result of the ESA listing of three Snake River salmon stocks. This SOS has two options:

- **SOS 1a (Pre–Salmon Summit Operation)** represents operations as they existed from 1983 through the 1990–91 operating year, including Northwest Power Act provisions to restore and protect fish populations in the basin. Specific volumes for the Water Budget would be provided from Dworshak and Brownlee reservoirs to attempt to meet a target flow of 85 kcfs (2,380 cms) at Lower Granite Dam in May. Sufficient flows would be provided on the Columbia River to meet a target flow of 134 kcfs (3,752 cms) at Priest Rapids Dam in May. Lower Snake River projects would operate within 3 to 5 feet (0.9 to 1.5 m) of full pool. Other projects would operate as they did in 1990–91, with no additional water provided from the Snake River above Brownlee Dam.

- **SOS 1b (Optimum Load–Following Operation)** represents operations as they existed prior to changes resulting from the Northwest Power Act. It is designed to demonstrate how much power could be produced if most flow–related operations to benefit anadromous fish were eliminated including: the Water Budget; fish spill requirements; restrictions on operation of Bonneville's second powerhouse; and refill targets for Libby, Hungry Horse, Grand Coulee, Dworshak, and Albeni Falls. It assumes that transportation would be used to the maximum to aid juvenile fish migration.

4.1.2 SOS 2-Current Operations

This alternative reflects operation of the Columbia River system with interim flow improvement measures made in response to ESA listings of Snake River salmon. It is very similar to the way the system operated in 1992 and reflects the results of ESA Section 7 consultation with NMFS then. The strategy is consistent with the 1992–93 operations described in the Corps' *1993 Interim Columbia and Snake Rivers Flow Improvement Measures Supplemental EIS* (SEIS). SOS 2 also most closely represents the recommendations issued by the NMFS Snake River Salmon Recovery Team in May 1994. Compared to SOS 1, the primary changes are additional flow augmentation in the Columbia and Snake Rivers and modified pool levels at lower Snake and John Day reservoirs during juvenile salmon migration. This strategy has two options:

- **SOS 2c (Final SEIS Operation- No Action Alternative)** matches exactly the decision made as a result of the 1993 SEIS. Flow augmentation water of up to 3.0 MAF (3.7 billion m^3) on the Columbia River (in addition to the existing Water Budget) would be stored during the winter and released in the spring in low–runoff years. Dworshak would provide at least an additional 300 KAF (370 million m^3) in the spring and 470 KAF (580 million m^3) in the summer for flow augmentation. System flood control shifts from Dworshak and Brownlee to Grand Coulee would occur through April as needed. It also provides up to 427 KAF (527 million m^3) of additional water from the Snake River above Brownlee Dam.

- **SOS 2d (1994–98 Biological Opinion)** matches the hydro operations contained in the 1994–98 Biological Opinion issued by NMFS in mid–1994. This alternative provides water for the existing Water Budget as well as additional water, up to 4 MAF, for flow augmentation to benefit the anadromous fish migration. The additional water of up to 4 MAF would be stored in Grand Coulee, Libby and Arrow, and provided on a sliding scale tied to runoff forecasts. Flow targets are established at Lower Granite and McNary.

In cases such as the SOR, where the proposed action is a new management plan, the No Action Alternative means continuing with the present course of action until that action is changed (46 FR 13027). Among all of the strategies and options, SOS 2c best meets this definition for the No Action Alternative.

4.1.3 SOS 4-Stable Storage Project Operation

This alternative is intended to operate the storage reservoirs to benefit recreation, resident fish, wildlife, and anadromous fish while minimizing impacts of such operation to power and flood control. Reservoirs would be kept full longer, but still provide spring flows for fish and space for flood control. The goal is to minimize reservoir fluctuations while moving closer to natural flow conditions. For the Final EIS, this alternative has one option:

- **SOS 4c (Stable Storage Operation with Modified Grand Coulee Flood Control)** applies year–round Integrated Rule Curves (IRCs) developed by the State of Montana for Libby and Hungry Horse. Other reservoirs would be managed to specific elevations on a monthly basis; they would be kept full longer, while still providing spring flows for fish and space for flood control. The goal is to minimize reservoir fluctuations while moving closer to natural flow conditions. Grand Coulee would meet elevation targets year–round to provide acceptable water retention times; however, upper rule curves would apply at Grand Coulee if the January to July runoff forecast at the project is greater than 68 MAF (84 billion m^3).

4.1.4 SOS 5-Natural River Operation

This alternative is designed to aid juvenile salmon migration by drawing down reservoirs (to increase the velocity of water) at four lower Snake River projects. SOS 5 reflects operations after the installation of new outlets in the lower Snake River dams, permitting the lowering of reservoirs approximately 100 feet (30 m) to near original riverbed levels. This operation could not be implemented for a number of years, because it requires major structural modifications to the dams. Elevations would be: Lower Granite – 623 feet (190 m); Little Goose – 524 feet (160 m); Lower Monumental – 432 feet (132 m); and Ice Harbor – 343 feet (105 m). Drafting would be at the rate of 2 feet (0.6 m) per day beginning February 18. The reservoirs would refill again with natural inflows and storage releases from upriver projects, if needed. John Day would be lowered as much as 11 feet (3.3 m) to minimum pool, elevation 257 feet (78.3 m), from May through August. All other projects would operate essentially the same as in SOS 1a, except that up to 3 MAF (3.7 billion m^3) of water (in addition to the Water Budget) would be provided to augment flows on the Columbia River in May and June. System flood control would shift from Brownlee and Dworshak to the lower Snake River projects. Also, Dworshak would operate for local flood control. This alternative has two options:

- **SOS 5b (Four and One–half Month Natural River Operation)** provides for a lower Snake River drawdown lasting 4.5 months, beginning April 16 and ending August 31. Dworshak would be drafted to refill the lower Snake River projects if natural inflow were inadequate for timely refill.

- **SOS 5c (Permanent Natural River Operation)** provides for a year–round drawdown, and projects would not be refilled after each migration season.

4.1.5 SOS 6-Fixed Drawdown

This alternative is designed to aid juvenile anadromous fish by drawing down one or all four lower Snake River projects to fixed elevations approximately 30 to 35 feet (9 to 10 m) below minimum operating pool. As with SOS 5, fixed drawdowns depend on prior structural modifications and could not be instituted for a number of years. Draft would be at the rate of 2 feet (0.6 m) per day beginning April 1. John Day would be lowered to elevation 257 feet (78.3 m) from May through August. All other projects would operate essentially the same as under SOS 1a, except that up to 3 MAF (3.7 billion m^3) of water would be provided to augment flows on the Columbia River in May and June. System flood control would shift from Brownlee and Dworshak to the lower Snake projects. Also, Dworshak would operate for local flood control. This alternative has two options:

- **SOS 6b (Four and One–half Month Fixed Drawdown)** provides for a 4.5–month drawdown at all four lower Snake River projects beginning April 16 and ending August 31. Elevations would be: Lower Granite – 705 feet (215 m); Little Goose – 605 feet (184 m); Lower Monumental – 507 feet (155 m); and Ice Harbor – 407 feet (124 m).

- **SOS 6d (Four and One–half Month Lower Granite Fixed Drawdown)** provides for a 4.5–month drawdown to elevation 705 feet at Lower Granite beginning April 16 and ending August 31.

4.1.6 SOS 9-Settlement Discussion Alternatives

This SOS represents operations suggested by USFWS and NMFS (as SOR cooperating agencies), the State fisheries agencies, Native American tribes, and the Federal operating agencies during the settlement discussions in response to a court ruling in the *IDFG v. NMFS* lawsuit. The objective of SOS 9 is to provide increased velocities for anadromous fish by establishing flow targets during the migration period and by carrying out other actions that benefit ESA–listed species. The specific options were developed by a group of technical staff representing the parties in the lawsuit. The group was known as the Reasonable and Prudent Alternatives Workgroup. They developed three possible operations in addition to the 1994–98 Biological Opinion. This strategy has three options:

- **SOS 9a (Detailed Fishery Operating Plan [DFOP])** establishes flow targets at The Dalles based on the previous year's end–of–year storage content, similar to how PNCA selects operating rule curves. Grand Coulee and other storage projects are used to meet The Dalles flow targets. Specific volumes of releases are made from Dworshak, Brownlee, and upper Snake River to try to meet Lower Granite flow targets. Lower Snake River projects are drawn down to near spillway crest level for 4 1/2 months. Specific spill percentages are established at run–of–river projects to achieve no higher than 120 percent daily average total dissolved gas. Fish transportation is assumed to be eliminated.

- **SOS 9b (Adaptive Management)** establishes flow targets at McNary and Lower Granite based on runoff forecasts. Grand Coulee and other storage projects are used to meet the McNary flow targets. Specific volumes of releases are made from Dworshak, Brownlee, and the upper Snake River to try to meet Lower Granite flow targets. Lower Snake River projects are drawn down to minimum operating pool levels and John Day is at minimum irrigation pool level. Specific spill percentages are established at run–of–river projects to achieve no higher than 120 percent daily average for total dissolved gas.

- **SOS 9c (Balanced Impacts Operation)** draws down the four lower Snake River projects to near spillway crest levels for 2 1/2 months during the spring salmon migration period. Full drawdown level is achieved on April 1. Refill begins after June 15. This alternative also provides 1994–98 Biological Opinion flow augmentation (as in SOS 2d), IRC operation at Libby and Hungry Horse, a reduced flow target at Lower Granite due to drawdown, limits on winter drafting at Albeni Falls, and spill to achieve no higher than 120 percent daily average for total dissolved gas.

4.1.7 SOS PA-Preferred Alternative

This SOS represents the operation recommended by NMFS and USFWS in their respective Biological Opinions issued on March 1, 1995. SOS PA is intended to support recovery of ESA–listed species by storing water during the fall and winter to meet spring and summer flow targets, and to protect other resources by managing detrimental effects through maximum summer draft limits, by providing public safety through flood protection, and by providing for reasonable power generation. This SOS would operate the system during the fall and winter to achieve a high confidence of refill to flood control elevations by April 15 of each year, and use this stored water for fish flow augmentation. It establishes spring flow targets at McNary and Lower Granite based on runoff forecasts, and a similar sliding scale flow target at Lower Granite and a fixed flow target at McNary for the summer. It establishes summer draft limits at Hungry Horse, Libby, Grand Coulee, and Dworshak. Libby is also operated to provide flows for Kootenai River white sturgeon. Lower Snake River projects are drawn down to minimum operating pool levels during the spring and summer. John Day is operated at minimum operating pool level year–round. Specific spill percentages are established at run–of–river projects to achieve 80–percent FPE, with no higher than 115–percent 12–hour daily average for total dissolved gas measured at the forebay of the next downstream project.

4.1.8 Rationale for Selection of the Final SOSs

Table 4–2 summarizes the changes to the set alternatives from the Draft EIS to the Final EIS. SOS 1a and 1b are unchanged from the Draft EIS. SOS 1a represents a base case condition and reflects system operation during the period from passage of the Northwest Power Planning and Conservation Act until ESA listings. It provides a baseline alternative that allows for comparison of the more recent alternatives and shows the recent historical operation. SOS 1b represents a limit for system operation directed at maximizing benefits from development–oriented uses, such as power generation, flood control, irrigation and navigation and away from natural resources protection. It serves as one end of the range of alternatives and provides a basis for comparison of the impacts to power generation from all other alternatives. Public comment did not recommend elimination of this alternative because it serves as a useful mile-post. However, the SOR agencies recognize it is unlikely that decisions would be made to move operations toward this alternative.

In the Draft EIS, SOS 2 represented current operation. Three options were considered. Two of these options have been eliminated for the Final EIS and one new option has been added. SOS 2c continues as the No Action Alternative. Maintaining this option as the No Action Alternative allows for consistent comparisons in the Final EIS to those made in the Draft EIS. However, within the current practice category, new operations have been developed since the original identification of SOS 2c. In 1994, the SOR agencies, in consultation with the NMFS and USFWS, agreed to an operation, which was reflected in the 1994–98 Biological Opinion. This operation (SOS 2d) has been modeled for the Final EIS and represents the most "current" practice. SOS 2d also provides a good baseline comparison for the other, more unique alternatives. SOS 2a and 2b from the Draft EIS were eliminated because they are so similar to SOS 2c. SOS 2a is identical to SOS 2c except for the lack of an assumed additional 427 KAF of water from the upper Snake River Basin. This additional water did not cause significant changes to the effects between SOS 2a and 2c. There is no reason to continue to consider an alternative that has impacts essentially equal to another alternative. SOS 2b is also similar to SOS 2c, except it modified operation at Libby for Kootenai River white sturgeon. Such modifications are included in several other alternatives, namely SOS 2d, 9a, 9c, and the Preferred Alternative.

SOS 3a and 3b, included in the Draft EIS, have been dropped from consideration in the Final EIS. Both of these alternatives involved anadromous fish flow augmentation by establishing flow targets based on runoff forecast on the Columbia and Snake Rivers. SOS 3b included additional water from the upper Snake River Basin over what was assumed for SOS 3a. This operation is now incorporated in several new alternatives, including SOS 9a and 9b. Public comment also did not support continued consideration of the SOS 3 alternatives.

Table 4–2. Summary of Alternatives in the Draft and Final EIS

Draft EIS Alternatives	Final EIS Alternatives
SOS 1 Pre–ESA Operation	SOS 1 Pre–ESA Operation
SOS 1a Pre–Salmon Summit Operation	SOS 1a Pre–Salmon Summit Operation
SOS 1b Optimum Load Following Operation	SOS 1b Optimum Load Following Operation
SOS 2 Current Practice	SOS 2 Current Practice
SOS 2a Final Supplemental EIS Operation	SOS2c Final Supplemental EIS Operation – No–Action Alternative
SOS 2b Final Supplemental EIS with Sturgeon Operations at Libby	**SOS 2d 1994–98 Biological Opinion Operation**
SOS2c Final Supplemental EIS Operation – No–Action Alternative	
SOS 3 Flow Augmentation	
SOS 3a Monthly Flow Targets	
SOS 3b Monthly Flow Targets with additional Snake River Water	
SOS 4 Stable Storage Project Operation	SOS 4 Stable Storage Project Operation
SOS 4a1 Enhanced Storage Level Operation	**SOS 4c Enhanced Operation with modified Grand Coulee Flood Control**
SOS 4a3 Enhanced Storage Level Operation	
SOS 4b1 Compromise Storage Level Operation	
SOS 4b3 Compromise Storage Level Operation	
SOS 4c Enhanced Operation with modified Grand Coulee Flood Control	
SOS 5 Natural River Operation	SOS 5 Natural River Operation
SOS 5a Two Month Natural River Operation	SOS 5b Four and One Half Month Natural River Operation
SOS 5b Four and One Half Month Natural River Operation	**SOS 5c Permanent Natural River Operation**
SOS 6 Fixed Drawdown	SOS 6 Fixed Drawdown
SOS 6a Two Month Fixed Drawdown Operation	SOS 6b Four and One Half Month Fixed Drawdown Operation
SOS 6b Four and One Half Month Fixed Drawdown Operation	SOS 6d Four and One Half Month Lower Granite Drawdown Operation
SOS 6c Two Month Lower Granite Drawdown Operation	
SOS 6d Four and One Half Month Lower Granite Drawdown Operation	
SOS 7 Federal Resource Agency Operations	**SOS 9 Settlement Discussion Alternatives**
SOS 7a Coordination Act Report Operation	**SOS 9a Detailed Fishery Operating Plan**
SOS 7b Incidental Take Statement Flow Targets	**SOS 9b Adaptive Management**
SOS 7c NMFS Conservation Recommendations	**SOS 9c Balance Impacts Operation**
	SOS Preferred Alternative

Bold indicates a new or revised SOS alternative

SOS 4 originally included 5 options in the Draft EIS. They were similar in operation and impact. In SOS 4a and 4b, the primary feature was the use of Biological Rule Curves for Libby and Hungry Horse reservoirs. SOS 4c also included these rule curves but went further by optimizing the operation of the other storage projects, particularly Grand Coulee and Dworshak. For the Final EIS, the SOR agencies have decided to update the alternative by substituting the IRC for the Biological Rule Curves and by eliminating SOS 4a and 4b. The IRCs are a more recent, acceptable version of minimum elevations for Libby and Hungry Horse. Significant public comment in support of this alternative with IRCs was received. Similar to SOS 2 above, SOS 4a and 4b were not different enough in operation or impacts to warrant continued consideration.

The Natural River (SOS 5) and the Spillway Crest Drawdown (SOS 6) alternatives in the Draft EIS originally included options for 2 months of drawdown to the appropriate pool level and 4 1/2 months of drawdown. The practicality of 2–month drawdowns was questioned during public review, particularly for the natural river. It did not appear that the time involved in drawing down the reservoirs and later refilling them provided the needed consideration for other uses. Flows are restricted to refill the reservoirs at a time when juvenile fall chinook are migrating downstream and various adult species are returning upstream. The 2 1/2 month drawdown strategies (SOS 5a, 6a, and 6c) have been dropped from the Final EIS. However, 2 1/2 month spillway crest drawdown at all four lower Snake projects is still an element in SOS 9c, so the impacts associated with this type of operation are assessed in the Final EIS.

A new option was added to SOS 5, namely SOS 5c. This option includes natural river drawdown of the lower Snake River projects on a permanent, year–round basis. The Corps received comment on this type of alternative during the review of Phase I of the SCS, a reconnaissance assessment of potential physical modifications for the system to enhance fish passage. Many believe the cost for such modification would be less than that required for periodic, temporary drawdowns, which would require specialized facilities to enable the projects to refill and operate at two different pool elevations.

SOS 7 Federal Resource Agencies Operations, which included 3 options in the Draft EIS, has been dropped from the Final EIS and replaced with an alternative now labeled as SOS 9 that also has 3 options. SOS 7a was suggested by the USFWS and represented the State fishery agencies and tribes' recommended operation. Since the issuance of the Draft EIS, this particular operation has been revised and replaced by the DFOP (SOS 9a). The SOR agencies received comment that the DFOP was not evaluated, but should be. Therefore, we have included this alternative exactly as proposed by these agencies; it is SOS 9a. SOS 7b and 7c were suggested by NMFS through the 1993 Biological Opinion. This opinion suggested two sets of flow targets as a way of increasing flow augmentation levels for anadromous fish. The flow targets came from the Incidental Take Statement and the Conservation Recommendation sections of that Biological Opinion. The opinion was judged as arbitrary and capricious as a result of legal action, and these operational alternatives have been replaced with other alternatives that were developed through settlement discussions among the parties to this lawsuit. SOS 7b and 7c have been dropped, but SOS 9b and 9c have been added to represent operations stemming from NMFS or other fishery agencies. In particular, SOS 9b is like DFOP but has reduced flow levels and forgoes drawdowns. It is a modification to DFOP. SOS 9c incorporates elements of operation supported by the State of Idaho in its "Idaho Plan." It includes a 2 1/2–month spillway crest drawdown on the lower Snake River projects and several other elements that attempt to strike a balance among the needs of anadromous fish, resident fish, wildlife and recreation.

Shortly after the alternatives for the Draft EIS were identified, the Nez Perce Tribe suggested an operation that involved drawdown of Lower Granite, significant additional amounts of upper Snake River water, and full pool operation at Dworshak (i.e., Dworshak remains full year round). It was labeled as SOS 8a. Hydroregulation of that operation was completed and provided to the Nez Perce Tribe. No technical response has been received from the Nez Perce Tribe regarding the features or results of this alternative. However, the elements of this operation are generally incorporated in one or more of the other alternatives, or impose requirements on the system or specific projects that are outside the range considered reasonable. Therefore, this alternative has not been carried forward into the Final EIS.

The Preferred Alternative represents operating requirements contained in the 1995 Biological Opinions issued by NMFS and USFWS on operation of the FCRPS. These opinions resulted from ESA consultation conducted during late 1994 and early 1995, which were a direct consequence of the lawsuit and subsequent judgement in *Idaho v. NMFS*. The SOR agencies are now implementing this operating strategy and have concluded that it represents an appropriate balance among the multiple uses of the river. This strategy recognizes the importance of anadromous fish and the need to adjust river flows to benefit the migration of all salmon stocks, as well as the needs of resident fish and wildlife species at storage projects.

4.2 ENERGY ANALYSIS

4.2.1 Data and Assumptions

A number of assumptions were necessary in order to determine the energy costs for each SOS. These assumptions are as follows:

Loads and resources

Energy loads and resources were taken from the BPA's 1994 Pacific Northwest Loads and Resources Study (also known as the White Book) for OY 1996 and OY 2004.

CT costs and operating characteristics

The total cost for capital and operation of a combined cycle CT in OY 1996 was 26.3 mills/kWh in 1996 dollars. Of this total, 14.9 mills/kWh was considered fixed and payable regardless of whether or not the CT was operating. The rest, 11.4 mills/kWh, was considered variable, displaceable in times of excess hydro generation. The total for OY 2004 was 27.1 mills/kWh in 1996 dollars, 14.0 fixed and 13.1 variable. Due to the cost–effectiveness of these new efficient CTs, in times of excess hydro, it was assumed that these resources would be displaced after existing high cost thermal resources. This is a change from the Draft EIS, and causes these CTs to operate more often than was assumed in the Draft.

Purchase power costs

Average purchase power costs for OY 1996 and OY 2004 are shown in Table 4–3. These averages are by month and reflect the average costs for the amount purchased shown in Column 1.

Nonfirm prices

Average nonfirm prices are shown in Table 4–4. These averages are by month and reflect the average prices for the amount sold shown in Column 1. These numbers differed in character from those used in the Draft EIS, as explained in Chapter 3. They are based on the savings realized from displacement of Pacific Southwest thermal plants.

DSI interruptible load

Given the overwhelming changes in regional electric markets since publishing of the Draft EIS, it was assumed for the final that the DSI interruptible load would be served as firm load by some regional party. Hence there was no longer a need to value or keep track of DSI load curtailment.

Table 4–3. Average Purchase Power Prices (Mills/kWh – 1996 Dollars)

OY 1995–96												
aMW	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
500	20.0	19.8	19.0	21.0	23.0	21.5	20.5	20.8	19.8	19.8	19.8	20.8
1000	21.3	23.3	19.9	22.3	24.5	23.3	22.3	23.4	22.4	22.4	22.4	24.3
1500	21.8	24.3	21.2	22.8	26.3	23.8	22.8	25.9	24.9	24.9	24.9	27.8
2000	22.3	25.0	22.4	23.3	26.8	25.0	24.3	28.4	27.4	27.4	27.4	29.2
2500	25.0	25.8	23.9	26.0	27.3	28.0	26.8	30.9	29.9	29.9	29.9	29.7
3000	28.0	26.9	25.4	29.0	29.5	31.0	29.3	32.9	31.9	31.9	31.9	30.4
3500	31.0	28.4	26.9	32.0	32.5	34.0	31.8	34.4	33.4	33.4	33.4	31.4
4000	34.0	29.9	28.4	35.0	35.5	37.0	34.3	35.9	34.9	34.9	34.9	32.4
4500	37.0	31.4	29.9	38.0	38.5	40.0	36.8	37.4	36.4	36.4	36.4	33.4
5000	40.0	32.9	31.4	41.0	41.5	43.0	39.3	38.9	37.9	37.9	37.9	34.4
5500	43.0	34.4	32.9	44.0	44.5	46.0	41.8	40.4	39.4	39.4	39.4	35.4
6000	46.0	35.9	34.4	47.0	47.5	49.0	44.3	41.9	40.9	40.9	40.9	36.4
OY 2003–04												
aMW	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
500	23.4	23.1	22.3	24.6	26.9	25.2	24.0	24.3	23.1	23.1	23.1	24.3
1000	24.9	27.2	23.3	26.1	28.7	27.2	26.1	27.4	26.2	26.2	26.2	28.4
1500	25.5	28.4	24.8	26.7	30.8	27.8	26.7	30.3	29.1	29.1	29.1	32.5
2000	26.1	29.3	26.3	27.2	31.3	29.3	28.4	33.2	32.0	32.0	32.0	34.2
2500	29.3	30.2	28.0	30.5	31.9	32.8	31.3	36.1	35.0	35.0	35.0	34.7
3000	32.8	31.5	29.8	34.0	34.6	36.3	34.3	38.5	37.3	37.3	37.3	35.6
3500	36.3	33.3	31.5	37.5	38.1	39.8	37.2	40.2	39.1	39.1	39.1	36.8
4000	39.8	35.0	33.3	41.0	41.6	43.4	40.1	42.0	40.8	40.8	40.8	38.0
4500	43.4	36.8	35.0	44.5	45.1	46.9	43.1	43.8	42.6	42.6	42.6	39.1
5000	46.9	38.5	36.8	48.0	48.6	50.4	46.0	45.5	44.3	44.3	44.3	40.3
5500	50.4	40.3	38.5	51.6	52.1	53.9	48.9	47.3	46.1	46.1	46.1	41.5
6000	53.9	42.1	40.3	55.1	55.7	57.4	51.8	49.0	47.9	47.9	47.9	42.6

Table 4–4. Average Nonfirm Prices (Mills/kWh – 1996 Dollars)

OY 1995–96												
aMW	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**
500	16.0	16.0	18.0	20.0	22.0	18.0	16.0	15.0	15.0	15.0	15.0	16.0
1000	15.5	15.5	17.5	19.5	21.5	17.5	15.5	15.0	14.5	14.5	14.5	15.5
1500	15.0	15.3	17.0	19.3	21.3	17.3	15.3	14.7	14.3	14.3	14.3	15.0
2000	14.5	15.3	16.8	19.3	21.3	17.0	15.0	14.3	14.0	14.0	14.0	14.5
2500	14.0	15.2	16.6	19.0	21.0	16.6	14.8	13.8	13.6	13.6	13.6	14.0
3000	13.5	15.0	16.5	18.7	20.7	16.3	14.5	13.3	13.2	13.0	13.2	13.7
3500	12.7	14.7	16.3	18.3	20.1	16.0	14.1	12.6	12.7	12.1	12.7	13.3
4000	11.6	14.4	16.0	17.9	19.6	15.6	13.8	11.5	11.9	11.3	12.1	12.6
4500	10.3	13.6	15.7	17.4	18.9	15.1	13.3	10.2	10.6	10.0	11.4	11.8
5000	9.3	12.2	15.2	17.0	18.1	14.2	12.6	9.2	9.5	9.0	10.3	10.6
5500	8.5	11.1	14.4	16.3	16.8	12.9	11.5	8.4	8.6	8.2	9.4	9.6
6000	7.8	10.2	13.2	15.3	15.4	11.8	10.5	7.7	7.9	7.5	8.6	8.8
OY 2003–04												
aMW	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**
500	19.0	18.7	21.1	23.4	26.0	21.0	18.0	18.0	18.0	17.0	17.0	18.0
1000	18.5	18.2	20.5	22.8	25.5	20.5	17.5	17.5	17.5	17.0	17.0	18.0
1500	18.0	18.0	19.9	22.7	25.0	20.0	17.3	17.3	17.0	16.7	16.7	17.7
2000	17.5	17.9	19.6	22.6	24.5	19.5	17.3	17.0	16.5	16.3	16.3	17.3
2500	17.0	17.8	19.4	22.3	24.0	19.2	17.0	16.6	16.2	16.0	15.8	16.8
3000	16.7	17.6	19.3	21.9	23.5	18.8	16.7	16.3	16.0	15.8	15.5	16.5
3500	16.4	17.3	19.1	21.4	23.1	18.6	16.4	16.1	15.9	15.6	15.3	16.3
4000	16.3	17.2	18.7	20.9	22.9	18.4	16.3	16.0	15.6	15.3	15.1	16.1
4500	16.0	17.0	18.4	20.5	22.7	18.2	16.1	15.8	15.3	14.7	14.9	15.9
5000	15.8	15.3	18.2	20.2	22.5	18.1	15.9	15.4	14.8	13.9	14.3	15.3
5500	15.3	13.9	18.0	19.9	22.1	17.8	15.3	14.7	13.9	12.6	13.4	13.9
6000	14.0	12.8	16.5	19.6	21.4	17.1	14.0	13.5	12.8	11.6	12.3	12.8

4.2.2 Total Hydropower System Generation

Each SOS was analyzed using HYDROSIM, a hydroregulation model. A description of this model can be found in Appendix A, River Operation Simulation. HYDROSIM determined the total monthly hydropower generation in average megawatts for each SOS for each of the 50 water conditions. Tables displaying this generation for each SOS appear as technical exhibits at the end of this appendix.

Table 4–5 summarizes the results, showing the monthly hydro generation, averaged over the 50 water years, for each SOS.

4.2.3 Surpluses and Deficits

Given the total hydropower generation described above, a table showing monthly surpluses and deficits for each of the 50 water years was developed for each SOS for OY 1996. These tables were calculated by subtracting the monthly load that the hydro system was being asked to serve from the monthly generation of the hydro system. If load exceeds hydro generation, a deficit exists; deficits are displayed as negative numbers in the surplus/deficit tables. If hydro generation exceeds load, a surplus exists; surpluses are displayed as positive numbers in the surplus/deficit tables. Surplus/deficit tables for each SOS for OY 1996 appear as technical exhibits at the end of this appendix.

Table 4–6 summarizes the results, showing the monthly surpluses or deficits, averaged over the 50 water years, for each SOS for OY 1996. Since this table shows results averaged over 50 water years, deficits are apparent only in some months. Deficits occur in low water years and are identified by water year in the surplus/deficit tables at the end of this appendix.

4.2.4 New Resource Acquisition

Many of the SOSs show large deficits in a number of months under low water conditions. These deficits must be replaced with other sources of power. Hence it is low, rather than average, water conditions which drive resource acquisitions. Again, it was assumed that a combination of spot market purchases and combined cycle combustion turbines would be used to replace lost hydro generation, based both on reliability and economics. In OY 1996, all replacements were assumed to be spot market purchases. The average MWs of CTs acquired by OY 2004 for each SOS are shown in Table 4–7.

Although CTs are acquired, they are only operated when energy from them is needed. For example, the preferred alternative shows acquisition of 2200 aMWs of CTs by OY 2004. However, in that year, these CTs run only 63 percent of the time, averaged over 50 water conditions. Also in that year, approximately 800 aMWs of spot market purchases are acquired and existing high cost thermal resources operate approximately 50 percent of the time. This compares to acquiring 700 aMWs of CTs in SOS 2c. These CTs operate 71 percent of the time; in addition, 1000 aMWs of spot market purchases are acquired and existing high cost thermal resources operate approximately 58 percent of the time.

