WCD Case Study

Grand Coulee Dam and the Columbia Basin Project USA

Final Report: November 2000

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Please cite this report as follows:
Ortolano, L., Kao Cushing, K., and Contributing Authors. 2000. *Grand Coulee Dam and the Columbia Basin Project, USA*, case study report prepared as an input to the World Commission on Dams, Cape Town, www.dams.org

The WCD Knowledge Base

This report is one component of the World Commission on Dams knowledge base from which the WCD drew to finalize its report "Dams and Development-A New Framework for Decision Making". The knowledge base consists of seven case studies, two country studies, one briefing paper, seventeen thematic reviews of five sectors, a cross check survey of 125 dams, four regional consultations and nearly 1000 topic-related submissions. All the reports listed below, are available on CD-ROM or can be downloaded from www.dams.org

Case Studies (Focal Dams)
- Grand Coulee Dam, Columbia River Basin, USA
- Tarbela Dam, Indus River Basin, Pakistan
- Aslantas Dam, Ceyhan River Basin, Turkey
- Kariba Dam, Zambezi River, Zambia/Zimbabwe
- Tucurui Dam, Tocantins River, Brazil
- Pak Mun Dam, Mun-Mekong River Basin, Thailand
- Glomma and Laagen Basin, Norway
- *Pilot Study of the Gariep and Van der Kloof dams- Orange River South Africa*

Country Studies
- India
- China

Briefing Paper
- Russia and NIS countries

Thematic Reviews
- TR I.1: Social Impact of Large Dams: Equity and Distributional Issues
- TR I.2: Dams, Indigenous People and Vulnerable Ethnic Minorities
- TR I.3: Displacement, Resettlement, Rehabilitation, Reparation and Development
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- TR II.1: Dams, Ecosystem Functions and Environmental Restoration
- TRII.1: Dams, Ecosystem Functions and Environmental Restoration
- TR II.2: Dams and Global Change
- TR III.1: Economic, Financial and Distributional Analysis
- TR III.2: International Trends in Project Financing
- TR IV.1: Electricity Supply and Demand Management Options
- TR IV.2: Irrigation Options
- TR IV.3: Water Supply Options
- TR IV.4: Flood Control and Management Options
- TR IV.5: Operation, Monitoring and Decommissioning of Dams
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- TR V.1: Planning Approaches
- TR V.2: Environmental and Social Assessment for Large Dams
- TR V.3: River Basins – Institutional Frameworks and Management Options
- TR V.4: Regulation, Compliance and Implementation
- TR V.5: Participation, Negotiation and Conflict Management: Large Dam Projects

- **Regional Consultations – Hanoi, Colombo, Sao Paulo and Cairo**

- **Cross-check Survey of 125 dams**

Acknowledgements

The editors and contributing authors wish to thank federal agency staff from the Bureau of Reclamation, Army Corps of Engineers, Bonneville Power Administration, and BC Hydro for assisting throughout the research process. In particular, we would like to thank Jim Mumford (USBR), Craig Sprankle (USBR), John Moody (USBR), Al Reiners (USBR), Brayton Willis (USACE), Peter Brooks (USACE), Ron Rodewald (BPA), John Hyde (BPA), Anthony White (BPA), Mary Algar (BC Hydro), Daryl Fields (BC Hydro), and Tim Newton (BC Hydro).

Additionally, we are grateful to Adeline Fredin and Mike Marchand of the Colville Confederated Tribes and Brian Flett and Tony Atkins of the Spokane Tribe of Indians for their participation in the study.
We would also like to thank Sophie Pierre and William Green, representing Canadian First Nations for their contribution to the case study. Thanks are also due to Josh Smienk of the Columbia Basin Trust.

Other significant contributors to the report include Kathryn Utter, Mark Frigo, John Pizzimenti, Peter Donatek, and Stan Hayes of Harza Engineering.

Finally, we are indebted to individuals representing various stakeholder groups, which included farmers, public utility districts, local government representatives, tribal members, and environmentalists, who allowed us to interview them.

Financial and in-kind Contributors:

Financial and in-kind support for the WCD process was received from 54 contributors including governments, international agencies, the private sector, NGOs and various foundations. According to the mandate of the Commission, all funds received were 'untied'-i.e. these funds were provided with no conditions attached to them.

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Executive Summary

1. THE WORLD COMMISSION ON DAMS GLOBAL CASE STUDY PROGRAMME

This study is one of eight case studies being undertaken worldwide with a common methodology and approach to inform the World Commission on Dams investigation of the development effectiveness of large dams. This particular case study concerns Grand Coulee Dam (GCD) and the Columbia Basin Project (CBP), which were originally authorised as a single project but today they have come to be known by the two principal parts of the original project. GCD constitutes the dam and powerplant, Lake Roosevelt, and ancillary facilities at the dam. CBP constitutes the project to pump water from Lake Roosevelt to irrigate more than one million acres of land in the semi-arid region in the State of Washington known as the Columbia Plateau.

2. CONTEXT AND SCOPE OF THE GRAND COULEE DAM AND COLUMBIA BASIN PROJECT CASE STUDY

During the early 1930s, the US Army Corps of Engineers ("the Corps") and the Bureau of Reclamation ("Reclamation") each produced similar but separate plans for a dam near an enormous canyon known as the Grand Coulee. Each report contained a plan for pumping water from a reservoir behind the dam to be pumped into an equalising reservoir that would then feed a series of canals, which would then irrigate part of the Columbia Plateau. Each plan recognised that hydroelectric power revenues would have to be used to subsidise irrigation water because without a substantial subsidy, farmers would not be able to earn their livelihood by cultivating the semi-arid lands. The Corps recommended against federal implementation of their plan, in part because it was felt there was insufficient demand for power. In contrast, Reclamation supported federal involvement in carrying out their plan. According to the Commissioner of Reclamation, by the time the project was completed, the demand for power would be sufficient to absorb the electricity generated at GCD, and the increased population from major cities in the region — Spokane, Seattle, Tacoma, and Portland — would provide a local market for the products of irrigated farms.

After the presidential election of Franklin Delano Roosevelt in 1932, members of the Roosevelt administration decided to go ahead with a different version of the plans advocated by the Corps and Reclamation. Roosevelt's principal objective in building a dam at the Grand Coulee was to make good on campaign promises by putting unemployed people to work building the dam. Roosevelt was also an advocate of public power, and he felt that inexpensive power provided by a dam at the Grand Coulee would curb tendencies of private utilities to charge excessively high rates for power. The version of the dam authorised by Roosevelt's administrators was a low dam at the Grand Coulee that would provide hydropower, but not irrigation water. Roosevelt was concerned about the price of the project as proposed (ie, a high dam plus irrigation facilities), particularly since he had already committed to supporting Bonneville Dam and was troubled about investing more of the New Deal's funding in the Northwest than its population warranted. Initially, the project was to be constructed by the State of Washington with federal funds, but GCD and CBP soon became a federal project to be built and operated by Reclamation.

In 1935, Roosevelt's administrators shifted their position by supporting a high dam that would provide both hydropower and irrigation water according to the 1932 plan developed by Reclamation. Lobbying for the high dam had been intense and it came from a number of quarters, including Reclamation, a congressional delegation from Washington, and local project supporters. Moreover, the irrigation components were a means of meeting Roosevelt's goals for a planned project where farmers from other parts of the country could be relocated, and for an ample supply of cheap public power that could help reduce the high rates being charged by private utilities. Following the Roosevelt administration's decision, a Supreme Court decision gave Congress an opportunity to authorise the dam, which it did. The congressional authorisation indicated that the project would be for the purpose of controlling floods, improving navigation, regulating stream flow, providing irrigation water for the reclamation of public lands and Indian reservations, and “for other beneficial uses”. The authorisation called for “the generation of electric energy as a means of financially aiding and assisting such undertakings”.

GCD, which is a mile wide and 550ft (170m) high, is the largest producer of electricity in the US and the third largest producer of electricity in the world. Construction of GCD and its associated electrical generating facilities was carried out in two stages, separated by nearly three decades. The first stage, which consisted of the dam and two powerhouses, started in 1933 and was completed in 1951. The second stage, consisting of the “Third Powerplant,” began in the mid-1960s and was completed in 1975. GCD has a total generating capacity of 6 809MW, and during the 1990s, gross generation in some years was greater then 25 billion kWh.

Construction of CBP began in 1945 and was largely completed in 1955. Detailed planning for settlement and CBP agricultural activities was conducted under the auspices of the Columbia Basin Joint Investigations in the mid-1940s. Settlement of project lands began in 1949, and the last addition of lands to CBP occurred in 1985.

Remaining sections of this report are organised as follows. Section 3 describes the projected and actual impacts, as well as unintended consequences, of GCD and CBP. There are eight major sub-sections contained within Section 3 and they discuss, in consecutive order, the following issues: irrigation, hydropower, flood control, recreation, ecosystem impacts, social effects on non-indigenous peoples, effects on Native Americans in the US, and effects on First Nations in Canada. Section 4 considers system-wide operations and basin-wide impacts; Section 5 examines the distribution of costs and benefits and provides stakeholder perspectives on the project. Section 6 examines the decision-making process for the construction of GCD and CBP, while Section 7 examines the evolution of policies affecting GCD and CBP from the time the projects were first built to the mid-1990s. Finally, Section 8 introduces lessons learned from the case study. Below we summarise the principal findings from each of these sections.

