DOCUMENTATION FOR THE LOADS AND RESOURCES STUDY

VOLUME 2

JUNE 1996

WP-96-FS-BPA-01B

The steps leading to BPA's forecasts of regional loads are detailed in Volume 1 of the Documentation for Loads and Resources Study (Documentation), WP-96-FS-BPA-01A.

In this volume, Volume 2, the data associated with balancing forecasted resources against forecasted loads will be shown. The netting of loads and resources determines the load to be placed on BPA for use in the rate making process.

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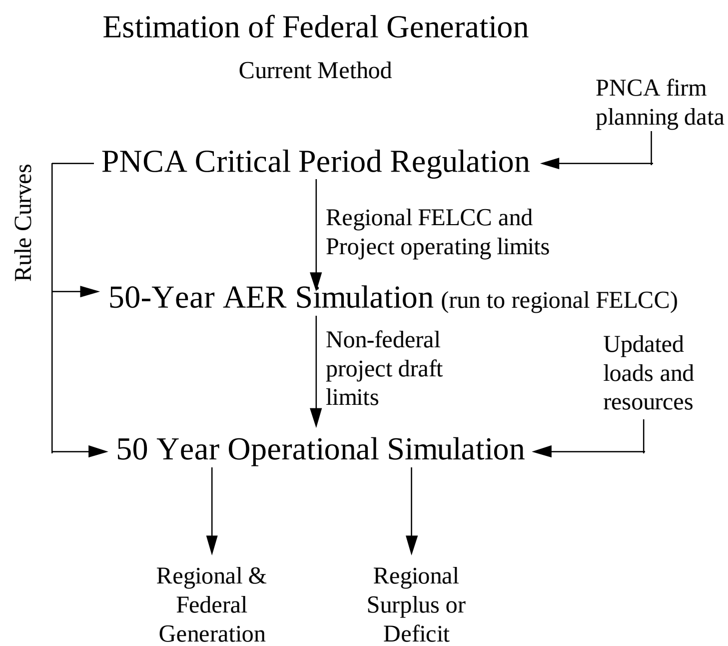
1. HYDRO REGULATION STUDY INTRODUCTION

For Bonneville Power Administration's (BPA's) Loads and Resources Study, BPA uses hydro regulation studies to estimate the energy production that can be expected from the Pacific Northwest hydro system when operating in a coordinated fashion while meeting both at-site and system operating requirements.

For the Load and Resource study BPA runs two types of 50-year studies[1]. The first type is an Actual Energy Regulation (AER) study, in which hydro projects are operated to Pacific Northwest Coordination Agreement (PNCA) loads[2] and resources. The second type is the Operational study, in which hydro projects are operated to a residual hydro load established from Pacific Northwest regional loads and resources. In the Operational study, in general, all federal and non-federal hydro projects operate no lower than the elevations they operated to in the AER study while operating to meet the Operational study's residual hydro load.



The results of the hydro studies are used to provide an estimate of the Federal firm energy generated on the hydro system for use in the Loads and Resources Study and an estimate of the Regional and Federal hydro generation for use in the Federal Secondary Energy Analysis (FSEA).

2. METHODS

2.1 Data Collection

The projected amounts of firm and secondary energy that can be produced by the hydro system are affected by the data and assumptions used in the study. Therefore, the hydro studies use the best available data to estimate hydro system energy production.

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[1] 50 year studies are mathematical simulations of Pacific Northwest hydro resource operations, running through 50 historical streamflow conditions. These studies indicate, by month, the project generation and physical operation of hydro projects.
[2] The load used for the AER study is the Firm Energy Load Carrying Capability (FELCC) of the Coordinated System

For the 1996 final rates proposal, BPA modeled the hydro system in two stages. The first stage, an Actual Energy Regulation (AER) study, determines 50 water years of contractually allowable draft at hydro projects, consistent with the PNCA. This stage operates the coordinated hydro system to meet its allowable firm energy load carrying capability (FELCC) under the 1995-96 PNCA final regulation. In this stage, although coordinated system projects in the U.S. are operated in accordance with the PNCA final regulation, Canadian projects in the coordinated system are operated according to the Canadian Treaty Assured Operating Plan (AOP). The second stage, an operational type study, operates the coordinated hydro system over 50 water years to meet estimated regional firm loads. However, while meeting the regional load, non-federal projects are kept to their AER operation, and all changes from AER operation occur at Federal hydro projects.

The data used in these hydro regulation studies include the following:

2.1.1 Hydro Plant Operating Characteristics.

Hydro plant operating characteristics are used to determine the expected energy production from a specific project given the streamflow conditions. This project-specific data was taken from PNCA data submittals (February 1st and April 1st of each year). The data provided in these submittals are from the various regional utilities and government agencies involved in operating hydro projects.

The data include:

a) Discharge vs. Generation
b) Discharge vs. Maximum Generation
c) Storage vs. Elevation
d) Discharge vs. Tailwater Elevation
e) Head vs. Power Conversion Factor (H/K Factor)
f) Head vs. Maximum Generation
g) Storage vs. Maximum Outflow
h) Head vs. Fullgate H/K
i) Head vs. Head Loss Table
j) Tandem Forebay Information
k) Special Logic
l) Limits Tables

2.1.2 Hydro Plant Operating Requirements.

Hydro plant operating requirements are used to regulate plant operations. These operating requirements are divided into five general groups. Within these groups are many specific types of requirements from many sources. These are summarized as follows:

1) Maximum storage contents include, but are not limited to the following:
   a) Flood controls provided by the Army Corps of Engineers (COE).
   b) Federal Energy Regulatory Commission (FERC) license requirements.
   c) International Joint Commission (IJC) rule curves.
   d) Necessary draft to provide flexibility for peaking operations defined by BPA in the PNCA regulation.

2) Minimum storage contents include, but are not limited to the following:
   a) Treaty storage limits defined in the Columbia River Treaty and related documents.
   b) Assured Operating Plan (AOP) rule curves defined by the Columbia River Treaty and related documents.
   c) Site-specific July refill constraints defined by the project operator of each seasonal reservoir or by the PNCA final regulation for the previous year.
   d) Site-specific requirements for the development of critical period operating rule curves defined by the project operators of each reservoir.
   e) IJC rule curves.
   f) Fish constraints defined by the National Marine Fisheries Service's (NMFS) Biological Opinion, by the Northwest Power Planning Council's (NPPC's) Fish and Wildlife Program, and by various state agencies.
   g) License requirements defined by FERC.
   h) Limits for irrigation pumping defined by the USBR.

3) Maximum draft rates are used for reservoir bank protection and are defined by the project operator for each appropriate site.

4) Maximum flow rates include, but are not limited to the following:
   a) Fisheries objectives defined by the NMFS Biological Opinion, by the NPPC's Fish and Wildlife Program, and by various state agencies.
   b) Mica/Arrow logic defined in the Columbia River Treaty and related documents.
   c) Requirements may be imposed because of a project downstream with a maximum elevation requirement and a restricted outflow.
   d) Draft protection defined by the various project operators.

5) Minimum flow rates include, but are not limited to the following:
   a) Fisheries objectives defined by the NMFS Biological Opinion, by the NPPC's Fish and Wildlife Program, and by various state agencies.
   b) Mica/Arrow logic defined in the Columbia River Treaty and related documents.
   c) Power discharge requirements (PDRs) defined by the COE's PNCA refill studies.
   d) Navigation flow limits defined by the COE.

2.2 Study Characterization

Extensive data is used to characterize hydro regulation studies. Firm loads, firm resources, markets for secondary energy, and project-by-project operating requirements all affect the amount and timing of energy available from the hydro system.

Information concerning the hydro regulation studies for the 1997 through 2001 levels of loads and resources development to be used for BPA's 1996 final rate proposal reflects BPA's best estimate of actual hydro operations for the rate period in question.

A summary of the major hydro constraints affecting the hydro regulation studies are listed below. It should be noted that the term ‘flow augmentation’ as used in this document refers to streamflow enhancement, not to a specific Federal program for such enhancement.

2.2.1 Modified Streamflows.

Modified streamflows are used to estimate power generation under historical streamflow conditions. The AER and Operational hydro regulation studies used in BPA’s 1996 final rate proposal are developed with the use of the 1990 level modified streamflows. These modified streamflows were developed by A. G. Crook Company, under contract with BPA for the Columbia River Water Management Group's Depletions Task Force. Irrigation depletions are included for the 1990 level of development.

The process by which the modified streamflows were created by A. G. Crook Company is beyond the scope of this document. For further information on this process, please refer to documents published by the Columbia River Water Management Group.

These modified streamflows are adjusted to include estimates of irrigation pumping at Grand Coulee as expected for the 1997 through 2001 operating years. This irrigation pumping provides water to the Columbia Basin Project (CBP). The pumping schedule is provided by the Bureau of Reclamation in its 1994-95 PNCA preliminary data submittal. Adjustments are also made to include the proper return flows downstream of Grand Coulee due to this updated pumping schedule.

