




Federal **Columbia River** Power System



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U.S. Army Corps of Engineers • Bonneville Power Administration • Bureau of Reclamation





Section 1: A RIVER OF MANY USES, MANY BENEFITS



Bonneville Dam Powerhouse II
Cover Photo: Bonneville Dam Spillway

The Federal Columbia River Power System (FCRPS) is a unique collaboration among three U.S. government agencies - the Bonneville Power Administration (BPA), the U.S. Army Corps of Engineers (the Corps) and the Bureau of Reclamation (Reclamation). Collectively, these agencies maximize the use of the Columbia River by generating power, protecting fish and wildlife, controlling floods, providing irrigation and navigation, and sustaining cultural resources.

The 31 federally owned multipurpose dams on the Columbia and its tributaries that comprise the FCRPS provide about 60 percent of the region's hydroelectric generating capacity. The dams operate to protect migrating fish, and they supply irrigation water to more than a million acres of land in Washington, Oregon, Idaho and Montana. As a major river navigation route, the Columbia-Snake Inland Waterway provides shipping access from the Pacific Ocean to Lewiston, Idaho, 465 miles inland. Water storage at all projects on the major tributaries and mainstem of the Columbia totals 55.3 million acre-feet, much of which enhances flood control.

An Ancient Resource

The Columbia River stretches 1,214 miles from Canada to the Pacific Ocean, and the Columbia River Basin covers 258,000 square miles in the northwestern United States and British Columbia. From the time people first inhabited the basin more than 10,000 years ago, the river has played a vital role in the region's survival and growth. Native Americans fed on its salmon and sturgeon. They harvested wild salmonberries and camas bulbs from its rich lowland marshes. Wildlife that visited the river's shores provided food and clothing. The river was at the heart of tribal cultures.

In 1792, a British sea captain, Robert Gray, sailed up the river from the Pacific Ocean and named it after his ship, the *Columbia Rediviva*. Soon to follow were the famous American explorers, Meriwether Lewis and William Clark, whose expedition was to find the most direct water route across the continent for future commerce. After traveling to the Missouri River's headwaters, they portaged to the waters of the Columbia and canoed to its mouth at the Pacific Ocean.

Further exploration and development was sporadic until the westward migration of the mid-1800s that brought farmers, loggers, miners and merchants, all seeking a better life. They too turned to the river to support their livelihood.

The river was a major means of commerce between the rich agricultural and mining areas east of the Cascade Mountains and the population centers to the west, with their access to international trade. The Corps of Engineers, created in 1775, saw early on that commercial development of the Northwest depended on improving river transportation. In the late 1800s, the Corps completed two canals near what are today John Day and McNary dams. The canals eliminated the need to portage watercraft around treacherous rapids and falls, and they greatly improved river commerce.

A Vision of Multiple Uses

The multiuse development of the Columbia River has its roots in the conservation movement of the early 1900s. In 1902, President Theodore Roosevelt signed the Reclamation Act, authorizing construction of dams for irrigation and land settlement. Acres of arid land were quickly reclaimed by irrigation, creating rich agricultural areas. The Corps received authority in 1917 to



Celilo Falls

PLANT	IN-SERVICE DATE	PLANT	IN-SERVICE DATE
Minidoka	1909	Bonneville	1938
Boise River Diversion	1912	Grand Coulee	1942
Black Canyon	1925	Anderson Ranch	1950



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build dams to prevent flooding, and ultimately the Corps was given authority to study the entire river basin for multipurpose development.

In the late 1920s, the Corps completed a comprehensive study of the Columbia and issued a “308 report” in 1931. While navigation remained an important justification for recommended development, the river’s potential for electric generation formed the basis of the report.

The power potential of the river gained national attention when Franklin Roosevelt visited the area during his bid for the presidency in the midst of America’s Great Depression. When campaigning in Portland, Oregon, in 1932, he promised the gathered crowd, “the next great hydroelectric development to be undertaken by the federal government must be that on the Columbia River.”

Massive unemployment, the public benefits that could be derived from hydropower and Roosevelt’s election led to authorizing construction of Bonneville and Grand Coulee dams as public works projects. The Corps would build Bonneville, while Reclamation would build Grand Coulee. Work began on Bonneville Dam in November 1933 and on Grand Coulee the following month. The Corps’ 308 report called for a total of 10

dams to be built on the Columbia, and it shaped the river’s development over the next 40 years.

CASE IN POINT:

When constructed, Bonneville Dam had a 1,500-foot-long spillway, a 1,000-foot-long powerhouse and one navigation lock. The resulting head between river and reservoir rim averaged 57 feet. Grand Coulee Dam dwarfed Bonneville. It was over 5,000 feet long, and its concrete face rose 350 feet above the Columbia River. Lake Roosevelt, created behind the dam, stretched 150 miles. The two dams combined had a generation capacity of more than 2,400 megawatts.

The Bonneville Project Act was signed in 1937, creating the Bonneville Power Administration to market electricity from the two dams. The agency was to build and operate transmission facilities and to market electricity to encourage its widest possible use. Preference to the system’s output was given to publicly and cooperatively owned utilities. Dam operations remained with the Corps and Reclamation.

In 1939, BPA first transmitted energy over its own facilities from Bonneville Dam to nearby Cascade Locks, Oregon, then from the dam to Portland, Oregon, over a 230-kilovolt line. That same year, BPA began building a transmission line connecting Bonneville Dam with Grand Coulee Dam, ensuring a means of delivering electricity to power-hungry population centers when Grand Coulee went on line in 1941.

The FCRPS played a vital role following America’s entry into World War II. With its low-cost power, the Pacific Northwest was the logical location for aluminum plants needed to produce the metal for airplanes. The Boeing Aircraft Works rapidly went into production near Seattle, Washington, and other wartime industries followed. Nearly all electricity available from BPA was committed to industrial loads by 1942 for war production. In addition to these contributions to the war effort, in January 1943,



Grand Coulee Dam

BPA began shipping a large block of power into an isolated area in southern Washington. It was later learned that the power was going to the Hanford Reservation for plutonium production.

Mid-Century Years of Growth

Post-war America was booming in the 1950s, and the need for electricity increased dramatically in the Northwest. Multipurpose development of the Columbia River made great progress during these years, with the construction of dams for power generation and the enhancement of flood control, navigation and irrigation. In addition, legislation in 1957 authorized BPA to transmit non-federally generated power, introducing the concept of wheeling and creating a means to market present and future hydro generation.

Flood control was another important impetus for dam construction in this period. On a Sunday afternoon in May 1948, the Columbia River crested at six times its normal volume and flooded the town of Vanport, Oregon, killing 32 people. The pressure was on for increased flood control protection.

Based on the Corps’ earlier study of the basin, an arrangement was struck with Canada to tap the storage capacity of the upper reaches of the Columbia. The United States and Canada signed the Columbia River Treaty in 1961, and it was implemented in 1964. Under the treaty, Canada built three large storage projects, and the United States built Libby Dam in Montana, doubling the storage capacity of the river system. The storage not only provided a better means of controlling the river’s flow to decrease flooding, but it also offered an abundance of water for power generation.