Table 4–5. Total Monthly Energy from Hydro System Generation for each SOS (aMW) (Average over 50 Water Conditions)

	1a	1b	2c	2d	4c	5b	5c	6b	6d	9a	9b	9c	PA
SEP	12429	12767	12355	12284	9911	11787	12021	11942	12401	9049	9019	9274	9999
OCT	12734	12996	12763	12730	12378	12850	12264	12992	12994	9286	9744	10972	11208
NOV	14229	14457	13938	13702	13441	13766	13566	14145	14145	11007	11608	13840	12483
DEC	16060	16150	15883	15747	17078	16059	15320	16244	16244	13977	15985	17148	15310
JAN	20433	20406	20098	17374	20105	20136	19300	20147	20147	16497	15902	17384	16922
FEB	19072	19219	19039	18618	18774	19260	17847	19074	19074	17794	17706	18546	17870
MAR	17781	17155	16797	18483	16499	16719	15506	16804	16791	17827	19639	18885	18180
15–Apr	18145	17612	18040	18257	18279	15818	15846	18138	17835	18682	19318	17367	19478
30–Apr	19121	19101	18511	18460	18989	16575	17185	17866	18414	20371	22079	18005	20808
MAY	22067	22183	21954	21061	21816	19225	20316	20792	21459	21102	21034	18938	21385
JUNE	20364	21242	21440	22402	22768	18902	19607	20413	21062	20832	22474	20750	22622
JULY	16411	17207	16248	17747	17590	14865	15496	15520	15793	17659	17174	17244	18311
15–Aug	13446	13620	13216	13015	13212	12351	12945	12661	12741	13848	13361	12844	14606
31–Aug	12264	12361	12087	12027	11149	11184	11671	11463	11581	13522	12082	11186	11972
AVG	16909	17080	16771	16737	16752	15943	15826	16494	16682	15676	16130	16042	16464

Table 4–6. Monthly Surplus/Deficit for each SOS for OY 1996 (aMW) (Average over 50 Water Conditions)

	1a	1b	2c	2d	4c	5b	5c	6b	6d	9a	9b	9c	PA
SEP	971	1309	897	826	−1547	329	563	484	943	−2409	−2439	−2185	−1459
OCT	840	1102	869	836	484	956	370	1098	1099	−2608	−2150	−922	−686
NOV	886	1114	595	359	98	423	223	802	802	−2336	−1735	497	−860
DEC	1509	1599	1332	1196	2527	1508	769	1693	1693	−574	1434	2597	759
JAN	5143	5116	4808	2084	4815	4846	4010	4857	4857	1207	613	2094	1632
FEB	4326	4473	4293	3872	4028	4514	3101	4328	4328	3048	2961	3800	3124
MAR	3438	2812	2454	4140	2156	2376	1163	2461	2448	3484	5296	4542	3837
15–Apr	4547	4014	4442	4659	4681	2220	2248	4540	4237	5084	5720	3769	5880
30–Apr	4676	4656	4066	4015	4544	2130	2740	3421	3969	5926	7634	3560	6363
MAY	7019	7135	6906	6013	6768	4177	5269	5744	6411	6054	5986	3890	6337
JUNE	6540	7417	7615	8577	8943	5077	5782	6588	7237	7007	8649	6925	8797
JULY	3872	4668	3709	5208	5051	2326	2957	2981	3254	5120	4635	4705	5772
15–Aug	850	1025	621	420	617	−244	350	66	146	1253	766	249	2011
31–Aug	−457	−360	−634	−694	−1572	−1537	−1050	−1258	−1140	801	−639	−1535	−749
AVG	3279	3451	3144	3109	3122	2318	2196	2868	3056	2044	2499	2414	2834

Table 4–7. CTs Built for Reliability and Economics (OY 2004, aMW)

SOS 1a	300
SOS 1b	500
SOS 2c	700
SOS 2d	1500
SOS 4c	700
SOS 5b	700
SOS 5c	815
SOS 6b	700
SOS 6d	700
SOS 9a	2875
SOS 9b	2250
SOS 9c	1625
SOS PA	2200

4.2.5 Regional Energy Impacts from Spreadsheet Model

Table 4–8 shows the results, in millions of 1996 dollars, from application of the spreadsheet model to the 13 final SOR alternatives. Results are the total costs of operating the Pacific Northwest regional power system for OY 1996 through OY 2004. The spreadsheet model calculates a cost for each of the 50 water conditions. The costs shown are the average costs over the 50 different water conditions. They include operating and maintenance costs for all Pacific Northwest thermal resources, costs for acquiring and operating CTs, plus costs of spot market purchases, less revenues from sales of power outside the region. They do not include any costs that would be required to modify existing structures to accommodate these operating strategies. They also do not include the cost of paying off the debt on existing system resources, which does not change across alternatives. In addition, costs for obtaining water from the upper Snake system are not included.

Costs for OY 1997 through OY 2003 were calculated by interpolating between the costs for OY 1996 and OY 2004, which were empirically estimated with the spreadsheet model.

Table 4–8. Total Regional Energy Costs (Millions 1996 Dollars)

	1996	1997	1998	1999	2000	2001	2002	2003	2004
SOS 1a	991	1048	1105	1161	1218	1275	1331	1388	1445
SOS 1b	979	1033	1086	1140	1193	1247	1300	1354	1407
SOS 2c	1026	1087	1147	1207	1268	1328	1388	1449	1509
SOS 2d	1055	1118	1181	1243	1306	1369	1432	1495	1558
SOS 4c	1075	1139	1203	1266	1330	1394	1458	1522	1585
SOS 5b	1108	1176	1243	1311	1379	1447	1514	1582	1650
SOS 5c	1132	1201	1270	1339	1407	1476	1545	1614	1683
SOS 6b	1054	1116	1179	1241	1303	1366	1428	1490	1553
SOS 6d	1038	1099	1159	1220	1280	1341	1401	1462	1522
SOS 9a	1268	1344	1420	1496	1571	1647	1723	1799	1874
SOS 9b	1226	1297	1367	1438	1509	1580	1650	1721	1792
SOS 9c	1167	1237	1308	1378	1449	1520	1590	1661	1732
SOS PA	1143	1211	1280	1349	1417	1486	1554	1623	1692

4.3 CAPACITY ANALYSIS

Data

Values for the capacity analysis are shown in Table 4–9. Values for sustained capacity were applied to all changes in sustained capacity and are based on market prices. A slight escalation in capacity values was assumed from OY 1996 to OY 2004. Values for instantaneous capacity were based on BPA's forecast of rates charged for reserves. No escalation was assumed in these prices.

4.3.1 50–Hour Sustained Capacity Analysis

As described above, a spreadsheet analysis was used to determine the monthly changes in the system's ability to produce 50–hour sustained capacity given each SOS. These changes are shown in Table 4–10. Capacity gains or losses are measured as compared to SOS 2c.

Given the market value of capacity shown in Table 4–9, the sustained capacity gains or losses in dollars as compared to SOS 2c are shown in Table 4–11 for OY 1996 through OY 2004. Again, interpolation was used to calculate values for the in–between years. These numbers have already been adjusted to include the capacity value from the CTs acquired in Table 4–7.

Table 4–9. Capacity Values ($/kW–month, 1996 Dollars)

	Sustained Capacity		Instantaneous Capacity
	OY 1996	OY 2004	
SEP	3.00	3.50	1.79
OCT	0.00	0.00	1.79
NOV	0.00	0.00	1.79
DEC	2.15	2.50	4.23
JAN	2.15	2.50	4.23
FEB	2.15	2.50	4.23
MAR	0.00	0.00	1.79
15–Apr	0.00	0.00	1.79
30–Apr	0.00	0.00	1.79
MAY	0.00	0.00	1.79
JUN	0.00	0.00	1.79
JUL	3.00	3.50	1.79
15–Aug	3.00	3.50	1.79
30–Aug	3.00	3.50	1.79

Table 4–10. Changes in 50–Hour Sustained Capacity from SOS 2c (MW)

	SEP	OCT	NOV	DEC	JAN	FEB	MAR	15Apr	30Apr	MAY	JUN	JUL	15Aug	30Aug
SOS 1a	400	–400	–300	–400	–100	–800	300	900	3800	–100	–5100	1500	–1100	–600
SOS 1b	–100	1600	1400	0	0	–600	0	1500	4400	–1300	–3800	1900	–500	–100
SOS 2c	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SOS 2d	300	–200	–300	0	–500	–1000	900	–900	5200	–800	500	1000	–300	–800
SOS 4c	–4000	–2500	–1600	–1000	–900	–1100	–900	1000	4700	–4600	–1700	300	–4800	–4000
SOS 5b	–2200	–400	400	–200	–200	–1000	–1400	–2500	–2400	–2400	–2100	–2600	–800	–1300
SOS 5c	–1600	–1200	–700	–2200	–2100	–2200	–1800	–2600	–2400	–2400	–2100	–2600	–800	–1300
SOS 6b	–1500	–200	600	–200	–200	–300	700	–600	–1300	–1200	–900	–2000	–500	–1100
SOS 6d	–500	–200	600	0	–200	–300	800	–800	–600	–300	–100	–1600	–300	–900
SOS 9a	–9100	–8200	–6000	–2900	–2600	–2300	–1600	–2200	4300	–2000	–1100	–400	–4600	–5100
SOS 9b	–5600	–3100	–3500	–400	–300	400	1000	–1000	6800	–1100	200	1900	–2300	–3100
SOS 9c	–4900	–1500	200	500	–100	–500	–500	–900	5400	–4500	–3700	–1200	–3100	–3000
SOS PA	–800	–900	–700	–1600	–1800	–600	200	–1500	6000	–2800	–100	600	–3600	–3200

4.3.2 Instantaneous Capacity Analysis

A similar spreadsheet analysis was used to determine the monthly changes in the system's ability to produce instantaneous capacity. These changes are shown in Table 4–12. Capacity gains or losses are measured as compared to SOS 2c.

Given the peak load/resource balance for OY 1996 and OY 2004, and the addition of the CTs in Table 4–7, the remaining instantaneous peak deficits are shown in Table 4–14. Valued at the rates shown in Table 4–9, the instantaneous capacity gains or losses in dollars as compared to SOS 2c are shown in Table 4–13 for OY 1996 through OY 2004. Again, interpolation was used to calculate values for the in–between years.

Table 4–11. Sustained Capacity Cost Deltas from SOS 2c (Millions 1996 Dollars)

	1996	1997	1998	1999	2000	2001	2002	2003	2004
SOS 1a	0	1	2	3	4	4	5	6	7
SOS 1b	−3	−3	−2	−2	−2	−1	−1	0	0
SOS 2c	0	0	0	0	0	0	0	0	0
SOS 2d	1	−1	−3	−5	−7	−9	−11	−13	−15
SOS 4c	31	31	32	33	33	34	35	35	36
SOS 5b	21	21	21	22	22	23	23	24	24
SOS 5c	30	30	30	31	31	31	32	32	32
SOS 6b	14	15	15	15	16	16	16	17	17
SOS 6d	9	9	10	10	10	10	10	11	11
SOS 9a	60	56	52	48	43	39	35	31	27
SOS 9b	20	16	13	10	6	3	0	−4	−7
SOS 9c	28	26	24	23	21	19	18	16	14
SOS PA	19	16	13	10	6	3	0	−4	−7

Table 4–12. Changes in Instantaneous Capacity from SOS 2c (MW)

	SEP	OCT	NOV	DEC	JAN	FEB	MAR	15Apr	30Apr	MAY	JUN	JUL	15Aug	30Aug
SOS 1a	−100	−100	−100	−100	−200	−300	−200	−200	−200	−700	−200	200	−100	−100
SOS 1b	−100	400	400	−100	−300	−500	−500	−600	−200	−200	400	600	300	200
SOS 2c	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SOS 2d	−100	−100	−100	−100	−100	−200	−100	−200	100	−500	−100	−100	−100	−100
SOS 4c	0	600	900	300	200	100	0	100	0	−500	−400	0	−900	−1000
SOS 5b	−3200	0	0	−100	−100	−2200	−3100	−3200	−3200	−3300	−3200	−3000	−3200	−3300
SOS 5c	−3200	−3100	−3100	−3200	−3200	−3200	−3200	−3200	−3200	−3300	−3200	−3000	−3200	−3300
SOS 6b	−2000	0	0	−100	−100	−100	−100	−1700	−1700	−1700	−1700	−1500	−1800	−2000
SOS 6d	−500	0	0	−100	−100	−100	−100	−600	−500	−600	−600	−300	−700	−1100
SOS 9a	−3700	−3300	−1700	−1100	−900	−800	−2800	−2200	−2400	−3400	−3300	−3800	−4200	−4200
SOS 9b	−800	−1400	−300	0	200	300	100	0	0	−1000	−1000	−1100	−1500	−1500
SOS 9c	−100	0	100	200	200	100	−1900	−1800	−2000	−3900	−3500	−900	−1200	−1200
SOS PA	−500	−600	−600	−200	−200	−200	−300	−500	−1300	−2000	−1700	−1900	−2600	−2300

Table 4–13. Instantaneous Capacity Cost Deltas from SOS 2c (Millions 1996 Dollars)

	1996	1997	1998	1999	2000	2001	2002	2003	2004
SOS 1a	0	1	2	3	4	5	6	7	8
SOS 1b	0	1	2	2	3	4	5	6	7
SOS 2c	0	0	0	0	0	0	0	0	0
SOS 2d	0	−1	−2	−2	−3	−4	−5	−5	−6
SOS 4c	0	0	−1	−1	−1	−1	−2	−2	−2
SOS 5b	0	1	3	4	5	6	8	9	10
SOS 5c	3	8	12	17	22	27	32	37	42
SOS 6b	0	0	0	0	1	1	1	1	1
SOS 6d	0	0	0	0	1	1	1	1	1
SOS 9a	0	−1	−2	−2	−3	−4	−5	−6	−6
SOS 9b	0	−1	−2	−2	−3	−4	−5	−6	−6
SOS 9c	0	−1	−2	−2	−3	−4	−5	−6	−6
SOS PA	0	−1	−2	−2	−3	−4	−5	−6	−6

Table 4–14. Remaining Instantaneous Capacity Deficits (MW)

For OY 1996				
	JAN	FEB		
SOS 5c	−260	−355		
For OY 2004				
	NOV	DEC	JAN	FEB
SOS 1a	0	−797	−1468	−1149
SOS 1b	0	−580	−1351	−1132
SOS 2c	0	−262	−833	−414
SOS 2d	0	0	−64	0
SOS 4c	0	0	−633	−314
SOS 5b	0	−362	−933	−2614
SOS 5c	−1528	−3340	−3911	−3492
SOS 6b	0	−362	−933	−514
SOS 6d	0	−362	−933	−514

4.4 TOTAL SYSTEM COSTS

Adding the total system energy costs to the changes in sustained and instantaneous capacity costs gives the total system costs that will be used to calculate the change in cost for each SOS in Chapter 5. This total cost in shown in Table 4–15. Costs in Table 4–15 are in 1996 dollars; they will be deflated to 1993 dollars in Appendix O, Economic and Social Impact, in order to be consistent with the rest of the SOR economic analysis.

Table 4–15. Total Regional Costs Including Total Regional Energy Costs plus Changes in Sustained and Instantaneous Capacity Costs (Millions 1996 Dollars)

	1996	1997	1998	1999	2000	2001	2002	2003	2004
SOS 1a	991	1049	1108	1167	1226	1284	1343	1402	1460
SOS 1b	976	1031	1085	1140	1195	1250	1304	1359	1414
SOS 2c	1026	1087	1147	1207	1268	1328	1388	1449	1509
SOS 2d	1056	1116	1176	1236	1297	1357	1417	1477	1537
SOS 4c	1106	1170	1234	1298	1362	1426	1491	1555	1619
SOS 5b	1129	1198	1267	1337	1406	1476	1545	1615	1684
SOS 5c	1165	1239	1313	1387	1461	1535	1609	1683	1757
SOS 6b	1069	1131	1194	1257	1320	1382	1445	1508	1571
SOS 6d	1048	1108	1169	1230	1291	1352	1412	1473	1534
SOS 9a	1328	1399	1470	1541	1612	1683	1753	1824	1895
SOS 9b	1246	1312	1379	1446	1512	1579	1645	1712	1778
SOS 9c	1194	1262	1331	1399	1467	1535	1603	1671	1739
SOS PA	1162	1227	1291	1356	1420	1485	1549	1614	1678

CHAPTER 5

COMPARISON OF ALTERNATIVES

5.1 ENERGY ANALYSIS

5.1.1 Changes in Hydropower System Generation

Table 5–1 shows the changes in the 50–year average annual hydro generation for each SOS as compared to SOS 2c. With the exception of SOS 2d, SOS 4c and SOS 6d, significant changes in annual hydro generation are shown for all the alternatives. In the drawdown alternatives (SOS 5 and SOS 6), actual turbines are taken out of service, or head is so severely reduced that large changes in total generation take place. They range from a decrease of 945 aMW in SOS 5c to a decrease of 89 aMW in SOS 6d.

Table 5–1. Changes in Average Annual Hydro Generation from SOS 2c (aMW)

SOS 1a	138
SOS 1b	309
SOS 2c	0
SOS 2d	−34
SOS 4c	−19
SOS 5b	−828
SOS 5c	−945
SOS 6b	−277
SOS 6d	−89
SOS 9a	−1095
SOS 9b	−641
SOS 9c	−729
SOS PA	−307

In SOS 9a, large amounts of water are spilled, along with drawdown of the lower Snake plants, accounting for most of the loss of 1095 aMW in generation. In addition, in some water conditions, Grand Coulee is emptied early in the year and can provide little energy for the rest of the year.

Most of the loss of 307 aMW associated with the preferred alternative is due to significant increases in spill compared to SOS 2c.

5.1.2 Results from Energy Cost Analysis

Table 5–2 shows the average annual changes in regional energy costs for OY 1996 through OY 2004 for each SOS as compared to SOS 2c. These costs were obtained by subtracting the total regional energy costs for SOS 2c from the total regional energy costs for each of the other SOSs. (Total regional energy costs appear in Table 4–8 in Chapter 4.) Positive numbers imply that costs have risen; negative numbers imply that costs have fallen. All costs are averages over the 50 water conditions.

SOS 9a is the most expensive alternative, with cost increases in the neighborhood of $300 million per year. The settlement discussion alternatives (SOS 9) require sizable amounts of replacement energy, specifically in the fall and winter, in place of hydro generation lost to large amounts of spill and drawdowns.

The preferred alternative is also costly, due to the need to replace significant amounts of energy lost in the fall and winter. Losses in this alternative are primarily due to the need to store water in reservoirs in the fall and winter in order to be at levels required for the spring/summer flow releases for anadromous fish, and losses in generation due to large amounts of spill.

Table 5–2. Average Annual Changes in Total Regional Energy Costs from SOS 2c (Millions 1996 Dollars)

	1996	1997	1998	1999	2000	2001	2002	2003	2004
SOS 1a	−35	−39	−42	−46	−50	−53	−57	−60	−64
SOS 1b	−47	−54	−61	−68	−74	−81	−88	−95	−102
SOS 2c	0	0	0	0	0	0	0	0	0
SOS 2d	28	31	34	36	39	41	44	47	49
SOS 4c	49	52	56	59	63	66	70	73	76
SOS 5b	82	89	97	104	111	119	126	134	141
SOS 5c	106	115	123	131	140	148	157	165	174
SOS 6b	28	30	32	34	36	38	40	42	44
SOS 6d	12	12	12	13	13	13	13	13	13
SOS 9a	242	257	273	288	304	319	335	350	365
SOS 9b	200	210	221	231	241	252	262	273	283
SOS 9c	140	151	161	171	181	192	202	212	223
SOS PA	116	125	133	141	150	158	166	174	183

Natural river drawdown alternatives (SOS 5) are the next most costly, due to the loss of generation from the four lower Snake plants. All other alternatives (SOS 2, SOS 4 and SOS 6) have yearly cost increases significantly less than $100 million per year. The least expensive alternatives are the pre–ESA operation alternatives (SOS 1), which show cost decreases as compared to SOS 2c. In these alternatives, the power system is allowed to take maximum advantage of the hydro system's flexibility, hence costs go down. SOS 1b is less expensive than SOS 2c by $100 million by OY 2004.

5.1.3 General Observations and Qualifications

In general, the energy analysis alone shows that the most expensive alternatives for the power system are the settlement discussion alternatives (SOS 9), the preferred alternative, the natural river drawdown alternatives (SOS 5), followed by the stable storage project alternative (SOS 4), the current operation alternatives (SOS 2) and the fixed drawdown alternatives (SOS 6). As mentioned above, the analysis performed here is adequate for ranking the alternatives as compared to one another, but not as good for predicting exactly how much costs to the power system would increase if one of these alternatives were implemented. Again, the energy costs do not include costs from capacity changes (see Section 5.2), costs for purchase of upper Snake water, or capital costs to physically change structures in order for these alternatives to be implemented. These latter costs will be presented in Appendix O, Economic and Social Impact.

Replacement of hydro system losses is accomplished with a combination of spot market purchases and acquisition of combined cycle combustion turbines. Due to recent reductions in the costs of CTs, this choice becomes relatively academic for the Final EIS if one considers only economics. Many combinations of purchases and CT acquisitions in OY 2004 yield nearly identical results. In fact, replacement of combined cycle CTs with single cycle CTs also affects the results only negligibly. Hence, since the combined cycle CTs operate a large percentage of the time (63 percent in the preferred alternative), they were selected instead of single cycle CTs, and the choice between combined cycle CTs and purchases was based on reliability considerations as well as economics, as described in Chapter 3.

5.1.4 Short-term Energy Analysis

The energy calculations shown here have been done based on the ability to shape energy to the market.

No short–term energy analysis has been done, which would account for losses which occur when either 1) the system loses flexibility and has to spill energy at night since it cannot be generated in the daytime; or 2) when the system experiences flows above turbine capacity for part of the month, even thought the month average flow appears usable.

Operating at minimum operating pool (MOP), within narrow forebay ranges, or having artificially high nighttime minimum flows can all result in energy being spilled at night. Some analysis was done on the short–term energy effects of the Northwest Power Planning Council's Phase II Amendments, and these showed nonfirm impacts in the range of 500–1000 MW–mo./year for MOP operations on the lower Snake projects and John Day. No analysis has been done on operating Grand Coulee, Libby, and Hungry Horse within narrow ranges, such as called for in SOS 4, but the energy losses can be expected to be significant, considering the normal variation of flow within a month.

Operating within 1 percent of peak efficiency also will result in significant spilling of energy on light load hours. Including such losses would, in general, increase the costs of alternatives that produce large excesses of nonfirm in some months.

5.2 CAPACITY ANALYSIS

5.2.1 Changes in Sustained and Instantaneous Capability

The changes in the ability of the hydro system to produce 50–hour sustained capacity and instantaneous capacity were shown in Tables 4–10 and 4–12 respectively in Section 4.3. These changes were estimated as compared to SOS 2c.

5.2.2 Results from Capacity Cost Analysis

Table 4–11 in Section 4.3 shows the changes in sustained capacity costs for OY 1996 through OY 2004 for each SOS as compared to SOS 2c. Table 4–13 in Section 4.3 shows the changes in instantaneous capacity costs for OY 1996 through OY 2004 for each SOS as compared to SOS 2c. Positive numbers indicate an increase in costs due to capacity changes and negative numbers indicate a decrease in costs from capacity changes. These changes are added below in Table 5–3.

Table 5–3. Changes in Both Sustained and Instantaneous Capacity Costs from SOS 2c (Millions 1996 Dollars)

	1996	1997	1998	1999	2000	2001	2002	2003	2004
SOS 1a	0	2	4	6	8	10	12	13	15
SOS 1b	−3	−2	−1	1	2	3	4	5	7
SOS 2c	0	0	0	0	0	0	0	0	0
SOS 2d	1	−2	−4	−7	−10	−13	−15	−18	−21
SOS 4c	31	31	31	32	32	32	33	33	33
SOS 5b	21	22	24	26	27	29	31	32	34
SOS 5c	32	38	43	48	53	59	64	69	74
SOS 6b	14	15	15	16	16	17	17	18	18
SOS 6d	9	10	10	10	11	11	11	12	12
SOS 9a	60	55	50	45	40	35	31	26	21
SOS 9b	20	16	11	7	3	−1	−5	−9	−14
SOS 9c	28	25	23	20	18	15	13	10	8
SOS PA	19	15	11	7	3	−1	−5	−9	−13

Changes in capacity costs are most significant for the natural river drawdown alternatives (SOS 5), especially SOS 5c, year−round drawdowns. In this case, loss of generation occurs all year long, leading to significant instantaneous capacity deficits during the winter months. Capacity costs also increase for SOS 4c, stable storage reservoirs, since the need to keep reservoirs full leads to both sustained and instantaneous capacity losses.

5.2.3 General Observations and Qualifications

The capacity changes, both in MW and dollars, shown here are based on a wide variety of assumptions about the nature of the capacity product. These assumptions were developed based on the best information currently available and were determined using a considerable amount of expert judgment. The capacity analysis should provide a good basis for comparing capacity changes across the alternatives examined in this study.

5.3 COMBINED IMPACT OF ENERGY AND CAPACITY CHANGES

Table 5−4 shows the combined impact of energy and capacity changes for each SOS as compared to SOS 2c.

SOS 9 continues to be the most expensive alternative, with yearly cost increases of between $150 and $400 million as compared to SOS 2c. The next most expensive is SOS 5, followed by the preferred alternative, SOS 4, SOS 6 and SOS 1.

The capacity results had the effect of slightly altering the comparison originally made on just the energy analysis. On energy impacts alone, the preferred alternative shows impacts greater than those for SOS 5. However, when capacity effects are included, the impacts from SOS 5 are greater than those from the preferred alternative. In addition, the cost decreases attributed to SOS 1 have been somewhat reduced.

Table 5−5 shows these same results in 1993 dollars, to be consistent with the rest of the SOR economic analysis.

Table 5–4. Combined Impact of Both Energy and Capacity Changes from SOS 2c (Millions 1996 Dollars)

	1996	1997	1998	1999	2000	2001	2002	2003	2004
SOS 1a	−36	−37	−39	−40	−42	−44	−45	−47	−49
SOS 1b	−50	−56	−62	−67	−73	−78	−84	−89	−95
SOS 2c	0	0	0	0	0	0	0	0	0
SOS 2d	29	29	29	29	29	29	29	29	28
SOS 4c	80	83	87	91	95	99	102	106	110
SOS 5b	102	111	120	130	139	148	157	166	175
SOS 5c	138	152	166	179	193	207	221	234	248
SOS 6b	42	45	47	50	52	54	57	59	62
SOS 6d	21	22	22	23	23	24	24	25	25
SOS 9a	302	312	323	333	344	355	365	376	386
SOS 9b	220	226	232	238	245	251	257	263	270
SOS 9c	168	176	184	191	199	207	215	223	230
SOS PA	136	140	144	148	153	157	161	165	169

Table 5–5. Combined Impact of Both Energy and Capacity Changes from SOS 2c (Millions 1993 Dollars)

	1996	1997	1998	1999	2000	2001	2002	2003	2004
SOS 1a	−33	−35	−36	−38	−39	−41	−42	−44	−45
SOS 1b	−47	−52	−57	−63	−68	−73	−78	−83	−88
SOS 2c	0	0	0	0	0	0	0	0	0
SOS 2d	27	27	27	27	27	27	27	27	27
SOS 4c	74	78	81	85	88	92	95	99	102
SOS 5b	95	104	112	121	129	138	146	155	163
SOS 5c	129	142	154	167	180	193	205	218	231
SOS 6b	39	42	44	46	48	51	53	55	58
SOS 6d	20	20	21	21	22	22	22	23	23
SOS 9a	281	291	301	311	321	330	340	350	360
SOS 9b	205	210	216	222	228	234	239	245	251
SOS 9c	157	164	171	178	186	193	200	207	215
SOS PA	127	131	134	138	142	146	150	154	158

5.4 CONSIDERATION OF THE FUTURE

5.4.1 Time Horizon for Economic Analysis

The results presented in this appendix have been for OY 1996 and OY 2004, with results interpolated for the in–between years. However, for a number of reasons, the SOR economic analysis will look at results for 100 years, from OY 1995 through OY 2094. This is primarily due to the fact that different SOSs will take different amounts of time to implement. For example, since the drawdown alternatives require physical dam modifications, they take longer to implement than alternatives which only require flow changes. In addition, in other use areas, more than one year is required for changes to take effect. Anadromous fish, for example, have a four to five year life cycle. So changes need to be measured over time. Hence a 100–year time horizon was selected.

5.4.2 Future Impacts

The implications for the power impact analysis of selecting a 100–year time horizon are that power system impacts should be traced out for 100 years, assuming the loads and resources of the future. A rigorous treatment would require different assumptions about future loads, future prices, future availability of resources, etc., and would need to account for physical changes in the hydro system, such as installation of fish bypass facilities. The differences across SOSs would need to be measured against the loads, resources and hydro system of all future years rather than just the loads, resources and hydro system of OY 1996 and OY 2004.

A rigorous analysis of this type was not performed for a number of reasons. Future analysis is complicated by assumptions concerning future installation of fish bypass facilities and future levels of spill. These assumptions influence the amount of generation the hydro system will produce in the future, yet they are speculative at best, and are not easily agreed upon.

Future changes in loads, resources, prices, etc., past OY 2004 are not likely to change the energy impact analysis and should not significantly change the deltas among the SOSs. CTs were added to each SOS by OY 2004 in order to maintain regional reliability (and in some cases, because acquisition of CTs was less expensive than purchasing). As the region becomes more energy deficit in the future, it is assumed that resources will be added to keep the region's reliability somewhat constant. The difference among the SOSs is driven by how the hydro system is operated, not by the loads and resources in place in the region. As time goes on, CTs may get a little more expensive, purchases may escalate in price, but the relationship among the SOSs is unlikely to change significantly.

Unfortunately, this does not necessarily hold true for the capacity analysis. The results of the capacity analysis are significantly affected by the assumed value of capacity. This value reflects a West coast market which is currently capacity surplus. As loads grow, it is likely that capacity deficits will arise, probably in the next decade or so. Both instantaneous and sustained capacity may be in shorter supply, and hence capacity's value would likely increase. This may affect the relationship among the SOSs. This has been somewhat taken into account as the value of capacity was assumed to increase between OY 1996 and OY 2004.

However, for this Final EIS, the power system impacts shown for OY 2004 will be assumed to be constant for the rest of the 100–year time horizon.

5.4.3 Equivalent Annual Power System Impacts

Given the assumptions above, an equivalent annual power system impact was calculated for each SOS in millions 1993 dollars, taking into account the 100–year time horizon and the date for implementation of each SOS. SOS implementation dates are shown in Table 5–6.

For each SOS, it was assumed that the power system impacts for OY 1995 would be identical to OY 1996, impacts through OY 2004 would be as shown previously in this chapter, and impacts from OY 2004 through OY 2094 would be constant at the level in OY 2004.