3. PROJECTED AND ACTUAL IMPACTS OF THE GRAND COULEE DAM AND COLUMBIA BASIN PROJECT

Irrigation

Only about half of the 1 029 000 acres (416 000ha) proposed for CBP (as of 1945) are receiving irrigation water because the "second half " of project lands were never developed. Although the actual acreage that received water is almost half of what was planned, the rate of development of irrigated acreage was faster than originally anticipated.

Gross value of output per acre (in constant dollars) doubled from 1962 to 1992. This resulted from improved crop yields, the shift from traditional field crops to high-value fruits and vegetables, and farm size expansions that took advantage of improved farm technologies and economies of scale. CBP land areas devoted to wheat, potatoes and tree crops were underestimated by Columbia Basin Joint Investigations planners in the 1940s; those crops have been instrumental in generating substantial growth in the gross value of CBP agriculture. If the predicted crops had been grown in the expected proportions, the 530 000 acres (215 000ha) irrigated in 1992 would have produced approximately $338 million in $1998. The actual cropping patterns resulted in a gross value of production of $637 million in 1998 US dollars, nearly twice as much as predicted. Average CBP farm size is about 500 acres (200ha), far greater then early constraints of 160 acres. Government restrictions on maximum farm size and actual farm sizes have both increased as a result of changes in farm technology and economics.

Reclamation estimated the construction cost to bring irrigation water to 560 000 acres (227 000ha) at

$1.25 billion, whereas the actual cost was $3.6 billion, nearly three times the predicted value for the same area. The original (1932) goal of having CBP farmers repay 50% of the cost of constructing irrigation works, including drainage facilities, has long since been replaced by estimates closer to between 10% and 15%. The subsidy to irrigators results, in part from payments made by the US Treasury (and in the future, to be made by Bonneville Power Administration (BPA) ratepayers) for a substantial portion of the total construction costs allocated to irrigation. There has been no link between repayment schedules and total irrigation project costs. Instead, irrigators are charged based on their "ability to pay".

In 1932, Reclamation envisaged substantial pumping subsidies for irrigators. Although comparisons depend heavily on assumptions made about rates that BPA charges its customers (which vary by type of customers), the predictions of the power subsidy in 1932 (ie approximately $19 million a year) are a reasonable approximation of the actual subsidy. However, foregone revenues from power sales are only one dimension of the energy-related subsidy to CBP. Another dimension involves revenues forgone because water that could otherwise be used to generate hydropower is diverted to irrigation. A conservative estimate places the annual value of these forgone revenues at $39 million. In addition, withdrawal of water from the Columbia River for irrigation purposes means there is less in-stream flow to support the river's anadromous fisheries. Irrigation has also decreased the quality of return flows and groundwater aquifers.

Prices of CBP irrigation water were set low as a matter of public policy. The justification for subsidies to irrigators was based on meeting a policy objective of fostering the growth of rural communities with many small family farms. However, this policy objective was only partially satisfied because of factors such as changing agricultural technology and economics, and unanticipated drainage costs. Originally estimated at about $5 million (about 60 million in $1998), drainage costs have grown to close to $130 million (in nominal dollars; ie dollars spent in the years in which costs were incurred). Part of the spiralling drainage cost was absorbed by Reclamation, and (in 1962) part of the cost was shifted to irrigators when their repayment obligation was raised from an average of $85 ($775 in $1998) per acre to about $132 ($710 in $1998) per acre.

Multiplier effects predicted qualitatively in 1932 have occurred, evidenced by the economic vitality of the CBP area. While these indirect economic benefits are important from a regional perspective, their significance is diminished when a national accounting stance is adopted.

Hydropower

Reclamation estimated the cost of GCD and the left and right powerhouses to be about $2 billion (in $1998). The actual cost of these facilities, which is represented in Reclamation records in nominal dollars, was $270 million. Based on assumptions about when these expenditures took place, the total cost for this portion of GCD was $2 670 million (in $1998). This was about one-third more than envisaged by the early designers. In 1932, Reclamation's planners estimated that there would be 15 main generating units of 105MW capacity each, yielding a total of 1 575MW. The planners also estimated that the facility would yield 800 000 kW of continuous firm power, which would be available for commercial sale. Project critics believed that demand for this power would not materialise in a timely fashion.

The availability of low-cost power in the US Northwest during the late 1930s (a result of the Corps' Bonneville Dam) and early 1940s (the result of power generated by Bonneville Dam and GCD) made the US Northwest an attractive location for numerous war-related activities, most notably, aluminum plants and other heavy industry, shipyards, and a nuclear weapons facility at Hanford, Washington. Since 1941, a combination of very low electric power rates, high electricity demand from aluminum and other industries, and population growth has provided a ready market for GCD power. Indeed, the existence of low-cost power from GCD and other dams on the Columbia River helped fuel the economic development of the US Northwest and created further demands for low-cost power.

As a consequence of the war-related economic activity generated in the US Northwest that occurred in the late 1930s and early 1940s, power generation for GCD was much higher than anticipated. For example, from 1949 on, actual capacity exceeded predicted capacity; and from the time GCD started generating power in 1941, the amount generated has been greater than predicted values. The Third Powerplant was not anticipated in the 1932 project design. Once the Third Powerplant came online in 1975, the 1932 predictions of generating capacity and generation were exceeded by an enormous margin.

Estimated cost for the Third Powerplant (converted to $1998 from values reported in Reclamation's 1967 planning documents) was $1.9 billion, whereas the actual cost was $2.93 billion, an overrun of approximately 55%. In spite of the large cost overrun, if the 1967 benefit cost calculations for the Third Powerplant had been redone using actual cost instead of estimated cost, the result would have been a benefit-cost ratio of a still favourable 2:1 instead of the actual 3.18:1.

Power from GCD becomes part of the regional supply transmitted and marketed by BPA, and thus it is not possible to identify customers served by GCD power per se. However, power produced by the Federal Columbia River Power System (FCRPS) and marketed by BPA is sold to several types of customers through a variety of power sales agreements and rates. Customers include public utility districts, municipalities, rural co-operatives, federal agencies, a collection of enterprises referred to as direct service industries (DSIs), and private utilities. GCD plays a pivotal role in FCRPS. For example, from 1950 to 1953, power from GCD accounted for about three-quarters of total FCRPS revenues. As more projects came online, the contribution of GCD diminished, but it still remained the centrepiece of hydropower generation, accounting for 20% to 33% of total FCRPS kilowatt hours from the late 1950s to the present. According to BPA, on a cumulative basis, by the early 1990s, GCD had generated revenues equivalent to over $2.9 billion (in nominal dollars).

Ancillary services and dynamic benefits are unanticipated benefits of GCD hydropower production. Using the language of power engineers, examples of these services and benefits include the following: voltage support, spinning and non-spinning reserves, energy imbalance, generator dropping, and station service. The sale of these ancillary services and dynamic benefits will become increasingly important in future years as power markets develop, but it is currently not possible to accurately estimate the market value of these services and benefits. Other benefits of GCD that were not anticipated in 1932 include the atmospheric pollutants avoided by using hydropower instead of the most likely alternative: coal-fired steam electric powerplants. While these benefits of pollutants avoided may be notable, it is not possible to provide defensible quantitative estimates of their value.

Flood Control

Project planners did not provide for flood control as part of GCD. Indeed, flood control only began to be considered in the context of GCD after massive damages accompanied record flooding in 1948. Although the idea of providing upstream storage (in both Canada and the US) on the Columbia River for power generation had been under discussion since the mid 1940s, the flood of 1948 spurred those discussions forward and placed flood protection on the agenda as a potential major function of GCD and other dams upstream of urban population centres such as Portland, Oregon.

Following a 1964 agreement between the US and Canada known as the Columbia River Treaty, four "Columbia River Treaty projects" were built: Duncan, Keenleyside (formerly named Arrow Lakes), and Mica dams in British Columbia (BC), Canada, and Libby Dam in Montana. Once the last of the Columbia River Treaty projects had been built in 1973, key dams in the US and Canada began to be operated jointly to optimise power generation and flood control, while respecting other project purposes, such as irrigation. On the US side, the principal players concerning management of the dams were the Corps, Reclamation, and BPA. For purposes of operating Canadian storage for basin-wide flood control, the Treaty called for management by the Corps, BPA, and BC Hydro.

Because GCD is operated as part of a large system that includes other FCRPS dams and the Columbia

River Treaty dams in Canada, it is difficult to completely separate the influence of GCD in controlling floods from the effects of other dams. However, a 1999 Corps study of the annual flood control benefits derived from Grand Coulee Dam storage estimates the amount to be $20 200 000 in $1998.

Although the literature on flood control contains many references to ways in which flood protection works lead to more intensive development of flood plains with consequent future increases in flood damages (when flood control works fail), no specific documentation of this phenomena occurring in the Columbia River Basin could be found.

Recreation

In 1932, Reclamation planners did not anticipate the recreational benefits that are now associated with GCD and CBP. However, the Columbia Basin Joint Investigations of the mid-1940s anticipated the recreational potential of Lake Roosevelt. While no specific projections were made of potential visits to the project area, the investigations concluded that new recreational areas should provide for capacity of at least 40 000 to 80 000 additional people within the two decades following the end of World War II. Locations of major recreational facilities created by GCD and CBP are as follows: Lake Roosevelt National Recreational Area (Lake Roosevelt NRA), the dam itself, and CBP lands. These three categories of facilities are administered separately. Collectively, they currently receive annual visitor days totalling over three million.

