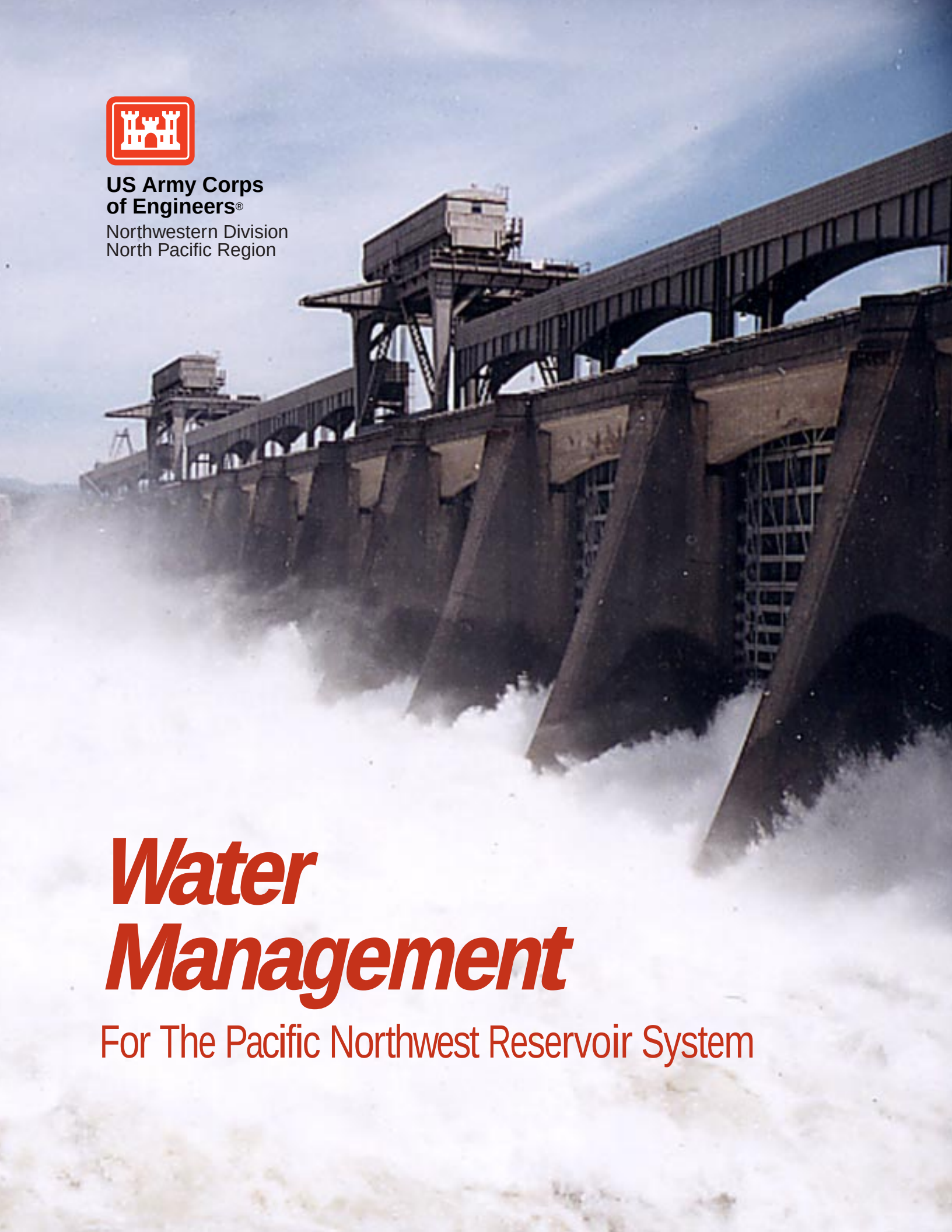


US Army Corps
of Engineers®
Northwestern Division
North Pacific Region

Water Management

For The Pacific Northwest Reservoir System

Columbia River Basin History

These photographs of Bonneville Dam portray the more than fifty years of Corps multipurpose water resource development in the Columbia River Basin. The original Bonneville Lock and Dam project was completed by the Corps of Engineers in 1938. The Columbia Basin is now one of the most intensively developed major river basins in the world. Construction of the Bonneville Second Powerhouse with the addition of eight operating units has increased Bonneville's hydraulic capacity to match that of more recently constructed projects upstream. Eight additional units have doubled the capacity of the initial installation to 1136 MW.