For SOSs with implementation dates later than OY 1995, the costs associated with SOS 2c were assumed from OY 1995 to the implementation date. For example, SOS 6b has an implementation date of OY 2005. To determine the equivalent annual power system impact for SOS 6b, the power system impacts for SOS 2c were assumed from OY 1995 through OY 2004, and the power system impacts for SOS 6b were assumed from OY 2005 through OY 2094.

Table 5–6. Implementation Dates for System Operating Strategies

SOS	Implementation Date
1a	1995
1b	1995
2c	1995
2d	1995
4c	1995
5b	2010
5c	2000
6b	2005
6d	2000
9a	2005
9b	1995
9c	2005
PA	1998

Table 5–7 shows the equivalent annual power system impact for each SOS compared to SOS 2c at two discount rates, 3 percent and 7.75 percent. Positive numbers are increases in costs; negative numbers are decreases in costs.

As can be seen, incorporating the effects of implementation timing and discounting of future costs has some effect on the economics of the various SOSs. For the 3 percent discount rate case, the preferred alternative is now more costly than SOS 5b, which takes a long time to implement (2010). Otherwise, the comparison among alternatives is nearly the same as before. The higher discount rate case has a more significant affect on this comparison, with alternatives with long lead–times (SOS 5b, SOS 6d, SOS 9a, SOS 9c) showing substantial decreases in costs. However, this comparison is not yet complete, since the costs for implementation have not been added. These costs will be addressed in Appendix O, Economic and Social Impact.

Table 5–7. Equivalent Annual Power System Impacts from SOS 2c (Millions 1993 Dollars)

	Discount Rate	
	3 percent	7.75 percent
SOS 1a	−43	−41
SOS 1b	−82	−75
SOS 2c	0	0
SOS 2d	27	27
SOS 4c	98	93
SOS 5b	101	53
SOS 5c	194	153
SOS 6b	42	27
SOS 6d	20	16
SOS 9a	263	171
SOS 9b	244	236
SOS 9c	157	102
SOS PA	142	122

5.5 REDUCING POWER SYSTEM IMPACTS

5.5.1 Optimization of Power Production

Traditionally, the Pacific Northwest hydro system has been operated for a number of uses: power, flood control, recreation, navigation, etc. In the past, uses other than power have specified their requirements. Once these requirements were met, the system was then allowed to optimize for power production.

Optimizing power production has taken a number of forms over the years, from adjusting thermal maintenance schedules to be more in line with excess hydro generation, to shifting and shaping water into times of highest economic value.

SOS 1a is an operation which has been optimized over the years to achieve non−power requirements and provide the most power and/or money as possible out of the hydro system. But, with the exception of some examination of thermal maintenance schedules (see next section), none of the other SOSs shown here have been "optimized" for non−power requirements and power production. Hence, if these SOSs were implemented, it is likely that over time, the impacts shown here could be reduced as the system became more "used to" operating in the new way.

5.5.2 Thermal Maintenance Schedules

As mentioned above, one way to optimize power production is to schedule maintenance on Pacific Northwest thermal plants to coincide with the greatest amount of excess hydro generation. This was done in the 1980's (in SOS 1a, for example) when the water budget was implemented. The water budget called for significant amounts of water (3.45 MAF (4,257 million m^3) on the Columbia River and 1.19 MAF (1,468 million m^3) on the Snake River) to be released from April 15 through June 15. Consequently, Pacific Northwest power operators began to schedule thermal maintenance during these months to take advantage of this situation. This reduced the water budget's cost to the region.

Pacific Northwest thermal maintenance scheduling was reviewed for the preferred alternative. The preferred alternative creates surpluses in every water year in the second half of April, all of May, all of June, and in all of July with the exception of five water years. Current thermal maintenance schedules in the Pacific Northwest have all thermal plants down sometime during this period. Hence no further optimization of maintenance schedules in the Pacific Northwest would be possible for the preferred alternative. Other alternatives were not reviewed in detail, and changing maintenance schedules on Pacific Southwest thermal plants was not considered.

5.5.3 Elasticity, Rates and Net Replacement Costs

This appendix has attempted to quantify how power system costs would change given changes in operation of the river system. As power system costs increase, these increases will need to be recovered from the rate payers of the Pacific Northwest. As rates increase, consumers react to those increases, often by purchasing less electricity. As consumers purchase less electricity, power system demand goes down, and hence not as much electricity is needed. Depending on the magnitude of the reaction by consumers to the rate increase, not as many resources may be needed after a rate increase.

This is the notion of elasticity in demand– –changes in the quantity of a good purchased based on changes in its price. Hence, for example, if an SOS originally required a "gross" purchase of 1000 aMW of CTs to meet power demands, after rates are increased (resulting in decreased demand), it may be possible to acquire less than 1000 aMW, say only a "net" of 800 aMW of CTs to meet demand. The cost of 800 aMWs is clearly less than that of 1000, and hence power system impacts are reduced.

The rate impacts from the SOSs, the subsequent elasticity effects, and the resulting net replacement cost are all described in the Appendix O, Economic and Social Impact.

5.5.4 Power Marketing Opportunities

The power impacts shown above have been calculated by making a number of estimates about the market value of power. Estimates have been made for prices for purchasing power from the Pacific Southwest (Chapter 4, Table 4–3), for displacing thermal resources in the Pacific Southwest with excess Pacific Northwest hydro generation (Chapter 4, Table 4–4) and for the value of both sustained and instantaneous capacity (Chapter 4, Table 4–9). The energy analysis specifically assumed that changes in hydro generation would be replaced with CTs and purchase power, and that excess hydro generation would be sold at nonfirm prices that reflect Pacific Southwest displacement values.

What if the Pacific Northwest is able to strike a better deal? What if creative exchanges can reduce costs for the Pacific Northwest when it is in the purchase market and increase revenues when it is trying to sell to the Pacific Southwest? What if what are essentially spot market and nonfirm sales can be turned into firm power deals with higher value?

The analysis has captured much of this potential value by basing nonfirm prices on displacement costs, rather than on the Pacific Southwest's willingness to pay for power. It is not anticipated that the Pacific Southwest will be willing to pay more for power than indicated by their thermal plant savings. In addition, the value of a firm power product in the spring/summer months could be very low. Due to widespread knowledge about the operations of the Pacific Northwest hydro system, most utilities in need of power in the spring/summer months know that it will be available with a great deal of certainty at nonfirm energy prices. Hence paying a premium for firm service is considered unnecessary.

Given the current surplus capacity market, selling capacity in the summer at attractive prices has also been ruled out, at least for the short–run. And the purchase prices for capacity already are assumed to be low. Hence there doesn't seem to be huge potential for attractive marketing deals in this area.

Hence it is not likely that creative marketing opportunities can reduce the power system impacts shown here by any significant amount. However, Pacific Northwest utilities will continue to strive for power system optimization given river system requirements for other use areas.

5.5.5 Mitigation for Power System Impacts

The above sections have discussed some potential ways of reducing power system impacts, ways that have not been quantified, but that would be put into place over time as experience with new operational schemes is developed. This could be referred to as "mitigation" for power system impacts. But in reality, mitigation for changes in hydro system operation is merely finding the least–costly way to meet the load requirements of the region given these new operations. This appendix has attempted to make reasonable assumptions about the least costly way to replace losses in hydro system generation. These assumptions, the resulting analyses, and the discussion above constitute the mitigation analysis for power system impacts.

5.6 MISCELLANEOUS INFORMATION

5.6.1 Pumping Loads

As elevations at Grand Coulee change from one SOS to another, the electricity required to pump for irrigation also changes. This leaves less power for the power system to use to serve other loads. This would imply that the power impact analysis should consider changes in pumping loads at Grand Coulee.

Pumping loads at Coulee were calculated in all the SOSs, and they vary by no more that 2 aMW across SOSs. Therefore, changes in pumping loads were ignored in the power impact analysis. (Effects on the farmer of increased pumping loads will be accounted for in the irrigation analysis.)

5.6.2 Federal vs. Regional Analysis

All power system impact numbers presented in this appendix are for the Pacific Northwest region as a whole, with some benefits accruing to the Pacific Southwest. No attempt was made to rigorously separate these impacts across different regional parties, such as Federal, non–Federal, investor–owned utility, etc.

Consequently, the rate impact analysis shown in Appendix O, Economic and Social Impact, will present rate changes on average for the region as a whole, with no attempt to determine which regional parties will bear the brunt of changes in Pacific Northwest hydro system operations.

CHAPTER 6

TECHNICAL EXHIBITS

Table 6–1. List of Preparers, Bonneville Power Administration

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Bob Neal	B.S. Physics 15 years	Short Term Operations	Capacity Analysis Review of Energy Analysis
Audrey Perino	M.A. Economics 15 years	Economic Studies of System Operations	Energy Impact Analysis, Overall Coordination, Document Preparation
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Table 6–2. List of Preparers, Pacific Northwest Utilities Conference Committee

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Table 6–4. Total Hydropower System Generation for SOS 1a

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	15–Apr	30–Apr	MAY	JUNE	JULY	15–Aug	31–Aug	AVERAGE
							Average Megawatts								
1929	12157	12455	13653	14725	14219	13236	12979	13670	15201	19355	13868	11759	11471	11378	13694
1930	10827	11125	12322	13395	13889	12906	12649	13340	14871	17760	13538	11429	11208	11115	12928
1931	10564	10862	12059	13132	13626	12643	12386	13072	14578	17169	13275	11166	11089	10996	12648
1932	10445	10743	11940	13013	13507	12513	13832	18918	20822	23719	18584	12881	12185	12369	14446
1933	12157	12455	13652	14725	22546	17797	16554	14805	18395	21474	23877	20994	16506	14472	17362
1934	13224	14808	17286	23152	26237	24650	21755	22743	24030	24054	13868	12778	12654	11387	18908
1935	12157	12455	13775	14725	20543	18427	15667	14009	15627	19457	17530	15088	13916	11320	15590
1936	12157	12455	13652	14725	17027	13556	15034	14015	22715	22263	14995	12422	12402	11378	14885
1937	10827	11125	12322	13395	13889	12907	12649	13340	14871	18667	13539	11430	11208	11115	13005
1938	10564	10862	12059	13132	20402	17387	18042	17290	21295	24169	20236	13485	11413	11320	15908
1939	12157	12455	13652	14726	14219	13237	13011	18555	18629	21021	14623	12413	11829	11320	14310
1940	12157	12455	13652	14725	14219	13776	16475	18665	18079	19279	13932	11955	12530	11378	14413
1941	10827	11126	12329	13550	13889	13866	13100	15598	14871	17839	13538	11429	11208	11115	13154
1942	10564	10862	12059	18266	21363	18187	13273	14992	16337	18198	15616	14765	11470	11320	15008
1943	12157	12455	13652	14725	20853	21136	18122	22244	24030	23243	22800	19499	15072	11320	17883
1944	12157	12455	13652	14725	14864	13478	12979	13670	15201	17265	13868	11759	11090	10996	13557
1945	10446	10744	11940	13013	13507	12525	12591	13282	14813	19047	16896	11371	11208	11115	13110
1946	10564	10862	12059	13132	21151	19495	19549	18863	23119	24821	19745	15688	13360	11355	16685
1947	12157	12455	14381	19517	22981	22092	20093	19130	20162	24569	17729	14869	11700	11320	17648
1948	12157	16799	17186	17012	24038	21147	18215	15912	23302	24821	27627	22657	15621	14345	19684
1949	12937	12455	13994	14725	18513	18481	19016	17155	22195	24821	20893	11759	11413	11320	16533
1950	12157	12455	13652	14725	21286	21606	21863	21502	21437	23424	24571	23457	15821	14059	18784
1951	12932	15006	18286	21382	25225	25186	22876	23228	21982	25064	22648	18815	15828	11400	20270
1952	12774	15965	15603	17454	21726	21122	18529	21462	24030	24821	21977	14977	12738	11320	18293
1953	12157	12455	13652	14725	20267	21465	16859	14166	15201	19017	24133	18487	13180	12299	16686
1954	12157	12455	14229	16493	23134	22003	19795	18333	20022	24821	24015	21957	19453	17808	19064
1955	15795	12892	15603	15803	20879	17784	14725	15130	15201	18101	22483	20763	15998	11325	16955
1956	12157	13948	17207	20873	25546	21505	22031	22816	24881	26995	28030	22046	13185	12650	20589
1957	12442	13047	14223	16911	20382	20406	20515	19176	18550	24821	24133	15010	11412	11320	17657
1958	12157	12455	13652	14725	19531	21358	18193	17410	19872	24821	20817	13112	11828	11320	16719
1959	12157	12455	14931	18085	25120	21087	19587	19500	19226	22621	24133	20129	14099	11959	18544
1960	17348	19212	18713	18621	21400	19624	20262	23969	19152	20461	20336	15493	13922	11320	18789
1961	12157	12455	14211	14725	22357	22571	20435	18833	15758	24124	24133	13835	11799	11729	17469
1962	12157	12455	13652	14725	19539	18664	16401	19245	21176	20942	18583	13327	13912	11637	16095
1963	12157	12559	16192	18509	21113	22615	16494	18414	15998	19481	17102	13309	11582	11320	16475
1964	12286	12455	13652	14725	21555	18308	16085	16384	16827	20470	24133	22887	15159	12396	17242
1965	13579	14023	14778	20840	26237	25272	21810	19576	23393	24468	23196	16260	15442	14427	19709
1966	13106	12944	14871	15385	22428	18391	17894	20068	15358	19318	15788	14153	13507	11320	16189
1967	12157	12455	13653	15108	23581	20151	17367	15347	15202	21125	24132	23612	14867	11977	17660
1968	12157	12765	14843	15498	21796	22222	20547	14159	15322	18537	19452	14909	12537	12589	16654
1969	15393	14917	17392	17762	24910	21362	19834	23969	24030	26071	24039	16924	11715	11320	19487
1970	12247	12850	13706	15159	20692	21900	16622	16707	15201	21464	24133	13107	11413	11320	16557
1971	12157	12455	13652	15205	26237	25272	24533	23345	24030	25995	28679	24010	17820	13187	20583
1972	13171	12567	15332	16503	25786	24874	26477	26807	24030	28340	29834	25941	19434	15895	21814
1973	13598	12610	13920	17380	16992	15555	13602	14018	15201	19992	13868	11759	11413	11320	14603
1974	12157	12455	13652	18177	26307	25272	24867	26046	28375	28854	30696	27068	17977	14781	21903
1975	13649	12455	13653	14957	22774	20059	19295	15241	16585	23401	24133	24546	12374	14426	18188
1976	13767	14265	17670	23670	26137	23787	21880	23969	23457	24821	24132	21641	20472	20715	21343
1977	17525	12455	13653	14725	14550	13464	13213	13770	15201	16840	13868	11759	11089	10996	13959
1978	10445	10743	11940	13915	18697	17258	18465	21416	18198	21110	20471	15682	11744	11320	15828
AVERAGE	**12429**	**12734**	**14229**	**16060**	**20433**	**19072**	**17781**	**18145**	**19121**	**22067**	**20364**	**16411**	**13446**	**12264**	**16909**

Table 6–5. Total Hydropower System Generation for SOS 1b

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	15–Apr	30–Apr	MAY	JUNE	JULY	15–Aug	31–Aug	AVERAGE
							Average Megawatts								
1929	12761	13059	14256	15329	14823	13840	13583	14274	15805	16285	14472	12363	11705	11612	13955
1930	11061	11359	12556	13629	14123	13140	12883	13574	15105	15585	13772	11663	11555	11462	12967
1931	10911	11209	12406	13479	13973	12990	12733	13424	14955	15435	13622	11513	10905	10812	12775
1932	10261	10559	11756	12829	13323	12340	13536	15881	20282	24913	20476	13559	12459	12508	14515
1933	12761	13059	14256	15329	21861	18158	15366	14274	16904	22515	24312	22645	16776	14636	17632
1934	13353	14176	17393	22917	26329	24744	22084	22872	24122	24849	15284	12363	11505	11412	19008
1935	12761	13059	14256	15329	19970	19194	14066	14274	15805	20010	18038	15456	14112	11412	15806
1936	12761	13059	14256	15329	15562	13840	13584	14274	17896	22242	16939	13404	11705	11612	14898
1937	11061	11359	12556	13629	14123	13140	12883	13574	15105	15585	14545	12279	11555	11462	13083
1938	10911	11209	12406	13479	21648	17368	17660	15964	21813	24913	22128	13791	11505	11412	16316
1939	12761	13059	14256	15329	14823	13840	13583	14899	17936	23396	14472	12363	11505	11412	14655
1940	12761	13059	14256	15329	14823	13840	14962	17103	16662	21322	14472	12363	11705	11612	14649
1941	11061	11359	12556	13629	14123	13140	12883	14224	15105	15585	13772	11663	11555	11462	12994
1942	10911	11209	12406	18464	21827	18630	12733	13424	16213	16062	16817	16165	12480	11495	15155
1943	12761	13059	14256	15329	18707	20612	18374	23202	24568	24244	23518	20223	14294	11412	18123
1944	12761	13059	14256	15329	14823	13840	13583	14274	15805	16285	14472	12363	10905	10812	13887
1945	10261	10559	11756	12829	13323	12340	12083	13374	14905	15982	18580	12409	11555	11462	12978
1946	10911	11209	12406	13479	21177	19529	18627	18095	23023	24913	22892	14854	13603	11455	16902
1947	12761	13059	14256	18539	23447	23009	18612	18819	19652	24913	19825	14737	11899	11412	17809
1948	12761	16209	17186	16837	24575	22195	16637	15577	23036	25291	28160	23417	15997	14476	19808
1949	12937	13059	14256	15329	18045	18161	18518	16580	22726	24913	21781	13133	11505	11412	16755
1950	12761	13059	14256	15329	21237	21197	20833	20167	20878	24379	25899	24033	16235	14182	19047
1951	12932	14540	18286	20488	25666	25364	23017	23156	21643	26003	23384	19735	16248	11500	20441
1952	12774	15450	15604	17076	22821	20405	18093	20363	24193	26437	22575	15424	12951	11412	18415
1953	12761	13059	14256	15329	17120	20196	16544	14274	16549	20700	24225	20760	13266	12407	16908
1954	12761	13059	14256	15863	23463	22642	18262	18006	19961	24913	25471	22604	20066	17969	19259
1955	15795	13059	15267	15746	21686	17957	13800	14274	15805	16523	24225	22286	16381	11427	17088
1956	12761	13369	17207	20261	26165	22558	21177	22104	25251	27296	28412	22715	13402	12760	20715
1957	12761	13059	14256	16569	20867	20694	19726	17825	17756	24913	25819	16309	11505	11412	17831
1958	12761	13059	14256	15329	19813	20588	17305	15968	18471	24913	24225	12363	11505	11412	16909
1959	12761	13059	14256	17827	25760	21708	18234	18905	17654	23912	24225	21396	14650	12064	18718
1960	17348	18375	18938	18042	22378	19725	19882	24061	19351	21162	20572	16840	14156	11412	18964
1961	12761	13059	14256	15329	22226	23053	18688	18351	15805	24829	24225	14945	11998	11839	17660
1962	12761	13059	14256	15329	18468	17257	15893	18962	22306	22276	18835	13932	14139	11739	16289
1963	12761	13059	15546	18178	21570	23496	14862	18010	15805	17644	20283	13931	12696	11412	16637
1964	12761	13059	14256	15329	20798	17558	15606	15040	16542	21522	24645	24369	15503	12505	17477
1965	13579	13777	14779	20668	26329	25364	21962	18412	24122	24913	24225	17413	15770	14553	19923
1966	13106	13059	14766	15582	22892	19369	16312	19788	15805	19559	17071	13711	13775	11412	16297
1967	12761	13059	14256	15329	23890	20823	15493	14493	15268	21873	24406	24423	15486	12086	17901
1968	12761	13059	14369	15329	22059	23184	19121	14274	15805	18944	20103	15586	12707	12553	16828
1969	15432	14299	17392	17281	25845	22357	18629	24061	24407	26593	24225	17989	11885	11412	19630
1970	12761	13059	14256	15329	20398	20806	16089	16609	15806	21514	24225	15440	11505	11412	16761
1971	12761	13059	14256	15329	26329	25364	23220	20535	24122	27340	29015	24765	18224	13295	20763
1972	13171	13059	15009	16502	26329	25364	25243	26788	24509	28790	30140	26648	19980	16031	21980
1973	13598	13059	14256	16747	16321	15287	13583	14274	15805	18956	14472	12363	11505	11412	14592
1974	12761	13059	14256	18349	26329	25364	25145	26161	28719	29299	30979	27609	18148	14839	22237
1975	13649	13059	14256	15329	21498	19603	18925	14900	16822	24471	24933	26087	12636	13739	18410
1976	13767	14186	17902	22899	26329	25364	21004	23841	22718	25780	24225	22874	21080	20848	21546
1977	17526	13059	14256	15329	14823	13840	13583	14274	15805	16285	14472	12363	10905	10812	14278
1978	10261	10559	11756	13795	15440	16554	18530	20773	19943	22172	20249	18686	11931	11412	15831
AVERAGE	**12767**	**12996**	**14457**	**16150**	**20406**	**19219**	**17155**	**17612**	**19101**	**22183**	**21242**	**17207**	**13620**	**12361**	**17080**

Table 6–6. Total Hydropower System Generation for SOS 2c

Average Megawatts

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	15–Apr	30–Apr	MAY	JUNE	JULY	15–Aug	31–Aug	AVERAGE
1929	11780	12144	13275	14348	12823	11725	11883	11594	13929	18399	19473	11382	11288	11123	13437
1930	10727	10833	12067	13102	12552	12070	11136	12593	13290	17476	17095	11174	11270	11105	12696
1931	10709	10815	12012	13085	12577	11549	11421	13222	12845	17108	17408	11171	11251	11086	12673
1932	10689	10805	11994	13066	12593	11677	13680	21444	21446	23738	18776	13125	11679	12032	14455
1933	11937	12049	13377	15031	21938	18628	15289	16278	16831	21163	24410	21869	16014	14101	17269
1934	13673	15061	17496	23268	26214	24837	20972	22737	24165	23730	13625	11382	11288	11123	18711
1935	10726	10833	14339	14971	20800	19910	14931	14790	14761	18622	17825	16029	12728	11164	15449
1936	11937	12040	13237	14311	14331	13762	13610	13953	19010	24383	17748	11382	11257	11164	14537
1937	11937	12055	13252	14325	12838	11815	11754	12450	14304	18180	15717	11382	11271	11105	13158
1938	10708	10815	12012	13085	21683	17657	17015	16483	21363	22936	19796	13783	11257	11164	15792
1939	11937	12055	13252	14325	12800	11699	15743	17354	18813	20910	14495	11891	11413	11164	14054
1940	11937	12041	13237	14311	14323	12529	18202	15867	16703	20302	13624	11382	11288	11123	14127
1941	10728	10906	12029	13549	13911	12979	12577	10785	11743	17444	17476	11174	11270	11105	12936
1942	10710	11250	12299	19053	19796	18249	11543	13407	14199	18021	20159	14728	12528	11164	15104
1943	11937	12041	13237	14310	22085	21576	17120	23068	24973	22605	23094	19920	13975	11317	17847
1944	11937	12283	13253	14325	12797	11739	11551	12209	13964	16606	17675	11382	11251	11086	13148
1945	10694	10801	11993	13065	12565	12059	11002	12199	14053	19831	20765	11215	11198	11106	13188
1946	10710	10824	12021	13094	21626	19074	18340	17548	22077	24606	21131	16186	12190	11165	16577
1947	12525	12796	13459	19748	23439	23120	19231	16741	20590	24154	17917	13428	11409	11164	17454
1948	11955	17248	17011	16838	23149	21631	17202	18171	20193	24832	28395	21644	15482	14239	19486
1949	13372	12951	13524	14325	18998	17679	20052	21696	21269	24832	16592	12188	11216	11123	16422
1950	10727	10847	13855	14830	21169	22824	21449	22150	19121	22664	26427	22468	16006	13788	18535
1951	13231	15628	17646	21131	25527	25269	22426	21249	22913	25169	21167	19440	15860	11315	20162
1952	12938	16567	14241	16848	22287	20965	16601	20842	23878	25438	20960	15124	12546	11164	18002
1953	11937	12055	13252	14325	20536	20492	15371	14882	15059	19807	24990	19283	12882	12110	16597
1954	12211	12841	13477	16183	22454	22752	18147	20455	17958	24665	24544	21766	19734	17475	18886
1955	16009	13350	15214	15532	20260	17098	11805	13748	14044	19420	24769	20759	15495	11164	16771
1956	12314	14676	16950	20666	25848	22210	20815	21794	24992	26831	28621	20891	13740	12659	20526
1957	12566	13671	13711	16522	18777	19377	17961	22681	20257	24832	24269	15226	11257	11164	17444
1958	11937	12055	13252	14325	19256	21390	17492	19612	18838	24832	22539	11382	11257	11165	16533
1959	11937	12055	15157	18424	25629	22281	18005	19172	17648	22332	24096	20334	13911	11769	18436
1960	17651	19105	18401	18010	21557	19531	19062	23948	23225	19877	19223	15197	13586	11165	18611
1961	12023	12515	14026	14342	21746	22422	19514	21106	16302	24166	24097	13455	11525	11476	17336
1962	11937	12040	13237	14311	20892	18739	14419	22519	22556	19885	18760	13512	12638	11377	15993
1963	11937	13606	15714	18156	20922	22784	13892	17012	14276	19049	21500	13454	11987	11164	16470
1964	12019	12041	13287	14310	21257	19324	13196	20352	16713	20894	24652	22538	15351	12125	17133
1965	12927	14401	14555	20779	26235	25086	21232	18551	23876	23566	23128	16399	15089	14332	19490
1966	13168	13699	14113	15099	21489	18675	14964	20212	15176	19881	17759	15045	12740	11164	16110
1967	11937	12041	13237	15142	23585	21808	16279	15845	15278	21369	24093	22682	15289	11829	17584
1968	12227	13177	14087	14993	21934	22676	19618	14236	15131	17957	21157	15016	12609	12259	16642
1969	14867	15130	16770	17292	25078	22485	18830	23347	24120	25554	24097	16434	11401	11164	19263
1970	11936	13027	13252	14444	19878	22009	16534	16430	15151	21652	25470	12354	11257	11164	16416
1971	11936	12050	13247	14350	26036	25271	23814	21876	23412	26881	28884	23416	18451	13250	20330
1972	13448	13644	14239	16110	25756	25273	26344	26140	23935	28303	29873	25261	19753	15879	21746
1973	13916	13550	13247	16841	17772	15603	13649	11509	12598	19067	15826	11382	11287	11123	14508
1974	10726	10833	14539	18856	26006	25059	25128	26003	27802	28433	31064	26643	17920	14741	21688
1975	13917	12055	13252	14614	22089	21979	19349	16783	15005	22439	25627	23665	11290	12648	18050
1976	13835	15021	17308	23521	26143	23641	20780	23646	22262	24832	23817	22187	20558	20332	21212
1977	17597	13005	13252	14325	12798	11766	11551	12209	13976	17014	17661	11382	11251	11085	13715
1978	10689	10796	11992	14318	18155	17187	17356	19112	19515	21011	19758	17905	11621	11378	15825
AVERAGE	**12355**	**12763**	**13938**	**15883**	**20098**	**19039**	**16797**	**18040**	**18511**	**21954**	**21440**	**16248**	**13216**	**12087**	**16771**

Table 6–7. Total Hydropower System Generation for SOS 2d

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	Average Megawatts MAR	15–Apr	30–Apr	MAY	JUNE	JULY	15–Aug	31–Aug	AVERAGE
1929	11991	12097	13287	14336	11263	10932	12244	11990	16487	18009	18946	13274	11280	10843	13481
1930	10636	10843	11949	13007	10898	12080	11412	12158	16417	17274	17588	10979	11254	10809	12659
1931	10604	10824	12035	13233	11215	10227	10856	13055	15843	17191	18648	11314	11226	10938	12645
1932	10303	10758	11143	12576	11386	12841	14463	18414	17076	19281	23235	17121	11388	11617	14358
1933	11652	11975	12779	14501	19455	20523	17342	14740	15276	19159	25835	22751	15598	14173	17135
1934	13559	14804	16829	23250	25622	25027	21822	22667	22303	22463	18502	13393	8072	10717	18895
1935	11029	10821	13982	14776	18084	21503	16696	12753	14686	17914	18753	16761	12324	11092	15440
1936	11612	12038	13316	14521	11224	10722	14618	12786	20467	24264	19617	14816	11460	10831	14555
1937	11806	12050	13291	14506	10997	10057	10598	12079	15354	17490	18725	14345	11245	11227	13248
1938	10347	10835	12085	13282	18178	17241	17866	16282	19477	21900	21193	14907	10374	10675	15508
1939	11660	11992	13014	14102	11531	12392	15913	16643	20242	18413	18902	12804	11335	10536	14174
1940	11838	12052	13319	14549	11910	13094	19592	15409	16212	17302	17797	11130	11345	10781	14120
1941	10549	10849	12083	13245	13041	12985	12465	11170	14588	16832	17140	10242	11254	11097	12785
1942	10551	11168	12074	17665	18077	13792	13155	13355	15604	16861	21670	18181	12513	11375	14979
1943	11752	11995	12848	14058	19616	22961	18299	23137	24928	21520	23848	19786	13416	11419	17712
1944	12015	12291	13211	14460	11734	11355	11383	12583	15794	17045	18531	11216	11262	11212	13219
1945	10958	10792	12028	13248	11050	11935	10978	11818	15670	17785	19930	14538	11969	11144	13211
1946	10474	10755	11592	12845	19022	19741	19211	16899	20273	22232	21524	19563	11932	11358	16414
1947	12572	12714	13324	19193	19243	20353	22684	22645	19160	21485	20258	17991	11366	11344	17661
1948	11841	17177	16426	16407	18838	17956	23188	19072	17182	25984	28891	21565	15253	14332	19277
1949	13257	12843	13379	14504	15284	14707	25475	21563	19428	22827	20278	13881	11382	10489	16498
1950	10580	10818	12635	14535	16775	25198	23394	20353	18564	22532	26484	22274	15658	13912	18241
1951	13235	15757	17609	20996	24094	26631	23355	21314	21638	24875	21743	19513	15191	11401	20176
1952	13063	16508	14182	16878	20595	22361	17949	20892	23724	25420	20516	15833	12316	11388	18104
1953	11778	11983	12986	14154	14999	20256	18523	17836	15736	19845	25373	19591	12555	12182	16521
1954	12327	12903	13881	16254	17615	25177	20903	18656	16247	23430	25615	21603	19488	17654	18772
1955	16115	13400	15223	15626	15441	12159	13122	18522	15953	19766	25902	23228	15897	11380	16749
1956	12150	14770	16937	20487	24155	23266	22670	21850	24881	26755	28567	21123	13412	12752	20599
1957	12604	13607	13119	16354	14810	17236	20360	26698	18823	24551	26375	15594	11451	11376	17386
1958	11795	11993	12939	14115	15031	18687	22212	19907	16459	25355	21353	15239	12541	11100	16546
1959	11998	11950	13386	18003	23729	23185	20270	18676	15877	19189	24796	23053	14068	11845	18289
1960	17795	19047	17752	17999	18130	17353	20658	28197	20261	19156	21183	18287	12419	10639	18580
1961	11721	12472	13898	14215	17232	20369	24082	21785	14984	21087	25563	17432	11385	11383	17294
1962	11809	12069	13295	14505	15832	15316	16676	25595	23334	19877	19220	15966	13251	11334	15932
1963	11779	13316	15362	17700	17242	19753	17362	13606	16575	19994	21031	17460	12446	11367	16479
1964	11783	12008	12932	14265	15943	19574	13971	25099	16829	18116	27144	23281	15060	12202	16936
1965	13038	14386	14530	20678	24930	26302	22410	18363	22296	22738	23398	18451	13880	13886	19554
1966	13230	13652	13921	15171	17267	16523	17678	21280	18403	18649	18972	18007	12407	11377	16227
1967	11836	12046	13315	15024	19205	23813	19185	13409	14984	16738	26461	23539	14996	11908	17354
1968	12257	13102	14119	15137	18414	19739	23048	15523	16586	17018	19810	19435	12278	12331	16699
1969	15000	15065	16172	16887	23234	23475	20551	23225	23577	25813	21823	20005	11426	11350	19371
1970	11784	12987	13176	14141	18018	19367	18135	16552	16894	20472	25371	15830	11708	10721	16406
1971	11789	12050	13283	14337	22512	27479	24506	21202	21458	27548	29149	23019	17915	13176	20161
1972	13492	13774	14101	16089	23032	27221	27820	24918	23237	28497	29884	25296	19451	16015	21732
1973	13776	13565	13314	16718	17559	15597	13851	11550	16149	17944	16399	11283	11234	10509	14554
1974	10587	10815	13554	18793	25070	25822	25095	25912	27737	28455	30933	26476	17644	14849	21529
1975	13948	11931	13267	14534	18247	22388	22690	18201	14553	22271	25784	23692	11253	12594	18062
1976	13683	15093	17059	23490	24672	24560	22597	22948	20586	25345	23226	23215	19594	20186	21224
1977	17693	12915	13107	14505	11383	10860	12138	11553	15478	17475	18673	11006	11370	11311	13719
1978	10562	10823	12059	13508	15842	18833	18660	18032	18721	20912	19551	18067	11192	11237	15681
AVERAGE	**12284**	**12730**	**13702**	**15747**	**17374**	**18618**	**18483**	**18257**	**18460**	**21061**	**22402**	**17747**	**13015**	**12027**	**16737**