The United States paid Canada a one-time fee of \$64 million for its estimated half of the resulting future flood control benefits. The United States and Canada equally shared the downstream power benefits attributed to improved stream flows that resulted from these new dams. Canada did not need its half of the power - called the Canadian Entitlement - and sold it to a group of U.S. utilities for a period of 30 years.

In the late 1960s, BPA developed and energized two 500-kilovolt alternating current transmission lines between the

Pacific Northwest and Southern California. In 1970, it energized the high-voltage, direct current intertie, capable of carrying 2,500 megawatts (MW) of power. These interties were an engineering marvel and a stroke of marketing genius. By capitalizing on the offsetting seasonal energy needs of the two regions, the generating potential of the river was realized year-round. The interties allow Northwest generators to sell their surplus power south. They also allow BPA to exchange power by shipping it south in summer to serve Southwest cooling needs, in exchange for the power that flows north in winter to help serve Northwest heating needs.

This new outlet for power not only helped cement the Columbia River Treaty, but also led to the construction of the third powerhouse at Grand Coulee Dam and the second powerhouse at Bonneville Dam. Bonneville’s second powerhouse, completed in 1983, increased the dam’s total generating capacity to 1,084 MW, while Grand Coulee’s expansion brought its total capacity to 6,809 MW.

The ratification of the Columbia River Treaty also led to the signing of the Pacific Northwest Coordination Agreement (PNCA) in 1964, initially among BPA, the Corps and non-federal generators. In 1981, Reclamation and a public utility district



Libby Dam

PLANT	IN-SERVICE DATE	PLANT	IN-SERVICE DATE
McNary	1952	Big Cliff	1953
Detroit	1953	Lookout Point	1953
Hungry Horse	1953	Albeni Falls	1955

PLANT	IN-SERVICE DATE	PLANT	IN-SERVICE DATE
Dexter	1954	Chief Joseph	1958
Chandler	1956	Palisades	1958
The Dalles	1957	Roza	1958



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joined, bringing the total to 17 entities. The purpose of the PNCA was to assure that all major hydroelectric projects in the region would operate for optimum power system capability by taking advantage of the system's flexibility. It envisioned operating the dams as though they had a single owner, optimizing their hydroelectric potential.

CASE IN POINT:

The PNCA concept was that all parties jointly determine the aggregate firm load they can serve and mutually support each other's operations to meet the load and optimize the river's resources. One feature of the agreement was the provision for assured and coordinated storage operations - a critical fact given that all but one party has generation downstream from storage facilities owned and operated by others. Another provision assures priority to non-power requirements over power needs. These non-power requirements, such as fish protection, may be unique to one owner or several, or may be contingent on coordinated upstream storage. In any case, addressing non-power requirements requires coordination among all PNCA parties.

Responding to Shortage

The 1970s and 80s dawned with projected energy shortages. Forty years of federal development of the Columbia River system was ending, as the river's hydroelectric potential was nearly fully developed. Public and private utilities would now turn to building and operating thermal plants.

A group of 16 Washington public utility districts and municipal utilities formed a joint operating agency, the Washington Public Power Supply System (WPPSS), in the 1960s to coordinate resource development. In 1963, WPPSS completed the Hanford Generating Plant, and BPA marketed its power. This was the region's first step in transitioning from a hydro-based to a hydro-thermal generation system.

WPPSS first planned to build three nuclear plants, but later increased the number to five. BPA and most of its preference

customers participated in the first three plants under a contract arrangement known as net billing. WPPSS also entered into separate arrangements with many of the same participants to construct the final two nuclear plants, which were legally separate from the BPA-backed projects.

The confluence of escalating costs and a revised projection for less demand for power ultimately led BPA to suspend construction of two of the three WPPSS projects it backed. In 1981, a final decision was made to halt construction and cease issuing project debt for two of the plants. One of the three projects came on line in 1982 and remains operational today. The last two WPPSS plants, supported by 88 Northwest public utilities, also met with difficulties and were never completed. The joint agency, now known as Energy Northwest, continues to operate generating facilities, as well as provide other energy services.

Three significant pieces of legislation with lasting effects on the FCRPS resulted from this period. First, the Federal Columbia River Transmission System Act in 1974 allowed BPA to use its revenues to operate and maintain the transmission system, rather than having to seek congressional funding. And for the first time, Congress granted BPA borrowing authority.

Second, in 1978, the National Energy Act was adopted. It contained five statutes, including the National Conservation Policy Act, which increased the nation's emphasis on energy conservation. This was followed by passage of the third piece of legislation, the Pacific Northwest Electric Power Planning and Conservation Act of 1980.

This Act created the Northwest Power Planning Council, which was charged with planning the long-range energy needs of the region. Key elements of the Act gave conservation the top priority in resource acquisition decisions and mandated equitable treatment for fish and wildlife. BPA has since spent more than \$2 billion on energy conservation efforts in the region and well over \$3 billion on fish and wildlife programs.

The Act's emphasis on equitable treatment for fish and wildlife drove a rebalancing of the FCRPS' operation of the dams. During the 1980s, changes in public and political sentiments, along with the mandates of the Act, were responsible for many of today's fish and wildlife and energy-planning programs in all three FCRPS agencies.

Full Steam Ahead for Fish Recovery

In the 1990s, environmental pressures on the FCRPS continued to escalate, particularly regarding fish and wildlife protection and recovery. Without a doubt, fish and wildlife have become a major influence on system operations since the Endangered Species Act (ESA) listings of salmon and other aquatic creatures. Snake River sockeye were listed for protection in 1991, followed by over a dozen more listings in the mid and late 1990s.

From the initial designs of Bonneville and Grand Coulee dams, mitigating harm to migrating fish, such as salmon, has been a priority in river operations. Most anadromous fish hatch in the upper reaches of the river and migrate to sea, then return to spawn and die. Overharvesting, pollution runoff, habitat degradation and dam construction have negatively affected this natural process by slowing river flows, decreasing water quality and blocking migration.



John Day Dam

The Corps, Reclamation and BPA began an environmental review of river operations - the Columbia River System Operation Review - in 1990. This study of the multipurpose operation of the river was needed in order to negotiate renewed PNCA and Canadian Entitlement Allocation Agreements. At the study's completion in 1996, the three agencies adopted an operating strategy for the system, including the recovery of fish listed under the ESA.

In 2000, the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS), issued a set of Biological Opinions on the operation and configuration of the FCRPS. These opinions established measures for how operations should be conducted to protect ESA-listed species. In response, the FCRPS agencies prepared an implementation plan, the first step in meeting performance standards over a 10-year period to measure the success of the recovery strategies.