Multipurpose Use Development

The area contained within the Northwestern Division, North Pacific Region (NPR), includes all of the United States portion of the Columbia River Basin and coastal river basins in Oregon and Washington. The Columbia River is the fourth largest river in North America. The geographic and hydrologic characteristics of the river, which drains a 259,000 square mile basin, are ideally suited to beneficial multiple-purpose storage development.

Since the 1930s, numerous dams, both Federal and private, have been built to store water for flood control, to generate hydroelectric power, and for other purposes. Total storage capacity of these dams is about 25 percent of the 156 million acre foot average annual runoff volume for the Columbia River at its mouth. Federal projects in the basin have 19,900 megawatts of existing hydroelectric capacity, and non-federal projects add 10,700 megawatts. Other major project purposes are fish and wildlife, navigation, municipal and industrial water supply, irrigation, and recreation.

Water Management Division, North Pacific Region, plays a key role in the development and operation of the complex system of multiple-purpose projects in the Pacific Northwest. This role involves hydrologic investigations, power system analyses, flood control studies, project economic studies, operational planning, seasonal, and day-to-day project control.


Water Quality


Flood Control


Navigation


Power Generation


Fish Protection


Wildlife

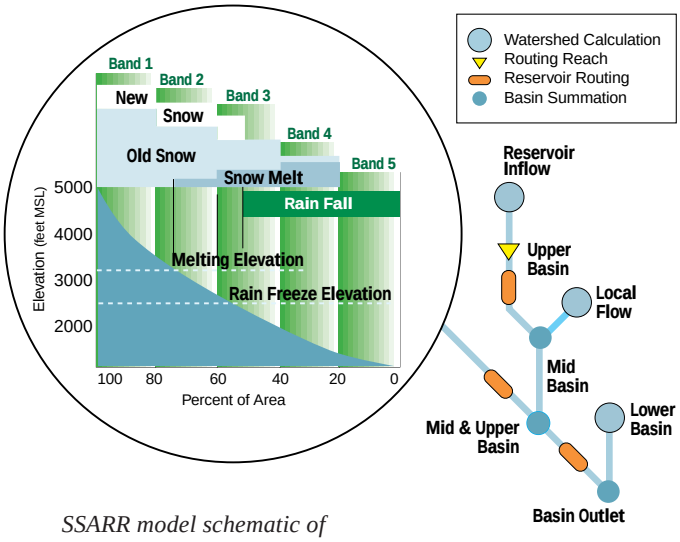

Recreation


Irrigation

Hydrologic Engineering Studies

Illustration showing a typical drainage basin.

The Streamflow Synthesis and Reservoir Regulation Model (SSARR) schematic (shown below) represents snow accumulation, snowmelt, and rainfall in elevation bands in the watershed calculation. Runoff is routed through lakes, streams, and control structures to complete the simulation. Calibration of the computer model is accomplished by adjusting conceptual hydrologic parameters to reproduce historic data. Once calibrated, the model is used to estimate hypothetical floods, extend streamflow records, perform regulation studies, produce forecasts of future streamflow, and establish project operating guidelines.