Table 6-8. Total Hydropower System Generation for SOS 4c

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	Average Megawatts MAR	15-Apr	30-Apr	MAY	JUNE	JULY	15-Aug	31-Aug	AVERAGE
1929	9975	11929	12576	13831	14044	13895	11241	12278	13119	14327	18759	13631	9288	9571	13016
1930	8309	10586	11321	14408	14994	13843	11349	14481	16114	12846	16028	13203	9170	9785	12628
1931	8752	10855	11548	14285	14794	13625	10415	12596	14201	14872	15689	9819	8279	8788	12203
1932	8763	9226	12804	17117	13646	12765	15157	20156	21863	25327	22876	15452	12423	11618	15518
1933	9399	11143	13109	15910	21032	17073	15848	17957	19506	20937	26472	22697	17256	13768	17324
1934	10539	14713	16268	24563	27032	22109	20716	25052	25177	23386	14194	14195	12124	10464	18670
1935	8706	10823	12971	15154	20541	19070	13711	16917	17275	18036	20878	17345	13891	10021	15496
1936	9146	10451	11898	13925	15871	12923	13523	12998	23773	25370	18041	11709	10029	9763	14267
1937	8810	10527	11489	13099	14293	12886	9144	11879	12933	17751	17214	12968	9636	9024	12489
1938	8492	10980	12194	15986	20988	17092	16999	17621	21651	24402	24673	17240	11236	9700	16594
1939	10062	11313	11479	13675	16572	14061	11661	17460	18418	20983	15680	14704	11104	9839	14051
1940	8749	12589	12746	15337	16744	14670	15507	17786	16823	16782	14969	12090	9533	9662	13925
1941	9487	11458	12068	14824	16330	14603	11626	15936	13786	14459	14424	9735	8204	9093	12696
1942	9659	11485	13260	19674	21271	17425	11173	14827	15752	18769	20748	16833	12394	10210	15565
1943	10400	12278	13856	15670	17939	20090	15833	22904	26571	24074	25889	21716	15154	10868	17926
1944	8980	11752	12503	14499	15310	14199	10526	12580	13288	13419	15567	10145	8526	8865	12367
1945	8466	10318	12437	15407	14253	14084	10919	12326	12186	20163	20306	12956	9609	8385	13373
1946	8238	11788	11724	16279	20534	19458	18250	16901	23332	26186	23346	18054	13908	10735	17183
1947	10221	11943	13292	20948	22189	20648	19836	20439	21761	23681	20019	16235	12052	9801	17574
1948	9861	16687	16469	17949	21824	19490	16599	14794	21751	27107	29680	22461	15990	13990	19286
1949	10703	12020	13131	15792	18004	17665	18346	17653	21460	26729	21287	12266	9531	8443	16194
1950	8610	11360	13026	16810	19767	22135	21749	25103	23159	22407	26153	24350	16873	13607	18789
1951	10195	14957	16687	21646	24320	25596	22702	24782	22719	24626	22636	20761	16208	10902	20087
1952	10241	15915	14358	18011	21384	20135	15946	21456	24299	26749	24445	16857	12339	9646	18147
1953	8952	11941	12183	13879	20139	21706	15143	10905	13237	20620	28029	20894	13995	11781	16505
1954	9728	11897	13246	18092	19702	21628	18935	21709	22268	24924	24925	22801	20392	17257	18880
1955	13414	12721	14622	16726	19435	15503	11940	14544	13701	19328	26264	22615	16828	10753	16704
1956	9695	13916	16245	21563	24967	20576	22902	24793	24802	26555	29291	21660	14371	12288	20460
1957	9860	12820	13224	18267	18873	18750	18125	19550	18579	27549	25957	15282	9914	9392	17276
1958	9053	12632	12836	15113	19227	21099	17291	14991	19876	26667	23815	12838	10443	10538	16512
1959	9521	12329	14521	19175	24133	21427	18735	20143	21948	21085	25397	22109	15451	11215	18549
1960	15184	18399	18168	19164	21174	18604	18520	24284	19394	21225	24106	17179	14341	10019	18796
1961	9745	11577	13156	15596	19987	21419	19066	18815	15785	25293	27005	16516	11750	11177	17315
1962	8468	11590	12691	15486	19444	17779	13645	19847	21803	21416	22455	15168	13278	11113	15910
1963	9355	12931	15099	19211	20799	22108	15602	16234	14110	19726	21128	15120	12004	10537	16426
1964	10276	12464	13330	15206	19303	16755	13215	15773	15251	22417	28488	23226	15782	11931	17001
1965	11139	13815	13685	21739	26261	23295	22394	19092	25226	23057	25005	19034	16167	13988	19708
1966	10164	12697	13006	15946	20514	17222	15153	20364	15530	20682	19342	16379	13755	10332	15918
1967	9211	11605	13054	16983	21926	21432	16198	17553	17552	19294	27171	23729	16169	11525	17640
1968	9624	12182	13826	17048	20594	21670	19083	13546	12399	18555	23766	17092	13267	12248	16585
1969	12995	14815	15979	18369	23947	21477	19094	25231	25858	25652	24358	18973	12756	10174	19365
1970	10120	12928	13251	16431	21836	20975	15087	10969	10832	22590	26412	14418	11521	9724	16269
1971	9239	12077	12774	16694	24063	25733	22008	27123	25330	26161	29967	24357	18594	12870	20377
1972	10731	12740	13726	18159	23009	24304	28944	26297	22558	28235	30100	26327	20310	15744	21559
1973	10987	12744	13243	18304	19857	16522	12098	13017	12452	16550	14731	13295	10198	8995	14215
1974	8866	11412	13809	19814	28482	24315	25556	25771	27305	27443	31153	27839	19280	14643	21842
1975	11127	11756	12749	16027	21432	20050	17675	15315	14979	23399	29163	25195	13043	13551	18081
1976	10796	14228	15031	23845	25929	21757	21164	26589	25400	24840	23807	23729	21332	20174	21006
1977	15054	12876	12930	14362	15571	14290	10009	11435	12909	12801	15281	9420	7972	8594	12730
1978	7497	10700	12448	17915	20951	18772	18604	23191	19431	21362	21292	16907	12950	10344	16607
AVERAGE	**9911**	**12378**	**13441**	**17078**	**20105**	**18774**	**16499**	**18279**	**18989**	**21816**	**22768**	**17590**	**13212**	**11149**	**16752**

Table 6-9. Total Hydropower System Generation for SOS 5b

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	15-Apr	30-Apr	MAY	JUNE	JULY	15-Aug	31-Aug	AVERAGE
							Average Megawatts								
1929	12409	12760	13737	15211	13738	11772	12142	11640	11981	17106	16587	8712	10308	10022	13016
1930	10776	10812	12922	13492	12053	12143	11287	11015	11017	15788	15415	9912	11814	10586	12230
1931	10712	10369	12942	12927	11997	10757	11616	11804	10960	15360	17093	9799	10658	10245	12118
1932	9953	9879	11998	13195	12616	11302	13129	18453	19289	20967	16173	12070	11005	11327	13447
1933	11588	12400	13341	14474	22012	19062	15138	13833	16370	18113	21272	20922	15261	13362	16467
1934	12750	14802	16676	23295	26438	24987	21147	20548	21557	21961	12813	10335	10138	10285	18006
1935	11829	11560	14132	14670	20362	19896	14941	13705	13874	15896	15593	14970	12053	10062	14859
1936	11946	12322	13710	14783	14354	14078	13779	11595	16470	21044	15656	11422	10827	10008	13962
1937	11070	11388	13039	14457	13231	11551	11966	11266	12092	16253	14054	9965	11470	10800	12489
1938	10511	10501	12134	13585	20930	17944	16696	13625	19470	19768	17221	12480	9879	9502	14816
1939	11541	12277	13609	15267	12698	12180	15739	14599	16892	18426	12905	10674	10701	10084	13464
1940	11874	12361	13434	14356	14353	12780	18294	13333	14536	17655	12427	10400	10316	9897	13508
1941	10487	11024	12174	13312	13463	13283	12490	9581	10018	15368	16468	10325	11087	10275	12400
1942	10158	11511	12256	18935	19806	18841	11974	11517	11697	15723	17612	13503	11826	10530	14404
1943	10122	11699	12232	14913	22244	21522	16823	19727	21686	19628	19615	17371	13032	10417	16515
1944	11330	12841	13293	14651	13607	11738	12585	11345	12130	14933	16222	9864	9457	10620	12739
1945	9389	10692	11977	13179	12677	12150	11211	10874	12120	17191	18127	9631	9761	11034	12342
1946	10353	10814	12086	12856	22062	19834	17868	14523	19774	21125	18928	14780	11293	10093	15689
1947	11263	12873	13139	19481	23385	23377	18853	15623	18659	20920	15452	12651	10687	10184	16550
1948	11454	16982	16376	17015	23733	21789	17073	16040	19139	21685	24546	20098	14745	13366	18525
1949	12221	12801	12894	14640	18988	17834	19052	19463	19474	21479	14316	11413	9434	9639	15374
1950	11476	12210	13509	14768	20605	22693	20603	19375	17883	19861	22994	20407	15081	12970	17615
1951	12006	15486	16950	21365	25514	25586	22121	19225	19936	21880	19055	18007	14819	10506	19151
1952	12103	16338	14150	17213	22278	21514	16631	16823	20887	22015	18110	13715	11696	10139	16973
1953	11554	12428	13313	15129	20016	20616	15671	12623	12718	17016	21346	17403	11998	11293	15704
1954	11349	12843	13366	16207	22405	23167	18138	17659	17395	21701	22325	19927	18933	16670	18039
1955	15133	13089	14895	15719	20260	17648	12455	12112	12204	17253	21470	19554	14924	10352	16004
1956	11434	14392	16120	20628	26084	22627	20293	19359	21746	23475	25181	19674	12884	11769	19392
1957	11608	13400	13008	16821	19373	20437	18166	18942	18080	21352	20834	13952	10257	10126	16444
1958	11770	12395	13211	14708	19278	21425	17116	16925	16606	21430	19702	10546	9873	10257	15658
1959	11825	12370	14208	17984	25611	22455	18395	16673	17248	19658	21102	18781	13070	10998	17590
1960	16484	19541	18416	18453	21563	20004	18826	21298	21630	17504	16877	14201	12783	10146	17880
1961	11475	12940	13596	14495	21619	23000	19666	19336	15308	21703	21689	12332	10820	10776	16675
1962	11522	12567	13478	14505	19408	18611	14296	19683	20862	17442	16359	12712	11804	10602	15166
1963	11544	13158	15228	18118	21100	22943	14388	15160	12384	16952	18839	12181	11132	10119	15687
1964	11174	12733	12720	14578	21021	19582	13398	17380	15602	17294	21280	20856	14486	11379	16157
1965	12647	14143	14304	20839	26776	25200	20792	15623	21190	19812	19688	14729	14075	13251	18383
1966	11706	13597	14259	15437	22040	19078	15406	18332	13382	17496	16231	13989	12010	9987	15487
1967	11789	12687	13434	14746	23341	21966	16438	13739	14486	18247	21002	21184	14279	11053	16773
1968	11425	12902	14001	15232	21777	22844	19604	12120	14009	15855	19022	14078	11875	11594	15941
1969	14209	15181	16725	17738	25251	22707	18493	20489	21101	22530	21644	15286	10695	9987	18373
1970	10984	13054	12982	14523	19968	22256	16686	14151	12363	19532	22174	11204	9195	9111	15432
1971	11440	12549	13122	14662	26416	25402	23063	18941	21295	23421	25237	21061	17324	12319	19238
1972	12170	13410	13698	16405	25674	25750	24758	23761	21621	25055	26368	23833	18966	15032	20554
1973	12645	13286	12535	17212	17788	15923	13398	10933	11530	16511	14407	10122	10633	10074	13778
1974	11839	11803	13662	19524	26242	25281	24332	22290	24382	25304	27520	24486	17008	13777	20703
1975	12824	12907	12828	14348	22004	22033	18860	14605	14290	19815	22132	20836	10412	11749	16986
1976	12719	14727	17069	23650	27041	23823	20302	20807	20029	21674	20696	20150	19365	19311	20140
1977	16516	13016	13000	14954	13481	12080	12481	11888	12565	14983	16533	10260	10318	10512	13326
1978	10268	10679	12432	14312	18108	17538	17353	16562	16825	18085	16771	16491	11087	10994	14970
AVERAGE	**11787**	**12850**	**13766**	**16059**	**20136**	**19260**	**16719**	**15818**	**16575**	**19225**	**18902**	**14865**	**12351**	**11184**	**15943**

Table 6–10. Total Hydropower System Generation for SOS 5c

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	Average Megawatts MAR	15–Apr	30–Apr	MAY	JUNE	JULY	15–Aug	31–Aug	AVERAGE
1929	13295	12227	13202	14382	13516	10980	11201	11650	12489	18261	17266	9170	10819	10474	13024
1930	10840	10493	12754	12970	12072	11267	10348	11028	11520	16936	16079	10406	12388	11069	12265
1931	10781	10053	12498	12908	11772	10096	10775	11816	11465	16504	17793	10275	11191	10724	12176
1932	10160	9629	11566	12933	12689	10645	11855	18501	19993	22078	16886	12667	11589	11845	13512
1933	11710	11913	13340	14178	21254	18252	14168	13853	17021	19327	22055	21677	15984	13944	16516
1934	12911	14476	16734	21847	24915	23700	20006	20507	22205	22802	13425	10850	10679	10773	17783
1935	11848	11231	14163	14309	20098	19016	14119	13719	14486	17037	16234	15643	12694	10548	14925
1936	11984	11923	13725	14386	14440	13412	12769	11612	17119	22241	16373	11956	11369	10466	14042
1937	11359	11027	13105	14178	12795	10931	11171	11276	12638	17360	14713	10447	12018	11288	12568
1938	10533	10197	12120	13068	20582	16897	15486	13647	20174	21062	18028	13096	10428	9955	14835
1939	11671	11817	13486	14584	12469	11307	14525	14618	17543	19619	13504	11202	11271	10558	13445
1940	11945	11908	13444	14178	13855	11711	16939	13351	15167	18909	13051	10919	10853	10357	13489
1941	10579	10562	12079	12970	12836	12291	11533	9599	10523	16502	17214	10855	11649	10756	12389
1942	10418	10758	11734	17967	19147	17723	11035	11536	12293	16859	18356	14126	12444	11032	14298
1943	10454	11258	12223	14178	21153	19855	15164	19756	22189	20853	20470	18066	13690	10926	16385
1944	11610	12127	13224	14178	13068	10818	11715	11356	12656	15980	16912	10356	9947	11102	12714
1945	9710	10246	11511	12933	12271	11038	10263	10885	12642	18352	18916	10147	10265	11512	12342
1946	10537	10103	11879	12641	20827	18340	16346	14545	20486	22113	19669	15449	11887	10569	15537
1947	11610	12060	12814	17878	22327	21530	17496	15645	19305	21924	16189	13250	11258	10654	16268
1948	11672	16409	16130	15869	22570	20125	15806	16071	19830	22731	24727	20856	15446	13943	18290
1949	12450	12157	12845	14178	18260	16460	17420	19514	20175	22435	14991	11963	9927	10074	15243
1950	11613	11659	13467	14247	20060	20927	19100	19423	18564	21080	23678	21155	15804	13526	17530
1951	12267	14692	16521	20010	24273	23275	20776	19273	20652	22817	19883	18747	15532	11000	18850
1952	12291	15583	14126	16218	21405	19837	15325	16875	21452	23053	18899	14346	12295	10600	16797
1953	11741	11908	13232	14314	19566	18809	14489	12639	13281	18185	22184	18136	12604	11801	15624
1954	11610	12255	13277	15579	21783	21495	17011	17702	18059	22678	23126	20624	19636	17330	17968
1955	15364	12543	14926	15079	19867	16815	11669	12127	12724	18446	22311	20285	15638	10839	16066
1956	11610	13889	16114	19356	24630	20853	18676	19407	22311	24016	25508	20417	13519	12291	19064
1957	11851	12751	12928	15846	18866	18853	16738	18991	18773	22519	21698	14599	10785	10577	16330
1958	11960	11890	13105	14178	18597	19634	15923	16967	17288	22608	20479	11059	10387	10731	15560
1959	12030	11898	13842	16725	24170	20900	17210	16701	17895	20763	21961	19552	13719	11498	17394
1960	16946	18307	17471	17402	20875	18889	17531	21344	22335	18625	17641	14844	13407	10609	17679
1961	11667	12405	13585	14178	20717	21606	18530	19377	15930	22732	22525	12915	11379	11274	16616
1962	11690	12064	13465	14178	18463	17424	13262	19732	21511	18629	17041	13308	12410	11093	15132
1963	11661	12369	15093	17147	20407	21215	13353	15177	12921	18118	19580	12764	11706	10604	15533
1964	11585	12174	12687	14178	20189	18230	12375	17422	16223	18457	22067	21614	15165	11894	16147
1965	13014	13575	13884	19174	24652	22574	19183	15657	21787	21128	20565	15424	14747	13821	17992
1966	12306	12622	13613	14393	21403	17932	14338	18369	13942	18683	16868	14605	12619	10458	15354
1967	11931	12172	13457	14178	22469	20652	15398	13757	15060	19451	21845	21959	14963	11556	16743
1968	11610	12306	13844	14513	21061	21059	18432	12137	14571	16980	19814	14712	12484	12087	15815
1969	14623	14365	15904	16605	23696	20841	16986	20538	21804	23418	22411	15902	11194	10421	18032
1970	11332	12438	13019	14178	18688	20320	15563	14169	12870	20711	23052	11730	9663	9520	15305
1971	11749	11906	12652	13964	24145	22713	21544	18989	22012	24184	25716	21844	18045	12830	18837
1972	12460	12532	13506	15324	24247	23518	22714	23774	22312	25673	26673	24639	19697	15629	20156
1973	12910	12473	12535	16078	16925	14740	12440	10944	12005	17637	15046	10590	11134	10514	13637
1974	11918	11275	13396	18454	24123	23197	22534	22337	24889	25982	27697	25241	17737	14333	20273
1975	13018	12189	12851	14178	20920	20343	17519	14621	14888	21093	22932	21589	10930	12237	16899
1976	13036	13863	16510	21955	25402	22033	18858	20856	20733	22930	21539	20898	20057	19922	19825
1977	16794	12284	12879	14209	13152	11294	11702	11895	13089	16067	17222	10715	10826	10981	13309
1978	10404	10217	11844	13446	17340	15975	15995	16613	17465	19278	17545	17191	11365	11020	14785
AVERAGE	**12021**	**12264**	**13566**	**15320**	**19300**	**17847**	**15506**	**15846**	**17185**	**20316**	**19607**	**15496**	**12945**	**11671**	**15826**

Table 6–11. Total Hydropower System Generation for SOS 6b

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	Average Megawatts MAR	15–Apr	30–Apr	MAY	JUNE	JULY	15–Aug	31–Aug	AVERAGE
1929	12409	12760	13737	15211	13738	11476	11966	13245	12694	18287	17980	9236	10539	10233	13351
1930	10927	10932	13312	13933	12053	11857	11101	12911	12055	16833	16330	10300	12056	10840	12623
1931	10891	10508	13030	13584	11997	10447	11359	13806	11566	16380	17652	10062	10837	10416	12439
1932	10001	9889	12030	13875	12619	11009	13196	21272	20760	22770	17654	12704	11267	11548	14018
1933	11794	12535	13634	14857	22012	18784	14986	15628	17521	19391	23439	21558	15535	13607	17001
1934	12653	15144	17409	23317	26438	24809	21255	23190	23012	22905	13328	10637	10351	10487	18419
1935	11909	11729	14380	15069	20618	19635	14683	15368	14958	17062	16720	15409	12255	10242	15272
1936	11873	12348	14193	15397	14355	13790	13655	13945	18590	22867	16674	11819	11052	10224	14490
1937	11276	11484	13508	14732	13231	11237	11686	12840	12760	17485	14976	10352	11708	11008	12853
1938	10598	10603	12657	14006	20966	17685	16751	16055	21173	21422	18892	13168	10157	9758	15427
1939	11804	12410	14110	15360	12698	11891	15774	16526	18141	19836	13637	11083	10913	10284	13890
1940	12029	12476	13840	14622	14354	12661	18472	15695	15741	19014	13288	10758	10511	10072	13969
1941	10729	11167	12640	13459	13478	13013	12342	11158	10627	16445	17558	10813	11387	10581	12789
1942	10584	11515	12468	19105	19806	18599	11803	13826	12959	16995	19031	14166	12100	10773	14888
1943	10256	11813	12660	15203	22244	21385	17213	22933	23792	21302	21594	18587	13496	10781	17280
1944	11448	12984	13796	14722	13607	11467	12351	13167	12810	15978	17291	10367	9762	10899	13113
1945	9663	10697	11993	13741	12678	11886	11031	12580	12845	18853	19643	10228	10035	11277	12817
1946	10695	10819	12488	13018	22062	19630	18171	17230	21705	22697	20168	15369	11591	10354	16274
1947	11419	13088	13571	19481	23385	23268	19036	17762	20017	22879	16846	13258	10979	10455	17124
1948	11515	17280	16899	17015	23733	21662	17156	18083	20832	23818	26690	20847	15185	13734	19202
1949	12259	12962	13432	14787	18988	17607	19527	22251	21199	23598	15562	11913	9683	9869	16001
1950	11736	12371	13879	14968	20605	22575	21036	22425	19555	21383	24980	21455	15519	13303	18333
1951	12111	15784	17355	21365	25514	25528	22444	22140	21553	23575	20511	18747	15175	10807	19782
1952	12075	16654	14712	17289	22278	21389	16742	20109	23004	24153	19752	14424	12070	10468	17676
1953	11764	12529	13791	15218	20016	20450	15674	14532	13770	18457	23504	18409	12361	11599	16300
1954	11352	12953	13875	16460	22405	23037	18123	20114	18895	23430	23688	20752	19265	17013	18621
1955	15197	13265	15430	15818	20260	17363	12164	14253	12900	18809	23257	20353	15246	10605	16518
1956	11373	14628	16754	20791	26084	22514	20812	22307	23883	25603	27169	20342	13284	12140	20148
1957	11687	13572	13543	16864	19373	20245	18398	21860	19657	23472	22708	14560	10570	10399	17113
1958	12086	12536	13626	14708	19278	21302	17147	18979	18178	23565	21235	11118	10190	10554	16254
1959	12192	12450	14634	17984	25611	22304	18438	18827	18362	20898	22881	19434	13378	11286	18121
1960	16935	19701	18416	18453	21563	19773	18952	24076	22706	18859	18394	14724	13097	10428	18390
1961	11482	13095	14155	14675	21619	22838	19707	21217	16165	23105	23129	12753	11041	10992	17146
1962	11619	12687	13983	14728	19408	18365	14190	22495	22593	18773	17822	13314	12128	10874	15713
1963	11482	13382	15842	18378	21100	22819	14286	17118	13198	18382	20547	12844	11447	10398	16212
1964	11238	12851	13240	14685	21021	19350	13290	19986	16699	18899	23415	21746	14893	11723	16766
1965	12930	14347	14471	20839	26776	25207	21295	18257	23315	21745	21839	15709	14587	13750	19144
1966	12311	13597	14259	15437	22040	18827	15322	20551	14188	18647	17144	14427	12244	10218	15864
1967	11807	12817	13970	15025	23341	21788	16340	15710	15261	19761	23056	21987	14591	11321	17334
1968	11376	13110	14562	15440	21777	22742	19682	13709	14582	17048	20469	14621	12185	11970	16400
1969	14578	15432	16725	17738	25251	22599	18790	23445	22855	24527	22940	15870	10980	10255	18984
1970	10943	13216	13478	14836	19968	22153	16651	15984	12993	21289	24339	12047	9546	9386	16026
1971	11835	12710	13229	14662	26416	25432	23512	21920	23086	25540	27365	22138	17768	12678	20010
1972	12351	13569	14096	16405	25674	25702	26130	26497	22966	27177	28515	24604	19380	15398	21349
1973	12778	13434	13041	17212	17788	15672	13246	12333	12101	17625	15250	10524	10888	10328	14111
1974	12145	11924	14037	19658	26242	25202	24998	25403	26507	27389	29606	25593	17473	14182	21526
1975	12841	13014	13313	14580	22004	21889	19017	16790	15590	21559	24267	22230	10843	12199	17681
1976	12943	14975	17224	23650	27041	23714	20589	23969	21747	23805	22324	20971	19803	19729	20827
1977	16707	13155	13361	14954	13481	11784	12183	13364	13126	15657	17136	10540	10527	10724	13567
1978	10482	10687	12454	14880	18340	17333	17529	19060	18089	19647	18431	17114	11162	10994	15537
AVERAGE	**11942**	**12992**	**14145**	**16244**	**20147**	**19074**	**16804**	**18138**	**17866**	**20792**	**20413**	**15520**	**12661**	**11463**	**16494**

Table 6-12. Total Hydropower System Generation for SOS 6d

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	Average Megawatts MAR	15-Apr	30-Apr	MAY	JUNE	JULY	15-Aug	31-Aug	AVERAGE
1929	12409	12760	13737	15211	13738	11476	11949	12708	12989	18788	18578	9452	10583	10321	13456
1930	11388	10932	13312	13933	12053	11857	11084	12425	12494	17274	16717	10458	12103	10947	12747
1931	11354	10508	13030	13584	11997	10447	11341	13339	11817	16810	17884	10169	10858	10487	12535
1932	10455	9889	12030	13875	12619	11009	13182	21119	21372	23534	18291	12966	11323	11640	14219
1933	12269	12535	13634	14857	22012	18784	14970	15138	18009	19935	24355	21821	15597	13710	17190
1934	13118	15144	17409	23317	26438	24809	21244	23027	23635	23301	13541	10759	10386	10571	18542
1935	12371	11729	14380	15069	20618	19635	14665	14842	15417	17557	17201	15589	12286	10317	15407
1936	12245	12433	14193	15397	14355	13790	13639	13506	19475	23639	17106	11981	11093	10315	14664
1937	11741	11484	13508	14732	13231	11237	11668	12297	13037	18008	15364	10511	11753	11095	12974
1938	11055	10603	12657	14006	20966	17685	16737	15694	21899	22127	19611	13455	10220	9865	15629
1939	12279	12410	14110	15360	12698	11891	15759	16073	18672	20438	13943	11250	10949	10368	14026
1940	12497	12476	13840	14622	14354	12661	18459	15308	16254	19594	13651	10904	10539	10145	14108
1941	11196	11167	12640	13459	13478	13013	12325	10610	10879	16901	18023	11014	11459	10711	12916
1942	11065	11515	12468	19105	19806	18599	11786	13418	13497	17536	19641	14442	12161	10875	15058
1943	10720	11813	12660	15203	22244	21385	17205	23071	24746	22015	22437	19108	13639	10935	17549
1944	11917	12984	13796	14722	13607	11467	12333	12668	13091	16420	17745	10574	9837	11017	13241
1945	10134	10697	11993	13741	12678	11886	11014	12060	13146	19534	20296	10475	10097	11379	12985
1946	11170	10819	12488	13018	22062	19630	18160	16933	22521	23369	20698	15612	11662	10463	16462
1947	11896	13088	13571	19481	23385	23268	19024	17363	20597	23704	17444	13509	11047	10569	17318
1948	11981	17280	16899	17015	23733	21662	17142	17725	21554	24754	27621	21160	15317	13890	19448
1949	12733	12962	13432	14787	18988	17607	19520	22113	21934	24481	16095	12119	9735	9965	16207
1950	12204	12371	13879	14968	20605	22575	21029	22383	20269	22033	25826	21901	15651	13443	18573
1951	12587	15784	17355	21365	25514	25528	22435	22065	22245	24295	21138	19055	15272	10933	19994
1952	12542	16654	14712	17289	22278	21389	16729	20177	23951	25069	20460	14719	12174	10607	17926
1953	12235	12529	13791	15218	20016	20450	15659	14048	14215	19073	24421	18835	12461	11728	16509
1954	11815	12953	13875	16460	22405	23037	18109	19897	19538	24166	24273	21098	19361	17158	18825
1955	15663	13265	15430	15818	20260	17363	12145	13808	13189	19475	24024	20687	15329	10711	16704
1956	11832	14628	16754	20791	26084	22514	20809	22237	24807	26502	28016	20619	13400	12298	20401
1957	12159	13572	13543	16864	19373	20245	18386	21785	20333	24418	23510	14812	10648	10513	17351
1958	12564	12536	13626	14708	19278	21302	17133	18688	18853	24493	21896	11354	10269	10679	16470
1959	12672	12450	14634	17984	25611	22304	18424	18534	18834	21425	23644	19704	13455	11408	18305
1960	17421	19701	18416	18453	21563	19773	18938	23936	23161	19436	19047	14940	13176	10547	18570
1961	11944	13095	14155	14675	21619	22838	19694	20907	16524	23703	23749	12925	11080	11083	17307
1962	12084	12687	13983	14728	19408	18365	14174	22359	23334	19342	18453	13564	12211	10988	15904
1963	11941	13382	15842	18378	21100	22819	14271	16662	13537	18994	21282	13120	11526	10515	16388
1964	11707	12851	13240	14685	21021	19350	13273	19798	17164	19586	24352	22123	15012	11868	16993
1965	13419	14347	14471	20839	26776	25207	21291	18028	24212	22565	22766	16127	14752	13965	19408
1966	12809	13597	14259	15437	22040	18827	15306	20303	14526	19137	17531	14608	12290	10316	16002
1967	12268	12817	13970	15025	23341	21788	16324	15244	15585	20408	23937	22326	14669	11434	17529
1968	11836	13110	14562	15440	21777	22742	19669	13168	14821	17554	21093	14845	12262	12130	16547
1969	15069	15432	16725	17738	25251	22599	18779	23387	23604	25363	23495	16110	11047	10367	19197
1970	11405	13216	13478	14836	19968	22153	16636	15485	13254	22034	25256	12400	9642	9501	16230
1971	12320	12710	13229	14662	26416	25432	23505	21859	23847	26485	28305	22596	17901	12829	20287
1972	12825	13569	14096	16405	25674	25702	26130	26402	23538	28066	29444	24924	19510	15552	21598
1973	13252	13434	13041	17212	17788	15672	13229	11743	12335	18093	15601	10689	10942	10437	14224
1974	12616	11924	14037	19658	26242	25202	25000	25421	27398	28265	30570	26066	17615	14354	21809
1975	13307	13014	13313	14580	22004	21889	19005	16368	16143	22299	25203	22827	10971	12390	17928
1976	13423	14975	17224	23650	27041	23714	20578	23962	22483	24706	23026	21315	19943	19907	21072
1977	17182	13155	13361	14954	13481	11784	12165	12804	13355	15935	17386	10652	10562	10812	13650
1978	10947	10687	12454	14880	18340	17333	17516	18852	18627	20318	19148	17372	11252	10994	15729
AVERAGE	**12401**	**12994**	**14145**	**16244**	**20147**	**19074**	**16791**	**17835**	**18414**	**21459**	**21062**	**15793**	**12741**	**11581**	**16682**