The Challenge Continues

An energy crisis that began in the winter of 2000 reinforced the challenges of balancing the many uses of the river system. As a result of the region's second worst drought in history, FCRPS generation in 2001 fell by about 2,500 average megawatts (aMW). The crisis emphasized the importance of continuing to improve dam operations and to explore and apply new technologies.

CASE IN POINT:

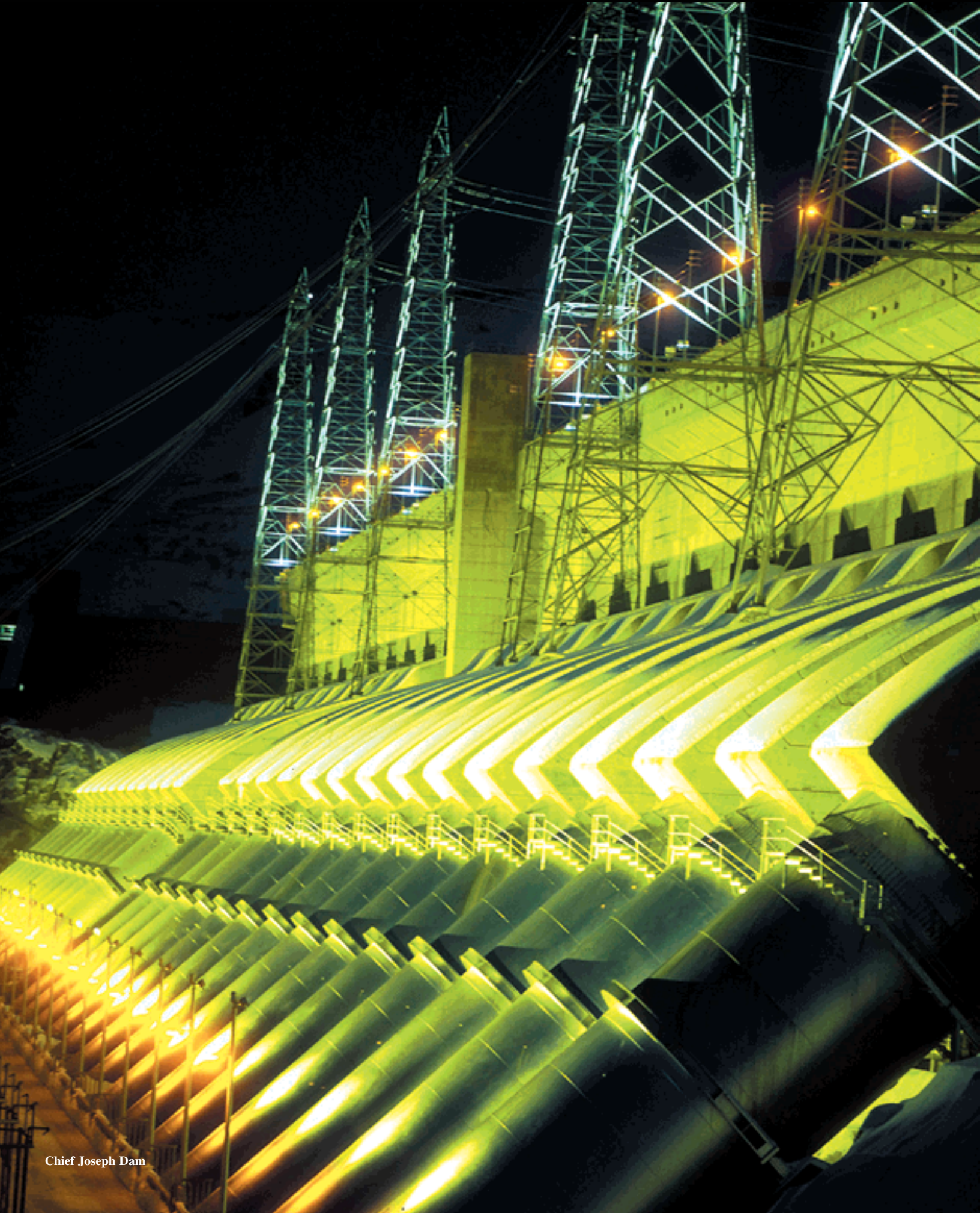
"But a great river is a coal mine that never thins out. It is an oil well that never runs dry. The Columbia River will flow through the Bonneville and Grand Coulee Dams...as long as rain falls and water flows downhill to the sea."

J. D. Ross, BPA's first administrator, 1937



PLANT	IN-SERVICE DATE	PLANT	IN-SERVICE DATE
Green Springs	1960	Cougar	1963
Ice Harbor	1962	Green Peter	1967
Hills Creek	1962	Foster	1967

PLANT	IN-SERVICE DATE	PLANT	IN-SERVICE DATE
Lower Monumental	1969	Dworshak	1973
Little Goose	1970	Libby	1975
John Day	1971	Lower Granite	1975
		Lost Creek	1977



Chief Joseph Dam



Section 2:

THE FCRPS IN CHANGING TIMES

The FCRPS operates today in a world that planners of the first hydroelectric plants on the Columbia River could only have imagined. Over the last two decades, intense economic and environmental pressures have been brought to bear on the federal dams, most of which are now between 40 and 60 years old.

Age alone has taken its toll on the system. All 31 dams in the FCRPS were completed prior to 1977. The oldest, Minidoka, began operating on the Snake River in 1909, and the Boise River Diversion Dam followed in 1912. The newest dams, Lower Granite on the Snake, Lost Creek on the Rogue and Libby on the Kootenai, went into service in the mid-1970s. The median age of the generating units in the system is 45 years, and as might be expected, maintenance demands have increased sharply over the past decade.

In addition, competitive power generation markets have been developing since the late 1970s, when federal legislation opened the door to independent power production. Laws and policies that once regulated wholesale generation continued to unravel through the 1980s. And in 1992, Congress adopted the Energy Policy Act, which took the nation a giant step forward along the path toward competition in electricity production. The Act exempted independent generators from being governed as public utilities and led the charge toward open transmission access. Like other regions in the country, the Pacific Northwest is grappling with the issues related to forming a Regional Transmission Organization and assuring non-discriminatory access to transmission lines. In addition, the 1992 Act enabled direct-funding agreements between BPA and the Corps and Reclamation described in the adjacent box.

DIRECT-FUNDING ERA BEGINS

The Energy Policy Act of 1992 signaled changes for the FCRPS. Along with spurring greater competition in wholesale power markets, it contained provisions that allowed the Corps and Reclamation to enter agreements under which BPA directly funds power-related operations and maintenance and capital investments at FCRPS dams. These "direct-funding agreements" opened the door to an integrated and business-like approach to system management and have contributed to improvements in overall performance.

The FCRPS agencies are also addressing the ESA in managing today's system. Power operations have been constrained in the past decade by the listings of several species of Columbia River Basin salmon and steelhead under the ESA. NMFS and the USFWS have influenced system operations over the past decade through a series of consultations, Biological Opinions and an elaborate, multilayered process for working through in-season operating changes.