Generation numbers for all hydro independent projects are based upon 1980 level modified streamflows. Updated information on hydro independent projects based upon new 1990 level modified streamflows should be available in the future.

2.2.2 Continuous vs Refill Hydro Studies.

Refill and Continuous hydro studies each serve the similar purpose of being used to estimate the energy production of the hydro system. Continuous hydro studies operate from one water year to another, using the previous water year’s final reservoir elevations as the initial reservoir elevations for the next water year. Refill studies operate each water year independent of all other water years, using the same initial reservoir elevations for each water year. Continuous studies are typically used when there is little or no information on initial reservoir elevations.

For the final rates proposal, enough information is known about the 1995-96 runoff to estimate the initial conditions of the 1996-97 water year. Therefore, the 1997 level of the 1996 BPA rates hydro studies is run in refill mode. Since the initial conditions for the 1998, 1999, 2000 and 2001 levels are not known, these hydro studies are run in continuous mode.[3]

2.2.3 Firm Loads and Resources.

For the AER hydro studies, PNCA loads[4] and resources are taken from the Operating Year 1995-96 (OY96) PNCA Final Regulation produced by the Northwest Power Pool. The OY96 Power Pool hydro study has a one-year critical period (September 1, 1936 through April 30, 1937). Thus, only one year of FELCC values are used for all water conditions. The AER hydro studies reflect coordination among PNCA parties to meet the coordinated system's FELCC and only generation from those resources coordinated under the PNCA are used to meet the FELCC. Therefore, generation from projects owned by non-PNCA parties (Brownlee, Oxbow, Hells Canyon and Packwood) are not used to meet PNCA loads in any water condition in the AER hydro studies.

In the Operational hydro studies, regional loads and resources are used to help determine the residual hydro load. It is this residual hydro load which the coordinated hydro system operates to meet. The Operational studies reflect coordination between regional parties in meeting regional firm loads. Therefore, generation from all projects, regardless of ownership, will be used to meet regional firm loads in all Operational studies.

BPA developed non-load growth hydro regulation studies with loads covering the time period from August 1996 through July 2001 (Operating Years 1997 through 2001).

The loads used in the Operational studies are from BPA's 1994 Midterm Forecast, dated August 1994, and include the total firm DSI loads representing the bottom three quartiles. These DSI loads were taken from BPA's 1993 Pacific Northwest Loads and Resources Study, medium case. The BPA forecast loads are prepared by BPA's Market Forecasting and Segment Analysis Group (formerly the Power Forecasting Branch). Updates are current as of March 1, 1995.

2.2.4 Critical Period.

In planning to meet future firm loads, BPA uses conservative estimates of its generating capability, based on current project capabilities and a reoccurrence of "critical" streamflows. This sequence of historical critical streamflows, or "critical period" is determined in the PNCA planning process and is the sequence of streamflows that produces the least amount of hydro generation while drafting reservoirs from full to empty and conforming to non-power requirements.

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[3] July 1929 Initial Conditions based upon Median Water; See Section 2.2.27 Initial Reservoir Storage Contents, Page 27.
[4] The load used for the AER study is the FELCC of the Coordinated System

The operation of reservoirs during the critical period is adjusted to obtain the maximum generating capability. The resulting reservoir operation or "rule curve" is used as a guide to determine the coordinated reservoir operation for the 50-year study.

The critical period can vary depending upon the assumptions which are used in the hydro study. In recent years, the critical period was established as the 42-month period from September 1, 1928, through February 29, 1932. Starting in the 1995-96 operating year the critical period changed to the 8-month period from September 1, 1936, through April 30, 1937. This shift in the critical period was the result of changing constraints and project operations on the hydro system. In general, the hydro generating capability decreases when the critical period decreases.

2.2.5 Shifting of Critical Period Firm Energy.

When the length of the critical period is greater than one year, shifting of hydro generation from the 2nd, 3rd and / or 4th year(s) into the 1st year allows for better use of expected runoff. The hydro operations resulting from implementation of the March 2, 1995, NMFS BO[5] produces generation on the coordinated hydro system that results in the critical period being 8-month. With a critical period of less than one year in duration, shifting of FELCC between years of the critical period is impossible.

2.2.6 Adoption of FELCC due to System Refill Not Modeled.

In past hydro regulation studies, when the critical period was greater than 1 year, the FELCC of the Federal system for a water year was dependent on the initial reservoir elevations. Typically with a four year critical period there would be four sets of FELCC available with greater FELCCs available when reservoirs started higher. With the 50-year historical streamflow record, reservoirs usually refilled sufficiently to cause adoption of 1st year FELCC (the highest) 70 to 75 percent of the time.

With the development of a one-year critical period only one FELCC is available and its selection is automatic. Therefore, the shifting available with a multi-year critical period is not possible during the study period. For the AER hydro studies, the coordinated system operates to meet the FELCC determined in OY96 PNCA planning. In the Operational hydro studies, for the August 1996 through July 2001 load development, firm loads for the respective study period are adopted in all 50 water years.

2.2.7 Secondary Market.

[5] See section 2.2.8 NMFS Biological Opinions. page 14

In the AER hydro studies, an unlimited secondary market is used with secondary loads equal to 30,000 MWs in each period. This allows federal and non-federal projects which are part of the coordinated hydro system to operate on their energy content curves (ECC's) when not operating below to meet FELCC.

In the Operational hydro studies, a limited (realistic) secondary market is used. This realistic secondary market reflects the limits of the Pacific Northwest to sell energy on the market rather than reflecting the ability of the interties to move the energy, once it is sold.

The following values are used for the limited secondary market in all of the Operational hydro studies: July is limited to 6000 MWs; August is limited to 6500 MWs; September through January are limited to 7000 MWs; February is limited to 6500 MWs; March is limited to 6000 MWs; and April through June are limited to 5500 MWs. These amounts reflect updated market information.

Additional secondary energy will not be produced in these periods unless the control projects on the coordinated hydro system are drafting to flood control or unless they hit a minimum flow constraint while firm generation exceeds firm hydro residual load by the amount of the secondary limit.

2.2.8 NMFS Biological Opinions.

On March 2, 1995, the NMFS issued a Biological Opinion (BO) which covers a five year period from 1994 through 1998. One of the provisions of the Proposed Action was to adopt the project constraints and operational measures described previously in the NMFS March 16, 1994 BO, Sections IIA through IIG. This was with the understanding that constraints from the March 2, 1995, BO take precedence over NMFS' 1994 BO.

Please refer to these documents for specific project and system operational constraints. These BOs provide for the drafting of Libby, Hungry Horse and Grand Coulee to help meet target flow criteria at McNary for Columbia River flow augmentation and for the drafting of Dworshak and Brownlee to help meet target flow criteria at Lower Granite for Snake River flow augmentation. The BOs also provide for spill at various projects along the lower Snake and lower Columbia Rivers to enhance streamflow conditions for salmon.

2.2.9 Columbia River Flow Augmentation.

Flow augmentation water increases regulated streamflows during target periods to help migrating anadromous fish stocks which have been listed as endangered species, including the Snake River sockeye, Snake River spring/summer Chinook, and the Snake River fall Chinook salmon. These augmented flows are most important in water years with low natural flows.

In the AER and the Operational hydro regulation studies developed for BPA’s 1996 final rate proposal, the Columbia River flow augmentation is modeled as a firm constraint. The NMFS Biological Opinion, dated March 2, 1995, includes a number of project operating constraints which change the character of the coordinated hydro system.

The following project operating constraints are included as Columbia River flow augmentation provisions used to help meet McNary flow objectives from mid-April through August:

- Libby operates to protect sturgeon from mid-April through July and then operates down to an elevation of 2439.0 feet (2061.3 ksfd) in August;
- Hungry Horse operates down to an elevation of 3540.0 feet (1313.2 ksfd);
- Albeni Falls operates to meet its April 20th flood control elevation (2056.0 feet, 279.0 ksfd), thus reducing storage during the flow augmentation period;
- Grand Coulee operates down to an elevation of 1280.0 feet (2216.4 ksfd).
- John Day is drawn down to improve Columbia River flow augmentation by reducing the cross-sectional areas of the project, and thus increases the relative velocity of the water through the project.
- Spill for juvenile fish passage at the four Lower Columbia projects is intended to improve juvenile fish survival by increasing the number of fish passing through non-turbine routes at the projects.
- In addition, in the Operational hydro studies only, Arrow stores 1.0 MAF of flow augmentation water when The Dalles’ hedged January through July runoff forecast is below 90.0 MAF.

Columbia River flow augmentation storage is a firm operational provision, with McNary target flows being provided for in all water conditions to the extent the above mentioned project operating constraints allow. Thus, both the AER and Operational hydro regulation studies do not incorporate the Columbia River Water Budget developed under the NPPC's Columbia River Basin Fish and Wildlife Program.