Table 6-13. Total Hydropower System Generation for SOS 9a

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	Average Megawatts MAR	15-Apr	30-Apr	MAY	JUNE	JULY	15-Aug	31-Aug	AVERAGE
1929	10602	9799	12142	13886	11164	10625	12525	13117	19786	22011	18973	14385	10400	9890	13572
1930	7557	7000	7861	10971	9513	11204	10710	12747	17085	16600	16913	15487	10644	9502	11566
1931	6941	7221	7900	9847	10170	9404	10656	13060	16342	16276	17332	14170	9671	9515	11193
1932	6677	6894	7920	10025	9924	9750	13125	15513	20748	20767	20932	16744	13454	13655	12882
1933	8421	8509	10469	13465	18591	16901	17310	18135	19392	20223	22261	20937	14812	13519	15833
1934	10415	11819	15817	23481	25438	22877	22689	25231	23170	22576	20608	12888	9688	9427	18503
1935	7410	7732	9512	11742	14998	18563	15602	17874	16810	17090	16480	17206	13049	13108	13871
1936	7884	9070	11469	12029	13575	12367	13847	13628	20899	23330	19839	16586	13105	12950	14201
1937	8101	7560	8024	10673	9911	9712	11670	12425	18831	19630	17834	16339	10722	9531	12116
1938	7412	7161	8832	11728	11780	14189	18017	18551	21659	20784	18990	18101	14182	13842	14264
1939	8744	8208	9326	11411	11099	11318	14809	16856	18378	17447	18384	16691	12813	12824	13167
1940	7873	7888	8443	11387	13563	12196	18418	15662	19381	19065	17515	15960	12267	10603	13450
1941	7781	7601	8516	10907	10773	10973	11062	10844	15327	16069	15170	15195	12218	11985	11613
1942	8001	7818	8828	13298	16604	15055	11994	12184	14605	17375	19471	16679	12831	12934	13448
1943	8337	8154	11440	13220	17279	19821	18676	25396	24690	22524	21227	17200	14101	13965	16384
1944	9372	9372	10912	12128	11248	11298	11934	12353	19667	20868	18012	9836	8916	9253	12502
1945	7472	7078	8030	9832	10349	11361	10765	11636	16155	16377	16481	15904	13370	13273	11745
1946	8179	8588	9502	11369	13444	16531	19645	18984	21969	22136	20580	18290	14303	14479	15257
1947	8739	9497	10306	16610	19230	21410	22114	19863	21785	21540	19297	17273	13426	13654	16681
1948	8430	9733	13368	14934	19716	19724	18555	17448	21640	24598	27333	19714	13931	13963	17457
1949	10951	11039	12913	15210	16359	17259	21526	20746	22416	21308	19400	17019	13775	13290	16505
1950	8376	8167	9448	11352	12527	21496	23884	23588	21590	20741	24712	20673	14868	16079	16585
1951	9530	12757	15862	20830	22997	25318	25093	24081	22659	22479	20935	20615	15949	15844	19618
1952	9016	10517	11323	15536	19321	19873	19013	23373	24389	23550	19518	18201	14494	14090	16999
1953	9120	8165	8994	10490	15618	20733	15705	14591	17272	19339	22971	18539	13394	13783	14893
1954	9306	10610	12365	15453	17958	21045	20959	21487	21610	22582	23334	19234	18118	16172	17608
1955	13948	11339	14897	15959	17201	15503	12798	15174	19784	21752	20319	19603	14392	13688	16237
1956	8846	11916	15363	20647	22065	21645	24129	24483	23237	24578	26809	21498	16878	16471	19838
1957	9195	9283	10226	13822	16786	19051	18883	23419	20385	21946	24516	16579	13629	13728	16298
1958	8811	8799	9557	11781	17138	21123	18700	18721	19870	23234	21853	16784	13229	12993	15816
1959	8757	8273	10893	14017	20936	20709	21323	21109	20063	19447	22824	19139	14678	14892	16787
1960	11780	16493	18680	18239	19444	19438	20245	26661	22254	21606	17974	16318	13624	13560	18181
1961	8610	8682	12252	12767	17375	21864	20060	21241	20169	21333	22590	16794	13761	13482	16346
1962	8526	8462	9456	13135	17113	16510	15086	22533	22810	21276	17206	16470	12950	13125	14904
1963	8847	9549	11320	15658	17994	21549	15906	15322	19403	18774	16795	16492	13282	12850	15243
1964	8815	8793	10194	12081	17201	18188	15048	21126	18893	21066	22352	20246	13825	13675	15634
1965	10534	11571	12805	18807	23364	23966	22991	19157	24201	21812	21706	19192	16055	15720	18671
1966	9435	9525	10112	13259	18649	18093	15890	21793	18279	19298	18294	16742	13131	13079	15188
1967	8158	8423	9429	12230	18123	20513	18631	17941	17972	19493	22176	20260	14898	15015	15840
1968	8732	10609	13042	15039	18039	21934	19895	14102	19437	21435	18714	16889	13222	14330	16231
1969	9385	11442	14486	14764	21471	22254	20427	24212	22947	23376	22603	20163	16317	14360	18247
1970	9372	8792	9319	11686	16151	21506	16253	15487	20281	22182	21340	16971	13839	13283	15378
1971	9464	8488	10224	12236	16893	22833	24212	23539	22521	25199	27727	21603	18286	17139	18271
1972	10307	10442	11023	16429	22055	24345	29907	25928	22230	26284	28085	23415	19505	18638	20454
1973	10542	9875	12499	17627	16977	15308	13879	11583	18820	22238	19440	12872	10281	8663	14656
1974	7801	7832	10117	13414	20759	24803	25303	23946	24577	25590	29538	24851	19476	18784	19422
1975	10085	9324	9686	14784	19841	20211	21401	18375	19143	22551	23829	21896	15630	16097	17349
1976	10183	10377	13979	20896	22167	21809	22857	25678	23085	22578	22394	21053	18920	17976	19262
1977	14676	11016	11292	14237	11717	11611	11003	12140	20413	21341	18317	10277	10522	9766	13489
1978	6984	7061	9966	13511	12259	13909	16214	21073	19525	19409	19676	16956	13544	13669	14156
AVERAGE	**9049**	**9286**	**11007**	**13977**	**16497**	**17794**	**17827**	**18682**	**20371**	**21102**	**20832**	**17659**	**13848**	**13522**	**15676**

Table 6–14. Total Hydropower System Generation for SOS 9b

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	15–Apr	30–Apr	MAY	JUNE	JULY	15–Aug	31–Aug	AVERAGE
							Average Megawatts								
1929	9954	10006	12478	13819	10674	10688	12174	12656	17700	17040	19127	14988	11187	9339	13036
1930	7741	7800	8326	12778	10721	11932	11878	12145	17711	16177	18679	12721	9754	9383	11932
1931	7314	8021	8493	11886	10652	9882	11028	12695	16717	16057	18270	13287	9414	8717	11561
1932	7053	7475	8587	10849	10739	11353	17461	24217	24294	21128	22748	16107	14127	14262	14331
1933	8389	8702	11789	15518	16431	15987	19909	18883	22335	19655	23629	23057	15262	14298	16546
1934	10069	12112	16801	24114	25379	21334	23154	25384	25236	22184	19982	8488	9049	9084	18141
1935	7745	8354	11859	15285	16345	17312	17770	18131	22121	19929	19886	13261	12964	9054	14882
1936	7745	8196	9277	13167	11085	10762	16706	13342	21976	24718	19454	14578	14216	9016	13758
1937	8407	8162	8429	11365	10180	9910	11720	13069	16495	16247	19494	15226	13279	8943	12091
1938	7800	8378	9514	14461	16871	15962	19645	18332	25774	22678	22848	13442	9856	8582	15228
1939	8570	8799	9434	14045	13070	13534	16519	16071	21014	17251	17725	14869	12651	9409	13613
1940	8163	8414	9236	15299	13148	12987	20517	15288	17032	16313	17583	13890	8464	8686	13365
1941	8119	8324	9311	13854	13330	13012	13153	11986	15837	15563	15899	11005	8870	8754	12018
1942	8396	8304	10104	19370	16333	15536	14135	12872	16866	16477	22556	16741	13907	13762	14722
1943	8235	8289	10368	16574	15625	19253	22088	27036	27193	22878	23342	17306	13837	13446	17039
1944	8850	9339	9321	14936	11183	11226	11309	12035	16662	15893	16885	10629	8256	8791	11869
1945	7882	7917	8715	10728	10942	12050	11379	12923	17172	19103	21656	14374	14586	11414	12728
1946	8266	8977	9376	12430	16024	18252	21909	20173	26999	23164	23684	17481	13830	10473	16255
1947	8718	9537	10588	19462	16971	20938	23866	20093	23517	21500	21803	16226	13404	10602	16928
1948	8500	11611	15218	16854	16758	18487	21094	17518	24884	26750	29226	20909	13919	14448	18398
1949	10018	11045	13097	15336	14053	16370	23970	20453	25643	22182	20527	15340	9878	8082	16154
1950	8489	8782	9975	14820	14734	20521	25463	23794	25239	22809	24738	22180	15119	14729	17647
1951	9229	12819	17402	21567	20903	24894	25952	24214	26461	24959	23022	17785	13795	10452	19629
1952	8726	12065	13704	17030	16851	20321	21140	24105	27389	25141	24579	14359	11222	8568	17436
1953	8739	8652	8941	11703	13740	23068	18744	14343	20379	19935	25367	19643	14186	14467	15801
1954	8689	9410	12031	17031	14958	19521	22655	21076	24375	23876	25175	20190	18578	16270	17797
1955	13363	11275	14250	15831	14480	11773	13323	20874	17118	19319	26016	22890	14716	14498	16361
1956	8411	10737	16233	20876	21110	21622	25447	24549	26999	26520	28695	20197	14549	14595	20010
1957	8828	9790	12240	17460	14175	17466	21470	24129	23315	24176	26878	15662	14481	9413	16964
1958	8872	9053	9824	14701	14811	19893	20653	18957	24536	24550	22474	15493	12944	9562	16079
1959	8652	8895	12239	17606	19633	20297	22817	20983	23155	20897	22701	21668	14288	14435	17645
1960	12087	16880	17728	18168	17005	18372	22208	26834	24189	18274	20033	17146	14571	14494	18153
1961	8601	8864	12122	14724	15940	20922	22338	21816	22010	21669	24942	16712	14615	13802	16879
1962	8514	8811	9766	14455	14585	15596	17704	23884	25474	18994	19357	15642	14256	14175	15186
1963	8740	9721	12827	17889	16225	21393	18179	14511	17351	19598	21021	16314	14435	13523	15954
1964	8671	8985	10564	15298	14339	16508	16667	20907	20223	18254	26864	23298	14628	14561	16211
1965	9119	11510	13198	21188	22480	24764	24842	20052	26869	22733	22726	18081	14632	14559	19032
1966	9297	11045	11956	15641	16374	17266	18459	21851	19038	17640	17984	17792	14498	13908	15670
1967	8424	8826	9742	16882	17409	19983	21067	18596	20463	19795	23599	22776	13940	14389	16841
1968	8341	10553	13131	15855	14885	20688	22362	15184	20309	16359	19702	19123	14538	14396	16091
1969	9501	12544	15954	17256	20634	22442	22634	24861	27226	25842	23604	17693	10550	9308	18639
1970	9484	9354	10876	15502	16152	19898	18575	17607	17823	19899	25249	15068	15120	9882	15816
1971	9403	9830	10102	13039	19729	25818	25288	25435	25473	28010	29867	22330	16114	15471	19512
1972	10084	10616	12996	17270	19491	23580	31150	26163	22788	28247	30026	24399	18534	15442	20772
1973	11321	11433	12801	17962	17308	15691	14315	12422	17607	16776	17964	10525	9405	7659	14120
1974	8801	8616	10780	19068	25208	26504	26180	25633	27299	28092	31230	26127	16751	15341	21066
1975	10228	9855	12059	16140	17769	19682	23484	17930	21719	22812	23735	23162	14450	15570	17814
1976	9890	11009	14594	23431	22314	21866	24986	26049	26419	24966	23873	21114	19043	18288	20253
1977	14807	11144	11686	14307	11091	10888	11330	12251	16955	16889	17313	9412	8353	8899	12669
1978	7709	8385	10347	14421	14278	17322	21116	21612	22551	21757	19943	18001	15039	14884	15857
AVERAGE	**9019**	**9744**	**11608**	**15985**	**15902**	**17706**	**19639**	**19318**	**22079**	**21034**	**22474**	**17174**	**13361**	**12082**	**16130**

Table 6-15. Total Hydropower System Generation for SOS 9c

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	15-Apr	30-Apr	MAY	JUNE	JULY	15-Aug	31-Aug	AVERAGE
							Average Megawatts								
1929	10090	10937	13543	14180	10865	10668	12391	12384	16735	15570	15376	11198	9488	9139	12394
1930	7873	8948	12649	14047	10641	12209	12017	12409	17253	15327	13656	11192	10211	9807	11944
1931	7859	9562	12554	13822	11103	10219	11571	12996	16366	15113	16033	8387	8485	8785	11628
1932	7238	9118	12156	15425	12962	14479	15663	16893	18299	18008	22074	17054	13544	11160	14505
1933	8504	9985	13547	16454	18101	20342	18377	13665	16194	17778	23376	22755	15827	13698	16558
1934	10165	13630	17422	24587	26745	23887	21995	21409	19870	20488	17093	14829	9900	9457	18407
1935	7834	9383	13303	14647	17734	21571	16343	12532	14548	16170	15780	17242	13230	11472	14621
1936	7876	9446	12270	14186	11616	10747	15810	12862	19737	23037	18045	13148	9745	9277	13512
1937	8525	9491	13151	13892	10490	9897	11242	12826	15953	15190	15199	12494	10003	9085	11965
1938	7969	9288	12814	15930	20408	18767	18494	14688	20040	20240	20346	16548	11077	9203	15676
1939	8950	9954	11949	13928	12271	12859	16828	16080	18965	17019	17141	11509	10293	8919	13290
1940	8273	10368	13317	14935	12657	13157	20693	14757	15885	15194	16355	9343	8558	8842	13192
1941	8283	9733	12301	14575	14044	13076	13008	11589	15206	14784	13620	8558	9147	9025	12032
1942	8633	9934	12684	21044	18666	13985	13706	11631	15043	14959	20494	17247	13337	11513	14774
1943	8400	9749	13747	15994	18551	22108	18783	22545	24505	20346	22366	19678	13403	11509	17100
1944	8930	9812	13130	14484	11652	11213	11676	12064	16061	14726	12612	8161	8288	9031	11590
1945	8020	8394	12852	15095	11568	12878	12176	12408	16599	15562	18530	13517	9566	9618	12714
1946	8437	9379	11703	15938	20678	21220	19775	15278	20328	20718	21081	18699	13528	10213	16416
1947	9016	11016	13208	21231	18626	18614	23381	22042	17837	19506	19767	16487	12898	9278	16818
1948	8681	15711	16777	18272	18251	17298	23168	16934	18361	23309	28701	21337	14487	13900	18626
1949	10275	11348	13609	15797	15144	14611	24963	20455	18154	20560	19105	12558	9229	8053	15498
1950	8620	9066	13377	17136	15664	25567	23933	19540	18884	19820	24780	22694	15864	14172	17857
1951	9357	14072	17339	22222	23453	27054	23986	19953	19135	22796	20419	19766	15010	12303	19437
1952	9209	15053	13863	18340	20391	21553	18382	19023	21970	23785	20653	15465	11655	8994	17280
1953	8886	9100	13109	14157	15969	19862	19323	15886	16618	16561	24884	19976	13608	12228	15884
1954	8799	10877	13394	18009	16184	25023	21424	17155	17392	20542	24389	21587	19398	16583	17918
1955	13468	11775	14751	17235	15601	11701	13550	16906	16309	15520	25034	23139	15631	12186	16039
1956	8553	13152	16668	21938	23988	22646	23271	20321	22657	25005	28132	20572	14042	12298	19877
1957	8895	11714	13526	18318	15358	17240	20421	24103	17490	22485	25607	15214	9643	8986	16561
1958	8782	10405	13636	14849	16011	19248	23104	18833	16066	22423	19849	14449	9352	9979	15805
1959	8820	10876	15053	20056	22791	23226	20568	16974	16538	18600	21491	23157	14265	12589	17882
1960	14043	17683	18456	19218	17043	16737	21864	26634	18483	16777	20424	18363	14042	10519	17946
1961	8689	10639	13364	15484	16720	19741	24654	21309	16302	17588	24369	17622	13509	10674	16622
1962	8611	9379	13205	15194	15416	15539	17113	24417	21947	17523	18089	15813	13600	10673	15085
1963	8873	11291	15473	19626	17055	20111	17694	12956	16369	17061	19280	16704	13573	9949	15772
1964	9084	10823	13620	15128	15794	17874	13865	23534	15963	16655	26367	23387	14481	13209	16330
1965	10015	12822	14310	22311	25062	25100	23139	16704	19830	20352	22918	19545	14618	14032	18992
1966	9558	11840	13258	16327	16735	15619	17558	20650	16969	16386	18152	17690	13869	9751	15308
1967	8497	10173	13505	16714	18415	24697	19189	13996	14863	16337	22977	23333	14972	12913	16805
1968	8380	11302	13839	16883	17043	20400	23305	13169	15370	15125	17292	19451	13866	11909	15847
1969	11756	13602	16541	18675	23038	23190	20229	22347	21687	23546	21060	19333	13618	9838	18694
1970	9599	10838	13200	16133	18248	19488	18627	16202	16413	17579	23255	15288	9698	8794	15619
1971	9556	10256	13103	15942	22528	27953	23915	20226	20535	25779	29145	22960	17014	13887	19694
1972	10236	11497	14062	17936	21104	27136	28177	23466	20503	26450	29458	25209	18944	14985	20832
1973	11016	12114	13648	18240	17693	15389	13939	13091	16346	15643	12304	10369	9192	7775	13621
1974	8980	8913	14093	21070	27170	25222	25379	23901	25220	25689	30814	26721	17810	14800	21224
1975	10583	10757	13525	15663	17690	21199	22586	17283	15474	19559	25064	24506	13694	11859	17504
1976	10053	13048	15626	24534	24728	23608	22859	21834	20241	22847	21550	22756	20243	19432	20222
1977	15101	11400	13655	14620	11522	10983	11263	12515	15787	15193	14339	7964	8148	8715	12376
1978	7823	8930	12091	16979	18003	20390	18890	16996	16927	19665	18637	17225	14607	14272	15820
AVERAGE	**9274**	**10972**	**13840**	**17148**	**17384**	**18546**	**18885**	**17367**	**18005**	**18938**	**20750**	**17244**	**12844**	**11186**	**16042**

Table 6–16. Total Hydropower System Generation for Preferred Alternative

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	Average Megawatts MAR	15–Apr	30–Apr	MAY	JUNE	JULY	15–Aug	31–Aug	AVERAGE
1929	10262	11072	11965	14281	10678	10736	11691	11910	18608	17060	20131	14812	9797	9054	13119
1930	8826	10144	11756	11649	9580	12545	10978	11808	18815	15608	17247	13585	10162	9768	12252
1931	10262	10152	11621	11584	10391	10172	10762	12974	16714	15278	19065	11882	8948	9132	12083
1932	10261	10560	11757	12830	10147	10503	13625	19683	23047	20853	23659	17858	14604	11094	14684
1933	9750	10559	11756	14636	17973	17789	17502	18933	19010	18852	27479	23475	18274	15177	17114
1934	10261	12376	15553	22639	25517	23508	22280	25525	24233	21889	17716	14865	8596	9265	18340
1935	9108	10359	12257	14564	17954	19654	15310	18242	18016	18511	20549	18392	14037	9096	15494
1936	9249	10238	10877	11625	11034	11049	14137	12257	21813	26049	20472	16128	9647	9167	13952
1937	9423	9876	11756	12373	10016	10084	10919	11827	17767	15890	18438	15083	10262	9256	12372
1938	9501	10222	11756	12260	19554	17039	17700	20159	23492	22276	21821	17071	11129	8715	15896
1939	10242	10559	11757	12460	11055	14058	15150	16270	21236	20356	16137	14969	10668	9168	13775
1940	9213	10559	11757	13518	12752	13734	18835	15428	18385	19529	15583	12166	8747	8988	13621
1941	9603	10466	11701	11352	13372	13401	11691	10961	16766	17673	16655	11227	9198	9248	12507
1942	9471	10422	11556	16279	18587	14221	12574	12213	17271	18346	21982	18762	17293	11888	15135
1943	8863	10559	11756	13789	18280	20138	18153	26988	27183	22079	24336	19156	17938	12044	17395
1944	9197	10559	11756	13388	11252	10898	11066	11774	17681	15148	17486	10185	8586	9149	12038
1945	10261	10106	11756	12678	10773	11631	11104	11936	17689	18606	18750	16642	10627	9579	13104
1946	9872	9768	11729	11881	19154	18410	19955	20905	24360	22564	22726	19621	17027	9981	16796
1947	9968	10559	11756	19203	18259	20355	22880	22575	20914	21495	21003	18104	15743	9459	17307
1948	9585	13975	15247	16689	18587	17328	21301	19965	22327	27039	29225	21097	18501	17373	19108
1949	10261	11831	11756	14897	15263	14579	23740	20150	23794	23157	22051	15833	8793	7685	16139
1950	8650	10294	11756	12829	15661	22642	23702	24220	22955	22668	26721	22231	17850	17052	18151
1951	10261	12448	15509	20556	23254	25113	24541	24437	23360	24880	21882	19374	18464	13815	19793
1952	9679	13273	13340	16974	20246	20660	18080	24110	26632	25490	21466	17676	13212	8990	17762
1953	9016	10268	11756	12540	14990	19747	18284	15732	18724	21016	24919	19352	18505	14891	16291
1954	9704	11056	11986	16470	16078	21965	20853	21756	20875	23793	26030	20893	19895	18670	18265
1955	13500	12254	14264	15466	15428	11502	12564	18540	18173	19499	26354	23275	18331	16403	16676
1956	9594	12126	15128	19880	23006	22210	23714	24721	25690	27035	28946	20331	18865	12673	20232
1957	9863	11490	11756	16347	15068	17022	19826	27176	19174	24716	26819	18091	10380	8917	16973
1958	9392	10559	11756	13560	15444	18640	20855	19471	20763	25364	22018	17204	9838	10000	16221
1959	9702	10559	12940	17830	22667	21102	21014	21464	19763	20233	24983	22299	18826	11929	18257
1960	12815	17295	17437	18350	17439	17811	20818	28236	21511	20302	21208	17826	16733	9154	18243
1961	9739	10821	12295	13502	16723	20244	22474	22629	17971	22024	25546	18361	15339	10524	17049
1962	8706	10558	11757	13798	15383	15160	16143	25828	23571	20829	19877	18141	12032	10473	15518
1963	9309	11366	13627	17732	16768	20107	16874	13837	19051	19606	21256	18351	15684	10605	16188
1964	10007	10559	11756	14071	15299	18856	12458	24979	17457	18534	28029	22592	18840	15314	16677
1965	10261	12327	12306	20401	23962	25411	22929	19853	25347	22969	24425	17930	18639	14485	19306
1966	9803	11090	12076	15396	17376	16058	16725	21436	19283	20111	18755	18382	14904	9643	15695
1967	9200	10559	11756	15065	18582	22025	19632	18423	16707	18237	26667	22573	18405	14475	17326
1968	9619	11369	12214	15384	16147	19610	22432	14498	16850	18456	20165	19146	17759	13289	16308
1969	11100	13276	14606	17261	23573	22810	20618	25193	25299	25709	22509	20253	13947	9701	19036
1970	10224	11185	11756	14797	17561	18804	17112	17248	18096	21019	25499	17304	10908	9709	16078
1971	9546	10560	11756	14067	22028	25393	24494	25615	23636	28077	29741	22317	19521	18215	20091
1972	10261	11864	12606	17025	21412	24277	29712	26562	23116	28799	30118	25373	20343	20072	21379
1973	10298	11827	12213	17677	17213	15601	12627	10950	18234	17412	15785	13295	9438	7959	13929
1974	10170	10173	12095	18596	25303	26295	25615	25809	27689	28541	31211	26526	19454	19383	21705
1975	10261	10619	11757	15184	18039	21348	20624	18870	19020	22694	26805	23701	16488	12937	17868
1976	10261	13009	14741	21908	24226	22302	23199	26255	23464	25567	22193	23029	21380	20399	20532
1977	15316	12130	11862	14521	11207	10858	10459	11054	18041	15448	17865	9821	8628	9340	12745
1978	10261	10559	11756	13716	15861	18099	19269	22527	20836	21987	20780	18967	19107	15273	16666
AVERAGE	**9999**	**11208**	**12483**	**15310**	**16922**	**17870**	**18180**	**19478**	**20808**	**21385**	**22622**	**18311**	**14606**	**11972**	**16464**

Table 6-17. Surplus/Deficit for SOS 1a for Operating Year 1995-96

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	Average Megawatts MAR	15-Apr	30-Apr	MAY	JUNE	JULY	15-Aug	31-Aug	AVERAGE
1929	699	561	310	174	-1071	-1510	-1364	72	756	4307	43	-780	-1124	-1343	46
1930	-631	-769	-1021	-1156	-1401	-1840	-1694	-258	426	2712	-287	-1110	-1387	-1606	-717
1931	-894	-1032	-1284	-1419	-1664	-2103	-1957	-526	133	2121	-550	-1373	-1506	-1725	-997
1932	-1013	-1151	-1403	-1538	-1783	-2233	-511	5320	6377	8671	4759	342	-410	-352	801
1933	699	561	309	174	7256	3051	2211	1207	3950	6426	10052	8455	3911	1751	3717
1934	1766	2914	3943	8601	10947	9904	7412	9145	9585	9006	43	239	59	-1334	5292
1935	699	561	432	174	5253	3681	1324	411	1182	4409	3705	2549	1321	-1401	1962
1936	699	561	309	174	1737	-1190	691	417	8270	7215	1170	-117	-193	-1343	1235
1937	-631	-769	-1021	-1156	-1401	-1839	-1694	-258	426	3619	-286	-1109	-1387	-1606	-642
1938	-894	-1032	-1284	-1419	5112	2641	3699	3692	6850	9121	6411	946	-1182	-1401	2273
1939	699	561	309	175	-1071	-1509	-1332	4957	4184	5973	798	-126	-766	-1401	664
1940	699	561	309	174	-1071	-970	2132	5067	3634	4231	107	-584	-65	-1343	770
1941	-631	-768	-1014	-1001	-1401	-880	-1243	2000	426	2791	-287	-1110	-1387	-1606	-486
1942	-894	-1032	-1284	3715	6073	3441	-1070	1394	1892	3150	1791	2226	-1125	-1401	1375
1943	699	561	309	174	5563	6390	3779	8646	9585	8195	8975	6960	2477	-1401	4272
1944	699	561	309	174	-426	-1268	-1364	72	756	2217	43	-780	-1505	-1725	-86
1945	-1012	-1150	-1403	-1538	-1783	-2221	-1752	-316	368	3999	3071	-1168	-1387	-1606	-536
1946	-894	-1032	-1284	-1419	5861	4749	5206	5265	8674	9773	5920	3149	765	-1366	3058
1947	699	561	1038	4966	7691	7346	5750	5532	5717	9521	3904	2330	-895	-1401	4024
1948	699	4905	3843	2461	8748	6401	3872	2314	8857	9773	13802	10118	3026	1624	6044
1949	1479	561	651	174	3223	3735	4673	3557	7750	9773	7068	-780	-1182	-1401	2910
1950	699	561	309	174	5996	6860	7520	7904	6992	8376	10746	10918	3226	1338	5157
1951	1474	3112	4943	6831	9935	10440	8533	9630	7537	10016	8823	6276	3233	-1321	6660
1952	1316	4071	2260	2903	6436	6376	4186	7864	9585	9773	8152	2438	143	-1401	4667
1953	699	561	309	174	4977	6719	2516	568	756	3969	10308	5948	585	-422	3077
1954	699	561	886	1942	7844	7257	5452	4735	5577	9773	10190	9418	6858	5087	5429
1955	4337	998	2260	1252	5589	3038	382	1532	756	3053	8658	8224	3403	-1396	3328
1956	699	2054	3864	6322	10256	6759	7688	9218	10436	11947	14205	9507	590	-71	6949
1957	984	1153	880	2360	5092	5660	6172	5578	4105	9773	10308	2471	-1183	-1401	4034
1958	699	561	309	174	4241	6612	3850	3812	5427	9773	6992	573	-767	-1401	3110
1959	699	561	1588	3534	9830	6341	5244	5902	4781	7573	10308	7590	1504	-762	4915
1960	5890	7318	5370	4070	6110	4878	5919	10371	4707	5413	6511	2954	1327	-1401	5161
1961	699	561	868	174	7067	7825	6092	5235	1313	9076	10308	1296	-796	-992	3862
1962	699	561	309	174	4249	3918	2058	5647	6731	5894	4758	788	1317	-1084	2476
1963	699	665	2849	3958	5823	7869	2151	4816	1553	4433	3277	770	-1013	-1401	2873
1964	828	561	309	174	6265	3562	1742	2786	2382	5422	10308	10348	2564	-325	3602
1965	2121	2129	1435	6289	10947	10526	7467	5978	8948	9420	9371	3721	2847	1706	6097
1966	1648	1050	1528	834	7138	3645	3551	6470	913	4270	1963	1614	912	-1401	2557
1967	699	561	310	557	8291	5405	3024	1749	757	6077	10307	11073	2272	-744	4027
1968	699	871	1500	947	6506	7476	6204	561	877	3489	5627	2370	-58	-132	3026
1969	3935	3023	4049	3211	9620	6616	5491	10371	9585	11023	10214	4385	-880	-1401	5867
1970	789	956	363	608	5402	7154	2279	3109	756	6416	10308	568	-1182	-1401	2957
1971	699	561	309	654	10947	10526	10190	9747	9585	10947	14854	11471	5225	466	6972
1972	1713	673	1989	1952	10496	10128	12134	13209	9585	13292	16009	13402	6839	3174	8183
1973	2140	716	577	2829	1702	809	-741	420	756	4944	43	-780	-1182	-1401	961
1974	699	561	309	3626	11017	10526	10524	12448	13930	13806	16871	14529	5382	2060	8282
1975	2191	561	310	406	7484	5313	4952	1643	2140	8353	10308	12007	-221	1705	4543
1976	2309	2371	4327	9119	10847	9041	7537	10371	9012	9773	10307	9102	7877	7994	7697
1977	6067	561	310	174	-740	-1282	-1130	172	756	1792	43	-780	-1506	-1725	322
1978	-1013	-1151	-1403	-636	3407	2512	4122	7818	3753	6062	6646	3143	-851	-1401	2196
AVERAGE	**971**	**840**	**886**	**1509**	**5143**	**4326**	**3438**	**4547**	**4676**	**7019**	**6540**	**3872**	**850**	**-457**	**3279**