Lake Roosevelt NRA houses numerous campgrounds, swimming beaches, boat ramps and boat docks. Six major facilities operated by the Colville Indian tribe offer houseboat and fishing rentals, fuel, and food. A 20-mile (32km) stretch of the shoreline along the Spokane River is also included in NRA. Recreation at GCD consist largely of guided tours and a laser light show featuring animated graphics on the downstream surface of the dam; the show runs every evening during summer and routinely attracts large crowds.

CBP created multiple opportunities for recreation, including major fishing areas such as Banks Lake and Potholes Reservoir. In addition there are six Washington State Parks and 32 other major state and federally managed recreation facilities in the CBP area. Recreation-related business is an economic mainstay for many communities located on our near major project reservoirs. These communities include Coulee Dam, Grand Coulee, and Electric City.

A number of issues related to recreation have become sources of tension. These include project operations that lower reservoir levels during the summer tourist season, and management conflicts between the National Park Service and the Colville and Spokane tribes.

Ecosystem Impacts

At that time GCD was planned, assessing ecological effects of proposed federal projects was neither a requirement nor a priority. The principal ecosystem impact of GCD and CBP has been on anadromous fish that once spawned past the dam, mainly, chinook, sockeye, and steelhead. Annual salmon populations in the Columbia River Basin have fluctuated widely, and estimates of numbers of fish vary significantly. Prior to white settlement in the 1800s, the basin supported a population estimated at between 7 and 30 million salmon and steelhead, with runs to the upper Columbia (ie, the portion of the basin above GCD) of between 500 000 and 1.3 million. Salmon and steelhead runs experienced substantial declines prior to construction of GCD because of factors such as the development of commercial fisheries, over-harvesting, grazing, timber harvesting, mining, dams on tributaries, Bonneville and Rock Island dams, roads, highways, railroads, and destruction of estuarine and freshwater wetlands. In 1938, before GCD cut off the upper Columbia River for migrating anadromous fish, the basin-wide run of salmon and steelhead was 2.2 million and the run to the upper Columbia River was estimated at 25 000.

Reclamation took control of GCD and CBP in 1933, but it was several years before it reached an agreement with the US Department of Fisheries (later, the US Fish and Wildlife Service (USFWS)) and the State of Washington regarding a plan to mitigate adverse effects on anadromous fish. This plan, the Grand Coulee Fish Maintenance Programme (GCFMP), was put forward by a board of consultants to the US Secretary of the Interior in 1937. Except for the Board's recommendation for a hatchery on the Okanogan River, the Board's plan was implemented.

The goal of GCFMP was to maintain a certain number of fish, not necessarily to preserve specific runs. For those in charge of the programme, fish were valued based on their commercial importance, and fisheries managers strove to maintain the commercial catch as measured in pounds. The economic losses associated with sport and commercial fishing were estimated at between \$250 000 and \$300 000 in 1937 dollars (\$2 841 000 to \$3 409 000 in \$1998). At the time GCFMP was developed, no significant consideration was given to the importance of salmon to indigenous people in either the US or Canada. Indeed, the Minister of Fisheries in Canada indicated little concern over the potential loss of salmon and steelhead because there were no commercial salmon fisheries on the Columbia River in Canada. The state of knowledge of ecosystems at the time was such that virtually no consideration was given to the maintenance of genetic biodiversity.

GCFMP entailed trapping all of the fish runs at the Rock Island Dam downstream of GCD and transporting them to four tributaries — the Wenatchee, Entiat, Methow, and Okanogan rivers — between Rock Island and Grand Coulee dams, for natural propagation; and to three hatcheries — Leavenworth, Entiat, and Winthrop — for purposes of artificial propagation. The hatchery at Leavenworth was completed in 1940, and the other two were completed the following year.

The underlying concept of GCFMP was that juvenile upper Columbia River fish stock reared at the aforementioned hatcheries and tributaries would, as adults, return naturally to the tributaries to spawn. The hatcheries would remain in operation merely to augment the run to populations larger than could be hoped for from natural runs alone. Natural propagation turned out to be far more successful than artificial propagation using hatcheries.

At the time GCFMP was developed and first implemented, there was an extensive commercial fishery and there were only two other main-stem dams (apart from GCD). Upper Columbia River stocks were then estimated at 25 000 in an average year. Although there were numerous problems that persisted over several years because of the experimental nature of the entire enterprise, the GCFMP target outcomes were attained. GCFMP met its own numerical goal: maintaining upper Columbia River stocks of 36 500 salmonids in an average year. In fact, during recent years, the upper Columbia River stocks have averaged approximately 48 700 per year.

A simple comparison of the Board's target with today's population sizes may lead one to believe that GCFMP has been successful since the original target has been exceeded. However, the changes that have occurred over the past 60 years make a meaningful comparison between the present populations and targets set in the late 1930s difficult, if not impossible. The inability to compare present populations to the Board's target of 36 500 salmonids is demonstrated by considering differences in commercial fishery takes. In the early 1930s, over 75 000 wild salmonids were caught in lower Columbia River commercial fisheries, whereas today no in-river commercial harvesting of salmonids is permitted. If a comparison is to be made, the escapement at Rock Island (25 000 wild salmonids) in the 1930s should be added to the 76 300 wild salmonids caught at that time by commercial fisheries to give 101 300 wild salmonids as the comparable 1930s escapement figure at Rock Island. This comparison — 101 300 in the 1930s versus 48 700 in recent years — places the effects of GCD and GCFMP in a different light. Another factor demonstrating why it is not meaningful to compare the 25 000 fish escapement at Rock Island in the 1930s with the current average escapement of 48 700 is that no hatcheries were in operation in the early 1930s, whereas numerous hatcheries are operating today. The salmonids at Rock Island in the 1930s were wild, whereas the majority of the 48 700 salmonids at Rock Island today are from hatcheries.

The aforementioned differences (among many others, including differences in the value attached to biodiversity and changes in regulations on sport fishing) are not the only factors that make it difficult to compare the salmonid runs of 1930s to those of the 1990s. Such a comparison is also difficult because of three significant irreversible effects that GCD and GCFMP have had on the mid- and upper-Columbia River anadromous fish. First, GCD blocks 1 100 miles (1 770km) of riverine habitat, making it a practical impossibility to significantly increase the number of salmonids in the upper-Columbia River Basin. This change is virtually irreversible since the likelihood that GCD will ever be removed is practically nil: the dam is of central importance to the Columbia River hydropower system. Second, the Board's plan makes it a practical impossibility to substantially increase the population sizes of the upper-Columbia River stocks in the mid-Columbia River tributaries because GCFMP was developed around a habitat area that cannot support significant population increases. And third, GCFMP made it impossible to ever recover the original stocks of the four mid-Columbia River tributaries. These stocks, considered insignificant at the time of the Board's analysis, were completely subsumed within the upper-Columbia River stocks through the trapping and transportation programme in the late 1930s and early 1940s.

High concentrations of total dissolved gas (TDG) can be fatal to anadromous fish, and operations at GCD affect dissolved gas in two ways. First, the dam carries TDG generated at upstream dams. Second, spill at GCD increases TDG down river. TDG is a basin-wide problem.

GCD provided the impetus for stocking Lake Roosevelt with native and introduced species of resident (as opposed to anadromous) fish. Although the Spokane and Colville tribes now operate kokanee and trout hatcheries funded by BPA, a number of problems have prevented attainment of target harvest levels. In particular, when Lake Roosevelt is drawn down beginning in the summer or early fall, the reduced volume and surface area limit food supply and volume of optimal water temperatures during periods that are often critical for trout. Also, there are conflicts between releasing flows for outmigration of anadromous smolts and maintaining ideal conditions for resident fish in Lake Roosevelt

GCD and CBP caused numerous changes in terrestrial ecosystems, including a substantial reduction in the original shrub steppe habitat that once existed in the project area. Although CBP-related habitat change has caused a decrease in the populations of species like pygmy rabbits and burrowing owls, CBP has also created large areas of new habitat in the form of wetlands, reservoirs, and riparian corridors. This has led to increases in many wildlife species, particularly waterfowl. However, physical changes in new habitats, such as artificial wetlands that are not regularly maintained, have led to a falloff in species abundance (compared to levels observed during the 1970s).

Social Effects: Non-indigenous Peoples

In keeping with the President Roosevelt's original motivations for supporting the project, GCD and CBP provided jobs for thousands of workers. Estimates of new employment range between 2 000 and 8 000 workers, depending on the year; the size of the local communities in the area around GCD grew to 15 000 during the construction period.

Between 3 000 and 4 000 non-indigenous peoples were displaced as a result of the creation of GCD. Lake Roosevelt itself flooded at least eight towns of non-indigenous peoples; while some towns were moved successfully to new locations, others were never reestablished. Notification of settlers to be displaced by dam-related activities was not conducted following any formal notification procedure. Compensation offered for land and property to be inundated was a major source of contention between Reclamation and some settlers who were displaced. At the time, Reclamation lacked legislative authority to assist in the relocation of people displaced by Lake Roosevelt.