Due to the firm nature of the Columbia River flow augmentation constraints, water is only released early because of at-site or downstream minimum flow requirements, such as the Vernita Bar constraint or because of a flood control constraint.

The AER and Operational hydro regulation studies model a sliding scale for McNary’s target flow from mid-April through June. Based on The Dalles forecast for January through July runoff of between 85.0 MAF and 105.0 MAF, McNary’s target flow is a linear interpolation between 220,000 cfs and 260,000 cfs. McNary’s target flow from July through August is 200,000 cfs.

To improve fish passage efficiencies, all four Lower Columbia projects operate their turbines within one percent of peak efficiency during the juvenile and adult migration seasons (March 15th through October 31st). This is in compliance with NMFS Biological Opinion, dated March 2, 1995.

2.2.10 Non-Treaty Storage.

The NMFS BO calls for Non-Treaty storage to be operated to provide flow augmentation water. Storage was to take place during the spring, to the extent the water could be released in July and August.

Unfortunately, the Non-Treaty Storage logic in the Hydrosim program will not readily facilitate such operations and provide accurate energy exchanges between British Columbia Hydro and Power Authority (B. C. Hydro) and the Federal system. Therefore Non-Treaty Storage is not operated in the hydro regulation studies. Due to time constraints, an adjustment to the generation output could not be attempted; however, the end results of such an adjustment would not affect the final proposed rates.

2.2.11 Mica, Arrow and Duncan Operations.

In the AER hydro studies, Mica, Arrow and Duncan are modeled as duplicating their final Assured Operating Plan (AOP) operations from the 1997 through 2001 AOPs for the 1997 through 2001 levels of the hydro studies, respectively. These operations allow the Canadian projects to be free of impacts due to fish operations on the United States side of the border.

In the Operational hydro studies, Mica and Duncan are modeled in the same way as in the AER hydro studies. Arrow's operation is adjusted to store 1.0 MAF of Columbia River flow augmentation water between January and mid-April of those years in which the hedged January through July runoff forecast at The Dalles is below 90 MAF. The operation is input into the hydro studies by way of minimum storage values. Water is released from mid-April through June to help meet McNary target flows.

For Arrow participation in Columbia River flow augmentation in the Operational hydro studies, the Canadians request that outflows from Keenleyside Dam (Arrow Reservoir) be controlled during the periods April through June to protect trout spawning. By increasing outflows in subsequent periods, dewatering of trout eggs can be avoided. All attempts to model this operation produced unacceptable results; therefore, this trout spawning operation is not modeled. In addition the Canadians also request that Arrow storage be controlled to protect against dust storms. Areas along the banks of Arrow Reservoir are seeded by the Canadians, but, once the reservoir starts to refill, those areas covered with water lose the protection of the ground cover. The Canadians, therefore, would like to limit the amount of drafting from April 1st through May 31st so re-exposed areas will not dry out and cause these dust storms. Storage constraints to limit dust problems at Arrow are not modeled in the Operational hydro studies.

2.2.12 Libby Operation.

Libby's operation in the AER hydro studies reflects the COE's PNCA data submittal. This includes the following: in August, Libby drafts as low as 2439.0 feet (2061.3 ksfd) to help meet McNary target outflows; in September through December, Libby is operated to meet December's flood control (2411.0 feet, 1502.2 ksfd); in January through mid-April, Libby is operated on minimum flow up to flood control (Libby does violate flood control to meet Corra Linn's IJC operation); and in mid-April through July, Libby is operated for protection of Sturgeon in all water conditions by meeting Bonners Ferry minimum flows. Minimum flow targets include: from April 16th through 30th (AP2), Libby outflows are increased so that Bonners Ferry flow is at 15,000 cfs on May 1st (AP2 average flow will vary by water year); from May 1st through 19th, Bonners Ferry's minimum flow is 15,000 cfs; from May 20th through June 30th, Bonners Ferry's minimum flow is 35,000 cfs (to be met only when Libby's outflow is 25,000 cfs or less); from July 1st through 21st, Bonners Ferry's minimum flow is 11,000 cfs; and from July 22nd through 31st, Libby's minimum flow is 4000 cfs. Libby's maximum outflow from mid-April through August is 25,000 cfs (assumed full-gate flow).

In the Operational hydro studies, Libby is operated in the same manner as in the AER hydro studies with the exception of the minimum flow targets for the mid-April through July time period. These minimum flow targets include: from April 16th through April 30th, Libby's minimum flow target is 4000 cfs; from May 1st through 9th, Bonners Ferry's minimum flow is 15,000 cfs; from May 10th through June 20th, Libby outflow reflects a full turbine operation (25,000 cfs); from June 21st through July 11th, Bonners Ferry's minimum flow is 11,000 cfs; from July 12th through 31st, Libby's minimum flow is 4000 cfs. As in the AER studies, in August, Libby drafts as low as 2439.0 feet (2061.3 ksfd) to help meet McNary target outflows.

2.2.13 Corra Linn Operation.

In both the AER and the Operational studies, Corra Linn has minimum and maximum storage values consistent with the IJC rule curves. Libby's and Duncan's outflows are reduced to prevent violations of these IJC rule curves.

2.2.14 Hungry Horse Operation.

In the AER hydro studies, Hungry Horse is operated as follows: in September through December, Hungry Horse is operated to meet a December minimum elevation of 3515.0 feet (1054.0 ksfd); in January through March, Hungry Horse is free to swing above its Biological Rule Curve (calculated according to instructions in the February 1, 1996 PNCA data submittal); in April through June, Hungry Horse is operated on or near flood control, drafting only for McNary flow augmentation; and in July through August, Hungry Horse continues to draft to as low as 3540.0 feet (1313.2 ksfd) for McNary flow augmentation.

In the Operational hydro studies, Hungry Horse is operated as follows: in September through December, Hungry Horse is operated to meet a December minimum elevation of 3523.0 feet (1129.0 ksfd); in January through mid-April, Hungry Horse is operated to its flood control; in mid-April through August, Hungry Horse operates to as low as 3540.0 feet (1313.2 ksfd) to meet the McNary flow targets. During this same period, Hungry Horse is modeled with a maximum flow constraint of 13,000 cfs. Hungry Horse is also modeled with a restricted outflow of 20,000 cfs for all other periods.

2.2.15 Albeni Falls Operation.

Albeni Falls is operated in the same manner in both the AER and the Operational hydro studies. Albeni Falls operation includes: in September, Albeni Falls is operated to 2060.0 feet (465.7 ksfd); in October through March, Albeni Falls is operated to 2055.0 feet (234.7 ksfd) in the 1997 level studies and to 2056.0 feet (279.0 ksfd) in the 1998, 1999, 2000 and 2001 level studies; in April, Albeni Falls is operated to 2056.0 feet (279.0 ksfd); in May, Albeni Falls is operated to 2057.0 feet (325.7 ksfd); and in June through August, Albeni Falls is operated to full (2062.5 feet, 582.4 ksfd).

2.2.16 Grand Coulee Operation.

In the AER hydro studies, Grand Coulee is operated as follows: in September through October, Grand Coulee is operated to as low as 1280.0 feet (2216.4 ksfd); in November, Grand Coulee is operated to as low as 1275.0 feet (2027.7 ksfd); and in December, Grand Coulee is operated to as low as 1265.0 feet (1665.4 ksfd).

In January through mid-April, minimum storage values are calculated for Grand Coulee which reflect the expected April 15th URC and storage needed for the appropriate Vernita Bar minimum flow requirement. Grand Coulee is then operated above these minimum storage points. In mid-April through August, Grand Coulee is drafted down to as low as 1280.0 feet (2216.4 ksfd) to meet McNary target flows for Columbia River flow augmentation. At-site minimum flow is equal to 30,000 cfs.

In the Operational hydro studies, Grand Coulee is operated in the following manner: in September through December, Grand Coulee is operated in the same manner as in the AER studies; in January through mid-April, Grand Coulee is operated to flood control; in mid-April through May, Grand Coulee is drafted as low as 1250.0 feet (1159.1 ksfd) to meet McNary's target flows; and in June through August, Grand Coulee is operated to as low as 1280.0 feet (2216.4 ksfd), again, to meet the McNary target flows. At-site minimum flow is 50,000 cfs for peaking purposes.