Table 6–18. Surplus/Deficit for SOS 1b for Operating Year 1995–96

Average Megawatts

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	15–Apr	30–Apr	MAY	JUNE	JULY	15–Aug	31–Aug	AVERAGE
1929	1303	1165	913	778	−467	−906	−760	676	1360	1237	647	−176	−890	−1109	313
1930	−397	−535	−787	−922	−1167	−1606	−1460	−24	660	537	−53	−876	−1040	−1259	−675
1931	−547	−685	−937	−1072	−1317	−1756	−1610	−174	510	387	−203	−1026	−1690	−1909	−866
1932	−1197	−1335	−1587	−1722	−1967	−2406	−807	2283	5837	9865	6651	1020	−136	−213	867
1933	1303	1165	913	778	6571	3412	1023	676	2459	7467	10487	10106	4181	1915	3987
1934	1895	2282	4050	8366	11039	9998	7741	9274	9677	9801	1459	−176	−1090	−1309	5394
1935	1303	1165	913	778	4680	4448	−277	676	1360	4962	4213	2917	1517	−1309	2185
1936	1303	1165	913	778	272	−906	−759	676	3451	7194	3114	865	−890	−1109	1250
1937	−397	−535	−787	−922	−1167	−1606	−1460	−24	660	537	720	−260	−1040	−1259	−559
1938	−547	−685	−937	−1072	6358	2622	3317	2366	7368	9865	8303	1252	−1090	−1309	2679
1939	1303	1165	913	778	−467	−906	−760	1301	3491	8348	647	−176	−1090	−1309	1003
1940	1303	1165	913	778	−467	−906	619	3505	2217	6274	647	−176	−890	−1109	1001
1941	−397	−535	−787	−922	−1167	−1606	−1460	626	660	537	−53	−876	−1040	−1259	−648
1942	−547	−685	−937	3913	6537	3884	−1610	−174	1768	1014	2992	3626	−115	−1226	1526
1943	1303	1165	913	778	3417	5866	4031	9604	10123	9196	9693	7684	1699	−1309	4509
1944	1303	1165	913	778	−467	−906	−760	676	1360	1237	647	−176	−1690	−1909	246
1945	−1197	−1335	−1587	−1722	−1967	−2406	−2260	−224	460	934	4755	−130	−1040	−1259	−662
1946	−547	−685	−937	−1072	5887	4783	4284	4497	8578	9865	9067	2315	1008	−1266	3281
1947	1303	1165	913	3988	8157	8263	4269	5221	5207	9865	6000	2198	−696	−1309	4194
1948	1303	4315	3843	2286	9285	7449	2294	1979	8591	10243	14335	10878	3402	1755	6175
1949	1479	1165	913	778	2755	3415	4175	2982	8281	9865	7956	594	−1090	−1309	3127
1950	1303	1165	913	778	5947	6451	6490	6569	6433	9331	12074	11494	3640	1461	5416
1951	1474	2646	4943	5937	10376	10618	8674	9558	7198	10955	9559	7196	3653	−1221	6831
1952	1316	3556	2261	2525	7531	5659	3750	6765	9748	11389	8750	2885	356	−1309	4784
1953	1303	1165	913	778	1830	5450	2201	676	2104	5652	10400	8221	671	−314	3290
1954	1303	1165	913	1312	8173	7896	3919	4408	5516	9865	11646	10065	7471	5248	5632
1955	4337	1165	1924	1195	6396	3211	−543	676	1360	1475	10400	9747	3786	−1294	3464
1956	1303	1475	3864	5710	10875	7812	6834	8506	10806	12248	14587	10176	807	39	7080
1957	1303	1165	913	2018	5577	5948	5383	4227	3311	9865	11994	3770	−1090	−1309	4209
1958	1303	1165	913	778	4523	5842	2962	2370	4026	9865	10400	−176	−1090	−1309	3298
1959	1303	1165	913	3276	10470	6962	3891	5307	3209	8864	10400	8857	2055	−657	5088
1960	5890	6481	5595	3491	7088	4979	5539	10463	4906	6114	6747	4301	1561	−1309	5336
1961	1303	1165	913	778	6936	8307	4345	4753	1360	9781	10400	2406	−597	−882	4054
1962	1303	1165	913	778	3178	2511	1550	5364	7861	7228	5010	1393	1544	−982	2660
1963	1303	1165	2203	3627	6280	8750	519	4412	1360	2596	6458	1392	101	−1309	3048
1964	1303	1165	913	778	5508	2812	1263	1442	2097	6474	10820	11830	2908	−216	3832
1965	2121	1883	1436	6117	11039	10618	7619	4814	9677	9865	10400	4874	3175	1832	6310
1966	1648	1165	1423	1031	7602	4623	1969	6190	1360	4511	3246	1172	1180	−1309	2675
1967	1303	1165	913	778	8600	6077	1150	895	823	6825	10581	11884	2891	−635	4272
1968	1303	1165	1026	778	6769	8438	4778	676	1360	3896	6278	3047	112	−168	3206
1969	3974	2405	4049	2730	10555	7611	4286	10463	9962	11545	10400	5450	−710	−1309	6017
1970	1303	1165	913	778	5108	6060	1746	3011	1361	6466	10400	2901	−1090	−1309	3152
1971	1303	1165	913	778	11039	10618	8877	6937	9677	12292	15190	12226	5629	574	7151
1972	1713	1165	1666	1951	11039	10618	10900	13190	10064	13742	16315	14109	7385	3310	8349
1973	2140	1165	913	2196	1031	541	−760	676	1360	3908	647	−176	−1090	−1309	952
1974	1303	1165	913	3798	11039	10618	10802	12563	14274	14251	17154	15070	5553	2118	8614
1975	2191	1165	913	778	6208	4857	4582	1302	2377	9423	11108	13548	41	1018	4762
1976	2309	2292	4559	8348	11039	10618	6661	10243	8273	10732	10400	10335	8485	8127	7905
1977	6068	1165	913	778	−467	−906	−760	676	1360	1237	647	−176	−1690	−1909	643
1978	−1197	−1335	−1587	−756	150	1808	4187	7175	5498	7124	6424	6147	−664	−1309	2193
AVERAGE	**1309**	**1102**	**1114**	**1599**	**5116**	**4473**	**2812**	**4014**	**4656**	**7135**	**7417**	**4668**	**1025**	**−360**	**3451**

Table 6–19. Surplus/Deficit for SOS 2c for Operating Year 1995–96

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	15–Apr	30–Apr	MAY	JUNE	JULY	15–Aug	31–Aug	AVERAGE
							Average Megawatts								
1929	322	250	−68	−203	−2467	−3021	−2460	−2004	−516	3351	5648	−1157	−1307	−1598	−210
1930	−731	−1061	−1276	−1449	−2738	−2676	−3207	−1005	−1155	2428	3270	−1365	−1325	−1616	−946
1931	−749	−1079	−1331	−1466	−2713	−3197	−2922	−376	−1600	2060	3583	−1368	−1344	−1635	−972
1932	−769	−1089	−1349	−1485	−2697	−3069	−663	7846	7001	8690	4951	586	−916	−689	811
1933	479	155	34	480	6648	3882	946	2680	2386	6115	10585	9330	3419	1380	3632
1934	2215	3167	4153	8717	10924	10091	6629	9139	9720	8682	−200	−1157	−1307	−1598	5100
1935	−732	−1061	996	420	5510	5164	588	1192	316	3574	4000	3490	133	−1557	1833
1936	479	146	−106	−240	−959	−984	−733	355	4565	9335	3923	−1157	−1338	−1557	893
1937	479	161	−91	−226	−2452	−2931	−2589	−1148	−141	3132	1892	−1157	−1324	−1616	−491
1938	−750	−1079	−1331	−1466	6393	2911	2672	2885	6918	7888	5971	1244	−1338	−1557	2159
1939	479	161	−91	−226	−2490	−3047	1400	3756	4368	5862	670	−648	−1182	−1557	397
1940	479	147	−106	−240	−967	−2217	3859	2269	2258	5254	−201	−1157	−1307	−1598	472
1941	−730	−988	−1314	−1002	−1379	−1767	−1766	−2813	−2702	2396	3651	−1365	−1325	−1616	−708
1942	−748	−644	−1044	4502	4506	3503	−2800	−191	−246	2973	6334	2189	−67	−1557	1478
1943	479	147	−106	−241	6795	6830	2777	9470	10528	7557	9269	7381	1380	−1404	4240
1944	479	389	−90	−226	−2493	−3007	−2792	−1389	−481	1558	3850	−1157	−1344	−1635	−493
1945	−764	−1093	−1350	−1486	−2725	−2687	−3341	−1399	−392	4783	6940	−1324	−1397	−1615	−454
1946	−748	−1070	−1322	−1457	6336	4328	3997	3950	7632	9558	7306	3647	−405	−1556	2949
1947	1067	902	116	5197	8149	8374	4888	3143	6145	9106	4092	889	−1186	−1557	3838
1948	497	5354	3668	2287	7859	6885	2859	4573	5748	9784	14570	9105	2887	1518	5853
1949	1914	1057	181	−226	3708	2933	5709	8098	6824	9784	2767	−351	−1379	−1598	2787
1950	−731	−1047	512	279	5879	8078	7106	8552	4676	7616	12602	9929	3411	1067	4923
1951	1773	3734	4303	6580	10237	10523	8083	7651	8468	10121	7342	6901	3265	−1406	6549
1952	1480	4673	898	2297	6997	6219	2258	7244	9433	10390	7135	2585	−49	−1557	4372
1953	479	161	−91	−226	5246	5746	1028	1284	614	4759	11165	6744	287	−611	2983
1954	753	947	134	1632	7164	8006	3804	6857	3513	9617	10719	9227	7139	4754	5261
1955	4551	1456	1871	981	4970	2352	−2538	150	−401	4372	10944	8220	2900	−1557	3144
1956	856	2782	3607	6115	10558	7464	6472	8196	10547	11783	14796	8352	1145	−62	6892
1957	1108	1777	368	1971	3487	4631	3618	9083	5812	9784	10444	2687	−1338	−1557	3823
1958	479	161	−91	−226	3966	6644	3149	6014	4393	9784	8714	−1157	−1338	−1556	2932
1959	479	161	1814	3873	10339	7535	3662	5574	3203	7284	10271	7795	1316	−952	4815
1960	6193	7211	5058	3459	6267	4785	4719	10350	8780	4829	5398	2658	991	−1556	4988
1961	565	621	683	−209	6456	7676	5171	7508	1857	9118	10272	916	−1070	−1245	3733
1962	479	146	−106	−240	5602	3993	76	8921	8111	4837	4935	973	43	−1344	2380
1963	479	1712	2371	3605	5632	8038	−451	3414	−169	4001	7675	915	−608	−1557	2876
1964	561	147	−56	−241	5967	4578	−1147	6754	2268	5846	10827	9999	2756	−596	3506
1965	1469	2507	1212	6228	10945	10340	6889	4953	9431	8518	9303	3860	2494	1611	5876
1966	1710	1805	770	548	6199	3929	621	6614	731	4833	3934	2506	145	−1557	2485
1967	479	147	−106	591	8295	7062	1936	2247	833	6321	10268	10143	2694	−892	3965
1968	769	1283	744	442	6644	7930	5275	638	686	2909	7332	2477	14	−462	3020
1969	3409	3236	3427	2741	9788	7739	4487	9749	9675	10506	10272	3895	−1194	−1557	5653
1970	478	1133	−91	−107	4588	7263	2191	2832	706	6604	11645	−185	−1338	−1557	2820
1971	478	156	−96	−201	10746	10525	9471	8278	8967	11833	15059	10877	5856	529	6722
1972	1990	1750	896	1559	10466	10527	12001	12542	9490	13255	16048	12722	7158	3158	8116
1973	2458	1656	−96	2290	2482	857	−694	−2089	−1847	4019	2001	−1157	−1308	−1598	866
1974	−732	−1061	1196	4305	10716	10313	10785	12405	13357	13385	17239	14104	5325	2020	8067
1975	2459	161	−91	63	6799	7233	5006	3185	560	7391	11802	11126	−1305	−73	4428
1976	2377	3127	3965	8970	10853	8895	6437	10048	7817	9784	9992	9648	7963	7611	7564
1977	6139	1111	−91	−226	−2492	−2980	−2792	−1389	−469	1966	3836	−1157	−1344	−1636	75
1978	−769	−1098	−1351	−233	2865	2441	3013	5514	5070	5963	5933	5366	−974	−1343	2189
AVERAGE	**897**	**869**	**595**	**1332**	**4808**	**4293**	**2454**	**4442**	**4066**	**6906**	**7615**	**3709**	**621**	**−634**	3144

Table 6-20. Surplus/Deficit for SOS 2d for Operating Year 1995-96

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	Average Megawatts MAR	15-Apr	30-Apr	MAY	JUNE	JULY	15-Aug	31-Aug	AVERAGE
1929	533	203	-56	-215	-4027	-3814	-2099	-1608	2042	2961	5121	735	-1315	-1878	-170
1930	-822	-1051	-1394	-1544	-4392	-2666	-2931	-1440	1972	2226	3763	-1560	-1341	-1912	-978
1931	-854	-1070	-1308	-1318	-4075	-4519	-3487	-543	1398	2143	4823	-1225	-1369	-1783	-1003
1932	-1155	-1136	-2200	-1975	-3904	-1905	120	4816	2631	4233	9410	4582	-1207	-1104	720
1933	194	81	-564	-50	4165	5777	2999	1142	831	4111	12010	10212	3003	1452	3512
1934	2101	2910	3486	8699	10332	10281	7479	9069	7858	7415	4677	854	-4523	-2004	5286
1935	-429	-1073	639	225	2794	6757	2353	-845	241	2866	4928	4222	-271	-1629	1836
1936	154	144	-27	-30	-4066	-4024	275	-812	6022	9216	5792	2277	-1135	-1890	900
1937	348	156	-52	-45	-4293	-4689	-3745	-1519	909	2442	4900	1806	-1350	-1494	-408
1938	-1111	-1059	-1258	-1269	2888	2495	3523	2684	5032	6852	7368	2368	-2221	-2046	1877
1939	202	98	-329	-449	-3759	-2354	1570	3045	5797	3365	5077	265	-1260	-2185	532
1940	380	158	-24	-2	-3380	-1652	5249	1811	1767	2254	3972	-1409	-1250	-1940	478
1941	-909	-1045	-1260	-1306	-2249	-1761	-1878	-2428	143	1784	3315	-2297	-1341	-1624	-853
1942	-907	-726	-1269	3114	2787	-954	-1188	-243	1159	1813	7845	5642	-82	-1346	1325
1943	294	101	-495	-493	4326	8215	3956	9539	10483	6472	10023	7247	821	-1302	4118
1944	557	397	-132	-91	-3556	-3391	-2960	-1015	1349	1997	4706	-1323	-1333	-1509	-421
1945	-500	-1102	-1315	-1303	-4240	-2811	-3365	-1780	1225	2737	6105	1999	-626	-1577	-431
1946	-984	-1139	-1751	-1706	3732	4995	4868	3301	5828	7184	7699	7024	-663	-1363	2789
1947	1114	820	-19	4642	3953	5607	8341	9047	4715	6437	6433	5452	-1229	-1377	4030
1948	383	5283	3083	1856	3548	3210	8845	5474	2737	10936	15066	9026	2658	1611	5623
1949	1799	949	36	-47	-6	-39	11132	7965	4983	7779	6453	1342	-1213	-2232	2846
1950	-878	-1076	-708	-16	1485	10452	9051	6755	4119	7484	12659	9735	3063	1191	4646
1951	1777	3863	4266	6445	8804	11885	9012	7716	7193	9827	7918	6974	2596	-1320	6572
1952	1605	4614	839	2327	5305	7615	3606	7294	9279	10372	6691	3294	-279	-1333	4479
1953	320	89	-357	-397	-291	5510	4180	4238	1291	4797	11548	7052	-40	-539	2911
1954	869	1009	538	1703	2325	10431	6560	5058	1802	8382	11790	9064	6893	4933	5168
1955	4657	1506	1880	1075	151	-2587	-1221	4924	1508	4718	12077	10689	3302	-1341	3095
1956	692	2876	3594	5936	8865	8520	8327	8252	10436	11707	14742	8584	817	31	6968
1957	1146	1713	-224	1803	-480	2490	6017	13100	4378	9503	12550	3055	-1144	-1345	3756
1958	337	99	-404	-436	-259	3941	7869	6309	2014	10307	7528	2700	-54	-1621	2917
1959	540	56	43	3452	8439	8439	5927	5078	1432	4141	10971	10514	1473	-876	4673
1960	6337	7153	4409	3448	2840	2607	6315	14599	5816	4108	7358	5748	-176	-2082	4950
1961	263	578	555	-336	1942	5623	9739	8187	539	6039	11738	4893	-1210	-1338	3677
1962	351	175	-48	-46	542	570	2333	11997	8889	4829	5395	3427	656	-1387	2300
1963	321	1422	2019	3149	1952	5007	3019	8	2130	4946	7206	4921	-149	-1354	2857
1964	325	114	-411	-286	653	4828	-372	11501	2384	3068	13319	10742	2465	-519	3325
1965	1580	2492	1187	6127	9640	11556	8067	4765	7851	7690	9573	5912	1285	1165	5946
1966	1772	1758	578	620	1977	1777	3335	7682	3958	3601	5147	5468	-188	-1344	2591
1967	378	152	-28	473	3915	9067	4842	-189	539	1690	12636	11000	2401	-813	3758
1968	799	1208	776	586	3124	4993	8705	1925	2141	1970	5985	6896	-317	-390	3060
1969	3542	3171	2829	2336	7944	8729	6208	9627	9132	10765	7998	7466	-1169	-1371	5758
1970	326	1093	-167	-410	2728	4621	3792	2954	2449	5424	11546	3291	-887	-2000	2792
1971	331	156	-60	-214	7222	12733	10163	7604	7013	12500	15324	10480	5320	455	6569
1972	2034	1880	758	1538	7742	12475	13477	11320	8792	13449	16059	12757	6856	3294	8108
1973	2318	1671	-29	2167	2269	851	-492	-2048	1704	2896	2574	-1256	-1361	-2212	918
1974	-871	-1079	211	4242	9780	11076	10752	12314	13292	13407	17108	13937	5049	2128	7913
1975	2490	37	-76	-17	2957	7642	8347	4603	108	7223	11959	11153	-1342	-127	4445
1976	2225	3199	3716	8939	9382	9814	8254	9350	6141	10297	9401	10676	6999	7465	7573
1977	6235	1021	-236	-46	-3907	-3886	-2205	-2045	1033	2427	4848	-1533	-1225	-1410	75
1978	-896	-1071	-1284	-1043	552	4087	4317	4434	4276	5864	5726	5528	-1403	-1484	2058
AVERAGE	**826**	**836**	**359**	**1196**	**2084**	**3872**	**4140**	**4659**	**4015**	**6013**	**8577**	**5208**	**420**	**-694**	**3109**

Table 6–21. Surplus/Deficit for SOS 4c for Operating Year 1995–96

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	Average Megawatts MAR	15–Apr	30–Apr	MAY	JUNE	JULY	15–Aug	31–Aug	AVERAGE
1929	−1483	35	−767	−720	−1246	−851	−3102	−1320	−1326	−721	4934	1092	−3307	−3150	−615
1930	−3149	−1308	−2022	−143	−296	−903	−2994	883	1669	−2202	2203	664	−3425	−2936	−1005
1931	−2706	−1039	−1795	−266	−496	−1121	−3928	−1002	−244	−176	1864	−2720	−4316	−3933	−1428
1932	−2695	−2668	−539	2566	−1644	−1981	814	6558	7418	10279	9051	2913	−172	−1103	1871
1933	−2059	−751	−234	1359	5742	2327	1505	4359	5061	5889	12647	10158	4661	1047	3679
1934	−919	2819	2925	10012	11742	7363	6373	11454	10732	8338	369	1656	−471	−2257	5034
1935	−2752	−1071	−372	603	5251	4324	−632	3319	2830	2988	7053	4806	1296	−2700	1881
1936	−2312	−1443	−1445	−626	581	−1823	−820	−600	9328	10322	4216	−830	−2566	−2958	619
1937	−2648	−1367	−1854	−1452	−997	−1860	−5199	−1719	−1512	2703	3389	429	−2959	−3697	−1150
1938	−2966	−914	−1149	1435	5698	2346	2656	4023	7206	9354	10848	4701	−1359	−3021	2953
1939	−1396	−581	−1864	−876	1282	−685	−2682	3862	3973	5935	1855	2165	−1491	−2882	407
1940	−2709	695	−597	786	1454	−76	1164	4188	2378	1734	1144	−449	−3062	−3059	281
1941	−1971	−436	−1275	273	1040	−143	−2717	2338	−659	−589	599	−2804	−4391	−3628	−933
1942	−1799	−409	−83	5123	5981	2679	−3170	1229	1307	3721	6923	4294	−201	−2511	1931
1943	−1058	384	513	1119	2649	5344	1490	9306	12126	9026	12064	9177	2559	−1853	4315
1944	−2478	−142	−840	−52	20	−547	−3817	−1018	−1157	−1629	1742	−2394	−4069	−3856	−1266
1945	−2992	−1576	−906	856	−1037	−662	−3424	−1272	−2259	5115	6481	417	−2986	−4336	−263
1946	−3220	−106	−1619	1728	5244	4712	3907	3303	8887	11138	9521	5515	1313	−1986	3548
1947	−1237	49	−51	6397	6899	5902	5493	6841	7316	8633	6194	3696	−543	−2920	3944
1948	−1597	4793	3126	3398	6534	4744	2256	1196	7306	12059	15855	9922	3395	1269	5639
1949	−755	126	−212	1241	2714	2919	4003	4055	7015	11681	7462	−273	−3064	−4278	2564
1950	−2848	−534	−317	2259	4477	7389	7406	11505	8714	7359	12328	11811	4278	886	5168
1951	−1263	3063	3344	7095	9030	10850	8359	11184	8274	9578	8811	8222	3613	−1819	6476
1952	−1217	4021	1015	3460	6094	5389	1603	7858	9854	11701	10620	4318	−256	−3075	4516
1953	−2506	47	−1160	−672	4849	6960	800	−2693	−1208	5572	14204	8355	1400	−940	2894
1954	−1730	3	−97	3541	4412	6882	4592	8111	7823	9876	11100	10262	7797	4536	5248
1955	1956	827	1279	2175	4145	757	−2403	946	−744	4280	12439	10076	4233	−1968	3064
1956	−1763	2022	2902	7012	9677	5830	8559	11195	10357	11507	15466	9121	1776	−433	6815
1957	−1598	926	−119	3716	3583	4004	3782	5952	4134	12501	12132	2743	−2681	−3329	3642
1958	−2405	738	−507	562	3937	6353	2948	1393	5431	11619	9990	299	−2152	−2183	2898
1959	−1937	435	1178	4624	8843	6681	4392	6545	7503	6037	11572	9570	2856	−1506	4925
1960	3726	6505	4825	4613	5884	3858	4177	10686	4949	6177	10281	4640	1746	−2702	5169
1961	−1713	−317	−187	1045	4697	6673	4723	5217	1340	10245	13180	3977	−845	−1544	3701
1962	−2990	−304	−652	935	4154	3033	−698	6249	7358	6368	8630	2629	683	−1608	2287
1963	−2103	1037	1756	4660	5509	7362	1259	2636	−335	4678	7303	2581	−591	−2184	2817
1964	−1182	570	−13	655	4013	2009	−1128	2175	806	7369	14663	10687	3187	−790	3361
1965	−319	1921	342	7188	10971	8549	8051	5494	10781	8009	11180	6495	3572	1267	6079
1966	−1294	803	−337	1395	5224	2476	810	6766	1085	5634	5517	3840	1160	−2389	2282
1967	−2247	−289	−289	2432	6636	6686	1855	3955	3107	4246	13346	11190	3574	−1196	4024
1968	−1834	288	483	2497	5304	6924	4740	−52	−2046	3507	9941	4553	672	−473	2954
1969	1537	2921	2636	3818	8657	6731	4751	11633	11413	10604	10533	6434	161	−2547	5746
1970	−1338	1034	−92	1880	6546	6229	744	−2629	−3613	7542	12587	1879	−1074	−2997	2655
1971	−2219	183	−569	2143	8773	10987	7665	13525	10885	11113	16142	11818	5999	149	6776
1972	−727	846	383	3608	7719	9558	14601	12699	8113	13187	16275	13788	7715	3023	7918
1973	−471	850	−100	3753	4567	1776	−2245	−581	−1993	1502	906	756	−2397	−3726	579
1974	−2592	−482	466	5263	13192	9569	11213	12173	12860	12395	17328	15300	6685	1922	8206
1975	−331	−138	−594	1476	6142	5304	3332	1717	534	8351	15338	12656	448	830	4442
1976	−662	2334	1688	9294	10639	7011	6821	12991	10955	9792	9982	11190	8737	7453	7346
1977	3596	982	−413	−189	281	−456	−4334	−2163	−1536	−2247	1456	−3119	−4623	−4127	−889
1978	−3961	−1194	−895	3364	5661	4026	4261	9593	4986	6314	7467	4368	355	−2377	2974
AVERAGE	**−1547**	**484**	**98**	**2527**	**4815**	**4028**	**2156**	**4681**	**4544**	**6768**	**8943**	**5051**	**617**	**−1572**	**3122**