The 1932 Reclamation Report did not say much about the influence of CBP on the development of the Columbia Plateau, but that subject was studied extensively during the 1940s by the Columbia Basin Joint Investigations. Although some early CBP planners had estimated there would be as many as 80

000 families on 10 000 farms within CBP, the actual results were far different. For example, in 1973, there were in 2 290 farms operating in the project area. Notwithstanding the differences between what was planned and what occurred, CBP has fostered development of an economically viable farming community that contributes significantly to the state's economy. In addition to farming and farm-related economic activity, tourism linked to GCD and CBP has made significant contributions to the overall prosperity of the region.

During the past few decades, social tension has developed between project supporters in eastern Washington and critics of FCRPS in Seattle, Portland, and other urban areas west of the Cascade Mountains. This tension, which revolves around the symbolic and ecological significance of salmon in the US Northwest, evolved gradually as the Seattle, Tacoma, and Portland metropolitan areas grew in size, and as the adverse effects of hydropower on salmon runs became more widely known. Another factor contributing to the escalating tension has been a shift in societal values, as many residents of the US Northwest have developed an increased appreciation for rivers in their natural state and as scientists come to better understand the significance of maintaining biodiversity.

Effects on Native Americans in the US

In keeping with 1930s practices concerning "executive order reservations", the US had no formal process for involving the Colville and Spokane tribes in GCD-related decisions concerning the taking of reservation lands or the destruction of tribal fisheries.

About 2 000 members of the Colville tribe and between 100 and 250 of the Spokane tribe were displaced as a result of GCD-related construction. After 1940, the Department of the Interior abandoned its former practice of acquiring Indian consent; thereafter, the government notified Native American landowners by mail concerning lands to be taken and apprised them of how much they would be paid. Appeals processes existed, but tribal members were not encouraged to engage in the process, nor were they supported when they initiated appeals. Although displaced tribal members appear to have received payments at the same level as displaced non-indigenous settlers, tribal members received their funds significantly later. Additionally, the process for assessing land did not value built structures on Native American lands (eg living quarters) the same as those of non-indigenous settlers. Two tribal towns — Keller and Inchelium — were forced to relocate. Inchelium had no water supply at its new site, and its residents did not regain telephone service for 30 years. The rate of filling Lake Roosevelt was such that many tribal graves were inundated; since then, many burial sites often have been exposed because of fluctuations in reservoir levels and increased bank erosion, leaving them open to theft and desecration. In addition, the physical barrier posed by Lake Roosevelt, and the increased density of settlement on the Columbia Plateau, cut off access of Colville and Spokane tribal members to food and medicinal plants and to each other's reservations.

According to tribal members we interviewed, government officials had indicated that the Colville and Spokane reservations would receive free electrical service from GCD, but they only acquired electricity much later and they usually paid a much higher price than typical off -reservation residents paid.

By completely eliminating runs of salmon above GCD, the project severely disrupted the way of life for the Colville and Spokane tribes: important salmon-based cultural and ritual ceremonies were eliminated, parts of language and crafts associated with fishing disappeared, and tribal members' diets changed significantly. For the Spokane and some of the tribes of the Colville Confederation, salmon probably accounted for about 40% to 50% of their daily diet before GCD. As a result of moving to foods high in fat, sugar, and salt, rates of heart disease, diabetes, and other diet-related illnesses have increased significantly on the reservations.

GCFMP further damaged the Colville tribe's fishery below GCD because the capture and transplantation of most adult fish to mid-Columbia River tributaries destroyed much of the remaining wild salmon that spawned between the Okanogan River and GCD, both on the main-stem Columbia River and on reservation streams. Collectively, problems with fish survival in the early days of the

GCFMP hatcheries, loss of fish that spawned in the upper reaches of the Columbia River, and genetic weakening through mixing stock made it much more difficult for members of mid-Columbia River Treaty tribes to maintain their traditional livelihood by fishing.

Fish losses and government mitigation efforts associated with GCD have exacerbated tensions between members of treaty reservations and executive order reservations. More generally, opportunities for misunderstandings among tribes have increased because salmon ceremonies, which used to provide an opportunity for enhanced understanding among members of different tribes, no longer take place. Other reasons for increased tensions include less salmon to go around and perceived inequities on how different tribes were compensated for the adverse effects of GCD (and FCRPS in general).

In 1978, acting on a claim by Colville Confederated Tribes, the Indian Claims Commission awarded more than $3 million (in nominal dollars) for the subsistence value of fish lost to the claimant tribes since 1940. In a claims case settled in favour of the Colvilles in the early 1990s, the US government made a $53 million lump sum payment (in nominal dollars) in recognition of the government's unfulfilled promise of 1933 to pay the tribes an annual share of power revenues. This settlement also included future payments by BPA to the tribes of approximately $15 million annually. Despite these monetary payments, many tribal members feel that no monetary compensation can make up for how GCD caused a loss of fisheries, towns, burial sites, cultural traditions, and, more generally, a way of life.

Effects on First Nations in Canada

As in the case of Native Americans, salmon were also central to the economic, cultural, and spiritual life of Canadian First Nations. Salmon were also integral to the daily diet of First Nations people. In contrast to Native American tribes, Canadian First Nations were unaware of plans to construct GCD. The federal government in Canada dismissed the importance of GCD as an impediment to migration of salmon because there was no commercial salmon fishery in the Canadian portion of the Columbia River Basin. GCD blocked all anadromous fish runs to the Ktunaxa, Shuswap, and Lakes-Sinixt territories. As a result of GCD construction, a number of fish populations or stocks were lost including Arrow, Slocan, and Whatshan sockeye, Columbia and Windermere Lake sockeye, and numerous stocks of chinook. GCFMP adversely affected the Okanogan sockeye population since it called for the harvesting of Okanogan sockeye for hatchery brood stock and the genetic mixing of wild and hatchery stocks.

The importance of salmon fishing to Canadian First Nations is demonstrated by the locations of current and former reserves at important fishing locations, including the confluence of the Kootenay and Columbia rivers. As a result of the loss of salmon along the Columbia River in Canada, members of the Arrow Lakes band disbursed to other communities. The Arrow Lakes band no longer has any enrolled members. Salmon provided the foundation for the subsistence economies of Canadian First Nations, and, at the time GCD was built, the subsistence economies were far more important than wage or commercial economies.

In contrast to the situation for Native Americans in the US, there has been no mitigation for the adverse impacts of GCD on Canadian First Nations. Canadian First Nations are actively pursuing mitigation and compensation for their salmon losses, particularly through efforts to achieve their long-term goal of salmon restoration.

4. BASIN-WIDE IMPACTS AND SYSTEM OPERATIONS

The 1932 Butler Report as a Plan for the Upper Columbia River Basin

In terms of hydroelectric power projects on the Columbia River above the Snake River, with minor modifications, every one of the dams in a 1932 Corps Report dealing with this reach of the river was eventually built. Key recommendations in this report, prepared by Major Butler of the Seattle District Office of the Corps, were overruled by the Chief of the Corps of Engineers. While Butler recommended that the government proceed with GCD and CBP, the Chief recommended against it. Instead, the official Corps position was that hydropower and irrigation projects in the Butler report be undertaken by parties other than the US government.

Influence of GCD on Decisions to Build other Water Projects within the Columbia River Basin

There is a strong linkage between GCD and many other dams on the Columbia River. In the US, this linkage is clearest for Libby Dam (located upstream in Montana) and Chief Joseph Dam (located immediately downstream). Libby was one of the Columbia River Treaty projects, and decisions to build each of those projects were directly affected by GCD. Operations at Chief Joseph Dam are tied closely to those at GCD.

The desire to increase power generation at GCD by having increased storage in Canada motivated discussions leading to the Columbia River Treaty. If the downstream power benefits to Canada resulting from the Treaty had not been made available, Canada was prepared to build coal-fired powerplants (instead of the Canadian treaty dams) to meet power needs in British Columbia. This makes clear the direct linkage between GCD and the Columbia River Treaty dams.

Effects of the Columbia River Treaty Dams on Canadian Resources and People

While there is substantial agreement about the nature of the flood control and power benefits of the Columbia River Treaty dams within Canada, differences of opinion exist about the adverse environmental and social effects of those dams within Canada. In general, the environmental and social effects concern loss of forestry resources and agricultural lands, effects on recreation and recreation related tourism, effects of fluctuations in reservoir levels, and the influence of the Canadian Treaty dams on the tax base of local communities.

Two major programmes have been established to compensate communities adversely affected by Canadian Treaty dams: one involves the Columbia Basin Fish and Wildlife Compensation Programme, a nonprofit entity separate from — but not independent of — its BC Hydro and BC Environment partners; and the second involves the Columbia Basin Trust, an entity with broad powers created to ensure that benefits derived from the Treaty help renew the economy and natural environment of the region impacted by the Treaty dams.

Cumulative Impacts of Projects on Ecosystems

Basin-wide factors affecting anadromous fish have been classified under the so-called “four H’s”: harvesting, referring primarily to adverse effects of over-harvesting; hatcheries; hydropower (ie, the influence of the many dams in the basin); and habitat, as affected by a number of activities including timber harvesting, wetland destruction, and irrigation.

Some scientists have suggested that spawning and spawned out salmon in the upper basin comprised an important source of nutrition for animals such as bears and eagles, and that GCD (along with other dams) blocked an important source of nutrient transfer from the Pacific Ocean to the upper Columbia River Basin. The specific effects of GCD have yet to be unraveled.