SSARR model schematic of watershed calculation

Reservoir Control Center

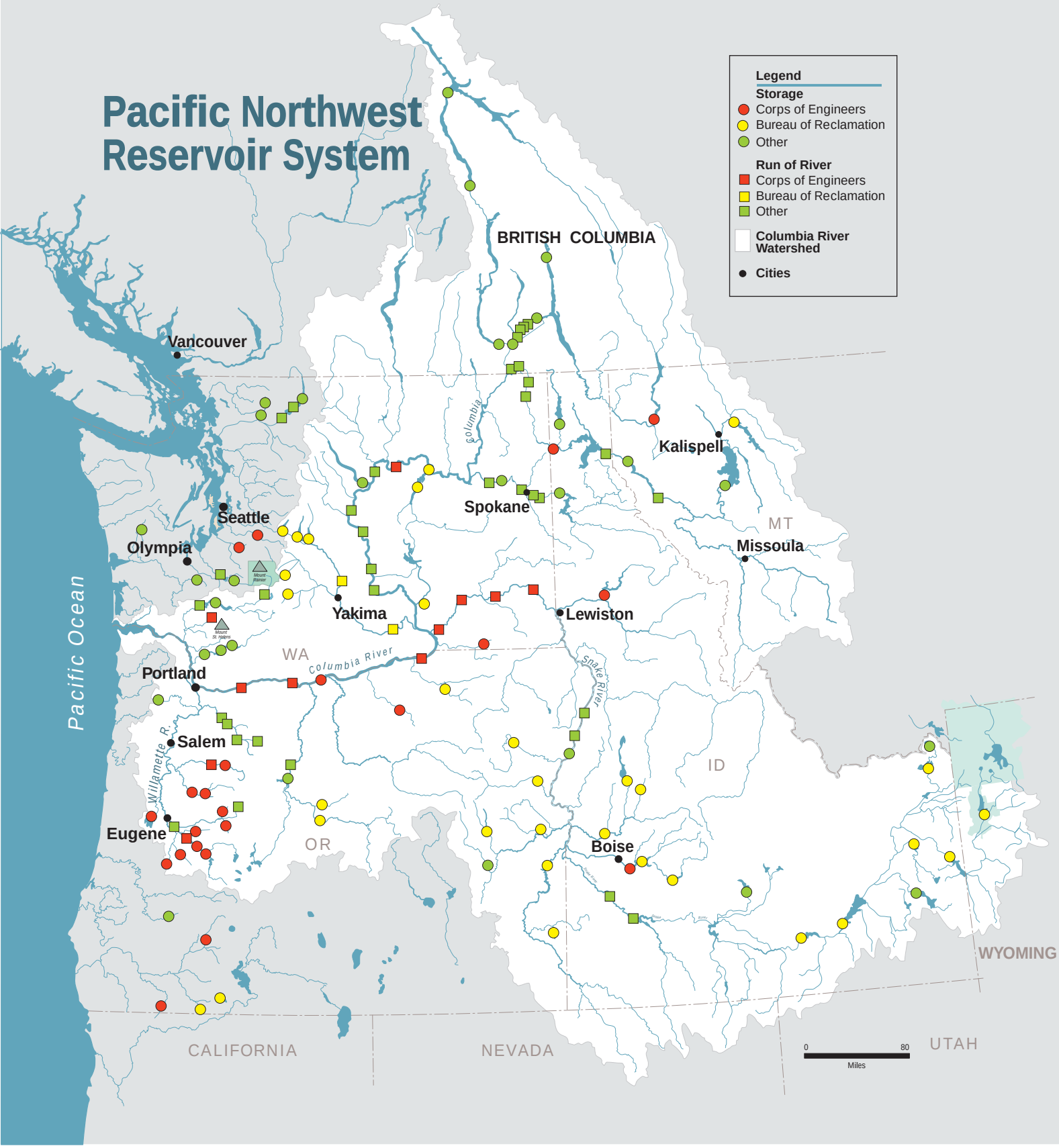
Reservoir Operating Guidelines

In the Pacific Northwest, 19 utilities own and operate hydroelectric facilities. Coordination is achieved through the Pacific Northwest Coordination Agreement (PNCA) and the Columbia River Treaty between Canada and the United States. The Columbia River Treaty is carried out by the Canadian Entity (B.C. Hydro) and U.S. Entity (represented by the Corps of Engineers and Bonneville Power Administration). The Reservoir Control Center is responsible for implementing the coordinated power plans in real-time using daily coordination between these agencies. Also important in daily operations is implementation of the Biological Opinion for endangered salmon and sturgeon. The daily objectives in reservoir operations include: power generation, flood control, fisheries, navigation, irrigation and recreation. In actual operations, these many objectives often conflict, so water supply and streamflow forecasts influence strategies and decision making. The Reservoir Control Center's role is to bring PNCA and Columbia River Treaty plans to life by adjusting them for the ever-changing streamflow forecasts.

Daily Briefing

Daily reservoir regulation briefings are conducted in the Water Management briefing room (pictured below). The briefing room utilizes automated large screen equipment to display computer produced plots and tabulations of observed and forecasted regulation data, such as forebay elevations, inflows, outflows and rule curves.

Reservoir Control Center briefing room



Map of Pacific Northwest Reservoir System showing both storage and run of river dams owned by the Corps of Engineers, Bureau of Reclamation and others.

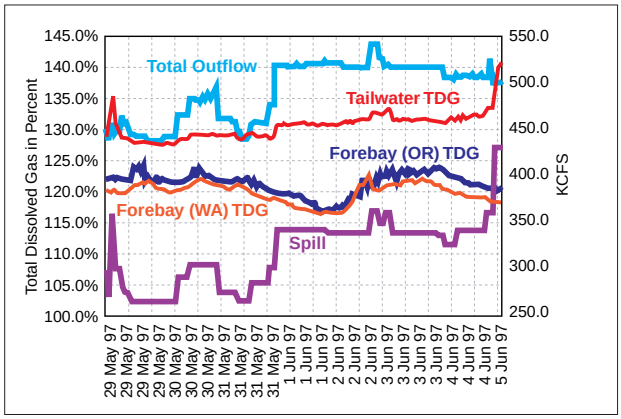
Water Quality

Meeting stringent water quality standards throughout the Pacific Northwest reservoir system is an integral part of the Water Management Division's scope of work. Water quality investigations are conducted to develop specifications associated with project planning, design, construction and operation.