Table 6–22. Surplus/Deficit for SOS 5b for Operating Year 1995–96

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	Average Megawatts MAR	15–Apr	30–Apr	MAY	JUNE	JULY	15–Aug	31–Aug	AVERAGE
1929	951	866	394	660	−1552	−2974	−2201	−1958	−2464	2058	2762	−3827	−2287	−2699	−631
1930	−682	−1082	−421	−1059	−3237	−2603	−3056	−2583	−3428	740	1590	−2627	−781	−2135	−1408
1931	−746	−1525	−401	−1624	−3293	−3989	−2727	−1794	−3485	312	3268	−2740	−1937	−2476	−1526
1932	−1505	−2015	−1345	−1356	−2674	−3444	−1214	4855	4844	5919	2348	−469	−1590	−1394	−200
1933	130	506	−2	−77	6722	4316	795	235	1925	3065	7447	8383	2666	641	2835
1934	1292	2908	3333	8744	11148	10241	6804	6950	7112	6913	−1012	−2204	−2457	−2436	4396
1935	371	−334	789	119	5072	5150	598	107	−571	848	1768	2431	−542	−2659	1248
1936	488	428	367	232	−936	−668	−564	−2003	2025	5996	1831	−1117	−1768	−2713	319
1937	−388	−506	−304	−94	−2059	−3195	−2377	−2332	−2353	1205	229	−2574	−1125	−1921	−1161
1938	−947	−1393	−1209	−966	5640	3198	2353	27	5025	4720	3396	−59	−2716	−3219	1191
1939	83	383	266	716	−2592	−2566	1396	1001	2447	3378	−920	−1865	−1894	−2637	−189
1940	416	467	91	−195	−937	−1966	3951	−265	91	2607	−1398	−2139	−2279	−2824	−145
1941	−971	−870	−1169	−1239	−1827	−1463	−1853	−4017	−4427	320	2643	−2214	−1508	−2446	−1237
1942	−1300	−383	−1087	4384	4516	4095	−2369	−2081	−2748	675	3787	964	−769	−2191	782
1943	−1336	−195	−1111	362	6954	6776	2480	6129	7241	4580	5790	4832	437	−2304	2907
1944	−128	947	−50	100	−1683	−3008	−1758	−2253	−2315	−115	2397	−2675	−3138	−2101	−906
1945	−2069	−1202	−1366	−1372	−2613	−2596	−3132	−2724	−2325	2143	4302	−2908	−2834	−1687	−1300
1946	−1105	−1080	−1257	−1695	6772	5088	3525	925	5329	6077	5103	2241	−1302	−2628	2069
1947	−195	979	−204	4930	8095	8631	4510	2025	4214	5872	1627	112	−1908	−2537	2938
1948	−4	5088	3033	2464	8443	7043	2730	2442	4694	6637	10721	7559	2150	645	4890
1949	763	907	−449	89	3698	3088	4709	5865	5029	6431	491	−1126	−3161	−3082	1744
1950	18	316	166	217	5315	7947	6260	5777	3438	4813	9169	7868	2486	249	4005
1951	548	3592	3607	6814	10224	10840	7778	5627	5491	6832	5230	5468	2224	−2215	5541
1952	645	4444	807	2662	6988	6768	2288	3225	6442	6967	4285	1176	−899	−2582	3344
1953	96	534	−30	578	4726	5870	1328	−975	−1727	1968	7521	4864	−597	−1428	2091
1954	−109	949	23	1656	7115	8421	3795	4061	2950	6653	8500	7388	6338	3949	4420
1955	3675	1195	1552	1168	4970	2902	−1888	−1486	−2241	2205	7645	7015	2329	−2369	2380
1956	−24	2498	2777	6077	10794	7881	5950	5761	7301	8427	11356	7135	289	−952	5756
1957	150	1506	−335	2270	4083	5691	3823	5344	3635	6304	7009	1413	−2338	−2595	2828
1958	312	501	−132	157	3988	6679	2773	3327	2161	6382	5877	−1993	−2722	−2464	2058
1959	367	476	865	3433	10321	7709	4052	3075	2803	4610	7277	6242	475	−1723	3972
1960	5026	7647	5073	3902	6273	5258	4483	7700	7185	2456	3052	1662	188	−2575	4257
1961	17	1046	253	−56	6329	8254	5323	5738	863	6655	7864	−207	−1775	−1945	3077
1962	64	673	135	−46	4118	3865	−47	6085	6417	2394	2534	173	−791	−2119	1555
1963	86	1264	1885	3567	5810	8197	45	1562	−2061	1904	5014	−358	−1463	−2602	2094
1964	−284	839	−623	27	5731	4836	−945	3782	1157	2246	7455	8317	1891	−1342	2529
1965	1189	2249	961	6288	11486	10454	6449	2025	6745	4764	5863	2190	1480	530	4774
1966	248	1703	916	886	6750	4332	1063	4734	−1063	2448	2406	1450	−585	−2734	1865
1967	331	793	91	195	8051	7220	2095	141	41	3199	7177	8645	1684	−1668	3158
1968	−33	1008	658	681	6487	8098	5261	−1478	−436	807	5197	1539	−720	−1127	2319
1969	2751	3287	3382	3187	9961	7961	4150	6891	6656	7482	7819	2747	−1900	−2734	4765
1970	−474	1160	−361	−28	4678	7510	2343	553	−2082	4484	8349	−1335	−3400	−3610	1838
1971	−18	655	−221	111	11126	10656	8720	5343	6850	8373	11412	8522	4729	−402	5633
1972	712	1516	355	1854	10384	11004	10415	10163	7176	10007	12543	11294	6371	2311	6925
1973	1187	1392	−808	2661	2498	1177	−945	−2665	−2915	1463	582	−2417	−1962	−2647	141
1974	381	−91	319	4973	10952	10535	9989	8692	9937	10256	13695	11947	4413	1056	7084
1975	1366	1013	−515	−203	6714	7287	4517	1007	−155	4767	8307	8297	−2183	−972	3367
1976	1261	2833	3726	9099	11751	9077	5959	7209	5584	6626	6871	7611	6770	6590	6491
1977	5058	1122	−343	403	−1809	−2666	−1862	−1710	−1880	−65	2708	−2279	−2277	−2209	−314
1978	−1190	−1215	−911	−239	2818	2792	3010	2964	2380	3037	2946	3952	−1508	−1727	1338
AVERAGE	329	956	423	1508	4846	4514	2376	2220	2130	4177	5077	2326	−244	−1537	2318

Table 6–23. Surplus/Deficit for SOS 5c for Operating Year 1995–96

Average Megawatts

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	15–Apr	30–Apr	MAY	JUNE	JULY	15–Aug	31–Aug	AVERAGE
1929	1837	333	−141	−169	−1774	−3766	−3142	−1948	−1956	3213	3441	−3369	−1776	−2247	−625
1930	−618	−1401	−589	−1581	−3218	−3479	−3995	−2570	−2925	1888	2254	−2133	−207	−1652	−1379
1931	−677	−1841	−845	−1643	−3518	−4650	−3568	−1782	−2980	1456	3968	−2264	−1404	−1997	−1472
1932	−1298	−2265	−1777	−1618	−2601	−4101	−2488	4903	5548	7030	3061	128	−1006	−876	−137
1933	252	19	−3	−373	5964	3506	−175	255	2576	4279	8230	9138	3389	1223	2880
1934	1453	2582	3391	7296	9625	8954	5663	6909	7760	7754	−400	−1689	−1916	−1948	4169
1935	390	−663	820	−242	4808	4270	−224	121	41	1989	2409	3104	99	−2173	1309
1936	526	29	382	−165	−850	−1334	−1574	−1986	2674	7193	2548	−583	−1226	−2255	398
1937	−99	−867	−238	−373	−2495	−3815	−3172	−2322	−1807	2312	888	−2092	−577	−1433	−1085
1938	−925	−1697	−1223	−1483	5292	2151	1143	49	5729	6014	4203	557	−2167	−2766	1205
1939	213	−77	143	33	−2821	−3439	182	1020	3098	4571	−321	−1337	−1324	−2163	−211
1940	487	14	101	−373	−1435	−3035	2596	−247	722	3861	−774	−1620	−1742	−2364	−166
1941	−879	−1332	−1264	−1581	−2454	−2455	−2810	−3999	−3922	1454	3389	−1684	−946	−1965	−1253
1942	−1040	−1136	−1609	3416	3857	2977	−3308	−2062	−2152	1811	4531	1587	−151	−1689	672
1943	−1004	−636	−1120	−373	5863	5109	821	6158	7744	5805	6645	5527	1095	−1795	2770
1944	152	233	−119	−373	−2222	−3928	−2628	−2242	−1789	932	3087	−2183	−2648	−1619	−933
1945	−1748	−1648	−1832	−1618	−3019	−3708	−4080	−2713	−1803	3304	5091	−2392	−2330	−1209	−1306
1946	−921	−1791	−1464	−1910	5537	3594	2003	947	6041	7065	5844	2910	−708	−2152	1911
1947	152	166	−529	3327	7037	6784	3153	2047	4860	6876	2364	711	−1337	−2067	2649
1948	214	4515	2787	1318	7280	5379	1463	2473	5385	7683	10902	8317	2851	1222	4652
1949	992	263	−498	−373	2970	1714	3077	5916	5730	7387	1166	−576	−2668	−2647	1607
1950	155	−235	124	−304	4770	6181	4757	5825	4119	6032	9853	8616	3209	805	3911
1951	809	2798	3178	5459	8983	8529	6433	5675	6207	7769	6058	6208	2937	−1721	5231
1952	833	3689	783	1667	6115	5091	982	3277	7007	8005	5074	1807	−300	−2121	3165
1953	283	14	−111	−237	4276	4063	146	−959	−1164	3137	8359	5597	9	−920	2001
1954	152	361	−66	1028	6493	6749	2668	4104	3614	7630	9301	8085	7041	4609	4340
1955	3906	649	1583	528	4577	2069	−2674	−1471	−1721	3398	8486	7746	3043	−1882	2438
1956	152	1995	2771	4805	9340	6107	4333	5809	7866	8968	11683	7878	924	−430	5426
1957	393	857	−415	1295	3576	4107	2395	5393	4328	7471	7873	2060	−1810	−2144	2708
1958	502	−4	−238	−373	3307	4888	1580	3369	2843	7560	6654	−1480	−2208	−1990	1950
1959	572	4	499	2174	8880	6154	2867	3103	3450	5715	8136	7013	1124	−1223	3770
1960	5488	6413	4128	2851	5585	4143	3188	7746	7890	3577	3816	2305	812	−2112	4055
1961	209	511	242	−373	5427	6860	4187	5779	1485	7684	8700	376	−1216	−1447	3010
1962	232	170	122	−373	3173	2678	−1081	6134	7066	3581	3216	769	−185	−1628	1515
1963	203	475	1750	2596	5117	6469	−990	1579	−1524	3070	5755	225	−889	−2117	1933
1964	127	280	−656	−373	4899	3484	−1968	3824	1778	3409	8242	9075	2570	−827	2516
1965	1556	1681	541	4623	9362	7828	4840	2059	7342	6080	6740	2885	2152	1100	4372
1966	848	728	270	−158	6113	3186	−5	4771	−503	3635	3043	2066	24	−2263	1728
1967	473	278	114	−373	7179	5906	1055	159	615	4403	8020	9420	2368	−1165	3122
1968	152	412	501	−38	5771	6313	4089	−1461	126	1932	5989	2173	−111	−634	2188
1969	3165	2471	2561	2054	8406	6095	2643	6940	7359	8370	8586	3363	−1401	−2300	4418
1970	−126	544	−324	−373	3398	5574	1220	571	−1575	5663	9227	−809	−2932	−3201	1702
1971	291	12	−691	−587	8855	7967	7201	5391	7567	9136	11891	9305	5450	109	5220
1972	1002	638	163	773	8957	8772	8371	10176	7867	10625	12848	12100	7102	2908	6523
1973	1452	579	−808	1527	1635	−6	−1903	−2654	−2440	2589	1221	−1949	−1461	−2207	−4
1974	460	−619	53	3903	8833	8451	8191	8739	10444	10934	13872	12702	5142	1612	6646
1975	1560	295	−492	−373	5630	5597	3176	1023	443	6045	9107	9050	−1665	−484	3271
1976	1578	1969	3167	7404	10112	7287	4515	7258	6288	7882	7714	8359	7462	7201	6174
1977	5336	390	−464	−342	−2138	−3452	−2641	−1703	−1356	1019	3397	−1824	−1769	−1740	−334
1978	−1054	−1677	−1499	−1105	2050	1229	1652	3015	3020	4230	3720	4652	−1230	−1701	1146
AVERAGE	**563**	**370**	**223**	**769**	**4010**	**3101**	**1163**	**2248**	**2740**	**5269**	**5782**	**2957**	**350**	**−1050**	**2196**

Table 6-24. Surplus/Deficit for SOS 6b for Operating Year 1995–96

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	15–Apr	30–Apr	MAY	JUNE	JULY	15–Aug	31–Aug	AVERAGE
							Average Megawatts								
1929	951	866	394	660	−1552	−3270	−2377	−353	−1751	3239	4155	−3303	−2056	−2488	−297
1930	−531	−962	−31	−618	−3237	−2889	−3242	−687	−2390	1785	2505	−2239	−539	−1881	−1017
1931	−567	−1386	−313	−967	−3293	−4299	−2984	208	−2879	1332	3827	−2477	−1758	−2305	−1208
1932	−1457	−2005	−1313	−676	−2671	−3737	−1147	7674	6315	7722	3829	165	−1328	−1173	371
1933	336	641	291	306	6722	4038	643	2030	3076	4343	9614	9019	2940	886	3368
1934	1195	3250	4066	8766	11148	10063	6912	9592	8567	7857	−497	−1902	−2244	−2234	4808
1935	451	−165	1037	518	5328	4889	340	1770	513	2014	2895	2870	−340	−2479	1659
1936	415	454	850	846	−935	−956	−688	347	4145	7819	2849	−720	−1543	−2497	847
1937	−182	−410	165	181	−2059	−3509	−2657	−758	−1685	2437	1151	−2187	−887	−1713	−799
1938	−860	−1291	−686	−545	5676	2939	2408	2457	6728	6374	5067	629	−2438	−2963	1800
1939	346	516	767	809	−2592	−2855	1431	2928	3696	4788	−188	−1456	−1682	−2437	235
1940	571	582	497	71	−936	−2085	4129	2097	1296	3966	−537	−1781	−2084	−2649	317
1941	−729	−727	−703	−1092	−1812	−1733	−2001	−2440	−3818	1397	3733	−1726	−1208	−2140	−850
1942	−874	−379	−875	4554	4516	3853	−2540	228	−1486	1947	5206	1627	−495	−1948	1265
1943	−1202	−81	−683	652	6954	6639	2870	9335	9347	6254	7769	6048	901	−1940	3670
1944	−10	1090	453	171	−1683	−3279	−1992	−431	−1635	930	3466	−2172	−2833	−1822	−532
1945	−1795	−1197	−1350	−810	−2612	−2860	−3312	−1018	−1600	3805	5818	−2311	−2560	−1444	−828
1946	−763	−1075	−855	−1533	6772	4884	3828	3632	7260	7649	6343	2830	−1004	−2367	2653
1947	−39	1194	228	4930	8095	8522	4693	4164	5572	7831	3021	719	−1616	−2266	3510
1948	57	5386	3556	2464	8443	6916	2813	4485	6387	8770	12865	8308	2590	1013	5568
1949	801	1068	89	236	3698	2861	5184	8653	6754	8550	1737	−626	−2912	−2852	2368
1950	278	477	536	417	5315	7829	6693	8827	5110	6335	11155	8916	2924	582	4723
1951	653	3890	4012	6814	10224	10782	8101	8542	7108	8527	6686	6208	2580	−1914	6171
1952	617	4760	1369	2738	6988	6643	2399	6511	8559	9105	5927	1885	−525	−2253	4048
1953	306	635	448	667	4726	5704	1331	934	−675	3409	9679	5870	−234	−1122	2686
1954	−106	1059	532	1909	7115	8291	3780	6516	4450	8382	9863	8213	6670	4292	5000
1955	3739	1371	2087	1267	4970	2617	−2179	655	−1545	3761	9432	7814	2651	−2116	2892
1956	−85	2734	3411	6240	10794	7768	6469	8709	9438	10555	13344	7803	689	−581	6513
1957	229	1678	200	2313	4083	5499	4055	8262	5212	8424	8883	2021	−2025	−2322	3496
1958	628	642	283	157	3988	6556	2804	5381	3733	8517	7410	−1421	−2405	−2167	2653
1959	734	556	1291	3433	10321	7558	4095	5229	3917	5850	9056	6895	783	−1435	4503
1960	5477	7807	5073	3902	6273	5027	4609	10478	8261	3811	4569	2185	502	−2293	4767
1961	24	1201	812	124	6329	8092	5364	7619	1720	8057	9304	214	−1554	−1729	3546
1962	161	793	640	177	4118	3619	−153	8897	8148	3725	3997	775	−467	−1847	2101
1963	24	1488	2499	3827	5810	8073	−57	3520	−1247	3334	6722	305	−1148	−2323	2619
1964	−220	957	−103	134	5731	4604	−1053	6388	2254	3851	9590	9207	2298	−998	3139
1965	1472	2453	1128	6288	11486	10461	6952	4659	8870	6697	8014	3170	1992	1029	5533
1966	853	1703	916	886	6750	4081	979	6953	−257	3599	3319	1888	−351	−2503	2241
1967	349	923	627	474	8051	7042	1997	2112	816	4713	9231	9448	1996	−1400	3718
1968	−82	1216	1219	889	6487	7996	5339	111	137	2000	6644	2082	−410	−751	2778
1969	3120	3538	3382	3187	9961	7853	4447	9847	8410	9479	9115	3331	−1615	−2466	5375
1970	−515	1322	135	285	4678	7407	2308	2386	−1452	6241	10514	−492	−3049	−3335	2430
1971	377	816	−114	111	11126	10686	9169	8322	8641	10492	13540	9599	5173	−43	6404
1972	893	1675	753	1854	10384	10956	11787	12899	8521	12129	14690	12065	6785	2677	7719
1973	1320	1540	−302	2661	2498	926	−1097	−1265	−2344	2577	1425	−2015	−1707	−2393	473
1974	687	30	694	5107	10952	10456	10655	11805	12062	12341	15781	13054	4878	1461	7905
1975	1383	1120	−30	29	6714	7143	4674	3192	1145	6511	10442	9691	−1752	−522	4059
1976	1485	3081	3881	9099	11751	8968	6246	10371	7302	8757	8499	8432	7208	7008	7179
1977	5249	1261	18	403	−1809	−2962	−2160	−234	−1319	609	3311	−1999	−2068	−1997	−74
1978	−976	−1207	−889	329	3050	2587	3186	5462	3644	4599	4606	4575	−1433	−1727	1903
AVERAGE	**484**	**1098**	**802**	**1693**	**4857**	**4328**	**2461**	**4540**	**3421**	**5744**	**6588**	**2981**	**66**	**−1258**	**2868**

Table 6–25. Surplus/Deficit for SOS 6d for Operating Year 1995–96

Average Megawatts

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	15–Apr	30–Apr	MAY	JUNE	JULY	15–Aug	31–Aug	AVERAGE
1929	951	866	394	660	−1552	−3270	−2394	−890	−1456	3740	4753	−3087	−2012	−2400	−193
1930	−70	−962	−31	−618	−3237	−2889	−3259	−1173	−1951	2226	2892	−2081	−492	−1774	−894
1931	−104	−1386	−313	−967	−3293	−4299	−3002	−259	−2628	1762	4059	−2370	−1737	−2234	−1112
1932	−1003	−2005	−1313	−676	−2671	−3737	−1161	7521	6927	8486	4466	427	−1272	−1081	572
1933	811	641	291	306	6722	4038	627	1540	3564	4887	10530	9282	3002	989	3557
1934	1660	3250	4066	8766	11148	10063	6901	9429	9190	8253	−284	−1780	−2209	−2150	4931
1935	913	−165	1037	518	5328	4889	322	1244	972	2509	3376	3050	−309	−2404	1794
1936	787	539	850	846	−935	−956	−704	−92	5030	8591	3281	−558	−1502	−2406	1021
1937	283	−410	165	181	−2059	−3509	−2675	−1301	−1408	2960	1539	−2028	−842	−1626	−678
1938	−403	−1291	−686	−545	5676	2939	2394	2096	7454	7079	5786	916	−2375	−2856	2002
1939	821	516	767	809	−2592	−2855	1416	2475	4227	5390	118	−1289	−1646	−2353	371
1940	1039	582	497	71	−936	−2085	4116	1710	1809	4546	−174	−1635	−2056	−2576	455
1941	−262	−727	−703	−1092	−1812	−1733	−2018	−2988	−3566	1853	4198	−1525	−1136	−2010	−723
1942	−393	−379	−875	4554	4516	3853	−2557	−180	−948	2488	5816	1903	−434	−1846	1435
1943	−738	−81	−683	652	6954	6639	2862	9473	10301	6967	8612	6569	1044	−1786	3939
1944	459	1090	453	171	−1683	−3279	−2010	−930	−1354	1372	3920	−1965	−2758	−1704	−404
1945	−1324	−1197	−1350	−810	−2612	−2860	−3329	−1538	−1299	4486	6471	−2064	−2498	−1342	−661
1946	−288	−1075	−855	−1533	6772	4884	3817	3335	8076	8321	6873	3073	−933	−2258	2842
1947	438	1194	228	4930	8095	8522	4681	3765	6152	8656	3619	970	−1548	−2152	3703
1948	523	5386	3556	2464	8443	6916	2799	4127	7109	9706	13796	8621	2722	1169	5814
1949	1275	1068	89	236	3698	2861	5177	8515	7489	9433	2270	−420	−2860	−2756	2573
1950	746	477	536	417	5315	7829	6686	8785	5824	6985	12001	9362	3056	722	4962
1951	1129	3890	4012	6814	10224	10782	8092	8467	7800	9247	7313	6516	2677	−1788	6383
1952	1084	4760	1369	2738	6988	6643	2386	6579	9506	10021	6635	2180	−421	−2114	4298
1953	777	635	448	667	4726	5704	1316	450	−230	4025	10596	6296	−134	−993	2895
1954	357	1059	532	1909	7115	8291	3766	6299	5093	9118	10448	8559	6766	4437	5204
1955	4205	1371	2087	1267	4970	2617	−2198	210	−1256	4427	10199	8148	2734	−2010	3078
1956	374	2734	3411	6240	10794	7768	6466	8639	10362	11454	14191	8080	805	−423	6767
1957	701	1678	200	2313	4083	5499	4043	8187	5888	9370	9685	2273	−1947	−2208	3734
1958	1106	642	283	157	3988	6556	2790	5090	4408	9445	8071	−1185	−2326	−2042	2868
1959	1214	556	1291	3433	10321	7558	4081	4936	4389	6377	9819	7165	860	−1313	4688
1960	5963	7807	5073	3902	6273	5027	4595	10338	8716	4388	5222	2401	581	−2174	4948
1961	486	1201	812	124	6329	8092	5351	7309	2079	8655	9924	386	−1515	−1638	3706
1962	626	793	640	177	4118	3619	−169	8761	8889	4294	4628	1025	−384	−1733	2293
1963	483	1488	2499	3827	5810	8073	−72	3064	−908	3946	7457	581	−1069	−2206	2794
1964	249	957	−103	134	5731	4604	−1070	6200	2719	4538	10527	9584	2417	−853	3366
1965	1961	2453	1128	6288	11486	10461	6948	4430	9767	7517	8941	3588	2157	1244	5798
1966	1351	1703	916	886	6750	4081	963	6705	81	4089	3706	2069	−305	−2405	2379
1967	810	923	627	474	8051	7042	1981	1646	1140	5360	10112	9787	2074	−1287	3913
1968	378	1216	1219	889	6487	7996	5326	−430	376	2506	7268	2306	−333	−591	2925
1969	3611	3538	3382	3187	9961	7853	4436	9789	9159	10315	9670	3571	−1548	−2354	5587
1970	−53	1322	135	285	4678	7407	2293	1887	−1191	6986	11431	−139	−2953	−3220	2634
1971	862	816	−114	111	11126	10686	9162	8261	9402	11437	14480	10057	5306	108	6680
1972	1367	1675	753	1854	10384	10956	11787	12804	9093	13018	15619	12385	6915	2831	7968
1973	1794	1540	−302	2661	2498	926	−1114	−1855	−2110	3045	1776	−1850	−1653	−2284	585
1974	1158	30	694	5107	10952	10456	10657	11823	12953	13217	16745	13527	5020	1633	8188
1975	1849	1120	−30	29	6714	7143	4662	2770	1698	7251	11378	10288	−1624	−331	4305
1976	1965	3081	3881	9099	11751	8968	6235	10364	8038	9658	9201	8776	7348	7186	7424
1977	5724	1261	18	403	−1809	−2962	−2178	−794	−1090	887	3561	−1887	−2033	−1909	9
1978	−511	−1207	−889	329	3050	2587	3173	5254	4182	5270	5323	4833	−1343	−1727	2095
AVERAGE	**943**	**1099**	**802**	**1693**	**4857**	**4328**	**2448**	**4237**	**3969**	**6411**	**7237**	**3254**	**146**	**−1140**	**3056**

Table 6–26. Surplus/Deficit for SOS 9a for Operating Year 1995–96

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	Average Megawatts MAR	15–Apr	30–Apr	MAY	JUNE	JULY	15–Aug	31–Aug	AVERAGE
1929	−856	−2095	−1201	−665	−4126	−4121	−1818	−481	5341	6963	5148	1846	−2195	−2831	−84
1930	−3901	−4894	−5482	−3580	−5777	−3542	−3633	−851	2640	1552	3088	2948	−1951	−3219	−2076
1931	−4517	−4673	−5443	−4704	−5120	−5342	−3687	−538	1897	1228	3507	1631	−2924	−3206	−2459
1932	−4781	−5000	−5423	−4526	−5366	−4996	−1218	1915	6303	5719	7107	4205	859	934	−773
1933	−3037	−3385	−2874	−1086	3301	2155	2967	4537	4947	5175	8436	8398	2217	798	2192
1934	−1043	−75	2474	8930	10148	8131	8346	11633	8725	7528	6783	349	−2907	−3294	4887
1935	−4048	−4162	−3831	−2809	−292	3817	1259	4276	2365	2042	2655	4667	454	387	253
1936	−3574	−2824	−1874	−2522	−1715	−2379	−496	30	6454	8282	6014	4047	510	229	548
1937	−3357	−4334	−5319	−3878	−5379	−5034	−2673	−1173	4386	4582	4009	3800	−1873	−3190	−1542
1938	−4046	−4733	−4511	−2823	−3510	−557	3674	4953	7214	5736	5165	5562	1587	1121	616
1939	−2714	−3686	−4017	−3140	−4191	−3428	466	3258	3933	2399	4559	4152	218	103	−487
1940	−3585	−4006	−4900	−3164	−1727	−2550	4075	2064	4936	4017	3690	3421	−328	−2118	−204
1941	−3677	−4293	−4827	−3644	−4517	−3773	−3281	−2754	882	1021	1345	2656	−377	−736	−2040
1942	−3457	−4076	−4515	−1253	1314	309	−2349	−1414	160	2327	5646	4140	236	213	−193
1943	−3121	−3740	−1903	−1331	1989	5075	4333	11798	10245	7476	7402	4661	1506	1244	2770
1944	−2086	−2522	−2431	−2423	−4042	−3448	−2409	−1245	5222	5820	4187	−2703	−3679	−3468	−1137
1945	−3986	−4816	−5313	−4719	−4941	−3385	−3578	−1962	1710	1329	2656	3365	775	552	−1904
1946	−3279	−3306	−3841	−3182	−1846	1785	5302	5386	7524	7088	6755	5751	1708	1758	1618
1947	−2719	−2397	−3037	2059	3940	6664	7771	6265	7340	6492	5472	4734	831	933	3055
1948	−3028	−2161	25	383	4426	4978	4212	3850	7195	9550	13508	7175	1336	1242	3823
1949	−507	−855	−430	659	1069	2513	7183	7148	7971	6260	5575	4480	1180	569	2865
1950	−3082	−3727	−3895	−3199	−2763	6750	9541	9990	7145	5693	10887	8134	2273	3358	2977
1951	−1928	863	2519	6279	7707	10572	10750	10483	8214	7431	7110	8076	3354	3123	5997
1952	−2442	−1377	−2020	985	4031	5127	4670	9775	9944	8502	5693	5662	1899	1369	3360
1953	−2338	−3729	−4349	−4061	328	5987	1362	993	2827	4291	9146	6000	799	1062	1290
1954	−2152	−1284	−978	902	2668	6299	6616	7889	7165	7534	9509	6695	5523	3451	3985
1955	2490	−555	1554	1408	1911	757	−1545	1576	5339	6704	6494	7064	1797	967	2593
1956	−2612	22	2020	6096	6775	6899	9786	10885	8792	9530	12984	8959	4283	3750	6193
1957	−2263	−2611	−3117	−729	1496	4305	4540	9821	5940	6898	10691	4040	1034	1007	2679
1958	−2647	−3095	−3786	−2770	1848	6377	4357	5123	5425	8186	8028	4245	634	272	2206
1959	−2701	−3621	−2450	−534	5646	5963	6980	7511	5618	4399	8999	6600	2083	2171	3164
1960	322	4599	5337	3688	4154	4692	5902	13063	7809	6558	4149	3779	1029	839	4546
1961	−2848	−3212	−1091	−1784	2085	7118	5717	7643	5724	6285	8765	4255	1166	761	2745
1962	−2932	−3432	−3887	−1416	1823	1764	743	8935	8365	6228	3381	3931	355	404	1269
1963	−2611	−2345	−2023	1107	2704	6803	1563	1724	4958	3726	2970	3953	687	129	1633
1964	−2643	−3101	−3149	−2470	1911	3442	705	7528	4448	6018	8527	7707	1230	954	2002
1965	−924	−323	−538	4256	8074	9220	8648	5559	9756	6764	7881	6653	3460	2999	5050
1966	−2023	−2369	−3231	−1292	3359	3347	1547	8195	3834	4250	4469	4203	536	358	1560
1967	−3300	−3471	−3914	−2321	2833	5767	4288	4343	3527	4445	8351	7721	2303	2294	2219
1968	−2726	−1285	−301	488	2749	7188	5552	504	4992	6387	4889	4350	627	1609	2596
1969	−2073	−452	1143	213	6181	7508	6084	10614	8502	8328	8778	7624	3722	1639	4631
1970	−2086	−3102	−4024	−2865	861	6760	1910	1889	5836	7134	7515	4432	1244	562	1775
1971	−1994	−3406	−3119	−2315	1603	8087	9869	9941	8076	10151	13902	9064	5691	4418	4659
1972	−1151	−1452	−2320	1878	6765	9599	15564	12330	7785	11236	14260	10876	6910	5917	6811
1973	−916	−2019	−844	3076	1687	562	−464	−2015	4375	7190	5615	333	−2314	−4058	1018
1974	−3657	−4062	−3226	−1137	5469	10057	10960	10348	10132	10542	15713	12312	6881	6063	5807
1975	−1373	−2570	−3657	233	4551	5465	7058	4777	4698	7503	10004	9357	3035	3376	3710
1976	−1275	−1517	636	6345	6877	7063	8514	12080	8640	7530	8569	8514	6325	5255	5617
1977	3218	−878	−2051	−314	−3573	−3135	−3340	−1458	5968	6293	4492	−2262	−2073	−2955	−151
1978	−4474	−4833	−3377	−1040	−3031	−837	1871	7475	5080	4361	5851	4417	949	948	511
AVERAGE	**−2409**	**−2608**	**−2336**	**−574**	**1207**	**3048**	**3484**	**5084**	**5926**	**6054**	**7007**	**5120**	**1253**	**801**	**2044**