The agencies estimate the system has lost about 1,000 aMW of annual energy production due to operational requirements brought about by the ESA listings. The energy loss comes at a time when population and development in the Pacific Northwest have grown rapidly. The population in the four Northwest states - Washington, Oregon, Idaho and Montana - grew by about 20 percent over the last decade, and the region's consumption of electricity increased accordingly. Load growth has taken a large jump in the region, particularly for residential and commercial use.

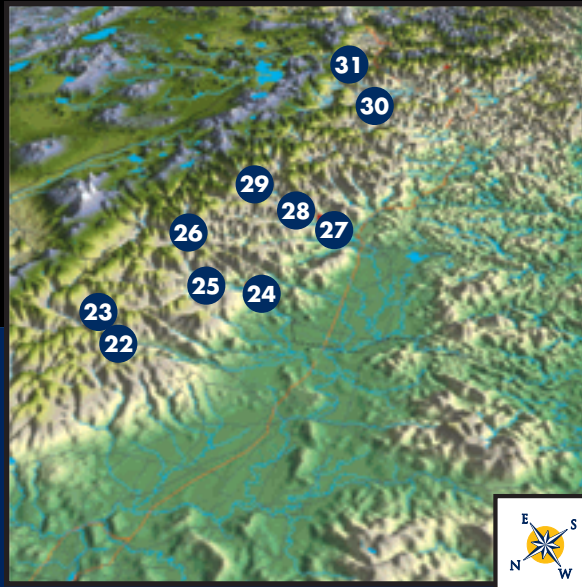
1 aMW of generation = 8,760 megawatt-hours

These economic, competitive and environmental pressures have affected the FCRPS, and they have transformed the needs and expectations of customers who purchase power from the system. In the mid-1990s, BPA customers demanded the opportunity to purchase power to meet some or all of their loads from the competitive power market. But they returned to the federal system five years later, seeking refuge from escalating market prices.

This is the backdrop against which the modern FCRPS operates and the federal agencies are planning and managing major system upgrades. Serious challenges are present, but the agencies have a growing store of tools to deal with them.

One of the most important of these tools is the integrated business management approach that is a result of the direct-funding agreements and an asset management strategy developed in 1999. Technology is also contributing muscle. As the FCRPS agencies rehabilitate facilities, they are taking advantage of advances in powerhouse engineering and mechanics, as well as computer software for optimizing hydro operations and extracting small efficiency increases that translate into big gains. In other words, the agencies recognize the challenges and are already on the way to meeting them.

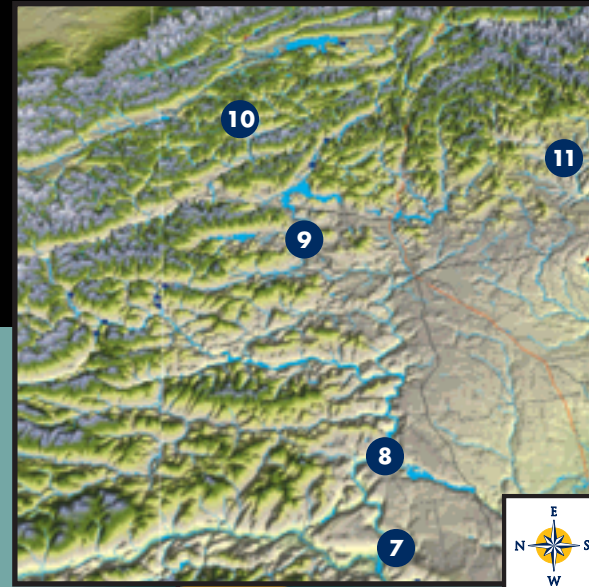
Willamette & Rogue



Lower Columbia



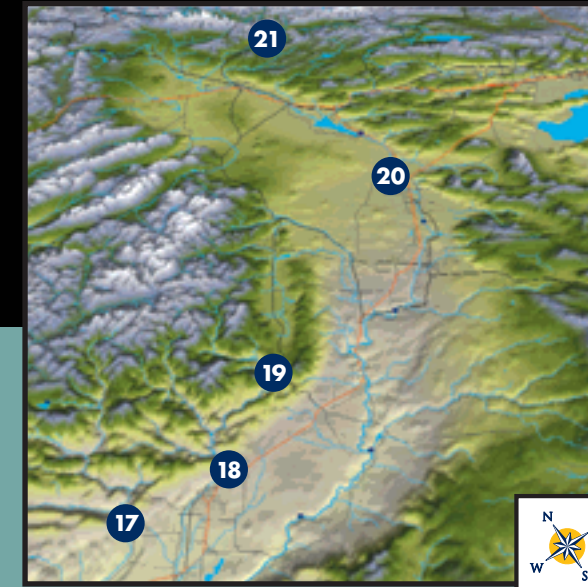
Upper Columbia



Lower Snake



Upper Snake



	PLANT	IN-SERVICE	PLANT CAPACITY (MW)	OPERATING AGENCY
Lower Columbia	1. Bonneville	1938	1104	Corps
	2. The Dalles	1957	2080	Corps
	3. John Day	1971	2480	Corps
	4. McNary	1952	1120	Corps
	5. Chandler	1956	12	Reclamation
	6. Roza	1958	13	Reclamation
Upper Columbia	7. Chief Joseph	1958	2614	Corps
	8. Grand Coulee	1942	6809	Reclamation
	9. Albeni Falls	1955	49	Corps
	10. Libby	1975	605	Corps
	11. Hungry Horse	1953	428	Reclamation
Lower Snake	12. Ice Harbor	1962	693	Corps
	13. Lower Monumental	1969	930	Corps
	14. Little Goose	1970	930	Corps
	15. Lower Granite	1975	930	Corps
	16. Dworshak	1973	465	Corps
	Upper Snake	17. Black Canyon	1925	10
18. Boise River Diversion		1912	2	Reclamation
19. Anderson Ranch		1950	40	Reclamation
20. Minidoka		1909	28	Reclamation
21. Palisades		1958	177	Reclamation
Willamette & Rogue	22. Big Cliff	1953	21	Corps
	23. Detroit	1953	115	Corps
	24. Foster	1967	23	Corps
	25. Green Peter	1967	92	Corps
	26. Cougar	1963	28	Corps
	27. Dexter	1954	17	Corps
	28. Lookout Point	1953	138	Corps
	29. Hills Creek	1962	34	Corps
	30. Lost Creek	1977	56	Corps
	31. Green Springs	1960	17	Reclamation
Total Corps of Engineers				14524 MW
Total Bureau of Reclamation				7536 MW
Total Federal Hydro				22060 MW



Section 2: THE FCRPS IN CHANGING TIMES

Early Efforts Jump-start Rehabilitation

Age, limited funds for operations and maintenance (O&M) and increased demands of maintaining fish-protection facilities have contributed to the overall decline in FCRPS generating unit availability. Beginning in 1990, the availability curve started downward, and by 1995, total system availability had declined to 82 percent, compared with an industry average of 90 percent.