Photo showing Spillway deflectors (flip lips) in operation

Spillway deflectors, called "flip lips" have been added to alleviate the problems of total dissolved gas supersaturation that affects juvenile and adult fish migrants.

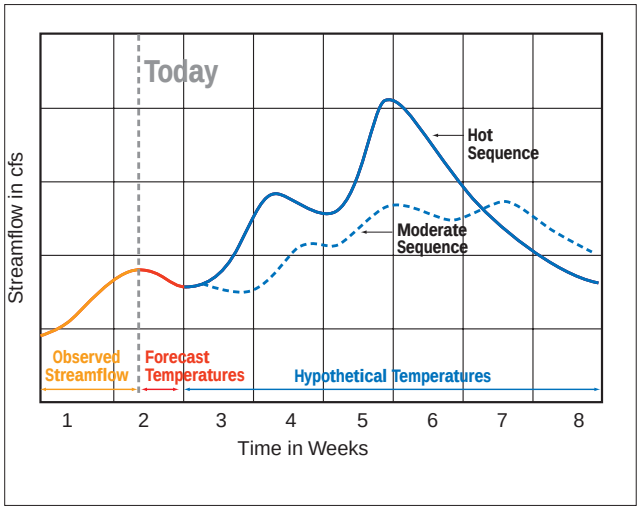
At six storage projects, selective withdrawal structures have been constructed to facilitate downstream temperature control. Water Management personnel are also in the forefront of developing and applying water quality monitoring techniques, instrumentation and mathematical modeling used as an aid to maintain water quality.



Water quality monitoring station

Flood Control and Streamflow Forecasting

Corps of Engineers flood control responsibilities include regulation of federal and non-federal reservoirs in the system. Streamflow forecasts are generated by the National Weather Service River Forecast Center to provide input for operational decisions. The sample forecast (below) illustrates the sensitivity of resultant streamflow based on



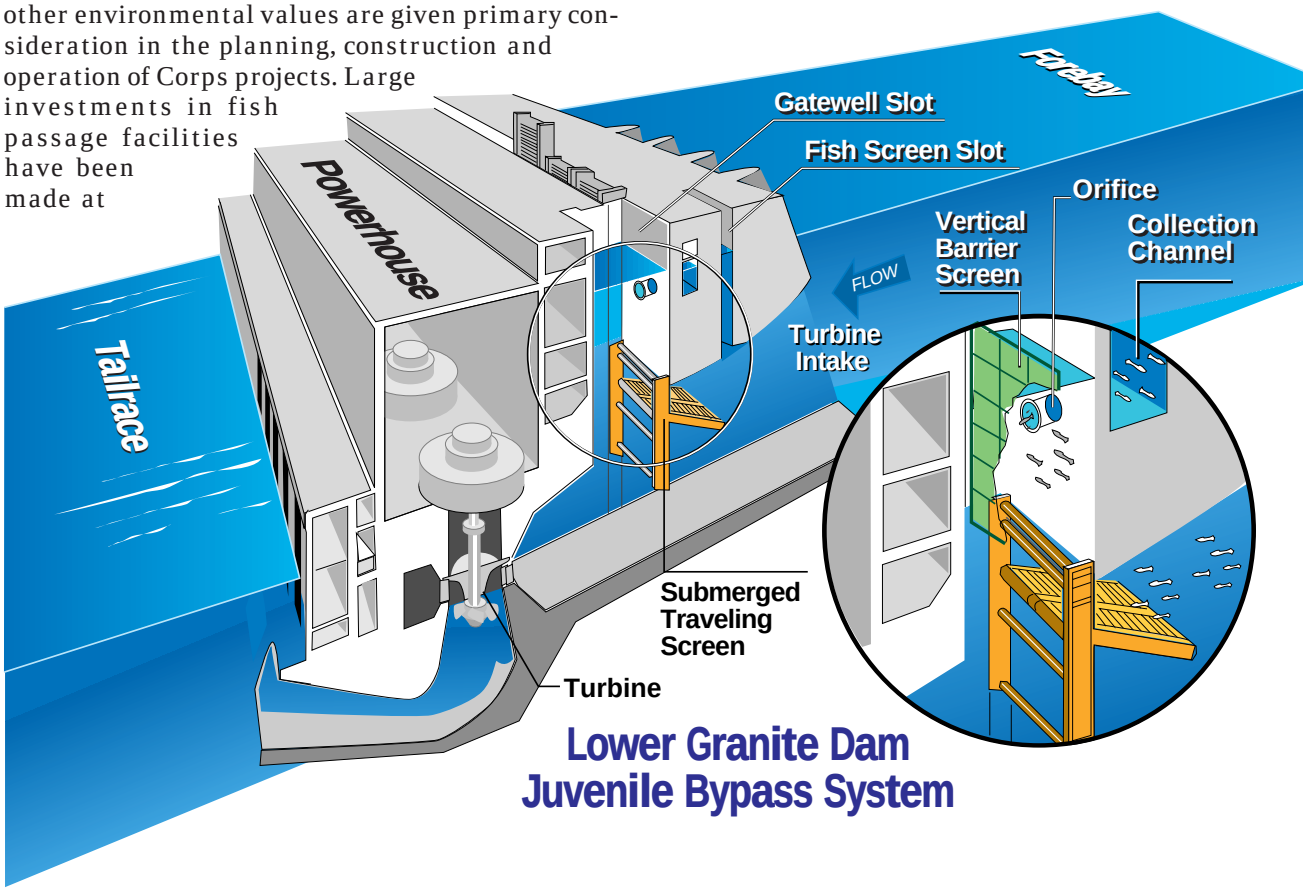
two assumed temperature sequences. Other parameters, such as precipitation, may also be entered into the simulation process. During decision making for system operation, alternate model system simulations have been used to help prevent billions of dollars of flood damages. Scheduling the daily or real-time reservoir regulation is largely centralized in the Water Management Division. The Corps operates 32 major reservoir projects in the Pacific Northwest for multiple purposes in coordination with 45 other non-federal projects including three major Canadian reservoirs. Automatic generation control is maintained by computer at key projects in the lower main stem of the Columbia River while upstream reservoirs are scheduled hour-by-hour.