Cumulative Socioeconomic Impacts

In the context of the Columbia River Basin, the significance of cumulative socioeconomic impacts of dams is undeniable. Indeed, the notion of cumulative effects is implicit in the basin-wide plans laid out in the 1932 Corps Report prepared by Major Butler. In terms of socioeconomic effects of GCD and

CBP, the cumulative effects are seen in the economic development of the CBP area, and, more generally, in the US Northwest.

An important set of cumulative effects involves the influence of the CBP's agricultural outputs on farming activities in other parts of the US and Canada. In particular, many potato farmers in Idaho, once one of the leading producers of potatoes in the US, shifted to other crops in the face of very stiff price competition from potato growers receiving CBP irrigation water. Similarly, growers of apples, potatoes and other crops in British Columbia have felt increased competition from CBP farmers who produce the same outputs with the advantage of subsidised irrigation water.

Relationships between cumulative socioeconomic impacts and cumulative ecosystem effects are also notable. For example, GCD promoters minimised the importance of GCD in interfering with anadromous fish runs by arguing that those runs (which decision-makers valued in economic terms) had already been diminished significantly by Rock Island and Bonneville dams prior to the construction of GCD.

System Operations

At the time it was completed in 1941, GCD was operated to optimise power generation. Between 1948, the time of massive flooding in the lower Columbia River, and 1972, GCD was relied upon more heavily for flood control; in addition, power generation shifted from project specific to more system-wide management. After all four Columbia River Treaty projects came online in 1973, power generation and flood control activities at GCD were organised as a basin-wide management system. Under conditions of the Columbia River Treaty, BPA, the Corps, and BC Hydro schedule basin-wide management, and Reclamation works with BPA and the Corps in running FCRPS. Following passage of the Northwest Power Act of 1980, the creation of the Northwest Power Planning Council (NPPC) and its 1983 fish and wildlife programme marked the increased consideration of anadromous fish in decision-making related to FCRPS. In all GCD operations, irrigation water rights have been respected.

In 1990, BPA, the Corps, and Reclamation used the EIS process established by the US National Environmental Policy Act (NEPA) of 1969 to conduct a "System Operation Review". The three organisations developed an FCRPS system-operating strategy to balance the varied and sometimes conflicting needs of water users in the US portion of the basin. During the mid-1990s, the National Marine Fisheries Service (NMFS) listed the following species as endangered under the Endangered Species Act (ESA): Snake River sockeye, Snake River spring/summer chinook, and Snake River fall chinook. The Biological Opinions issued by NMFS in connection with the above-noted listings outlined what was required for species recovery. The federal operating agencies (BPA, the Corps, and Reclamation) have tried to adopt the general recommendations in the Biological Opinions in developing a preferred system operating strategy for FCRPS.

Current GCD operations reflect trade-offs among various project purposes. Reclamation develops operating requirements specific to irrigation at CBP, and BPA requests that reservoir operators (eg, Reclamation and the Corps) maintain reservoir levels to maximise power output given the limits imposed by requirements for irrigation, flood control, and maintenance of anadromous fisheries. Other issues, such as recreation, are also considered, but they have a lower priority.

Evolution of Basin-wide Planning Institutions

Advocates of basin-wide planning and management made a valiant effort during the 1930s and 1940s to create a new institution for comprehensive planning in the Columbia River Basin: the Columbia Valley Authority (CVA). That effort failed. Long-term squabbles between Reclamation and the Corps, and the reluctance of US Northwest residents to surrender the economic future of their region to some unknown and untested body helped kill the CVA idea.

BPA, initially created in 1937 as a temporary entity to market power from Bonneville Dam, became a permanent agency charged with marketing power from all federal dams on the Columbia River, including GCD. Between World War II and the ratification of the Columbia River Treaty in 1964, BPA, Reclamation, and the Corps dominated decisions associated with hydropower. Once the treaty was in force, BC Hydro joined this group of agencies as one of the principal participants in managing basin-wide operations. Currently, numerous federal, state, and local agencies, tribal governments, and others (including NPPC) are all taking a hand in planning and developing resources within the basin.

This ongoing proliferation of agencies has resulted inevitably in duplication of effort and cases where agencies, unable to work together and poorly co-ordinated, have missed or ignored cautions presented by others. The most striking of these ignored warnings were the ones issued by USFWS in the 1940s in which that agency cautioned that without proper planning, dams proposed by the Corps would seriously endanger annual salmon runs.

5. DISTRIBUTION OF BENEFITS AND COSTS

Anticipated Beneficiaries and Cost Bearers

The most comprehensive analysis of beneficiaries prior to the decision to build GCD was made in the 1932 Butler Report on the Columbia River and its tributaries. This report identified direct benefits in the form of profits to farmers and businesses; indirect benefits in the form of increased values for farmland and urban land: and public benefits in the form of an increased supply of produce for consumption and processing as well as reduced food prices. The 1932 report also included an elaborate analysis of secondary benefits based on multiplier effects (eg, the increased economic activity for agribusiness, banking, wholesaling, retailing, and transportation).

Major Beneficiaries and Cost Bearers

Major project beneficiaries include irrigators, who receive subsidised CBP water and power (as well as associated agribusiness); BPA ratepayers, who enjoy relatively low electric power rates; residents and businesses protected from floods downstream; recreators and recreation-related commerce; US Northwest residents (since GCD helped develop the region economically during and after World War II); and BC Hydro ratepayers, who enjoy very low electric power rates.

Major cost bearers include Native Americans and First Nation tribes; non-Native Americans who were forced to resettle; commercial and sport fishing interests (for anadromous fish) in the US and Canada; US taxpayers, who have thus far paid the bulk of the irrigation construction costs; individuals concerned with maintaining ecosystem integrity (because of the loss of wild salmon and the Columbia River in its natural state); some US farmers outside the CBP area (because of increased competition from CBP farmers); and, upstream residents and businesses whose resources and livelihoods were affected by GCD or the Columbia River Treaty dams.

Stakeholder Perspectives

We interviewed nine stakeholders in the US who represented tribal entities and environmental groups, and they shared similar perspectives on the benefits and costs of the project. In aggregate, they viewed major beneficiaries as irrigators, electric power users (particularly, public utilities, citizens, and large aluminum companies), and residents of the Northwest (who gained from the overall socioeconomic development of the region). Tribal members and environmental groups saw the Native American, sport and commercial fishing interests, and US citizens generally (from the perspective of ecosystems lost and modified) as the primary cost bearers. Tribal members felt that the adverse impacts on many Native Americans were adverse, severe, and irreversible. Additional stakeholder input from the Canadian perspective was captured during a WCD meeting held in Castlegar, British Columbia. Attendees at this meeting voiced the opinion that First Nations tribes that had traditionally depended on upstream salmon spawning also suffered many of the same adverse impacts as Native American tribes in the US.

The other 12 stakeholders we interviewed represented governments of communities near GCD, a public utility district, and CBP farmers. In aggregate, they viewed the principal beneficiaries as irrigators, electric power users, residents of the US Northwest, local towns, and recreators. These 12 individuals saw the Native American tribes as the primary cost bearers, but they felt that the tribes also benefited from the project (eg, via tourism) and that the net positive impacts of GCD and CBP far outweighed the cost borne by Native Americans.

Cost Allocation and Repayment

Repayment obligations for BPA include the cost of constructing hydropower-related facilities and interest during construction, interest during the repayment period, and what is known as ”irrigation assistance”. The latter is the difference between the irrigators’ allocated share of construction costs (including interest) and the amount that irrigators actually re-pay. The US Treasury pays for non-reimbursable capital costs (eg, cost for flood control).

As of 30 September 1998 the total construction cost for GCD and CBP was $1.93 billion (in nominal dollars), and nearly 88% of that total cost was returnable from BPA’s power revenues. As of that date, BPA had paid the full cost allocated to commercial power ($1.1 billion) but it had paid almost none of the costs associated with irrigation. BPA is not required to begin those payments until 2009, and those payments are scheduled to end in 2045.

Thus far, about $445 million (nominal) dollars (24% of the total project cost) has been paid to the US government. As of 1998, irrigators had paid in about $51 million (less than 3% of total project cost, about 12% of total repayment) of the total project cost. Revenues collected by BPA from power sales had repaid about $389 million (approximately 20% of total project costs and about 88% of total repayment). These figures are in nominal dollars, and the repayment obligations are specified in nominal dollars (ie, dollars that are not adjusted for inflation).

Irrigation assistance, as of 1997, was to be approximately $585 million, which is 87% of the project costs allocated to irrigation. This means that irrigators will eventually pay 13% of their allocated project cost. Since there is no interest on these payments, the revenues will be deposited lump sum in the US Treasury according to the contract for each irrigation block.

All FCRPS projects are grouped together as part of a basin-wide accounting system in which revenues and costs generated by projects in the system are pooled into a common fund. Using this accounting scheme, Reclamation derives income from various revenue-producing power facilities to fund works that would not otherwise be economically feasible under Reclamation law. The basin-wide accounting system has been criticised for obscuring projects that are not economically feasible by lumping them together with more economically viable projects. The practice of basin-wide accounting is widespread in the US and is used, for example, for Reclamation projects in the Colorado, Missouri, and the Bighorn river basins.