2.2.17 Vernita Bar.

The following table summarizes the Vernita Bar minimum flows used in the various studies:

Vernita Bar Minimum Flows (December through May)

Year	97 Level	98 Level	99 Level	00 Level	01 Level	Year	97 Level	98 Level	99 Level	00 Level	01 Level
1929	60,000	55,000	55,000	55,000	55,000	1954	60,000	50,000	55,000	55,000	55,000
1930	60,000	60,000	55,000	60,000	60,000	1955	70,000	60,000	60,000	65,000	65,000
1931	60,000	55,000	55,000	55,000	55,000	1956	70,000	60,000	55,000	60,000	60,000
1932	60,000	55,000	50,000	55,000	55,000	1957	55,000	50,000	50,000	50,000	50,000
1933	50,000	50,000	50,000	55,000	55,000	1958	55,000	50,000	50,000	50,000	50,000
1934	70,000	70,000	70,000	70,000	70,000	1959	55,000	50,000	50,000	50,000	55,000
1935	55,000	50,000	55,000	55,000	55,000	1960	70,000	70,000	70,000	70,000	70,000
1936	60,000	60,000	55,000	55,000	55,000	1961	60,000	50,000	55,000	55,000	55,000
1937	65,000	60,000	60,000	60,000	60,000	1962	55,000	50,000	50,000	50,000	55,000
1938	55,000	55,000	50,000	55,000	55,000	1963	65,000	50,000	55,000	55,000	55,000
1939	55,000	50,000	50,000	55,000	55,000	1964	55,000	50,000	55,000	55,000	55,000
1940	60,000	55,000	55,000	60,000	60,000	1965	70,000	55,000	55,000	55,000	60,000
1941	60,000	55,000	55,000	55,000	55,000	1966	60,000	55,000	55,000	55,000	55,000
1942	55,000	55,000	50,000	55,000	55,000	1967	55,000	50,000	50,000	55,000	55,000
1943	50,000	50,000	55,000	55,000	55,000	1968	65,000	55,000	55,000	55,000	55,000
1944	55,000	50,000	50,000	50,000	50,000	1969	70,000	60,000	60,000	60,000	60,000
1945	60,000	60,000	55,000	60,000	60,000	1970	60,000	55,000	55,000	55,000	55,000
1946	55,000	55,000	50,000	50,000	50,000	1971	50,000	50,000	50,000	50,000	50,000
1947	55,000	50,000	50,000	50,000	50,000	1972	55,000	50,000	50,000	50,000	50,000
1948	70,000	60,000	65,000	65,000	65,000	1973	60,000	50,000	50,000	50,000	50,000
1949	60,000	50,000	50,000	55,000	55,000	1974	50,000	50,000	50,000	50,000	50,000
1950	50,000	55,000	55,000	60,000	60,000	1975	50,000	50,000	50,000	50,000	50,000
1951	70,000	60,000	55,000	60,000	55,000	1976	70,000	65,000	60,000	60,000	60,000
1952	65,000	60,000	55,000	60,000	60,000	1977	60,000	55,000	55,000	55,000	55,000
1953	60,000	55,000	50,000	55,000	55,000	1978	50,000	50,000	50,000	55,000	55,000

Vernita Bar minimum flows for December through May vary by water condition, with minimum flows established as the lesser of a) 68% of the Wanapum's October or November flows or b) 70,000 cfs. Values less than 70,000 cfs are rounded to the nearest 5,000 cfs. The streamflows used for this determination are from the hydro studies used in the 1996 Initial Rates Proposal for the various study levels. Differences between the various levels are due to different AOP operations.

2.2.18 Snake River Flow Augmentation.

Flow augmentation water increases regulated streamflows during target periods to help migrating anadromous fish stocks which have been listed as endangered species, including the Snake River sockeye, Snake River spring/summer Chinook, and the Snake River fall Chinook salmon. These augmented flows are most important in water years with low natural flows.

Snake River flow augmentation is modeled as a firm constraint in the AER and the Operational hydro regulation studies. Augmentation of streamflows on the Snake River is accomplished by releases of Upper Snake water (both Water Bank rentals and other water), by drafts from Brownlee reservoir, and by Dworshak's operation from the COE's 1995-96 PNCA (February 1, 1995) preliminary data submittal. Specifically, Dworshak operates down to an elevation of 1520.0 feet (395.8 ksfd) between April and August to help meet Lower Granite flow objectives.

Due to the firm nature of the Snake River flow augmentation constraints, water is only released early because of at-site or downstream minimum flow requirements or because of a flood control constraint.

The AER and Operational hydro regulation studies model a sliding scale for Lower Granite’s target flows from April 10th through June 20th. Based on the Lower Granite forecast for April through July runoff of between 16.0 MAF and 20.0 MAF, Lower Granite’s target flow is a linear interpolation between 85,000 cfs and 100,000 cfs.

Lower Granite’s target flow from June 21st through August 31st is again based upon a sliding scale. Based on the Lower Granite forecast for April through July runoff of between 16.0 MAF and 28.0 MAF, Lower Granite’s target flow is a linear interpolation between 50,000 cfs and 55,000 cfs.

The NMFS Biological Opinion, dated March 2, 1995, includes the drawdown of the four Lower Snake projects to minimum operating pool levels. This drawdown operation improves Snake River flow augmentation by reducing the cross-sectional areas of the projects, and thus increases the relative velocities of the water through the projects.

The NMFS BO, dated March 2, 1995, includes spill for juvenile fish passage at the four Lower Snake projects. This fish spill operation is intended to improve juvenile fish survival by increasing the number of fish passing through non-turbine routes at the projects.

To improve fish passage efficiencies, all four Lower Snake projects operate their turbines within one percent of peak efficiency during the juvenile and adult migration seasons (March 15th through November 30th). This is in compliance with NMFS Biological Opinion, dated March 2, 1995.

2.2.19 Fish Spill Requirements.

Fish spill requirements for Federal projects on the Lower Snake and Lower Columbia Rivers are developed in the NMFS Biological Opinion, dated March 2, 1995. These projects include Lower Granite, Little Goose, Lower Monumental, and Ice Harbor on the lower Snake River and McNary, John Day, The Dalles, and Bonneville on the lower Columbia River.

The fish spill requirements called for in the NMFS BO are designed to obtain an 80% fish passage efficiency at all the Federal projects, except for Bonneville Dam. Bonneville Dam will only provide a fish passage efficiency of 74% in the springtime (April 20th through June 30th) and an efficiency of 59% in the summertime (July 1st through August 31st).

The NMFS BO states that spill values are to be reduced: 1) when the 12-hour average total dissolved gas concentration exceeds 115% of saturation as measured at the forebay monitor; 2) when the 12-hour average total dissolved gas concentration exceeds 120% of saturation as measured at the tailrace monitor; or 3) when any instantaneous total dissolved gas concentration exceeds 125% of saturation for two hours as measured at any monitor. This dissolved gas limitation is modeled in the current hydro regulation studies through the use of spill caps. These spill caps reflect the best information available through consultation between BPA and NMFS.

The following spill values were modeled in the hydro regulation studies:

- Lower Granite, from April 10th through June 20th, for 12 hours per day (18:00 PM to 06:00 AM), is to spill 80% of its instantaneous project flow. If Lower Granite has unregulated average monthly flows of less than 100,000 cfs, then no spill occurs at Lower Granite.
- Lower Granite, from June 21st through August 31st, does not have a spill constraint during this time of juvenile fish transport since Lower Granite is a collection dam and spill reduces the number of fish guided into the transport system.

- Little Goose, from April 10th through June 20th, for 12 hours per day (18:00 PM to 06:00 AM), is to spill 80% of its instantaneous project flow. If Lower Granite has unregulated average monthly flows of less than 85,000 cfs, then no spill occurs at Little Goose.
- Little Goose, from June 21st through August 31st, does not have a spill constraint during this time of juvenile fish transport since Little Goose is a collection dam and spill reduces the number of fish guided into the transport system.

- Lower Monumental, from April 10th through June 20th, for 12 hours per day (18:00 PM to 06:00 AM), is to spill 81% of its instantaneous project flow. If Lower Granite has unregulated average monthly flows of less than 85,000 cfs, then no spill occurs at Lower Monumental.
- Lower Monumental, from June 21st through August 31st, does not have a spill constraint during this time of juvenile fish transport since Lower Monumental is a collection dam and spill reduces the number of fish guided into the transport system.

- Ice Harbor, from April 10th through June 20th, for 24 hours per day, is to spill 27% of its instantaneous project flow.
- Ice Harbor, from June 21st through August 31st, for 24 hours per day, is to spill 70% of its instantaneous project flow.

- McNary, from April 20th through June 30th, for 12 hours per day (18:00 PM to 06:00 AM), is to spill 50% of its instantaneous project flow.
- McNary, from July 1st through August 31st, does not have a spill constraint during this time of juvenile fish transport since McNary is a collection dam and spill reduces the number of fish guided into the transport system.

- John Day, from April 20th through June 30th, for 12 hours per day (18:00 PM to 06:00 AM), is to spill 33% of its instantaneous project flow.
- John Day, from July 1st through August 31st, for 12 hours per day (18:00 PM to 06:00 AM), is to spill 86% of its instantaneous project flow.

- The Dalles, from April 20th through June 30th, for 24 hours per day, is to spill 64% of its instantaneous project flow.
- The Dalles, from July 1st through August 31st, for 24 hours per day, is to spill 64% of its instantaneous project flow.