The situation began to turn around in 1996. The direct-funding agreements cut the amount of time it took to secure funds and increased the amount of money available for both O&M and capital improvements. The agreements contributed to an immediate upswing in unit availability, which has continued for a number of years.

Several major projects at FCRPS facilities were begun in recent years. These projects aim to improve availability and address escalating O&M costs. For example, a modernization project at John Day Dam was completed in the late 1990s, and major rehabilitation efforts are now under way at Bonneville and The Dalles dams. At Grand Coulee Dam, the generator stator windings and cores were replaced on three units, and a major turbine-runner replacement program is ongoing. At Minidoka, the powerhouse was extensively rehabilitated, replacing five old units with two new larger ones. In addition, there have been less extensive projects, including generator rewinds and replacement of exciters at The Dalles.

This initial work made a major contribution toward FCRPS renewal. But despite these successful early undertakings, the FCRPS agencies realized in the late 1990s that a more methodical, collaborative approach was needed to restore the system and once again maximize its enormous potential. In 1998, a multiagency team began to craft a solution. The Asset Management Strategy for the Federal Columbia River Power System, released in June 1999, signaled a new way of doing business.

CASE IN POINT:

Rehabilitating an FCRPS Pioneer

The first powerhouse at Bonneville Dam is currently undergoing a multimillion-dollar overhaul. In July 1996, after several years of preparation, the Corps began the on-site work to replace 10 turbines and rewind and replace stator cores on six generators in the oldest federal hydro plant on the mainstem of the Columbia River. Many other improvements are planned, including rehabilitating or repairing bridge cranes and rails, and replacing mechanical components in the governors with electronic digital controls.

Bonneville Dam has served the Northwest since 1938, when the first powerhouse came on line with a capacity of 526 MW. A second powerhouse added 558 MW in 1983.

The rehabilitation is already contributing to increased unit availability and reliability in the FCRPS. The work on several generating units is done, and the others are scheduled to be complete in 2011. The total project cost has been estimated at over \$130 million, including all contracts and in-house labor. When the project is finished, the Corps expects to see an 8 percent efficiency gain with new turbines.

CASE IN POINT:

A Rush of Excitement at The Dalles

By 1996, it was clear that the exciters on generators at The Dalles Dam were affecting unit availability and reliability. The 40-year-old rotating exciters were difficult to maintain and prone to failure.

Problems with the exciters reduced availability at the powerhouse by 26 percent during the mid-1990s and put one of the 22 generating units out of commission entirely. While the Corps planned to replace the exciters during a major rehabilitation at The Dalles, the exciters posed an immediate concern.

The Corps and BPA decided in March 1996 that direct funding provided an opportunity to replace the rotating exciters sooner. The agencies entered into an agreement to replace exciters on eight units with state-of-the-art static exciters. The installations began in 1997. The economic analysis showed the FCRPS would recover its \$2 million investment within seven months. In addition to increased reliability and restored generating capacity, the FCRPS has saved considerably on maintenance costs since the exciter installations were completed in January 1998. A Corps effort to replace the remaining 14 exciters at The Dalles wrapped up in 2000.

CASE IN POINT:

Replacement Up and Running at Grand Coulee

Reclamation has a major project under way at Grand Coulee Dam to upgrade turbines and replace turbine runners. With an installed capacity of 6,809 MW, Grand Coulee is the largest generating project in the FCRPS. A study of replacing the runners began in 1994, when a Reclamation/BPA team explored the benefits of installing state-of-the-art runners in conjunction with a scheduled overhaul of the 18 units in the left and right powerhouses. Each of these units is rated at 125 MW. The team determined that new runners could increase efficiency and enhance total annual energy production by an estimated 31 aMW.

Currently, the upgrade/runner-replacement program is estimated to cost about \$90 million, and the value of the increased generation is forecast to be \$10.5 million annually. The runner-replacement program is being financed by BPA through a direct-funding agreement with Reclamation, an example of how direct funding can be used to provide energy benefits to the FCRPS more quickly.

The first runner installation was completed in late 2001, and the unit is back in operation. Tests show that the rehabilitation increased the efficiency of that unit by 3.9 percent, greater than the 3.75 percent originally projected. Work continues on the runner replacements, and the schedule calls for completing two or three every year. The program is scheduled to wrap up by 2009.



Ice Harbor Dam



Section 2: THE FCRPS IN CHANGING TIMES

Asset Management: A Blueprint for Collaboration

BPA convened a team in 1998 to develop an asset management strategy that focused on the long-term needs of the FCRPS. The team's goal was to characterize the investments needed over the next 12 to 15 years to restore the FCRPS to a high standard of reliability and to assess the ability of the system to produce additional revenue. With participants from the Corps, Reclamation, BPA, Energy Northwest and a consulting engineering firm, the team assessed the condition of the generating assets and compared their performance to other North American hydropower plants. The team then identified projects needed to restore reliability and enhance revenues. Improving O&M practices and business processes were other topics the team explored. The result of this joint effort was a strategy to guide activities and investments in a targeted, business-like way to maximize FCRPS value.

The team estimated that an investment of \$825 million over 13 years would return the FCRPS to at least 90 percent availability. Major investments were needed to rewind generators, replace unit circuit breakers and refurbish turbines. In addition, the team cited other investments totaling \$150 million that would enhance FCRPS revenues. Turbine runner replacements and optimization improvements would bring about \$75 million in net benefits over the next 14 years and \$190 million over the next 40 years, according to team



The value of the FCRPS goes beyond dollars and cents. The Columbia River has enormous environmental and cultural significance for the citizens of the Northwest, and environmental stewardship is a key indicator identified in the asset management strategy to measure system performance.

projections. Updated calculations indicate the benefits would be greater than originally projected.

The FCRPS agencies adopted the asset management strategy as their blueprint to renew and revitalize the system. The strategy calls for making targeted investments to improve the condition of the generating equipment and restore the reliability of the FCRPS. With this strategy, the agencies expect to achieve significant reliability and revenue benefits. A number of case studies in the sections ahead illustrate the work the agencies are doing to implement the asset management strategy. These efforts are readying the FCRPS for a future of productive operation and contributions to the lives of the citizens of the Northwest, as well as to a nation that values clean and renewable resources.

A Business Model for the 21st Century

The asset management strategy has brought significant and constructive changes to the way the rehabilitation of the FCRPS is being managed. The collaboration that went into forging direct-funding agreements and developing the strategy has nurtured a spirit of cooperation among the FCRPS agencies. While each agency has its own distinct identity and mission, much greater effort is being made to plan and manage the system collectively and to arrive at shared objectives. Multiagency teams that plan and implement solutions have become standard operating procedure in today's FCRPS.