Reservoir Control Center employees in conference

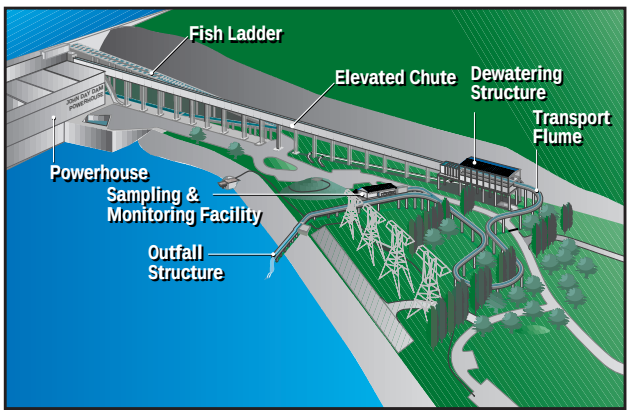
Both water quality and reservoir operations require large amounts of data to be collected and analyzed. The Columbia River Operational Hydromet System (CROHMS) serves this need. CROHMS provides state-of-the-art techniques in automated collection, communication, and processing of hydro-meteorological data. The CROHMS database is maintained by the Corps for use by numerous agencies concerned with water management.

Environmental Issues

The Columbia River supports important resident and anadromous fisheries. These resources and other environmental values are given primary consideration in the planning, construction and operation of Corps projects. Large investments in fish passage facilities have been made at mainstem Columbia River projects and additional work, such as juvenile surface bypass, is being completed. Water Management fishery and water quality experts work closely with fishery biologists from the Federal, State, and Tribal interests. They develop and conduct research programs as well as determine operational criteria for use in system regulation to increase fish passage and survival rates. Experiments with various bypass, collection and transport systems to support improvements in fishery management with juvenile fish transportation continues to be an important element of the overall fish passage program.



Juvenile fish transporter (fish barge)



Juvenile fish sampling and monitoring facility at John Day Dam

Hydropower Unit Outage Coordination

The Corps of Engineers analyzes the factors associated with Hydropower Unit maintenance and resultant outages with respect to all desired uses. They then weigh the relative risks to electrical and mechanical systems of the units against power system needs, fish, water quality, navigation, irrigation and other authorized uses. The Corps also coordinates changes to annual outage schedules between stake holders.

Lower Granite Dam, Snake River

Generators in Chief Joseph Dam powerhouse, Columbia River

Control Room at Bonneville Dam, Columbia River

Power Branch

Operational Planning Section

The mission of the Operational Planning Section of the Power Branch is to develop hydropower regulations for the operation of the Columbia River system. These regulations establish guidelines for the operation of the system to meet the multipurpose needs of the Pacific Northwest.