Table 6–27. Surplus/Deficit for SOS 9b for Operating Year 1995–96

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	15–Apr	30–Apr	MAY	JUNE	JULY	15–Aug	31–Aug	AVERAGE
							Average Megawatts								
1929	−1504	−1888	−865	−732	−4616	−4058	−2169	−942	3255	1992	5302	2449	−1408	−3382	−611
1930	−3717	−4094	−5017	−1773	−4569	−2814	−2465	−1453	3266	1129	4854	182	−2841	−3338	−1706
1931	−4144	−3873	−4850	−2665	−4638	−4864	−3315	−903	2272	1009	4445	748	−3181	−4004	−2088
1932	−4405	−4419	−4756	−3702	−4551	−3393	3118	10619	9849	6080	8923	3568	1532	1541	686
1933	−3069	−3192	−1554	967	1141	1241	5566	5285	7890	4607	9804	10518	2667	1577	2895
1934	−1389	218	3458	9563	10089	6588	8811	11786	10791	7136	6157	−4051	−3546	−3637	4523
1935	−3713	−3540	−1484	734	1055	2566	3427	4533	7676	4881	6061	722	369	−3667	1264
1936	−3713	−3698	−4066	−1384	−4205	−3984	2363	−256	7531	9670	5629	2039	1621	−3705	104
1937	−3051	−3732	−4914	−3186	−5110	−4836	−2623	−529	2050	1199	5669	2687	684	−3778	−1557
1938	−3658	−3516	−3829	−90	1581	1216	5302	4734	11329	7630	9023	903	−2739	−4139	1596
1939	−2888	−3095	−3909	−506	−2220	−1212	2176	2473	6569	2203	3900	2330	56	−3312	−27
1940	−3295	−3480	−4107	748	−2142	−1759	6174	1690	2587	1265	3758	1351	−4131	−4035	−286
1941	−3339	−3570	−4032	−697	−1960	−1734	−1190	−1612	1392	515	2074	−1534	−3725	−3967	−1619
1942	−3062	−3590	−3239	4819	1043	790	−208	−726	2421	1429	8731	4202	1312	1041	1078
1943	−3223	−3605	−2975	2023	335	4507	7745	13438	12748	7830	9517	4767	1242	725	3416
1944	−2608	−2555	−4022	385	−4107	−3520	−3034	−1563	2217	845	3060	−1910	−4339	−3930	−1773
1945	−3576	−3977	−4628	−3823	−4348	−2696	−2964	−675	2727	4055	7831	1835	1991	−1307	−910
1946	−3192	−2917	−3967	−2121	734	3506	7566	6575	12554	8116	9859	4942	1235	−2248	2632
1947	−2740	−2357	−2755	4911	1681	6192	9523	6495	9072	6452	7978	3687	809	−2119	3308
1948	−2958	−283	1875	2303	1468	3741	6751	3920	10439	11702	15401	8370	1324	1727	4756
1949	−1440	−849	−246	785	−1237	1624	9627	6855	11198	7134	6702	2801	−2717	−4639	2521
1950	−2969	−3112	−3368	269	−556	5775	11120	10196	10794	7761	10913	9641	2524	2008	4020
1951	−2229	925	4059	7016	5613	10148	11609	10616	12016	9911	9197	5246	1200	−2269	6023
1952	−2732	171	361	2479	1561	5575	6797	10507	12944	10093	10754	1820	−1373	−4153	3820
1953	−2719	−3242	−4402	−2848	−1550	8322	4401	745	5934	4887	11542	7104	1591	1746	2209
1954	−2769	−2484	−1312	2480	−332	4775	8312	7478	9930	8828	11350	7651	5983	3549	4164
1955	1905	−619	907	1280	−810	−2973	−1020	7276	2673	4271	12191	10351	2121	1777	2701
1956	−3047	−1157	2890	6325	5820	6876	11104	10951	12554	11472	14870	7658	1954	1874	6373
1957	−2630	−2104	−1103	2909	−1115	2720	7127	10531	8870	9128	13053	3123	1886	−3308	3341
1958	−2586	−2841	−3519	150	−479	5147	6310	5359	10091	9502	8649	2954	349	−3159	2467
1959	−2806	−2999	−1104	3055	4343	5551	8474	7385	8710	5849	8876	9129	1693	1714	4010
1960	629	4986	4385	3617	1715	3626	7865	13236	9744	3226	6208	4607	1976	1773	4519
1961	−2857	−3030	−1221	173	650	6176	7995	8218	7565	6621	11117	4173	2020	1081	3270
1962	−2944	−3083	−3577	−96	−705	850	3361	10286	11029	3946	5532	3103	1661	1454	1550
1963	−2718	−2173	−516	3338	935	6647	3836	913	2906	4550	7196	3775	1840	802	2342
1964	−2787	−2909	−2779	747	−951	1762	2324	7309	5778	3206	13039	10759	2033	1840	2574
1965	−2339	−384	−145	6637	7190	10018	10499	6454	12424	7685	8901	5542	2037	1838	5415
1966	−2161	−849	−1387	1090	1084	2520	4116	8253	4593	2592	4159	5253	1903	1187	2032
1967	−3034	−3068	−3601	2331	2119	5237	6724	4998	6018	4747	9774	10237	1345	1668	3207
1968	−3117	−1341	−212	1304	−405	5942	8019	1586	5864	1311	5877	6584	1943	1675	2458
1969	−1957	650	2611	2705	5344	7696	8291	11263	12781	10794	9779	5154	−2045	−3413	5030
1970	−1974	−2540	−2467	951	862	5152	4232	4009	3378	4851	11424	2529	2525	−2839	2213
1971	−2055	−2064	−3241	−1512	4439	11072	10945	11837	11028	12962	16042	9791	3519	2750	5912
1972	−1374	−1278	−347	2719	4201	8834	16807	12565	8343	13199	16201	11860	5939	2721	7134
1973	−137	−461	−542	3411	2018	945	−28	−1176	3162	1728	4139	−2014	−3190	−5062	494
1974	−2657	−3278	−2563	4517	9918	11758	11837	12035	12854	13044	17405	13588	4156	2620	7450
1975	−1230	−2039	−1284	1589	2479	4936	9141	4332	7274	7764	9910	10623	1855	2849	4170
1976	−1568	−885	1251	8880	7024	7120	10643	12451	11974	9918	10048	8575	6448	5567	6602
1977	3349	−750	−1657	−244	−4199	−3858	−3013	−1347	2510	1841	3488	−3127	−4242	−3822	−968
1978	−3749	−3509	−2996	−130	−1012	2576	6773	8014	8106	6709	6118	5462	2444	2163	2217
AVERAGE	**−2439**	**−2150**	**−1735**	**1434**	**613**	**2961**	**5296**	**5720**	**7634**	**5986**	**8649**	**4635**	**766**	**−639**	**2499**

Table 6-28. Surplus/Deficit for SOS 9c for Operating Year 1995-96

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	Average Megawatts MAR	15-Apr	30-Apr	MAY	JUNE	JULY	15-Aug	31-Aug	AVERAGE
1929	-1368	-957	200	-371	-4425	-4078	-1952	-1214	2290	522	1551	-1341	-3107	-3582	-1252
1930	-3585	-2946	-694	-504	-4649	-2537	-2326	-1189	2808	279	-169	-1347	-2384	-2914	-1693
1931	-3599	-2332	-789	-729	-4187	-4527	-2772	-602	1921	65	2208	-4152	-4110	-3936	-2015
1932	-4220	-2776	-1187	874	-2328	-267	1320	3295	3854	2960	8249	4515	949	-1561	867
1933	-2954	-1909	204	1903	2811	5596	4034	67	1749	2730	9551	10216	3232	977	2933
1934	-1293	1736	4079	10036	11455	9141	7652	7811	5425	5440	3268	2290	-2695	-3264	4787
1935	-3624	-2511	-40	96	2444	6825	2000	-1066	103	1122	1955	4703	635	-1249	1015
1936	-3582	-2448	-1073	-365	-3674	-3999	1467	-736	5292	7989	4220	609	-2850	-3444	-144
1937	-2933	-2403	-192	-659	-4800	-4849	-3101	-772	1508	142	1374	-45	-2592	-3636	-1684
1938	-3489	-2606	-529	1379	5118	4021	4151	1090	5595	5192	6521	4009	-1518	-3518	2049
1939	-2508	-1940	-1394	-623	-3019	-1887	2485	2482	4520	1971	3316	-1030	-2302	-3802	-348
1940	-3185	-1526	-26	384	-2633	-1589	6350	1159	1440	146	2530	-3196	-4037	-3879	-450
1941	-3175	-2161	-1042	24	-1246	-1670	-1335	-2009	761	-264	-205	-3981	-3448	-3696	-1604
1942	-2825	-1960	-659	6493	3376	-761	-637	-1967	598	-89	6669	4708	742	-1208	1116
1943	-3058	-2145	404	1443	3261	7362	4440	8947	10060	5298	8541	7139	808	-1212	3499
1944	-2528	-2082	-213	-67	-3638	-3533	-2667	-1534	1616	-322	-1213	-4378	-4307	-3690	-2050
1945	-3438	-3500	-491	544	-3722	-1868	-2167	-1190	2154	514	4705	978	-3029	-3103	-919
1946	-3021	-2515	-1640	1387	5388	6474	5432	1680	5883	5670	7256	6160	933	-2508	2799
1947	-2442	-878	-135	6680	3336	3868	9038	8444	3392	4458	5942	3948	303	-3443	3180
1948	-2777	3817	3434	3721	2961	2552	8825	3336	3916	8261	14876	8798	1892	1179	4969
1949	-1183	-546	266	1246	-146	-135	10620	6857	3709	5512	5280	19	-3366	-4668	1850
1950	-2838	-2828	34	2585	374	10821	9590	5942	4439	4772	10955	10155	3269	1451	4264
1951	-2101	2178	3996	7671	8163	12308	9643	6355	4690	7748	6594	7227	2415	-418	5829
1952	-2249	3159	520	3789	5101	6807	4039	5425	7525	8737	6828	2926	-940	-3727	3650
1953	-2572	-2794	-234	-394	679	5116	4980	2288	2173	1513	11059	7437	1013	-493	2273
1954	-2659	-1017	51	3458	894	10277	7081	3557	2947	5494	10564	9048	6803	3862	4315
1955	2010	-119	1408	2684	311	-3045	-793	3308	1864	472	11209	10600	3036	-535	2381
1956	-2905	1258	3325	7387	8698	7900	8928	6723	8212	9957	14307	8033	1447	-423	6239
1957	-2563	-180	183	3767	68	2494	6078	10505	3045	7437	11782	2675	-2952	-3735	2931
1958	-2676	-1489	293	298	721	4502	8761	5235	1621	7375	6024	1910	-3243	-2742	2180
1959	-2638	-1018	1710	5505	7501	8480	6225	3376	2093	3552	7666	10618	1670	-132	4259
1960	2585	5789	5113	4667	1753	1991	7521	13036	4038	1729	6599	5824	1447	-2202	4311
1961	-2769	-1255	21	933	1430	4995	10311	7711	1857	2540	10544	5083	914	-2047	3004
1962	-2847	-2515	-138	643	126	793	2770	10819	7502	2475	4264	3274	1005	-2048	1457
1963	-2585	-603	2130	5075	1765	5365	3351	-642	1924	2013	5455	4165	978	-2772	2156
1964	-2374	-1071	277	577	504	3128	-478	9936	1518	1607	12542	10848	1886	488	2706
1965	-1443	928	967	7760	9772	10354	8796	3106	5385	5304	9093	7006	2023	1311	5371
1966	-1900	-54	-85	1776	1445	873	3215	7052	2524	1338	4327	5151	1274	-2970	1669
1967	-2961	-1721	162	2163	3125	9951	4846	398	418	1289	9152	10794	2377	192	3208
1968	-3078	-592	496	2332	1753	5654	8962	-429	925	77	3467	6912	1271	-812	2205
1969	298	1708	3198	4124	7748	8444	5886	8749	7242	8498	7235	6794	1023	-2883	5083
1970	-1859	-1056	-143	1582	2958	4742	4284	2604	1968	2531	9430	2749	-2897	-3927	2008
1971	-1902	-1638	-240	1391	7238	13207	9572	6628	6090	10731	15320	10421	4419	1166	6104
1972	-1222	-397	719	3385	5814	12390	13834	9868	6058	11402	15633	12670	6349	2264	7208
1973	-442	220	305	3689	2403	643	-404	-507	1901	595	-1521	-2170	-3403	-4946	-13
1974	-2478	-2981	750	6519	11880	10476	11036	10303	10775	10641	16989	14182	5215	2079	7600
1975	-875	-1137	182	1112	2400	6453	8243	3685	1029	4511	11239	11967	1099	-862	3881
1976	-1405	1154	2283	9983	9438	8862	8516	8236	5796	7799	7725	10217	7648	6711	6564
1977	3643	-494	312	69	-3768	-3763	-3080	-1083	1342	145	514	-4575	-4447	-4006	-1258
1978	-3635	-2964	-1252	2428	2713	5644	4547	3398	2482	4617	4812	4686	2012	1551	2193
AVERAGE	**-2185**	**-922**	**497**	**2597**	**2094**	**3800**	**4542**	**3769**	**3560**	**3890**	**6925**	**4705**	**249**	**-1535**	**2414**

Table 6-29. Surplus/Deficit for Preferred Alternative for Operating Year 1995-96

Average Megawatts

WATER YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	15-Apr	30-Apr	MAY	JUNE	JULY	15-Aug	31-Aug	AVERAGE
1929	−1196	−822	−1378	−270	−4612	−4010	−2652	−1688	4163	2012	6306	2273	−2798	−3667	−529
1930	−2632	−1750	−1587	−2902	−5710	−2201	−3365	−1790	4370	560	3422	1046	−2433	−2953	−1377
1931	−1196	−1742	−1722	−2967	−4899	−4574	−3581	−624	2269	230	5240	−657	−3647	−3589	−1555
1932	−1197	−1334	−1586	−1721	−5143	−4243	−718	6085	8602	5805	9834	5319	2009	−1627	1046
1933	−1708	−1335	−1587	85	2683	3043	3159	5335	4565	3804	13654	10936	5679	2456	3479
1934	−1197	482	2210	8088	10227	8762	7937	11927	9788	6841	3891	2326	−3999	−3456	4725
1935	−2350	−1535	−1086	13	2664	4908	967	4644	3571	3463	6724	5853	1442	−3625	1886
1936	−2209	−1656	−2466	−2926	−4256	−3697	−206	−1341	7368	11001	6647	3589	−2948	−3554	299
1937	−2035	−2018	−1587	−2178	−5274	−4662	−3424	−1771	3322	842	4613	2544	−2333	−3465	−1275
1938	−1957	−1672	−1587	−2291	4264	2293	3357	6561	9047	7228	7996	4532	−1466	−4006	2269
1939	−1216	−1335	−1586	−2091	−4235	−688	807	2672	6791	5308	2312	2430	−1927	−3553	141
1940	−2245	−1335	−1586	−1033	−2538	−1012	4492	1830	3940	4481	1758	−373	−3848	−3733	−25
1941	−1855	−1428	−1642	−3199	−1918	−1345	−2652	−2637	2321	2625	2830	−1312	−3397	−3473	−1124
1942	−1987	−1472	−1787	1728	3297	−525	−1769	−1385	2826	3298	8157	6223	4698	−833	1485
1943	−2595	−1335	−1587	−762	2990	5392	3810	13390	12738	7031	10511	6617	5343	−677	3789
1944	−2261	−1335	−1587	−1163	−4038	−3848	−3277	−1824	3236	100	3661	−2354	−4009	−3572	−1599
1945	−1197	−1788	−1587	−1873	−4517	−3115	−3239	−1662	3244	3558	4925	4103	−1968	−3142	−541
1946	−1586	−2126	−1614	−2670	3864	3664	5612	7307	9915	7516	8901	7082	4432	−2740	3175
1947	−1490	−1335	−1587	4652	2969	5609	8537	8977	6469	6447	7178	5565	3148	−3262	3684
1948	−1873	2081	1904	2138	3297	2582	6958	6367	7882	11991	15400	8558	5906	4652	5453
1949	−1197	−63	−1587	346	−27	−167	9397	6552	9349	8109	8226	3294	−3802	−5036	2489
1950	−2808	−1600	−1587	−1722	371	7896	9359	10622	8510	7620	12896	9692	5255	4331	4540
1951	−1197	554	2166	6005	7964	10367	10198	10839	8915	9832	8057	6835	5869	1094	6178
1952	−1779	1379	−3	2423	4956	5914	3737	10512	12187	10442	7641	5137	617	−3731	4137
1953	−2442	−1626	−1587	−2011	−300	5001	3941	2134	4279	5968	11094	6813	5910	2170	2675
1954	−1754	−838	−1357	1919	788	7219	6510	8158	6430	8745	12205	8354	7300	5949	4642
1955	2042	360	921	915	138	−3244	−1779	4942	3728	4451	12529	10736	5736	3682	3009
1956	−1864	232	1785	5329	7716	7464	9371	11123	11245	11987	15121	7792	6270	−48	6602
1957	−1595	−404	−1587	1796	−222	2276	5483	13578	4729	9668	12994	5552	−2215	−3804	3342
1958	−2066	−1335	−1587	−991	154	3894	6512	5873	6318	10316	8193	4665	−2757	−2721	2593
1959	−1756	−1335	−403	3279	7377	6356	6671	7866	5318	5185	11158	9760	6231	−792	4634
1960	1357	5401	4094	3799	2149	3065	6475	14638	7066	5254	7383	5287	4138	−3567	4617
1961	−1719	−1073	−1048	−1049	1433	5498	8131	9031	3526	6976	11721	5822	2744	−2197	3437
1962	−2752	−1336	−1586	−753	93	414	1800	12230	9126	5781	6052	5602	−563	−2248	1882
1963	−2149	−528	284	3181	1478	5361	2531	239	4606	4558	7431	5812	3089	−2116	2572
1964	−1451	−1335	−1587	−480	9	4110	−1885	11381	3012	3486	14204	10053	6245	2593	3062
1965	−1197	433	−1037	5850	8672	10665	8586	6255	10902	7921	10600	5391	6044	1764	5697
1966	−1655	−804	−1267	845	2086	1312	2382	7838	4838	5063	4930	5843	2309	−3078	2057
1967	−2258	−1335	−1587	514	3292	7279	5289	4825	2262	3189	12842	10034	5810	1754	3715
1968	−1839	−525	−1129	833	857	4864	8089	900	2405	3408	6340	6607	5164	568	2669
1969	−358	1382	1263	2710	8283	8064	6275	11595	10854	10661	8684	7714	1352	−3020	5422
1970	−1234	−709	−1587	246	2271	4058	2769	3650	3651	5971	11674	4765	−1687	−3012	2460
1971	−1912	−1334	−1587	−484	6738	10647	10151	12017	9191	13029	15916	9778	6926	5494	6480
1972	−1197	−30	−737	2474	6122	9531	15369	12964	8671	13751	16293	12834	7748	7351	7731
1973	−1160	−67	−1130	3126	1923	855	−1716	−2648	3789	2364	1960	756	−3157	−4762	294
1974	−1288	−1721	−1248	4045	10013	11549	11272	12211	13244	13493	17386	13987	6859	6662	8081
1975	−1197	−1275	−1586	633	2749	6602	6281	5272	4575	7646	12980	11162	3893	216	4248
1976	−1197	1115	1398	7357	8936	7556	8856	12657	9019	10519	8368	10490	8785	7678	6872
1977	3858	236	−1481	−30	−4083	−3888	−3884	−2544	3596	400	4040	−2718	−3967	−3381	−892
1978	−1197	−1335	−1587	−835	571	3353	4926	8929	6391	6939	6955	6428	6512	2552	3034
AVERAGE	**−1459**	**−686**	**−860**	**759**	**1632**	**3124**	**3837**	**5880**	**6363**	**6337**	**8797**	**5772**	**2011**	**−749**	**2834**

CHAPTER 7

GLOSSARY

Acre–foot: The volume of water that will cover an area of one acre to a depth of one foot (326,000 gallons or 0.5 second foot days).

Anadromous fish: Fish, such as salmon or steelhead trout, that hatch in freshwater, migrate to and mature in the ocean, and return to freshwater as adults to spawn.

Average megawatt (aMW): The average amount of energy (in megawatts) supplied or demanded over a specified period of time; equivalent to the energy produced by the continuous operation of one megawatt of capacity over the specified period.

Baseload: In a demand sense, a load that varies only slightly in level over a specified time period. In a supply sense, a plant that operates most efficiently at a relatively constant level of generation.

Canadian Entitlement Allocation Agreements: Contracts that specify how much power is to be provided by five mid–Columbia projects as a result of increased flows made possible by the Columbia River Treaty projects.

Canadian Entitlement: Canada's share of hydro–power generated at downstream projects by the use of the Columbia River Treaty projects.

Capacity: The maximum sustainable amount of power that can be produced by a generating resource at specified times under specified conditions or carried by a transmission facility; also, the maximum rate at which power can be saved by a non generating resource.

Capacity/energy exchange: A transaction in which one utility provides another with capacity service in exchange for additional amounts of firm energy (exchange energy) or money, under specified conditions, usually during off–peak hours.

Circuit Mile: The total length, in miles, of separate circuits or transmission lines.

Columbia River Treaty: A Treaty between the United States and Canada allowing the construction and coordinated operation of Libby Dam in the United States, and Mica, Duncan, and Keenleyside (Arrow Lakes) Dams in Canada.

Columbia Storage Power Exchange (CSPE): A non–profit corporation of 11 Northwest utilities that issued revenue bonds to purchase the Canadian Entitlement and sell it to 41 Northwest utilities through a Bonneville Power Administration exchange agreement.

Content: An amount of water stored in a reservoir, usually expressed in terms of KSFD or MAF.

Coordinated operation: The operation of interconnected electrical systems to achieve greater reliability and economy; as applied to hydro resources, the operation of a group of hydro plants to obtain optimal power benefits.

Critical period: That portion of the historical 50–year stream flow record which, when combined with the drafting of all storage reservoirs from full to empty, would produce the least amount of energy shaped to seasonal load patterns.

Critical water: Stream flows which occurred during the critical period.

Cubic feet per second (cfs): A measurement of water flow representing one cubic foot of water moving past a given point in one second. One cfs is equal to 7.48 gallons per second and 0.028 m^3 per second. A thousand cubic feet per second is abbreviated as kcfs.

Demand: The rate at which electric energy is delivered to or by a system; usually expressed in kilowatts or megawatts over a designated period of time.

Discharge: Volume of water flowing at a given time, usually expressed in cubic feet per second.

Displacement: The substitution of less–expensive energy generation for more–expensive energy generation (usually hydroelectric energy transmitted from the Pacific Northwest or Canada is substituted for more expensive coal and oil–fired generation in California). Such displacement usually means that a thermal plant can reduce or shut down its production, saving money and often reducing air pollution.

Draft: Release of water from a storage reservoir, usually measured in feet of reservoir elevation.

Drawdown: The distance that the water surface of a reservoir is lowered from a given elevation as water is released from the reservoir. Also refers to the act of lowering reservoir levels. (Similar to Draft.)

Elevation: Height in feet above sea level. Usually refers to reservoir forebay; used interchangeably with content, because a forebay elevation implies a specific reservoir content. Tail water level is also expressed as an elevation.

Energy: Average power production over a stated interval of time, expressed in kilowatt–hours, megawatt–hours, average kilowatts, or average megawatts.

Firm energy: The amount of energy that can be generated given the region's worst historical water conditions. It is energy produced on a guaranteed basis.

Firm energy load carrying capability (FELCC): The amount of energy the region's generating system, or an individual utility or project, can be called on to produce on a firm basis during actual operations. FELCC is made up of both hydro and non–hydro resources, including power purchases.

Fish passage facilities: Features of a dam that enable fish to move around, through, or over without harm. Generally an upstream fish ladder or a downstream bypass system.

Flow: The volume of water passing a given point per unit of time. Same as stream flow.

Forced outage reserves: Peak generating capability planned to be available to serve peak loads during forced outages of generating units.

Forced outage: An unforeseen outage that results from emergency conditions.

Forebay: The portion of a reservoir at a hydroelectric plant that is immediately upstream of a dam or powerhouse.

Forebay elevation: Height of top of the forebay above sea level.

Freshet: A rapid temporary rise in stream flow caused by heavy rains or rapid snow melt.

Generation: Production of electric energy from other forms of energy; also refers to amount of electric energy produced.

Headwater benefits: Gains in usable downstream energy as a result of upstream storage.

Historical stream flow record: The unregulated stream flow data base of the 50 years beginning in July 1928; data are modified to adjust for factors such as irrigation depletions and evaporations for the particular operating year being studied.

Hydraulic Head: The vertical distance between the surface of the reservoir and the surface of the river immediately downstream from the powerhouse. Head is the difference between forebay and tail water elevations.

Hydroelectricity: The production of electric power through use of the gravitational force of falling water.

Hydrology: The science dealing with the continuous cycle of evapotranspiration, precipitation, and runoff.

Hydrometeorological observations: Data that combine snowpack measurements and climatic forecasts to predict runoff.

Inflow: Water that flows into a reservoir or forebay during a specified period.

Intake: The entrance to a conduit through a dam or water facility.

Interruptible: A supply of power which, by agreement, can be shut off on relatively short notice (from minutes to a few days).

Juvenile: The early stage in the life cycle of anadromous fish when they migrate downstream to the ocean.

KAF: A thousand acre feet; same as .504 thousand second foot days.

KCFS: A measurement of water flow equivalent to 1,000 cubic feet of water passing a given point for an entire second.

KSFD: A volume of water equal to 1,000 cubic feet of water flowing past a point for an entire day. Same as 1.98 KAF.

Levee: An embankment constructed to prevent a river from overflowing.

Load: The amount of electric power or energy delivered or required at any specified point or points on a system. Load originates primarily at the energy–consuming equipment of customers.

Load shaping: The adjustment of storage releases so that generation and load are continuously in balance.

Lock: A chambered structure on a waterway closed off with gates for the purpose of raising or lowering the water level within the lock chamber so ships can move from one elevation to another along the waterway.

MAF: Million acre feet. The equivalent volume of water that will cover an area of one million acres to a depth of one foot. One MAF equals 1,000 KAF.

Mainstem: The principal river in a basin, as opposed to the tributary streams and smaller rivers that feed into it.

Megawatt (MW): A unit of electric power equal to one million watts, or one thousand kilowatts.

Megawatt–hour (MWh): A unit of electrical energy equal to one megawatt of power applied for one hour.

Mid–Columbia: The section of the Columbia River from the Canadian border to its junction with the Snake River.

Nonfirm energy: Energy in excess of firm energy, which is available when water conditions are better than those in the critical period; generally such energy is sold on an interruptible (non guaranteed) basis. Also called secondary energy.

Nonpower operating requirements: Operating requirements at hydroelectric projects that pertain to navigation, flood control, fish and wildlife, recreation, irrigation, and other nonpower uses of the river.

Northwest Power Pool Coordinating Group: An operating group made up of BPA, the Corps, Reclamation, and public and private generating utilities in the Northwest. One of the group's functions is administering the Pacific Northwest Coordination Agreement.

Off–peak hours: Period of relatively low demand for electrical energy, as specified by the supplier (such as the middle of the night).

Operating requirements: Guidelines and limits that must be followed in the operation of a reservoir or generating project. These requirements may originate from authorizing legislation, physical plant limitations, environmental impact analysis or input from government agencies and other entities representing specific river uses. Operating requirements are submitted annually to the Northwest Power Pool by project owners for planning purposes.

Outages: Periods, both planned and unexpected, during which the transmission of power stops or a particular power–producing facility ceases to provide generation.

Outflow: The volume of water per unit of time discharged at a hydroelectric project.

Pacific Northwest Coordination Agreement: A binding agreement among BPA, the Corps, Reclamation, and the major hydro generating utilities in the Pacific Northwest that stemmed from the Columbia River Treaty. The Agreement specifies a multitude of operating rules, criteria, and procedures for coordinating operation of the Pacific Northwest hydropower system for optimal power production. It directs operation of major generating facilities as though they belonged to a single owner.

Peak load: The maximum electrical demand in a stated period of time. It may be the maximum instantaneous load or the maximum average load within a designated period of time.

Project: Run–of–river or storage dam and related facilities; also a diversion facility.

Project outflow: The volume of water per unit of time released from a project. Same as discharge and outflow.

Refill: The point at which the hydro system is considered "full" from the seasonal snow melt runoff. Also, refers to the annual process of filling a reservoir.

Reliability: For a power system, a measure of the degree of certainty that the system will continue to meet load for a specified period of time.

Reregulating reservoir: A reservoir located downstream from a hydroelectric peaking plant having sufficient pondage to store the widely fluctuating discharges from the peaking plant and release them in a relatively uniform manner downstream.

Reregulation: Storing erratic discharges of water from an upstream hydroelectric plant and releasing them uniformly from a downstream storage plant.

Reservoir content: See content and reservoir storage.

Reservoir draft rate: The rate at which water, released from storage behind a dam, reduces the elevation of the reservoir.

Reservoir elevation: The height above sea level of the water stored behind a dam. Same as forebay elevation.

Reservoir storage: The volume of water in a reservoir at a given time. Same as reservoir content. Reservoir storage implies a reservoir elevation. Tables are used to convert content to elevation at each reservoir.

Resident fish: Fish species that reside in freshwater throughout their lives.

Run–of–river dams: Hydroelectric generating plants that operate based only on available inflow and a limited amount of short–term storage (daily/weekly pondage).

Secondary energy: Hydroelectric energy in excess of firm energy, often used to displace thermal resources. Also called nonfirm energy.

Shaping: The scheduling and operation of generating resources to meet seasonal and hourly load variations. Load shaping on a hydro system usually involves the adjustment of reservoir releases so that generation and load are continuously in balance. In planning, moving surplus or deficit FELCC from one period to another period within the year.

Shifting: In planning, moving surplus or deficit FELCC from one year of the critical period to another to increase the FELCC's value.

Spill: Water passed over a spillway without going through turbines to produce electricity. Spill can be forced, when there is no storage capability and flows exceed turbine capacity, or planned, for example, when water is spilled to enhance juvenile fish survival.

Spillway: Overflow structure of a dam.

Storage energy: The energy equivalent of water stored in a reservoir above normal bottom elevation.

Storage reservoirs: Reservoirs with space for retaining water from the annual high–water season to the following low–water season. Careful scheduling of reservoir refill serves to prevent floods in high runoff years. Retained water is released as necessary for multiple uses — power production, fish passage, irrigation, and navigation.

Stream flow: The rate at which water passes a given point in a stream, usually expressed in cubic feet per second (cfs).

Surplus: Energy generated that is beyond the immediate needs of the producing system. This energy may be sold on an interruptible basis or as firm power.

Tail water: Water immediately below the power plant. Tail water elevation refers to the level of that water.

Thermal resource: Electrical generating means that rely on conventional fuels such as coal, oil, and gas.

Transmission: Transporting electric energy in bulk from one point to another in the power system rather than to individual customers.

Transmission grid: An inter–connected system of electric transmission lines and associated equipment for transferring electric energy in bulk.

Turbine: Machinery that converts kinetic energy of a moving fluid, such as falling water or steam, to mechanical power. Turbines are used to turn generators that convert mechanical energy to electricity.

Usable storage capacity: The portion of the reservoir storage capacity in which water normally is stored, or from which water is withdrawn for beneficial uses, in compliance with operating agreements.

Water budget: A part of the Northwest Power Planning Council's Fish and Wildlife Program calling for a volume of water to be reserved and released during the spring, if needed, to assist in the downstream migration of juvenile salmon and steelhead.

Water rights: Priority claims to water. In western States, water rights are based on the principle "first in time, first in right," meaning older claims take precedence over newer ones.

Watt: A unit of electrical power or rate of doing work. The rate of energy transfer equivalent to one ampere flowing under a pressure of one volt at unity power factor. It is analogous to horsepower or foot–pounds per minute of mechanical power. One horsepower is equivalent to approximately 746 watts. A kilowatt equals 1,000 watts, a megawatt equals 1,000,000 watts.

Wheeling: Using transmission facilities of one system to transmit power of and for another system.