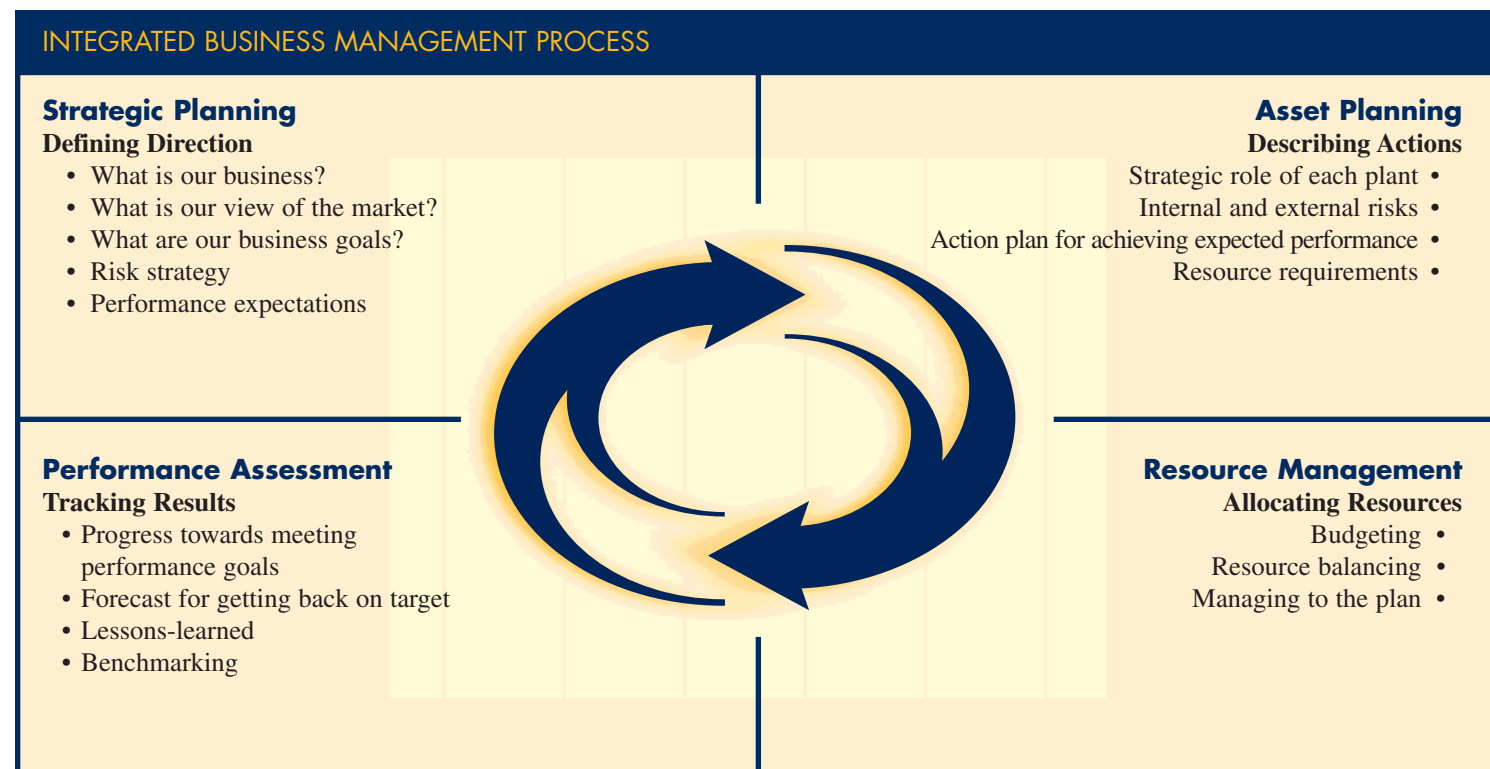


The FCRPS agencies are working with the tribes of the Columbia River Basin to plan and fund cultural resource management. A coordinated, multiparty effort has significantly enhanced what the agencies can offer the tribes in terms of assistance and funding.

The strategy pointed the way to an integrated business management process for the federal system that the agencies are using today to plan and execute projects and to evaluate their success. The process, which is illustrated in the diagram below, takes a systemwide view of asset management and begins with joint **strategic planning**. In the initial phase, the FCRPS agencies work together to develop broad annual goals and performance expectations, which are then shaped into a business strategy.

Depending on the project, this third phase can last for years. In the last phase, **performance assessment**, the agencies track progress toward meeting the performance goals and conduct lessons-learned exercises and benchmarking to feed back into the strategic planning process.

The integrated business management process is evolving. But the initial framework, which has been in development over the past couple of years, gives the FCRPS agencies a systematic



As part of phase two, **asset planning**, the agencies consider the role of individual hydro plants, then define their contribution toward meeting corporate goals. The agencies conduct cost/benefit analyses that are used to establish budgets sufficient to correct deficiencies or enhance efficiencies in the FCRPS.

Resource management, the action phase of the process, is where project prioritization, resource allocation and program implementation take place. The actual investment of dollars is made during this phase. All expenditures are tracked and compared against the plans with course corrections and adjustments made.

way to plan and deploy their resources most effectively, avoiding redundancies and discovering synergies that contribute to operating and maintaining the FCRPS for maximum benefits. Improvements in technology are augmenting the benefits as the agencies implement the asset management strategy and carry out reliability and efficiency enhancement measures. Advances in hardware and software, from turbine runners to electronic controls, offer opportunity to achieve even greater benefit from the FCRPS. As the agencies modernize powerhouses and optimize system operations, they are doing so with state-of-the-art technology that improves reliability and performance.



Section 2: THE FCRPS IN CHANGING TIMES

CASE IN POINT:

Managing Space Transformers

A multiyear study that began in 2002 is helping the Corps and BPA determine the economic benefit of maintaining an inventory of spare main unit transformers. The agencies started with a six-month effort to assess the condition of 155 transformers at 21 Corps dams. The transformers, which vary in age from 10 to 50 years, were rated as good, fair, or poor, based on performance tests, maintenance and operation history, and age.

With the condition information at hand, an economic analysis was done to organize the transformers into categories depending on the priority for replacement and the economic benefit that would result. Each transformer was finally ranked into one of the following four categories: spare exists and one or more appears justified; no spare exists and one or more appears justified; spare exists and none is justified; and no spare exists and none is justified.

The study results have been used to develop a plan for making objective, cost-effective investments in the multimillion-dollar transformer units. A top priority is purchasing spare units for the powerhouse at McNary Dam. The study identified where other transformer purchases are warranted, and further evaluation is now under way.

CASE IN POINT:

Rolling Out New Breakers; Governors Up Next

The Corps has begun installing new breakers at four FCRPS dams: Bonneville, Chief Joseph, The Dalles and McNary. After decades of service, the breakers at these facilities need to be replaced, and the Corps and BPA started to draw up plans in late 1999 to purchase and install new SF6-type units. These state-of-the-art breakers require less maintenance than mechanical types. The Corps has established a \$29 million contract to install 43 breakers over the next five years, with the first installation to begin at The Dalles. Eventually, the Corps will replace a total of 83 breakers at a number of plants. Reclamation has similar plans for replacing the original breakers at Grand Coulee.