The Columbia River Treaty with Canada and the Pacific Northwest Coordination Agreement (PNCA) between parties in the U.S. are in place to optimize the Columbia River for Canadian and U.S. needs. The Water Management Division of the Corps of Engineers provides data and hydropower regulations for the development of the operating plans required by the Treaty and the PNCA.

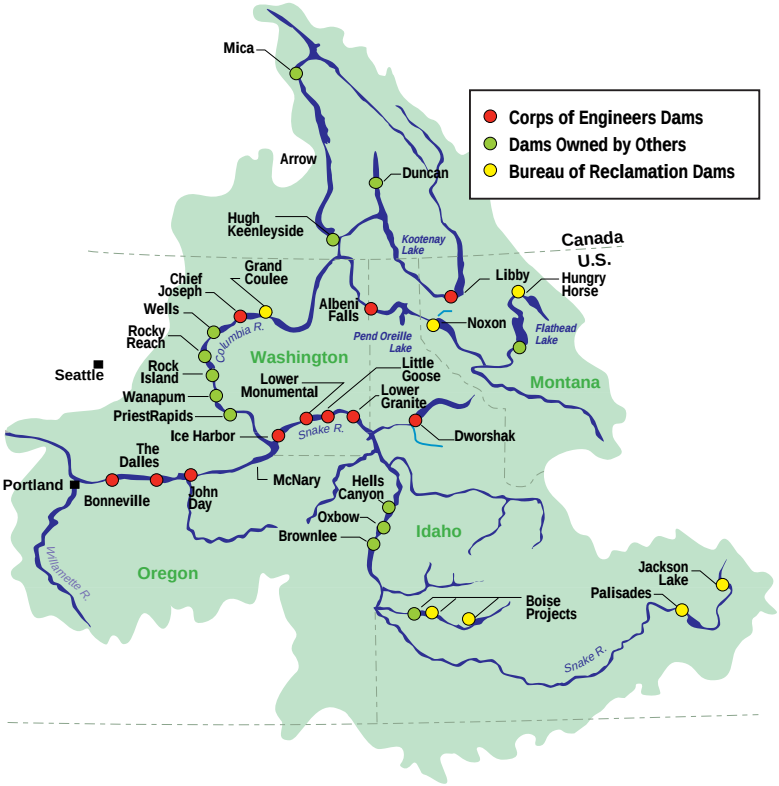
Chief Joseph Dam, Columbia River, Washington

Columbia River Treaty

In 1964, the U.S. Congress ratified the Columbia River Treaty with Canada which cleared the way for the construction of Mica, Arrow, and Duncan Dams, in Canada, and Libby Dam in northwest Montana. These dams doubled the storage capacity of the Columbia River system.

The U.S. agreed to return to Canada one-half of the power generation gained by the improved streamflow at U.S. projects (downstream benefits).

As part of the Treaty requirements, each year the U.S. runs hydropower computer regulations to determine how the Columbia system will operate. The Corps of Engineers Water Management Division, as part of the U.S. Entity, helps develop these regulations. The Assured Operating Plan (AOP), defines the Canadian storage operation six years in advance. These regulations determine rule curves which provide both entities with optimal benefits. They also determine the downstream power benefits, half of which Canada is entitled to. Another set of regulations, called the Detailed Operating Plan (DOP), is focused on the upcoming operating



year. These regulations include the results from the AOP for the Canadian projects along with current U.S. system loads and requirements. The results of these regulations become the guidelines by which the system is operated on a real-time basis.

To maintain an open relationship with Canada, the United States (represented by the Corps of Engineers and Bonneville Power Administration) regularly meet with their Canadian counterparts at the Columbia River Treaty Operating Committee meetings. These sessions provide a forum for discussions and decisions on how to operate the Columbia River Treaty projects to meet the ever changing requirements of the system.