- Bonneville, from April 20th through June 30th, spills for 24 hours per day, including spilling in the daytime to its daytime limit of 75,000 cfs and spilling in the nighttime to 100% of its instantaneous project flow. This spill constraint translates into an average monthly spill value of 68% of at-site instantaneous springtime flow.
- Bonneville, from July 1st through August 31st, spills for 24 hours per day, including spilling in the daytime to its daytime limit of 75,000 cfs and spilling in the nighttime to 100% of its instantaneous project flow. This spill constraint translates into an average monthly spill value of 77% of at-site instantaneous summertime flow.

2.2.20 Upper Snake Water.

Adjustments to Brownlee inflows due to changes in storage at projects in the middle and upper portions of the Snake River are reflected in information received by BPA from the Bureau of Reclamation. This data reflects the BOR's best efforts to implement provisions of the NMFS' BO. The operation tries to release 427 kaf as many years as possible in the 50-year record during the May through August period.

2.2.21 Brownlee Operation.

Brownlee's operation is the same for both the AER and the Operational studies. Brownlee's operation is as follows: in January through April, Brownlee is full; in May, Brownlee is drafted to 2069.0 feet (436.4 ksfd); in June, May's elevation is maintained; in July, Brownlee is drafted 2 feet down to 2067.0 feet (423.1 ksfd); in July and August, this elevation is maintained; and in September, Brownlee drafts an additional 100 kaf or 50 ksfd to 372.6 ksfd.

In October, Brownlee is drafted to elevation 2051.0 feet (325.7 ksfd) in low water years in order to achieve a target flow of 9000 cfs in November and December at Hells Canyon. In October in median and high water years, Brownlee is drafted to elevation 2034.6 feet (240.1 ksfd) in order to achieve a target flow of 9000 cfs in November and December at Hells Canyon.

2.2.22 Dworshak Operation.

Dworshak's operation is the same for both the AER and the Operational studies. Dworshak is on minimum flow of 1500 cfs all periods, with the exception of April through August when it operates to meet Lower Granite target flows for Snake River flow augmentation. Dworshak's outflow is limited to 14,000 cfs during the flow augmentation period and is limited to 25,000 cfs in all other periods for downstream flood control. This operation is described in the February 1,1996, PNCA data submittal.

2.2.23 Lower Snake Operation.

The Lower Snake projects (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor) are operated according to the constraints placed upon the projects by the COE in its 1995-96 PNCA preliminary data submittal, the NMFS BO dated March 16, 1994, and the NMFS BO dated March 2, 1995. These constraints are modeled within the limits of BPA's Hydrosim model.

All four Lower Snake projects are to operate their turbines within one percent of peak efficiency during the juvenile and adult migration seasons (March 15th through November 30th). This operation improves the fish passage efficiency for those fish which do pass a project by way of the turbines. All four Lower Snake projects modeled this constraint using a hydro availability table which limits the maximum generation capability of each project for each of the fourteen periods.

The project specific constraints are summarized as follows:

Lower Granite has the following operation: in April through October, Lower Granite is operated to within one foot of its minimum operating pool (MOP), elevation 734.0 feet (226.3 ksfd); in November through March, Lower Granite is operated to full, elevation 738.0 feet (244.0 ksfd). An exception to this operation is in February of water year 1932, the end of the traditional four-year critical period, in which Lower Granite is operated to within one foot of its MOP.

Lower Granite's target flows include: from March 1st through April 9th, Lower Granite's target flow is 11,500 cfs. From April 10th through June 20th, Lower Granite's target flow is based on the April forecast for the April through July runoff at Lower Granite. A sliding scale is used so that if the forecast is between 16.0 MAF and 20.0 MAF, Lower Granite's target flow is a linear interpolation between 85,000 cfs and 100,000 cfs. From June 21st through August 31st, Lower Granite's target flow is based on the April forecast for the April through July runoff at Lower Granite with a sliding scale being used. If the forecast is between 16.0 MAF and 28.0 MAF, Lower Granite's target flow is a linear interpolation between 50,000 cfs and 55,000 cfs. From September 1st through November 30th, Lower Granite's target flow is 11,500 cfs.

Lower Granite, from April 10th through June 20th, for 12 hours per day (18:00 PM to 06:00 AM), is to spill 80% of its instantaneous project flow. If Lower Granite has unregulated average monthly flows of less than 100,000 cfs, then no spill occurs at Lower Granite. Lower Granite does not have a spill constraint from June 21st through August 31st, a time of juvenile fish transport, since Lower Granite is a collection dam and spill reduces the number of fish guided into the transport system. At-site fish spill is limited to 20,000 cfs because of the dissolved gas limit.

Little Goose has the following constraints: in April through August, Little Goose is operated to within one foot of its minimum operating pool (MOP), elevation 634.0 feet (265.1 ksfd); in September through March, Little Goose is operated to full, elevation 638.0 feet (284.8 ksfd). An exception to this operation is in February of water year 1932, the end of the traditional four-year critical period, in which Little Goose is operated to within one foot of MOP.

From March through November, Little Goose's minimum flow is 11,500 cfs.

Little Goose, from April 10th through June 20th, for 12 hours per day (18:00 PM to 06:00 AM), is to spill 80% of its instantaneous project flow. If Lower Granite has unregulated average monthly flows of less than 85,000 cfs, then no spill occurs at Little Goose. Little Goose does not have a spill constraint from June 21st through August 31st, a time of juvenile fish transport, since Little Goose is a collection dam and spill reduces the number of fish guided into the transport system. At-site fish spill is limited to 17,500 cfs because of the dissolved gas limit.

Lower Monumental has the following constraints: in April through August, Lower Monumental is operated to within one foot of its minimum operating pool (MOP), elevation 538.0 feet (182.9 ksfd); in September through March, Lower Monumental is operated to full, elevation 540.0 feet (189.6 ksfd). An exception to this operation is in February of water year 1932, the end of the traditional four-year critical period, in which Lower Monumental is operated to within one foot of MOP.

From March through November, Lower Monumental's minimum flow is 11,500 cfs.

Lower Monumental, from April 10th through June 20th, for 12 hours per day (18:00 PM to 06:00 AM), is to spill 81% of its instantaneous project flow. This spill constraint is provided to increase fish passage efficiencies to 80%. If Lower Granite has unregulated average monthly flows of less than 85,000 cfs, then no Lower Monumental spill occurs. Lower Monumental does not have a spill constraint from June 21st through August 31st, a time of juvenile fish transport, since Lower Monumental is a collection dam and spill reduces the number of fish guided into the transport system. At-site fish spill is limited to 15,000 cfs because of the dissolved gas limit.

Ice Harbor has the following constraints: in April through August, Ice Harbor is operated to within one foot of its minimum operating pool (MOP), elevation 438.0 feet (196.3 ksfd); in September through March, Ice Harbor is modeled as operating to full, elevation 440.0 feet (204.7 ksfd). An exception to this operation is in February of water year 1932, the end of the traditional four-year critical period, in which Ice Harbor is operated to within one foot of MOP.

From March through July, Ice Harbor's minimum flow is 9,500 cfs; from August through November, Ice Harbor's minimum flow is 7,500 cfs.

Ice Harbor, from April 10th through June 20th, for 24 hours per day, is to spill 27% of its instantaneous project flow. Ice Harbor, from June 21st through August 31st, for 24 hours per day, is to spill 70% of its instantaneous project flow. At-site fish spill is limited to 25,000 cfs because of the dissolved gas limit.

2.2.24 Lower Columbia Operation.

The Lower Columbia projects (McNary, John Day, The Dalles, and Bonneville) are operated according to the constraints placed upon the projects by the COE in its 1995-96 PNCA preliminary data submittal, the NMFS BO, dated March 16, 1994, and the NMFS BO, dated March 2, 1995. These constraints are modeled within the limits of BPA's Hydrosim model.

All four Lower Columbia projects are to operate their turbines within one percent of peak efficiency during the juvenile and adult migration seasons (March 15th through October 31st). This operation improves the fish passage efficiency for those fish which do pass a project by way of the turbines. All four Lower Columbia projects modeled this constraint using a hydro availability table which limits the maximum generation capability of each project for each of the fourteen periods.

The project-specific constraints are summarized as follows:

McNary's target flows include: from April 20th through June 30th, McNary's target flow is based on The Dalles January through July runoff forecast. A sliding scale is used so that if the forecast is between 85.0 MAF and 105.0 MAF, McNary's target flow is a linear interpolation between 220,000 cfs and 260,000 cfs. From July 1st through August 31st, McNary's target flow requirement is 200,000 cfs. From September 1st through November 30th, McNary's target flow constraint is 50,000 cfs.

McNary, from April 20th through June 30th, for 12 hours per day (18:00 PM to 06:00 AM), is to spill 50% of its instantaneous project flow. McNary does not have a spill constraint from July 1st through August 31st, a time of juvenile fish transport, since McNary is a collection dam and spill reduces the number of fish guided into the transport system. At-site fish spill is limited to 50,000 cfs because of the dissolved gas limit.