The Corps and BPA are also collaborating on specifications for new digital governors to replace the old mechanical equipment throughout the FCRPS. The nearly \$50 million program to change out as many as 160 governors at Corps projects will improve system reliability, and new measuring equipment - also part of the plan - is expected to increase plant efficiency.

CASE IN POINT:

Optimization Extracts MWs

The FCRPS Hydro Optimization and Power Plant Efficiency Improvements Project, which began in 1998, is employing computer technology to optimize plant operations and gain generating efficiency. A software tool called the Near Real Time Optimizer (NRTO) is at the heart of the effort to improve the efficiency of the water-to-energy conversion at generating plants in the system. Optimization is complex in a system with over 200 generating units, and the power of the NRTO is the speed at which it can perform mathematical calculations for schedulers to keep units operating at peak efficiency.

Every generating unit in the FCRPS has a unique performance curve at a particular hydraulic head. While the unit can operate anywhere along the curve, there is a certain point at which it generates most efficiently. The NRTO combines the individual performance curves and plots a composite for the plant to determine the best combination of unit generating levels. The power scheduler and plant operators can use NRTO to adjust generation levels of the plants and units to maximize the generation efficiency.

The development of NRTO is being carried out in stages. Version one of the software has been developed and is now being tested to insure it will help BPA's duty schedulers to determine efficient plant basepoints. The Corps and Reclamation will later test NRTO at Grand Coulee and The Dalles dams. During the tests, NRTO will mirror real-time operations and allow plant operators to gauge how their control systems dispatch the generating units and whether this software could improve the efficiency of generation.

Optimization is one of the most promising tools for increasing efficiency in the FCRPS. It offers a cost-effective way to extract marginal efficiencies, which increase the benefits of the system. Developing and implementing the NRTO is part of a larger optimization effort. The agencies expect to gain up to 400 aMW over the next decade for a total investment of about \$75 million.

CASE IN POINT:

McNary Modernization Under Study

The next major turbine upgrade in the FCRPS will likely be at McNary Dam. A study of the modernization options is complete, and a Corps/BPA team concluded the most cost-effective course of action would be to replace all 14 turbines at the plant.

McNary Dam, brought into service in the mid-1950s, has substantially less hydraulic capacity than other projects downriver - 38 percent less than John Day, 61 percent less than The Dalles and 25 percent less than at Bonneville. Modernization presents an opportunity to install turbines with higher flow capacity, allowing more water to move through the powerhouse and augment generation.

In 2000, the team began looking at options for modernization and quickly focused on turbine replacement involving a new type of runner. Fish passage is also a big issue at the dam, and the team factored into its recommendation the requirements of NMFS' 2000 Biological Opinion. The team's recommendation calls for considering turbines that may reduce impacts to migrating fish and suggests testing to assure that the turbine selected provides adequate passage.

In the end, the team concluded the greatest economic benefit would come from installing increased-diameter minimum-gap diagonal-flow runners. This option would increase the hydraulic capacity of the powerhouse from 172 thousand cubic-feet per second (kcfs) to 255 kcfs; increase the capacity of each generating unit from 84.7 megawatt-amperes (MVA) to 100 MVA; increase overall energy production by 99 aMW; and provide a net economic benefit that ranges from \$60 million to \$198 million on a total capital investment of \$172 million.

CASE IN POINT:

G-DACS Boosts Reliability

Within the next year, the Corps will complete an extensive project to replace or install data acquisition and control systems at 10 of its hydroelectric projects. The FCRPS experienced several serious disturbances in the summer of 1996, including a voltage collapse. As a result, a Corps/BPA team went to work to fund, design and install the Generic Data Acquisition and Control System (G-DACS) to help enhance system reliability.

The team determined that the data acquisition and control systems needed to be standardized among the hydro projects, and subgroups researched various software options and reviewed their performance. Hardware specifications and purchases were another part of the project, followed by extensive testing. The first G-DACS installation took place at McNary Dam in the spring of 1999, and installation is wrapping up at powerhouses at The Dalles and John Day. G-DACS installations at Bonneville, Dworshak, Chief Joseph and the four lower Snake River plants will be completed by 2004.

The overall cost of G-DACS, which is being financed through a direct-funding subagreement, is \$38 million. BPA and the Corps have formalized a long-term maintenance program to assure that G-DACS remains up to date and reliable.

Grand Coulee Dam





Section 2: THE FCRPS IN CHANGING TIMES

A Solid Future for a Sterling Resource

The direct-funding agreements, the asset management strategy, the integrated business management process and the new era of cooperation and collaboration they engendered have produced tangible results for the FCRPS. The systemwide unit availability rate has increased from 82 percent in 1995 to an average of about 88 percent in recent years. In addition, the forced-outage factor at FCRPS plants has dropped from 6 percent to about 3 percent or less, which adds up to lower maintenance costs and improved system reliability. Simply put, the system is in shape to produce power more reliably and operate more efficiently, and it will get even better as investments in powerhouses are made and O&M practices improved.

Examples of improved O&M management are evident throughout the FCRPS today. The operating agencies are applying the latest techniques - reliability-centered maintenance and materials inventory and handling systems - and continuously improving their practices to assure that generating units are at top performance and available when they are needed.

Communication among agencies, including a weekly system-operations conference call, and increased coordination - deploying technical experts to projects around the system, regardless of their agency affiliation - are saving dollars and adding value. In addition, the agencies are working at the project level to provide staff with a greater appreciation for their role in the big FCRPS picture.

The 31 federal dams of the FCRPS are the foundation of the Northwest's power supply, and in large measure, they fuel the region's economy. With a transmission grid that reaches thousands of miles, the FCRPS provides power to customers up and down the West Coast - from Canada to California - and eastward to the Desert Southwest.

These hydro plants provide a sustainable source of electricity, a particularly important attribute at a time when global tensions and environmental concerns threaten our national energy security. The FCRPS agencies are setting a course for a clean and renewable energy future by investing in powerhouse modernization and other improvements to maximize the multipurpose use of the Columbia River.



CASE IN POINT:

New Life for an Obsolete Plant

A historic Reclamation power plant, sidelined for 20 years, could be generating electricity again within a year. Reclamation has partnered with BPA to rehabilitate the Boise River Diversion Dam Powerplant, seven miles southeast of Boise, Idaho. The hydro plant was built in 1912, four years after the dam was originally completed, to supply power for construction of Arrowrock Dam upriver. The three original generating units had a total capacity of 1.9 MW.