6. OPTIONS ASSESSMENTS AND DECISION-MAKING PROCESSES

Decision to Build a Dam at Grand Coulee

The 1932 planning studies prepared by the Corps and Reclamation and the associated congressional debates were not the key factors in the decision to build GCD. Instead, it was President Franklin Roosevelt, newly elected in 1932, who pushed the project forward. The mechanism used was legislation establishing the Public Works Administration, which allowed Roosevelt and his advisers to circumvent the congressional authorisation process to bring major infrastructure projects online during the Great Depression. At first, the project was to be a low dam for hydropower to be built by the State of Washington. Within months, the project became a federal project to be constructed and operated by Reclamation. By 1935, the Roosevelt administration amended its original plan and directed Reclamation to proceed with a high dam that would include facilities for irrigating the Columbia Plateau. Later in 1935, a Supreme Court decision forced a change in plans by requiring the administration to submit GCD and CBP, along with many other projects, to the congressional authorisation process. Although construction of the project was well underway, the congressional debates were contentious. In the end, GCD and CBP received congressional authorisation.

Early Attempts to Compensate Native Americans for Expected Losses

While the project was still under the jurisdiction of the State of Washington, tribes that would be affected by GCD used the Federal Power Act of 1920 to ensure that fish passage facilities would be provided at GCD and that annual payments would be made to Colville and Spokane tribes for tribal lands flooded by the reservoir. When the project became federalised, provisions of the Federal Power Act of 1920 requiring fish passage and annual payments no longer applied. However, Secretary of the Interior Harold Ickes endorsed correspondence between the Commissioners of Indian Affairs and Reclamation indicating that the government would pay the tribes for a share of power revenues generated from water on tribal lands. Until court actions in the 1970s, the federal government ignored these provisions.

Columbia Basin Joint Investigations

The Reclamation Act of 1939, which applied to CBP, called for the kind of orderly and systematic planning advocated by New Deal leaders. The Columbia Basin Joint Investigations were launched as part of this planning process. The investigations, which involved over 300 people from over 40 organisations during the period from 1941 to 1943, examined 28 potential issues related to the project, including the types of crops that should be grown, the optimum size of farm units, and the annual rate at which lands should be brought into production. The investigations played a key role in shaping CBP.

Acreage Limitations and Anti-speculation Statutes

The Roosevelt administration was concerned that word of the planned irrigation in the CBP area would cause individuals to buy out land with hopes that prices would rise and windfall profits could be made by selling project land at inflated prices. In response, Congress passed the anti-speculation pact, which limited the size of project farms in CBP to 40 acres (16ha) for an individual, and 80 acres (32ha) for a husband and wife. In 1943, these provisions were modified to allow farmers receiving CBP irrigation water to hold as much as 160 acres (64ha). This limit, while thought to be adequate, was low enough to maintain the vision of CBP as a project populated primarily with family farms, not the large corporate farms that have come to be referred to as “agribusiness”.

7. CRITERIA AND GUIDELINES: POLICY EVOLUTION AND COMPLIANCE

The most significant GCD-related policy changes after the mid-1950s were as follows: (i) the Columbia River Treaty, which formalised basin-wide management of operations for hydropower and flood protection; (ii) NEPA, which institutionalised an environmental impact statement (EIS) process that was used to considerable advantage in the context of FCRPS’s System Operation Review, and in Reclamation’s decision not to irrigate the CBP’s “second half” at the current time; (iii) the Northwest Power Act of 1980, which called for a fish and wildlife management programme for the US portion of the basin and opened up the decision-making process related to FCRPS operations to Native Americans and other previously excluded groups; and (iv) the ESA listings and NMFS Biological Opinions related to Columbia River Basin anadromous fish, because those listings and opinions have profoundly affected operations of FCRPS.

8. LESSONS LEARNED

Open Planning Process

Lesson: An open planning process facilitates identifying and resolving conflicts among stakeholders; a closed process serves the opposite purpose.

Evidence: Inadequacies in opportunities for Native Americans and Canadian First Nations to participate in decision-making has fostered conflicts over GCD for several decades.

Managing Debates on Project Operations

Lesson: In a multipurpose water project, it is common for project purposes (eg, flood control and recreation) to be in conflict. Because conflicts among competing purposes are practically inevitable, a process for managing stakeholder contributions to debates on project operations should be institutionalised for future projects**.**

Evidence: Operation of GCD has changed in response to shifts in social values and changing political and economic circumstances. Some stakeholders concerned with residential fish and recreation feel that they lack a productive forum for advocating their interests related to project operations.

Incorporating Changing Social Values into Operations

Lesson: For future projects, periodic, planned re-evaluations can provide a mechanism for incorporating temporal changes in social values into project operations. To meet social policy objectives, it might be necessary to reduce uncertainties for stakeholders whose decisions would be influenced by results from re-evaluations.

Evidence: Support for the social goal of having small family farms located in the semi-arid Columbia Plateau has faded, but long-term contracts with subsidised prices for irrigation water persist. Support for maintaining wild salmon and steelhead in the upper Columbia River is much stronger today than it was when the project was planned.

Incorporating Changes in Science and Technology into Operations

Lesson: For future projects, periodic, planned re-evaluations provide a mechanism for incorporating changes in science and technology into project operations. To meet social policy objectives, it might be necessary to reduce uncertainties for stakeholders whose decisions would be influenced by the results of re-evaluations.

Evidence: Biologists' views on native vs. hatchery fish have changed. Changes in farm technology have increased pressures for larger farms than anticipated by CBP planners.

Sensitivity Analysis of Economic Parameters

Lesson: Substantial inflation-corrected cost overruns in the GCD and the CBP reflect the uncertainties that surround large construction projects. These uncertainties underscore the need for wide-ranging sensitivity analyses to ensure that project goals and objectives are robust and can be met with available resources. Implicit or indirect subsidies need to be evaluated under alternative market conditions to be sure that the subsidies are in line with a project's social objectives.

Evidence: Inflation-corrected Third Powerplant costs were approximately 55% above planned costs. CPB costs were nearly three times those projected with the result that repayments by beneficiaries is roughly 15% of construction costs rather than the planned 50%. Indirect energy subsidies of the CPB have increased over time as the value of firm power to BPA non-agricultural customers has increased.

Developing a Shared Conceptual Framework for Project Appraisal

Lesson: Stakeholders and planners involved in an open planning process need to work with a common conceptual framework and vocabulary in making formal project appraisals. Of particular importance is the distinction between private and social (economy-wide) perspectives. Failure to develop a shared conceptual framework and vocabulary can lead to unnecessary acrimony.

Evidence: Interviews with and letters from stakeholders indicate that numerous disagreements and misunderstandings resulted because of the absence of a shared framework and vocabulary for appraising projects. Particular sources of difficulty include the distinctions between financial and economic prices and between direct and indirect (secondary) benefits.

Mechanisms for Ensuring Just Compensation

Lesson: In large water resources projects, those who bear the costs may not receive many benefits. Therefore, mechanisms for ensuring just compensation are important. In a project that has impacts that cross international borders, the usual forums for allowing parties to make compensation claims — typically the judicial system in the US — may not be satisfactory, and alternative forums should be considered. Alternative dispute resolution mechanisms may also be able to speed up the settlements of claims normally brought using the court system.

Evidence: In the case of GCD and CBP, there were not adequate opportunities for Native Americans and Canadian First Nations to obtain appropriate compensation for project-related losses in a timely fashion

Limits to Government Planning in a Market Economy

Lesson: Limits exist on the extent to which government plans can be implemented effectively in a market-driven, capitalistic economy.

Evidence: Changes in the economics and technology of farming provide irrigators with incentives to circumvent Reclamation's acreage limitations.

Centralised vs. Decentralised Basin Management Institutions

Lesson: In designing institutions for river basin management, centralisation and decentralisation each have their advantages and disadvantages.

Evidence: Co-ordinated decision-making process by four agencies — BPA, the Corps, Reclamation, and BC Hydro — has been effective in managing flood control and hydropower, but some stakeholders feel left out of the decision-making processes for operations. Decentralised decision-making can mean responsiveness to particular constituencies, but inter-agency co-ordination difficulties in the Columbia River Basin have led to problems in this regard.

Actions Having Significant Irreversible Effects

Lesson: Decisions that introduce significant irreversible effects should only be taken after very careful study and broad input from those affected at the grassroots level.

Evidence: Building GCD without fish passage facilities was, for all practical purposes, virtually irreversible; the decision was made without significant study and participation by all affected parties.

Cumulative Impact Assessment

Lesson: Tools for cumulative impact assessment need to be applied to avoid resource management problems.

Evidence: Failure in the past to account for cumulative impacts of dams is at the heart of many fisheries-related controversies within the Columbia River Basin today. The lack of a cumulative impact assessment for the series of major dams on the Columbia and Snake rivers constituted a failure to recognise a major fisheries management problem before it occurred.

9. REFLECTIONS ON THE DEVELOPMENT EFFECTIVENESS OF GCD AND CBP

Criteria for Gauging Effectiveness

An assessment of development effectiveness cannot be undertaken without first delineating the criteria to be used in judging effectiveness. In the context of GCD and CBP, applicable criteria can be categorised as follows: economic efficiency, income redistribution, regional economic development, and environmental quality. Inevitably, significant differences of opinion arise about the value of GCD and CBP because the relative weight attached to different criteria for judging effectiveness varies across individuals and groups. Finding a consensus about weights is complicated further because weights frequently vary over time as a result of changes in cultural values, social norms, and economic conditions. A mechanical calculation cannot be used to determine weights or to combine weighted objectives and make choices; a political process is employed to accomplish these ends.