John Day has the following constraints: in mid-April through September, John Day is operated to its minimum irrigation pool (MIP), elevation 262.5 feet (127.7 ksfd). In October through mid-April, John Day is operated to elevation 263.55 feet (153.7 ksfd). In the NMFS' BO, John Day is required to operate to its minimum operating pool (MOP), elevation 257.0 feet (0.0 ksfd). Because of funding limitations, the COE will not operate John Day to MOP.

John Day, from April 20th through June 30th, for 12 hours per day (18:00 PM to 06:00 AM), is to spill 33% of its instantaneous project flow. John Day, from July 1st through August 31st, for 12 hours per day (18:00 PM to 06:00 AM), is to spill 86% of its instantaneous project flow. At-site fish spill is limited to 5000 cfs because of the dissolved gas limit.

The Dalles, from April 20th through June 30th, for 24 hours per day, The Dalles is to spill 64% of its instantaneous project flow. The Dalles, from July 1st through August 31st, for 24 hours per day, The Dalles is to spill 64% of its instantaneous project flow. At-site fish spill is limited to 140,000 cfs because of the dissolved gas limit.

Bonneville, from April 20th through June 30th, is to spill for 24 hours per day, including spilling in the daytime to its daytime limit of 75,000 cfs and spilling in the nighttime to 100% of its instantaneous project flow. This spill constraint increases fish passage efficiencies to 74%. This spill constraint translates into an average monthly spill value of 68% of at-site instantaneous springtime flow. Bonneville, from July 1st through August 31st, is to spill for 24 hours per day, including spilling in the daytime to its daytime limit of 75,000 cfs and spilling in the nighttime to 100% of its instantaneous project flow. This spill constraint translates into an average monthly spill value of 77% of at-site instantaneous summertime flow. This spill constraint increases fish passage efficiencies to 59%. At-site fish spill is limited to 120,000 cfs because of the dissolved gas limit.

2.2.25 Willamette Projects.

The COE's Willamette projects (Big Cliff, Detroit, Foster, Green Peter, Cougar, Dexter, Lookout Point, and Hills Creek) are modeled as hydro independent projects. The COE's Willamette Basin operations included in this year's hydro studies are based upon the use of the 1980 modified streamflows with the 1980 level of irrigation depletions.

Two of Eugene Water and Electric Board's (EWEB's) Willamette projects, Leaburg and Walterville, on the Mckenzie River in Oregon, are downstream from Cougar. Because of the complexity of the EWEB's 1994-95 PNCA (February 1, 1994) preliminary data submittal, BPA calculated the generation of these two projects on an Excel spreadsheet and then treated the projects as hydro independents in the hydro regulation studies. These projects also use the 1980 level modified streamflows, with adjustments made to the streamflows at the projects to correspond to the hydro independent operation which the COE submitted for its upstream project, Cougar. As soon as the COE updates Cougar's operation for the 1990 modified streamflows, Leaburg and Walterville will also need to be updated.

2.2.26 Flood Controls.

The COE, in September 1995, updated flood controls for Mica, Arrow, Libby, Duncan, Hungry Horse, Grand Coulee, Brownlee, Dworshak, and John Day. These flood control are based upon synthetic forecasts.

Kerr did not have its flood control operating curves updated, therefore, Kerr’s flood controls were taken from the previous flood control input file.

The flood control file continues to include the four Lower Snake projects (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor), which are still being modeled as reservoirs.

The flood control input file excludes two of EWEB's Willamette projects (Leaburg and Walterville), which are now listed as hydro independent projects. The flood control input file continues to exclude the eight COE Willamette projects, which continue to be modeled as hydro independent projects.

2.2.27 Initial Reservoir Storage Contents.

The hydro regulation studies use initial reservoir storage contents that were developed in BPA's System Operations Review (SOR) Studies. These initial reservoir storage contents are developed by running a hydro regulation study with the 1937-38 modified streamflows (used in the SOR as median water), and establishing contents at which the reservoirs started and finished. These expected initial storage contents for median water are then adjusted for the rates hydro studies as follows:

Mica now uses its July storage target, developed in the joint Canadian-U.S. AOP process, as an initial storage content, rather than full. The Mica storage targets for the 1997 through 2001 levels of development are 5900.0 ksfd, 5900.0 ksfd, 5900.0 ksfd, 5950.0 ksfd, and 6000.0 ksfd, respectively.

The four Lower Snake projects have initial storage contents of one foot above their minimum operating pools, as established by the COE's 1994-95 PNCA (February 1, 1994) preliminary data submittal. One foot above minimum operating pool translates into the following initial storage values:

a) Lower Granite has an initial content of 734.0 feet (226.3 ksfd).
b) Little Goose has an initial content of 634.0 feet (265.1 ksfd).
c) Lower Monumental has an initial content of 538.0 feet (182.9 ksfd).
d) Ice Harbor has an initial content of 438.0 feet (196.3 ksfd).

Merwin now has a more realistic initial content of 91.9 ksfd (239.5 feet). This is the result of a minimum flow operation in July 1929 after being full in June.

John Day has an initial storage content of 258.5 feet (32.7 ksfd), as defined in the COE's 1994-95 PNCA (February 1, 1994) preliminary data submittal.

Brownlee, in the 1998 through 2001 levels of the AER hydro studies, has an initial storage content of 2067.0 feet (422.6 ksfd). This end-of-July content reflects the 1993 Brownlee operation and represents drafting 137 kaf from storage during July for Snake River flow augmentation. In the 1997 level of the AER hydro study and all levels of the Operational hydro studies, Brownlee has an initial storage content of 372.2 ksfd (2058.8 ft), representing a draft of 237 kaf from storage during July for Snake River flow augmentation.

With the AER and Operational 1997 level hydro studies being Refill type studies, the following projects had changes between the 1997 initial storage contents and initial storage contents for the study levels run in Continuous mode:

Libby has an initial storage content of 2443.0 ksfd (2456.1 ft) for the 1997 level and of 2061.3 ksfd (2439.0 ft) for the 1998 through 2001 levels of the Operational studies. Libby has an initial storage content of 2443.0 ksfd (2456.1 ft) for the 1997 level and of 2510.5 ksfd (2459.0 ft) for the 1998 through 2001 levels of the AER studies.

Hungry Horse has an initial storage content of 1533.8 ksfd (3558.8 ft) for the 1997 level and of 1313.2 ksfd (3540.0 ft) for the 1998 through 2001 levels of the Operational studies. Hungry Horse has an initial storage content of 1533.8 ksfd (3558.8 ft) for the 1997 level and of 1548.5 ksfd (3560.0 ft) for the 1998 through 2001 levels of the AER studies.

Dworshak has an initial storage content of 870.2 ksfd (1584.0 ft) for the 1997 level and of 393.9 ksfd (1519.7 ft) for the 1998 through 2001 levels of the Operational studies. Dworshak has an initial storage content of 870.2 ksfd (1584.0 ft) for the 1997 level and of 753.0 ksfd (1570.0 ft) for the 1998 through 2001 levels of the AER studies.

2.2.28 Critical Rule Curves.

In the 1997 level AER study: The 1st year rule curves are taken from the 1st year of the 1995-96 PNCA final regulation. Ordinarily, they would have come from the 1st year of the 1996-97 final regulation, but this regulation has not yet been run. The 2nd year rule curves ordinarily would come from the 2nd year of the 1995-96 PNCA final regulation. However, the 1995-96 PNCA final regulation has a critical period of one year in length. Therefore, there are no 2nd year rule curves included in the 1997 level AER hydro study. The 3rd year rule curves are taken from the 3rd year of the 1994-95 PNCA final regulation. The 4th year rule curves are taken from the 4th year of the 1993-94 PNCA final regulation.

In the 1998 level AER study: The 1st year rule curves are taken from the 1st year of the 1995-96 PNCA final regulation. Ordinarily, they would have come from the 1st year of the 1997-98 final regulation, but this regulation has not yet been run. The 2nd year rule curves ordinarily would come from the 2nd year of the 1996-97 PNCA final regulation, but this regulation has not yet been run. Therefore, there are no 2nd year rule curves included in the 1998 level AER hydro study. The 3rd year rule curves ordinarily would come from the 3rd year of the 1995-96 PNCA final regulation, but this regulation has only a one year critical period. Therefore, there are no 3rd year rule curves included in the 1998 level AER hydro study. The 4th year rule curves are taken from the 4th year of the 1994-95 PNCA final regulation.

In the 1999 level AER study: The 1st year rule curves are taken from the 1st year of the 1995-96 PNCA final regulation. Ordinarily, they would have come from the 1st year of the 1998-99 final regulation, but this regulation has not yet been run. The 2nd and 3rd year rule curves ordinarily would come from the 2nd and 3rd years of the 1997-98 and 1996-97 PNCA final regulations, respectively. Since these regulations have not yet been run, there are no 2nd or 3rd year rule curves included in the 1999 level AER hydro study. The 4th year rule curves ordinarily would come from the 4th year of the 1995-96 PNCA final regulation, but this regulation has only a one year critical period. Therefore, there are no 4th year rule curves included in the 1999 level AER hydro study.