Salmon swimming up river

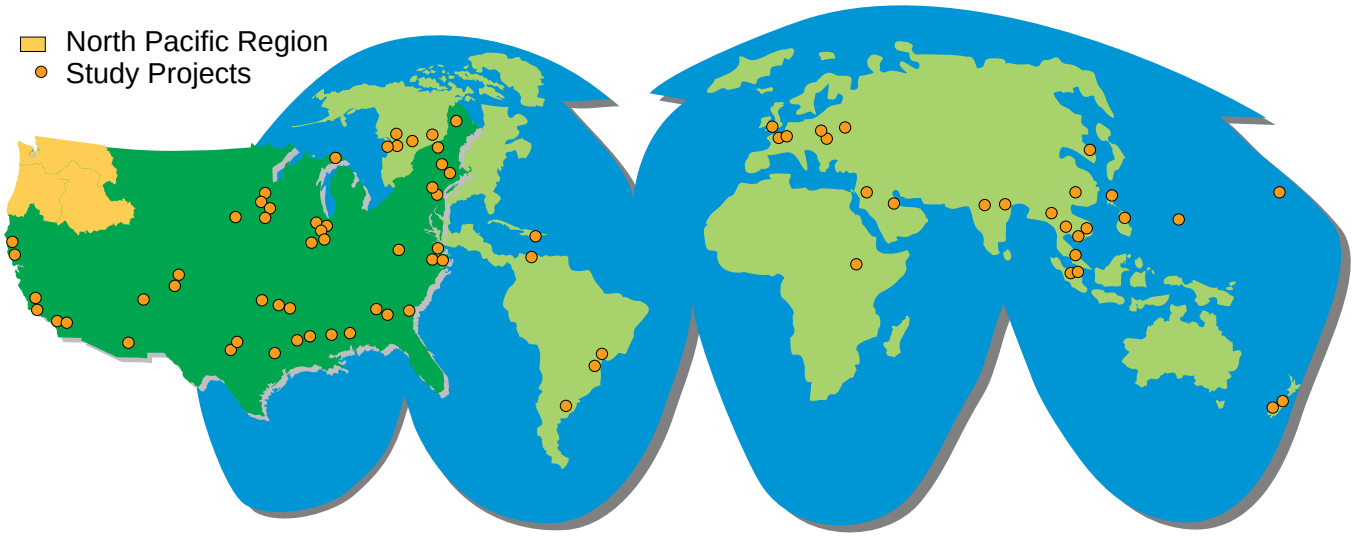
Pacific Northwest Coordination Agreement

Ratification of the Columbia River Treaty made coordination of the Columbia River reservoir system imperative to realize the benefits of Canadian storage. The Treaty specifies that in the determination of downstream power benefits, the Columbia River projects in the U.S. will be maintained and operated "in a manner that makes the most effective use of the improvement in streamflow resulting from operation of the Canadian storage for flood control and hydroelectric power generation."

The Pacific Northwest Coordination Agreement became effective January 4, 1965. The agreement established rights and obligations for receiving and delivering the energy needed to meet the parties' firm energy needs. The PNCA defines operating guidelines and targets for each project's storage so that production will be met, both non-power and power, with optimum system power benefits.

Generators at The Dalles Dam, Columbia River

Center of Expertise for Hydropower System-Economic Evaluation



The Hydropower Evaluation Section of the Power Branch has been designated as a Corps-wide Center of Expertise for Hydropower System-Economic

Turbine blade

Evaluation. This designation is based on expertise gained from extensive analysis of hydropower projects located throughout the Corps as well as in many foreign countries. The Hydropower Evaluation Section performs power systems analysis involving hydropower project outputs and economic benefit evaluations on a wide variety of existing and proposed hydroelectric projects. Work is often done in partnership with the Corps of Engineers Hydroelectric Design Center, which provides expertise throughout the Corps in hydropower project and major pumping plant equipment engineering and design. Examples of some of the services the center can provide include:

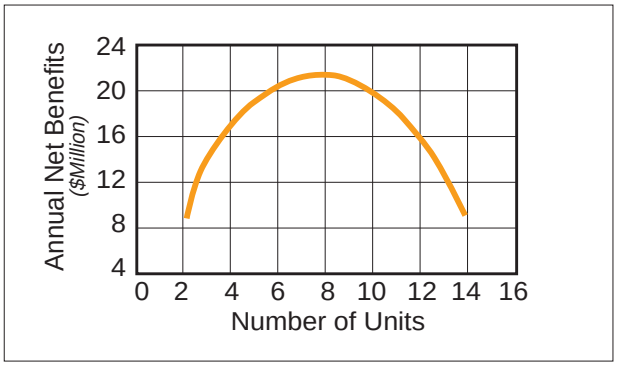
Powerplant Equipment Rehabilitation Studies analyze the hydropower output and provide economic evaluations in support of a full range of powerplant equipment rehabilitation studies. Examples of past studies include generator rewind and uprate studies, turbine replacement and refurbishment studies, and peripheral electrical equipment studies.

Environmental/Fishery Studies analyze the effects of modifications in project operations, project changes for environmental/fishery reasons such as fish screens, fish bypass systems, water quality improvement facilities, and other similar changes.