At a conceptual level, the above-noted factors used to characterise development effectiveness can be defined as follows. “Economic efficiency” refers to the condition in which the difference between the present value of economic benefits of a project and the present value of economic costs is as large as possible. (Economic benefits are not the same as monetary benefits except in the case where markets are reasonably competitive.) “Regional development” refers to the objective of fostering growth in a particular geographic area. “Equity” refers to the fair distribution of a project’s economic, environmental, and social effects (both positive and negative) among stakeholders. The lack of widespread agreement on what constitutes a fair outcome makes it difficult to apply this criterion. Project analysts do not have formal calculation procedures for gauging whether project outcomes are distributed fairly; a helpful analysis is one that makes the distribution of project gains and losses clear to decision-makers. “Environmental quality” is a broad category that includes a project’s effects on the biological and physical environment as well as effects on social conditions and cultural resources. It is possible to conceive of additional objectives of water resources development projects, such as the maintenance of national food security, but the four categories of factors above are appropriate for characterising development effectiveness in the context of GCD and CBP.

Temporal Shifts in Weights Ascribed to Different Effectiveness Criteria

Each of the above-noted objectives plays a role in water resources planning, but the roles of economic efficiency, regional development, equity, and environmental quality in contemporary US water resources planning are different from those roles at the time GCD and CBP were being planned. In examining the development effectiveness of GCD and CBP, it is useful to review how criteria for gauging the effectiveness of US water projects have changed over the past several decades.

Both the Butler and Reclamation reports were focused on regional development and neither was concerned with economic efficiency in the sense of maximising net economic benefits. When the authors of those reports talked of the economic feasibility of GCD and CBP, they had in mind whether or not the beneficiaries of the project could, collectively, pay for the project's monetary costs. In the view of the US Army Chief of Engineers writing in 1932, "the irrigation of land as pertains to the Columbia River area under consideration is not an economical proposition at this time and should await the future" (USACE, 1933: 4).

Writing in 1932, the Commissioner of Reclamation, Elwood Mead, took exception to the US Army Chief of Engineers. Mead argued that GCD and CBP "will enable the largest single water supply of the arid region to be used to give cheap power to industries, and make feasible the irrigation of the largest and finest body of unreclaimed land left in the arid region" (USACE, 1933: 5). Both the Butler and Reclamation reports recognised that the goal of bringing irrigated agriculture to the Columbia Plateau could not be satisfied without using hydroelectric power revenues to cover a sizeable portion of the investment costs for irrigation.

Because an economic efficiency objective (ie, the condition that economic benefits exceed costs) for water resources projects developed by Reclamation and the Corps did not come about until the late 1930s and early 1940s, this objective had little formal influence on the planning of GCD and CBP. However, concerns about what would now be termed economic efficiency were raised in the context of GCD and CBP. For example, the US Secretary of Agriculture and the Chief of the US Army Corps of Engineers both used economic efficiency arguments to support their opposition to the project. Both were concerned with what they perceived as the absence of sufficient demand for agricultural outputs. However, these critics of the economics of the project did not carry the day. Political factors — including extensive lobbying by local project supporters and Franklin Delano Roosevelt's strategy for using water projects to increase employment and his desire to honour political commitments to the US Northwest — played the key roles in the decision to proceed with GCD.

The overriding significance of regional development as an objective of GCD and CBP has continued, and it is reflected in contemporary project assessments by some stakeholders. For example, the consensus of the 12 individuals we interviewed representing irrigators, PUDs, and local governments in the CBP area was that the net positive impacts of GCD and CBP for the region far outweighed the costs to Native Americans. Such regional development arguments frequently ignore the subtleties involved in making arguments related to economic efficiency. Indeed, some of those who trumpet the economic significance of the project do not recognise either the failure to pay interest on the capital cost of irrigation or the lost power revenues associated with providing below-market price energy to pump irrigation water as signs of economic inefficiency.

The other components of development effectiveness — what we have termed equity and environmental quality — did not become major elements of US water resources planning until the late1960s and early 1970s. This is reflected in passage in 1969 of NEPA, which intended to force all agencies of the federal government to integrate environmental and social concerns into their planning and decision-making. This Act introduced requirements for environmental impact statements, documents that were to disclose fully the environmental and social impacts of proposed federal projects and alternatives to those projects. Implementation rules issued subsequently by the US Council of Environmental Quality required that EISs highlight any irreversible and irretrievable commitments of resources which would be involved in a proposed action should it be implemented.

The period from the1960s through the 1980s witnessed an upsurge in use of the US judicial system by citizens making claims of unjust treatment in cases involving environmental impacts. US Supreme Court decisions in the 1960s and 1970s made it possible (for the first time) for environmental groups to bring suit in US courts in instances where adverse environmental impacts were significant but plaintiffs had not suffered direct monetary damages. Since the late 1960s, citizens and non-governmental organisations have used the courts to press claims centring on the adverse environmental effects of development projects or alleged instances of "environmental injustice" (ie, the inequitable distribution of environmental costs and gains).

GCD and CBP: Trade-offs Between Regional Development and Economic Efficiency

If judged only in terms of regional development goals (without regard to environmental and social impacts), GCD and CBP would be judged as developmentally effective by many people. Indeed, this is clear from our interviews with irrigators and users of the relatively inexpensive hydroelectric power in the US Northwest who feel that GCD and CBP is a great success. They point to the contributions of low-cost electricity to: 1) the booming economy of the US Northwest, 2) the contributions of agriculture to the regional economy and food supply, 3) the numerous monetary benefits associated with recreation and flood control, and 4) the way storage at GCD creates opportunities to generate additional power at downstream dams.

Circumstances exist under which projects advocated from a regional perspective are perfectly compatible with the efficient use of resources as seen from a national point of view. However, when regional development becomes a principal policy objective, governments frequently intervene (directly or indirectly) in markets for inputs to and outputs from production processes. With the exception of instances where such interventions are a response to incomplete or imperfect markets, the distorting policy interventions needed to implement a regional development objective lead to an inefficient allocation of national resources.

The attitudes of regional stakeholders toward such government interventions depend, of course, upon whether the interventions constitute a tax or a subsidy. The formation of these attitudes is complicated by the fact that many taxes and subsidies are implicit or indirect. In our interviews with people affected by GCD and CBP, for example, interviewees acknowledged that direct payments, such as those used to cover a large part of the cost of CBP's construction, were a subsidy. They often failed to see, however, that market interventions that indirectly enhance an industry's financial competitive position are subsidies.

In the case of GCD and CBP, the criterion for efficient energy use has been met, to some degree, by the energy component of the project. Environmental and social issues aside, energy production by GCD, including its associated Third Powerplant, has contributed greatly to the development of the US Northwest. Although below-market energy pricing has reduced revenues to the government from what they might have been, the project has repaid the US Treasury for the cost of constructing hydroelectric power facilities at GCD, and the portion of the project related to hydropower clearly has a positive economic benefit-cost ratio.

Supporters of agricultural development in CBP, past and present, have argued that development of irrigation facilities should also be seen as positive from a national perspective. Although the original planners acknowledged that agricultural development could not pay for itself, those planners maintained that substantial national benefits would accrue from the regional development in the form of secondary benefits. This claim was controversial when it was made in the 1930s, and secondary benefits are now inadmissible in evaluating the economic efficiency of federal water projects.

When GCD and CBP are analysed separately, it is apparent that the magnitude of the direct government subsidy involved in the construction of CBP has been substantial. Irrigators will pay only about 15% of this cost in dollars uncorrected for inflation. The US Treasury has paid the remaining cost. Eventually, this remainder will be repaid (in dollars uncorrected for inflation) by BPA using revenues power sales.

But direct construction subsidies to the CBP covered by power sales have not been the only drain on funds that would otherwise have remained with the US Treasury. Indirect subsidies have been provided to a variety of regional power users (eg, DSIs and PUDs) by contractual and regulatory arrangements that have delivered energy at below-market costs. Also, energy used for pumping water has been provided to the CBP at roughly the cost of production at the GCD, again well below the market price.

Interventions that distort prices also create second order effects as inefficiencies become embedded in private decisions. For example, BPA has been criticised for setting prices of electricity at below-market levels for some consumers (as BPA must as a matter of federal law) because these below-market costs failed to encourage parsimonious use of electricity. Experiences from other areas (eg, California in the drought years of the mid-1980s) indicate that there is substantial room for better water management when water becomes truly scarce. When subsidies keep the cost of irrigation water low, farmers are less likely to give attention to a more water-efficient agriculture.

The regional development objectives of GCD and CBP have, to a considerable extent, been achieved. But they have come at a substantial cost to the rest of the economy, both in terms of direct construction subsidies and in revenues foregone from indirect subsidies in the form of below-market energy prices.

GCD and CBP: Trade-offs Between Regional Development, Equity, and the Environment

Trade-offs also exist between regional development and objectives related to equity and the environment. This is clearly shown by the way GCD affected indigenous peoples in the upper Columbia River Basin. In the view of many Native Americans and members of First Nations in Canada, GCD was nothing short of catastrophic. For them, the project had a disastrous affect on the continuance of their culture. In our interviews, Native Americans and members of First Nations highlighted the importance of Kettle Falls and other fishing areas as places where different tribes came together to enhance mutual understanding, share language and stories, and continue rituals and other traditions. These opportunities were lost after GCD blocked the runs of salmon to the upper Columbia River.