In the 2000 level AER study: The 1st year rule curves are taken from the 1st year of the 1995-96 PNCA final regulation. Ordinarily, they would have come from the 1st year of the 1999-2000 final regulation, but this regulation has not yet been run. The 2nd, 3rd and 4th year rule curves ordinarily would come from the 2nd, 3rd and 4th years of the 1998-99, 1997-98 and 1996-97 PNCA final regulations, respectively. Since these regulations have not yet been run, there are no 2nd, 3rd or 4th year rule curves included in the 2000 level AER hydro study.

In the 2001 level AER study: The 1st year rule curves are taken from the 1st year of the 1995-96 PNCA final regulation. Ordinarily, they would have come from the 1st year of the 2000-01 final regulation, but this regulation has not yet been run. The 2nd, 3rd and 4th year rule curves ordinarily would come from the 2nd, 3rd and 4th years of the 1999-2000, 1998-99 and 1997-98 PNCA final regulations, respectively. Since these regulations have not yet been run, there are no 2nd, 3rd or 4th year rule curves included in the 2001 level AER hydro study.

In addition to these rule curves from the specific PNCA final regulations, rule curves are also input into all levels of the AER hydro studies for Lower Granite, Little Goose, Lower Monumental, Ice Harbor, John Day and Packwood Lake.

For all levels of the Operational studies: The 1st year rule curves are taken from the 1st year of the 1995-96 PNCA final regulation. The 1995-96 PNCA final regulation has a critical period of one year in length, therefore, there are no 2nd year rule curves included. The 3rd year rule curves are taken from the 3rd year of the 1994-95 PNCA final regulation. The 4th year rule curves are taken from the 4th year of the 1993-94 PNCA final regulation. Each level of the Operational studies should have included the same PNCA rule curves as did the respective level of the AER studies. Even though the rule curves for each level of the Operational studies did not exactly match the rule curves for the respective level of the AER studies, there should only be minor differences in the Operational studies from how they should have been operated. This is due to the 1st year rule curve (which controls the operation for the majority of water conditions) is the same for each of the hydro regulations - the 1995-96 PNCA final regulation.

In addition to these rule curves from the specific PNCA final regulations, rule curves are also input into all levels of the Operational hydro studies for Lower Granite, Little Goose, Lower Monumental, Ice Harbor, John Day and Packwood Lake.

The rule curves for Lower Granite, Little Goose, Lower Monumental and Ice Harbor are consistent with the NMFS BO dated March 2, 1995.

The rule curves for John Day are from the operation described in Section 2.2.23 of this document, entitled ‘Lower Columbia Operation’.

The rule curves for Packwood Lake (Washington Public Power Supply System) are generic rule curves used in BPA studies. Packwood Lake is not modeled in the PNCA planning studies, therefore, its CRCs are not updated.

2.3 Hydro Regulation Process.

Hydro regulation studies are used to estimate the amount of firm and nonfirm energy that can be expected to be generated by the Pacific Northwest hydro system. Two types of studies were run in past rates proposals: first, a critical period study was used to determine the firm energy that the regional hydro system could generate given a recurrence of critical water conditions; and second, a long-term study using 50-years of historical water records (50-year study) was then used to determine the nonfirm energy availability, up to a market limit. These studies use data supplied through the PNCA planning process.

In past rate proposals BPA would run a critical period study to simulate the PNCA planning process. This study would determine the Federal firm energy capability and reservoir rule curves that would then be used in the 50-year study. For the current rates proposal, BPA is using the PNCA critical period study instead of replicating it. BPA is also simulating the PNCA AER for the 50 year streamflow record. The AER is a hydro regulation simulation that is used to determine the coordinated system operation as provided for by the PNCA. Simulating the AER for the 50-year record is a more accurate way of representing the implementation of coordinated system operations for the rate proposal, and provides the best estimate of non-federal operations.

In the current rate proposal a 50-year study is used to determine the availability of nonfirm generation. This Operational hydro study shows how the entire regional hydro system could operate to meet the residual hydro load resulting from regional firm loads and resources. In this study non-federal projects are not permitted to draft below their AER operations. Filling above their AER operations is permitted to store excess water when energy generation is not needed.

In the current rate proposal, the Federal hydro system operation is constrained in both the AER and Operational studies to reflect nonpower requirements specified in the NMFS Biological Opinion.[6] Under the Biological Opinion, Federal reservoirs have a lower limit, trending towards flood control by mid April, below which the project may not draft. Both Columbia River and Snake River flow augmentation occur every year and are measured as target flows, not as a specific storage volume. With flow augmentation measured as target flows, the Water Budget, developed under the Northwest Power Planning Council's (NPPC's) Columbia River Basin Fish and Wildlife Program, is no longer modeled as a hydro regulation constraint.

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[6] Dated March 2, 1995, and included in PNCA firm planning starting in the 1995-96 operating year.

Columbia River flow augmentation includes storing water at Arrow, Libby, Hungry Horse, and Grand Coulee for later release to meet McNary target flows mid-April through August. Snake River flow augmentation includes releases of water from Dworshak, Brownlee and the Upper Snake River Basin to try to meet Lower Granite target flows April through August. This process shapes generation, with less FELCC available to meet firm loads when the hydro system is storing water (January through mid-April), and with more FELCC available to meet firm loads when the hydro system is releasing stored water during flow augmentation periods (mid-April through August).

In the current hydro regulation studies, Canadian projects are modeled as duplicating their Assured Operating Plan (AOP) operations. Whenever the hedged January through July runoff forecast at The Dalles is below 90 MAF, Arrow is adjusted to include storing up to 1.0 MAF of flow augmentation water in the Operational studies. Arrow's special operation to meet trout flows and also to prevent dust problems from exposed lake shores in dry weather are not included due to modeling difficulties.

Since the critical period is less than one year in duration, the hydro studies do not include the shifting of FELCC, including not shifting to support DSI top quartile loads. Also, the adoption of system FELCC is automatic and not based upon July 31st system refill. The hydro studies show the amount of nonfirm energy available on the system, as well as system deficits, for which spot market purchases are made.

The projected amount of firm and nonfirm energy that can be produced by the hydro system is affected by the load forecast, resource availability, and hydro system operating requirements. Therefore, the hydroregulation studies used the best available data to estimate hydro system energy production.

2.4 Output.

2.4.1 Energy Results from the 50-year Operational Hydro Studies.

This year, due to changing constraints and project operations on the hydro system, the critical period has been found to be the 8-month period of historical streamflows that occurred from September 1, 1936, through April 30, 1937.

Since only 50-year hydro regulation studies were modeled, BPA estimates the amount of firm energy production which would have taken place in a critical period hydro study by examining generation from the 1930 water year, consistent with rate case assumptions.

The availability of nonfirm energy has changed dramatically compared to the last rate filing. The NMFS Biological Opinion dated March 2, 1995, created significant impacts on the ability of the system to shape energy generation to follow monthly loads. In September through December, there was little nonfirm energy available. In January through mid-April, there were deficits due to Columbia River flow augmentation storage. In the second part of April through June, the release of flow augmentation water created overgenerations. With these changes, nonfirm energy should more appropriately be analyzed on a seasonal rather than an annual basis.

In September through December, numerous deficits occur during this time period as Grand Coulee, Dworshak, Hungry Horse and Libby are all either on minimum flow or low flow operations, recovering from fish operations which caused the drafting of these projects through the end of August. Of the 200 periods represented by September through December in all 50 water conditions, surplus energy was generated as the following table shows.

Surplus Energy Generation for September through December

	Surplus	L/R Balance	Deficit	50-year Avg
1997 Level	150 in 200	0 in 200	50 in 200	1654.6 aMW
1998 Level	112 in 200	22 in 200	66 in 200	1014.1 aMW
1999 Level	88 in 200	5 in 200	107 in 200	553.5 aMW
2000 Level	95 in 200	5 in 200	100 in 200	565.8 a MW
2001 Level	97 in 200	4 in 200	99 in 200	547.9 aMW

In January through mid-April, the federal system operates to store water for flow augmentation. Of the 200 periods represented by January through mid-April in all 50 water conditions, surplus energy was generated as the following table shows.

Surplus Energy Generation for January through Mid-April

	Surplus	L/R Balance	Deficit	50-year Avg
1997 Level	160 in 200	4 in 200	36 in 200	4003.9 aMW
1998 Level	162 in 200	6 in 200	32 in 200	4282.4 aMW
1999 Level	164 in 200	3 in 200	33 in 200	4216.6 aMW
2000 Level	154 in 200	2 in 200	44 in 200	3291.5 a MW
2001 Level	156 in 200	1 in 200	43 in 200	3364.5 aMW

In mid-April through July, flow augmentation targets occur for all water conditions in the 50 water years. Therefore, nonfirm energy is abundant. Of the 200 periods represented by mid-April through July in all 50 water conditions, surplus energy was generated as the following table shows.