In 1982 after 70 years of service, Reclamation idled the plant due to increasing O&M costs and deteriorating equipment. In the early 1990s, Reclamation began studying whether to rehabilitate or replace the plant. BPA agreed in 1995 to pay for rehabilitation, but uncertainties about the power market kept the project in limbo for several years. A 2001 study indicated the time is right to bring the plant back into operation. The dam and power plant, which is still furnished with its 1912 equipment, are listed on the National Register of Historic Places.

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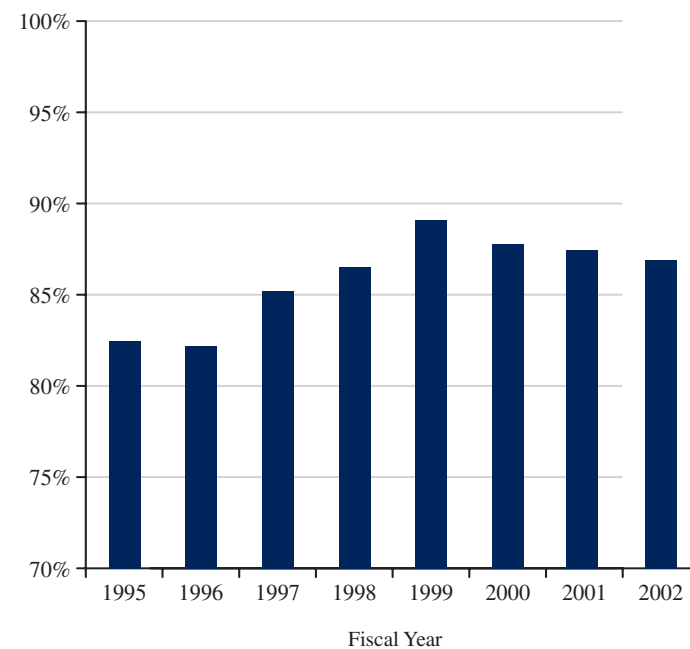
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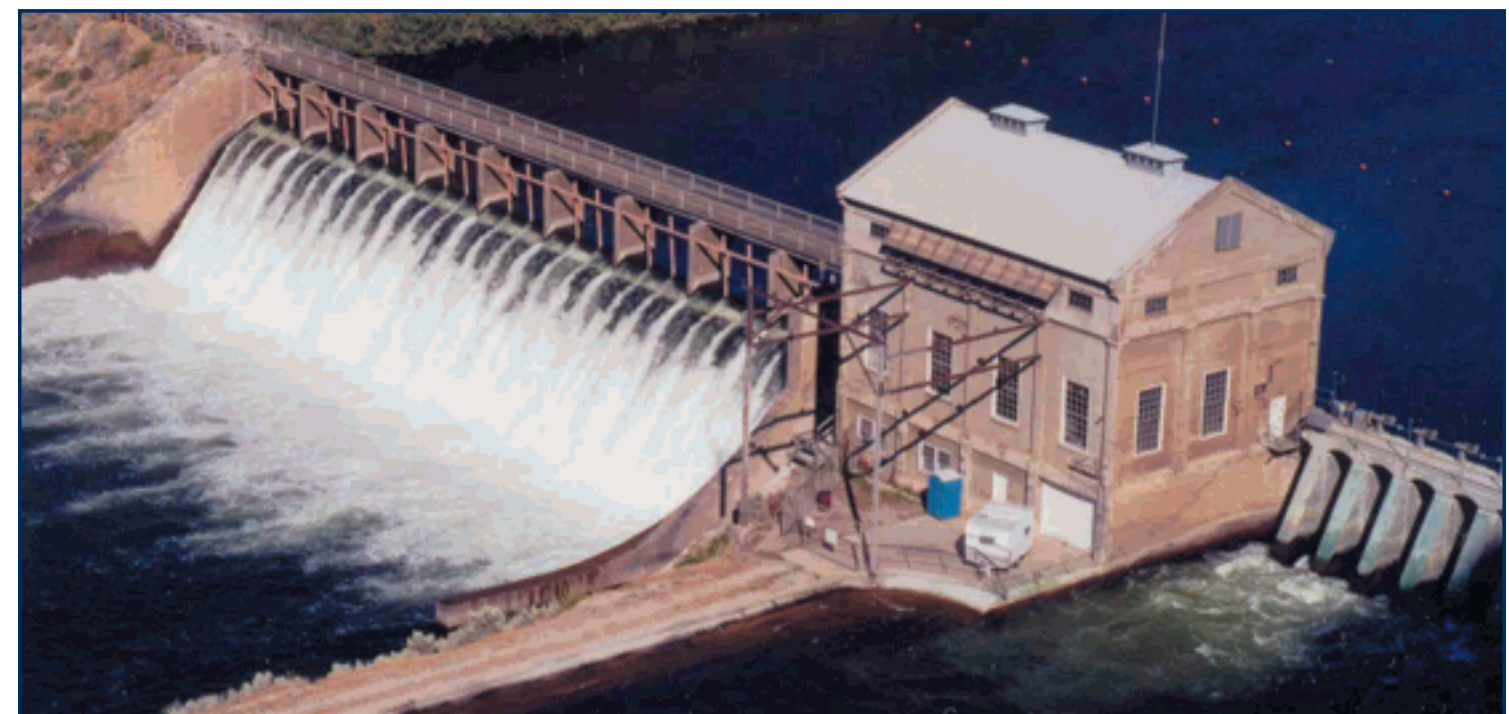
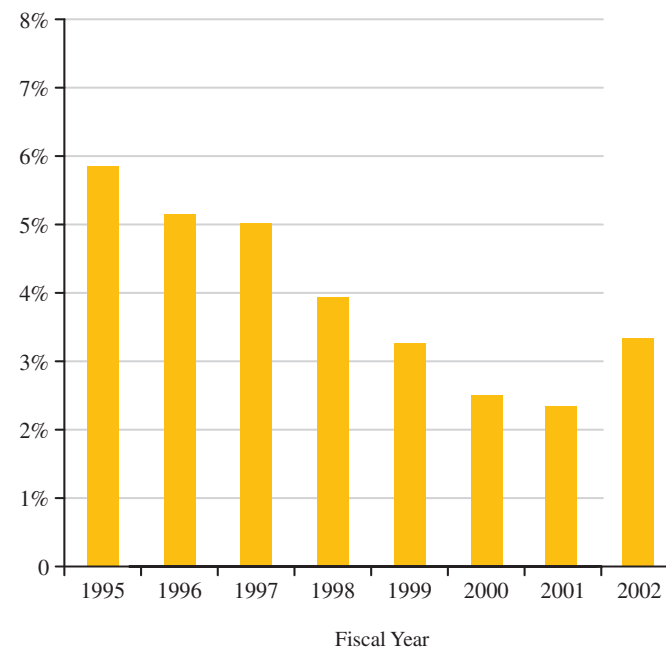
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IMPROVEMENT IN UNIT AVAILABILITY AND FORCED OUTAGE

FCRPS MW-Weighted Availability



FCRPS Forced Outage Factor



Boise River Diversion Dam