River Basin System and Project Planning Studies provide power system studies and economic analysis on all types of river basin systems and hydropower projects.

Fish viewing at Chittenden Locks

Plant Expansion Studies analyze the feasibility of expanding the generation capabilities at existing powerplants or adding new generation at non-power projects.



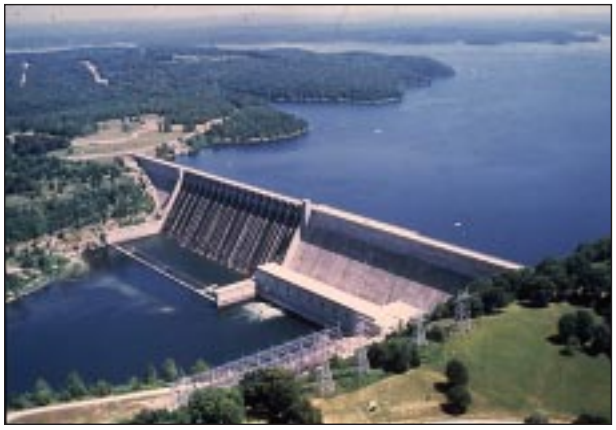
Cost Allocation and Reallocation Studies analyze the hydropower benefit component in cost allocation and water supply reallocation studies for multipurpose water resource projects. Numerous water storage reallocation studies have been done which require the identification of power benefits and revenues foregone due to reallocation of storage for municipal and industrial water supply withdrawals.

Power Value Computations of energy and capacity values are used in power benefit analysis. Power system production cost models and the databases for these models are maintained by the Hydropower Evaluation Section. These system models are necessary to determine power values for all regions of the country. Coordination with the Federal Energy Regulatory Commission, Federal Power Marketing Agencies, and other interested power groups is an intergral part of this type of analysis.

Training and Consultation on Hydropower Analysis are provided by the Hydropower Evaluation Section to others on all types of hydropower analysis and economic evaluation of hydropower projects.

Generator installation at Bonneville Second Powerhouse

US Army Corps of Engineers
Northwestern Division
Water Management Division
P.O. Box 2870
Portland, Oregon 97208-2870
(503) 808-3974 *Voice*
(503) 808-3985 *FAX*



Bull Shoals, Little Rock District

Downtown Portland, Oregon

Water Management Activities

Wind surfing on the Columbia River at Hood River, west of The Dalles Dam.

Fish ladder at Lower Monumental, Snake River, Idaho

Chittenden Lock, Seattle, Washington

Northwestern Division, North Pacific Region Office, Portland, Oregon

River Basin System and Project Planning

- ★ Resource Inventory
- ★ Flood Control Regulation Studies
- ★ Power System Regulation Studies
- ★ Flow Simulations and Reconstitutions
- ★ Power Planning and Economic Analysis

Project Design

- ★ Spillway Design Flood Derivations
- ★ Water Surface Profile Studies
- ★ Powerplant Size Optimization

Operations Planning and Reservoir Regulation

- ★ Annual Planning & System Operations
- ★ Water Supply and Streamflow Forecasts
- ★ Reservoir Regulation
- ★ Collection and Dissemination of Hydrometeorological Information

The Water Management Division maintains a family of computer programs to simulate river and reservoir system operations as well as power system operation. Among the objectives of these programs are:

- ★ Modeling of the hydrologic runoff characteristics of river basins
- ★ Determination of regulated streamflows and river stages
- ★ Expected reservoir elevations
- ★ Assured yield of flow during dry periods
- ★ Project and system power generating capabilities
- ★ Rate of change of water levels in power plant forebays and downstream river reaches
- ★ Economic analysis of power system operating costs

Together this family of programs permits analysis of the operation of the system in the detail appropriate to any particular need.

HYSSR **Hydro System Seasonal Regulation**
(seasonal studies using sequential monthly data)

SSARR **Streamflow Synthesis and Reservoir Regulation**
(streamflow forecasting and hydrologic design flood derivations)

HALLO **Hydropower Allocation**
Utilized in hydropower analysis to allocate project discharge to individual units at a powerhouse with multiple and/or different generating units

PROSYM **Production Costs Model.**
Computes the costs of operation of a hydrothermal power system

DAMBRK **Dam Break**
Simulation model of dynamic wave flood routing

GASSPILL **Total Dissolved Gas Model**
Simulates levels of total dissolved gas above and below spilling projects

HEC-5Q WRE **Hydrologic Engineering Center Water Quality model**
Simulates reservoir and stream temperature and a multitude of other water quality parameters