Surplus Energy Generation for Mid-April through July

	Surplus	L/R Balance	Deficit	50-year Avg
1997 Level	194 in 200	3 in 200	3 in 200	7286.6 aMW
1998 Level	190 in 200	6 in 200	4 in 200	7471.1 aMW
1999 Level	189 in 200	4 in 200	7 in 200	7266.6 aMW
2000 Level	189 in 200	2 in 200	9 in 200	7318.0 aMW
2001 Level	192 in 200	5 in 200	3 in 200	7189.9 aMW

August is a nondescript transitional period. Although fish target flows for McNary and Lower Granite are in place, the flow augmentation draft limits at the reservoirs limit flows to levels lower than the targets. Of the 100 periods represented by both halves of August in all 50 water conditions, surplus energy was generated as the following table shows.

Surplus Energy Generation for August

	Surplus	L/R Balance	Deficit	50-year Avg
1997 Level	87 in 100	0 in 100	13 in 100	2629.3 aMW
1998 Level	47 in 100	6 in 100	47 in 100	1227.6 aMW
1999 Level	50 in 100	3 in 100	47 in 100	1102.0 aMW
2000 Level	48 in 100	3 in 100	49 in 100	927.9 aMW
2001 Level	51 in 100	3 in 100	46 in 100	1106.9 aMW

2.4.2 Hydro Results from the 50-year Operational Hydro Studies.

Arrow is to store 1.0 MAF of flow augmentation water when The Dalles' hedged January through July runoff forecast is below 90.0 MAF. There are 23 water years in which Arrow is required to store 1.0 MAF of flow augmentation water by mid-April.

NMFS' BO requests Libby to operate with a 75% confidence of refilling to its flood control elevation by April 20th. Libby actually operates to its April 15th flood control elevation less than the target of 75%, as the following table shows. The HYDROSIM model establishes project operations on April 15th. These values are used to determine the compliance of BO targets for April 20th flood control. This is in spite of Libby hitting its December flood control between 90% and 100% of the time.

Libby Operation to its December and to its April 15th Flood Controls

	December Flood Control	Percentage for December	April 15th Flood Control	Percentage for April 15th
1997 Level	50 in 50	100%	25 in 50	50%
1998 Level	47 in 50	94%	25 in 50	50%
1999 Level	45 in 50	90%	25 in 50	50%
2000 Level	47 in 50	94%	25 in 50	50%
2001 Level	46 in 50	92%	25 in 50	50%

Libby is operated in May through July to meet minimum outflows at Libby and Bonners Ferry for local sturgeon populations. These sturgeon flows are met 100% of the time (50 out of 50 years) in each of the hydro studies.

With Libby meeting the sturgeon flows every year, Libby's storage elevation goes above its August 31st flow augmentation draft limit 34 percent of the time (17 times out of 50 water years) in the 1997 level Operational study. This reflects the refill study with a better than normal runoff the preceding year, causing high initial storage contents for Libby.

The other Operational studies (1998-2001 continuous studies) show Libby going below its August 31st flow augmentation draft limit of 2439.0 feet (2061.3 ksfd) in 16 out of the 50 water years to meet sturgeon flows in each of the hydro studies. This allows Libby to provide extra water in August to help meet McNary anadromous fish flow augmentation target flows in only 34 out of the 50 water years in each of the hydro studies.

NMFS' BO requests Hungry Horse to operate with a 75% confidence of refilling to its flood control elevation by April 20th. Hungry Horse actually operates to its April 15th flood control elevation less than the 75% target, as the following table shows.

Hungry Horse Operation to its April 15th Flood Control Elevation

	>April 15th Flood Control	Percentage for April 15th
1997 Level	35 in 50	70%
1998 Level	35 in 50	70%
1999 Level	35 in 50	70%
2000 Level	35 in 50	70%
2001 Level	35 in 50	70%

NMFS' BO requests Albeni Falls to operate with a 90% confidence of refilling to its flood control elevation (2056.0 feet, 279.0 ksfd) by April 20th. Albeni Falls actually operates to its April 15th flood control elevation 100% of the time. In addition, Albeni Falls stores above its April 30th flood control, as the following table shows.

Albeni Falls Operation above its April 30th Flood Control Elevation

	>April 30th Flood Control	Percentage for April 30th
1997 Level	12 in 50	24%
1998 Level	12 in 50	24%
1999 Level	12 in 50	24%
2000 Level	12 in 50	24%
2001 Level	12 in 50	24%

NMFS' BO requests Grand Coulee to operate with an 85% confidence of refilling to its flood control elevation by April 20th. Grand Coulee actually operates to its April 15th flood control elevation from 92% to 100% of the time, as the following table shows.

Grand Coulee Operation to its April 15th Flood Control Elevation

	April 15th Flood Control	Percentage for April 15th
1997 Level	49 in 50	98%
1998 Level	48 in 50	96%
1999 Level	50 in 50	100%
2000 Level	46 in 50	92%
2001 Level	47 in 50	94%

The Vernita Bar minimum flow requirements are met in all but three periods (two AP2's in the 1997 level study; one AP2 in the 1998 level study).

The Lower Granite target flows from April 10th through August 31st vary depending upon the April forecast for April through July runoff at Lower Granite. These variable target flow levels are met less than the 100% target in each of the hydro studies, as the following table shows.

Lower Granite Target Flows Met

	April 1-15	April 16-30	May	June	July	August 1-15	August 16-31
1997 Level	45 in 50	24 in 50	35 in 50	37 in 50	22 in 50	0 in 50	0 in 50
1998 Level	44 in 50	24 in 50	35 in 50	37 in 50	22 in 50	0 in 50	0 in 50
1999 Level	44 in 50	24 in 50	35 in 50	37 in 50	22 in 50	0 in 50	0 in 50
2000 Level	44 in 50	24 in 50	35 in 50	37 in 50	22 in 50	0 in 50	0 in 50
2001 Level	44 in 50	24 in 50	35 in 50	37 in 50	22 in 50	0 in 50	0 in 50

Percentage of Lower Granite Targets Met

	April 1-15	April 16-30	May	June	July	August 1-15	August 16-31
1997 Level	90%	48%	70%	74%	44%	0%	0%
1998 Level	88%	48%	70%	74%	44%	0%	0%
1999 Level	88%	48%	70%	74%	44%	0%	0%
2000 Level	88%	48%	70%	74%	44%	0%	0%
2001 Level	88%	48%	70%	74%	44%	0%	0%

The McNary target flows from April 20th through June 30th vary depending upon the January through July runoff forecast at The Dalles. The McNary target flows from July 1st through August 31st is 200,000 cfs. These target flows are met less than the 100% target in each of the hydro studies, as the following table shows.

McNary Target Flows Met

	April 16-30	May	June	July	August 1-15	August 16-31
1997 Level	43 in 50	38 in 50	34 in 50	22 in 50	4 in 50	1 in 50
1998 Level	39 in 50	41 in 50	34 in 50	23 in 50	13 in 50	3 in 50
1999 Level	40 in 50	43 in 50	35 in 50	22 in 50	13 in 50	3 in 50
2000 Level	42 in 50	46 in 50	32 in 50	22 in 50	13 in 50	3 in 50
2001 Level	40 in 50	42 in 50	36 in 50	24 in 50	16 in 50	3 in 50

Percentage of McNary Targets Met

	April 16-30	May	June	July	August 1-15	August 16-31
1997 Level	86%	76%	68%	44%	8%	2%
1998 Level	78%	82%	68%	46%	26%	6%
1999 Level	80%	86%	70%	44%	26%	6%
2000 Level	84%	92%	64%	44%	26%	6%
2001 Level	80%	84%	72%	48%	32%	6%

ENERGY ANALYSIS

SECTION 3. LOADS AND RESOURCES

Energy Analysis for OYs 1996-97 through 2001-02 Under 1930 Water Conditions

ENERGY ANALYSIS

SECTION 4. NON-HYDRO DEPENDENT SUPPORTING DATA

Energy Analysis for OYs 1996-97 through 2001-02 Under 1930 Water Conditions

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ENERGY ANALYSIS

SECTION 5. HYDRO DEPENDENT SUPPORTING DATA

Energy Analysis for OYs 1996-97 through 2001-02 Under 1930 Water Conditions

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CAPACITY ANALYSIS

SECTION 6. LOAD AND RESOURCES

Capacity Analysis for OYs 1996-97 through 2001-02 Under 1930 Water Conditions

CAPACITY ANALYSIS

SECTION 7. NON-HYDRO DEPENDENT SUPPORTING DATA

Capacity Analysis for OYs 1996-97 through 2001-02 Under 1930 Water Conditions

CAPACITY ANALYSIS

SECTION 8. HYDRO DEPENDENT SUPPORTING DATA

Capacity Analysis for OYs 1996-97 through 2001-02 Under 1930 Water Conditions

A-3	Regulated Projects
A-4	Independent Hydro Projects
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A-18	Wells and Chelan Allocation
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