There is no calculation procedure that allows a balancing of these negative social impacts and cultural losses against the substantial regional development benefits that the US Northwest has enjoyed as a result of GCD and CBP. Today, US citizens rely on an open planning process tied to NEPA to help decision-makers become aware of trade-offs: how much of one objective, such as the quality of the environment, must be sacrificed when attempting to augment another, such as regional development. However, nothing equivalent to NEPA existed at the time that President Franklin Delano Roosevelt and his administrators decided to proceed with construction of GCD. Moreover, even the open planning prescribed by NEPA has limitations. For example the NEPA process does not necessarily address the consequences of unequal power among stakeholders, a problem that still plagues the anadromous fish recovery and recreational jurisdiction issues associated with GCD and CBP.

Effects on Native Americans and First Nations are not the only ones that would be questioned in gauging the development effectiveness of GCD and CBP using contemporary criteria. The effects on salmon and steelhead upstream of the dam would also be called into question, primarily because the placement of GCD constituted an irreversible commitment to eliminate anadromous fish in the hundreds of miles of habitat upstream of the dam. The fish mitigation programme implemented in the late 1930s and early 1940s also had an irreversible impact: the hatchery and transplantation elements of GCFMP constituted the irreversible elimination of the wild stocks of salmon and steelhead in the mid-Columbia River tributaries.

The observations in this section about the history of decision-making criteria used by federal resources development agencies during the 20th-century in America help put the discussion by stakeholders of the draft version of our report in perspective. After nearly 60 years of project operations, those who have benefited from GCD and CBP have, quite naturally, become focused on maintaining the advantages they have enjoyed as a result of the project — mainly low-cost irrigation water, low-cost electricity, and benefits from flood control and recreation. At the same time, groups that were disadvantaged by the project (ie, Native Americans and First Nations), are continuing their struggles to obtain compensation for what they perceive as broken promises and grave injustices of the past). It is possible that individuals who gain or lose from future water resources projects will be just as tenacious in defending their gains or seeking compensation for their losses many years after basic project decisions have been made.

Contents

List of Annexes

(found in separate document)

Acronyms and Abbreviations

BC	British Columbia
BC Hydro	British Columbia Hydroelectric
BIA	Bureau of Indian Affairs
BPA	Bonneville Power Administration
CBFWCP	Columbia Basin Fish and Wildlife Compensation Programme
CBP	Columbia Basin Project
CBT	Columbia Basin Trust
CCT	Colville Confederated Tribes
CEAA	Canadian Entitlement Allocation Agreement
cfs	cubic feet per second
Corps	US Army Corps of Engineers
CRITFC	Columbia River Inter-Tribal Fish Commission
DOE	Department of Energy
DSI	Direct Service Industry
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ft	feet
FCRPS	Federal Columbia River Power System
FELCC	Firm Energy Load Carrying Capability
FERC	Federal Energy Regulatory Commission
GCD	Grand Coulee Dam
GCFMP	Grand Coulee Fish Mitigation Programme
GNP	Gross National Product
GVP	Gross value of production
ha	hectares
ICC	Indian Claims Commission
IJC	International Joint Commission
IRA	Indian Reorganisation Act
kcfs	thousands of cubic feet per second
km	kilometre
kWh	kilowatt-hour
LRNRA	Lake Roosevelt National Recreation Area
m	metre
MAF	million acre feet
MOA	Memorandum of Agreement
NMFS	National Marine Fisheries Service
NPPC	Northwest Power Planning Council
NPS	National Park Service
O&M	operations and maintenance
PNCA	Pacific Northwest Co-ordination Agreement
PUD	Public Utility District
Reclamation	US Bureau of Reclamation
ROR	Run of the river
SOR	System Operation Review
TDG	Total Dissolved Gas
TMT	Technical Management Team
UCUT	Upper Columbia United Tribes
US	United States
USACE	US Army Corps of Engineers
USBR	US Bureau of Reclamation
USFWS	US Fish and Wildlife Service
USGS	US Geological Service
WCD	World Commission on Dams

1. The World Commission on Dams Global Case Study Programme

The two-year mandate of the World Commission on Dams (WCD) calls for a review of the "development effectiveness" of large dams in the world. As part of the work programme, several case studies, including projects in the developed and developing nations, were conducted to provide in-depth analysis on specific dams. The Grand Coulee Dam (GCD), located in eastern Washington State within the United States (US) was selected as one of the case studies. This project is a key component of many water resources development plans for the entire Columbia River and its tributaries. Among all the case studies being conducted for the Commission, GCD is the oldest.

Completed in 1941, GCD is a multi-purpose project; its purposes include irrigation, hydropower generation, flood control, fish and wildlife enhancement, and recreation. This case study is illustrative of how large water resources projects in the US Northwest have evolved in the context of changing social values, increased public concern over environmental issues, growth in scientific knowledge, and changes in the technology and socioeconomic conditions in the region.

The Grand Coulee case study was carried out in two phases. In the first phase, a California-based inter-disciplinary project team, advised by WCD staff, prepared a draft scoping report. This document was reviewed and commented on by relevant stakeholder groups. A public consultative stakeholder meeting was held on 20 May 1999 in Spokane, Washington to discuss the study objectives and proposed methodology for the case study. At that time, the project team and WCD staff solicited feedback from meeting attendees. Input from the 20 May meeting was used in determining the research plan for the second phase of the study.

The second phase of the project took place from July 1999 to March 2000. During this period, additional experts joined the project team to conduct field investigations, review literature, and assist in writing and reviewing sections of the report. Altogether, a team of over a dozen professionals, representing fields including water resources planning, Native American and First Nations studies, resource and agricultural economics, history, power systems engineering, and fisheries biology contributed to the compilation of this report. Additionally, in kind contributions from the Bureau of Reclamation, Bonneville Power Administration, and the Army Corps of Engineers facilitated data collection and access to key government personnel. A group of representatives of British Columbia Hydro (BCH), the Columbia Basin Trust (CBT), and other Canadian interests also contributed to the study. This report was distributed to stakeholder groups in December 1999 and was discussed at a second consultative stakeholder meeting held on 13 January 2000 in Portland, Oregon. Minutes of both consultative meetings, lists of attendees, and written comments submitted in response to the December 1999 draft report are presented in the Annex titled “Consultative Meetings and Comments”. The draft report was then revised to incorporate, where reasonable, comments and perspectives put forward at the second stakeholder meeting. This document is the case study’s final report.

Several fundamental research questions put forward by the WCD affected the structure of case study data collection and analysis. These questions, which are presented below, were addressed in each WCD case study, including GCD.

1. What were the projected versus actual benefits, costs, and impacts? (Section 3)
2. What were the unexpected benefits, costs and impacts? (Sections 3 and 4)
3. What was the distribution of costs and benefits? Who gained and who lost? (Section 5)
4. How were key project decisions made? (Section 6)
5. How did the project evolve in response to changes in policies and decision-making criteria? (Section 7)
6. What lessons can be learned from the experiences of this project? (Section 8)
7. How can the development effectiveness of the project be evaluated? (Section 9)

The overarching purpose of this case study was to learn lessons from the past, focusing on those that are particularly relevant to the planning, implementation, and operation of large dams worldwide.

The Commission's approach recognises that there is not always unanimity in interpretation of data, or in the perceptions of different interest groups. In order to understand differing perceptions of development effectiveness we need to take account of the convergent and divergent views and perspectives of different stakeholder groups affected by GCD and the associated irrigated lands known as the Columbia Basin Project (CBP).

This report does not adopt a single "position" (eg, it does not pass judgement on whether or not the project should have been built or how things should have been done differently) and it does not comment on the future evolution or management of GCD and CBP. The case study used existing data sources and reports in its assessment because project resource did not permit new research to be undertaken. In this respect, data availability limited the study's findings

2. Context and Scope of the Grand Coulee Dam and Columbia Basin Project Case Study

2.1 Major Features of the Columbia River Basin

The study area for this case is the Columbia River Basin within the US and Canada. The focus is on GCD, which is located on the mainstream Columbia River, and the land irrigated by water stored in Lake Roosevelt, the reservoir created by the dam. Following common usage, the term Columbia Basin Project (CBP) refers to the portion of the overall project that involves irrigation.[1]

The Columbia River is the 4th largest river in North America, running over 1 210 miles (1 953km) from its headwaters to the ocean (see Figure 1) (USDOE et al. (Main Report), 1995:2–1).[2] The river has a total catchment of almost 260 000 square miles (67 x 10^6 hectares) (USACE, 1958) – an area larger than that of France, Belgium, and the Netherlands combined. The basin includes large portions of Oregon, Washington, Idaho, and Montana, as well as the south-eastern drainage of the Canadian Province of British Columbia (USACE, 1958).

The Columbia River originates in British Columbia and is bounded by the Rocky Mountain system to the east and the Cascade Range to the West. Numerous mountainous ridges in British Columbia, northern and central Idaho, and western Montana, which capture snowmelt, are the most significant contributors to the basin's water supply (USACE, 1958:2). From Canada, the Columbia River flows mostly southwards through Washington, then westward where the Columbia comprises the Washington–Oregon border. The river then flows through the famous Columbia River Gorge, which bisects the Cascade Range near its midpoint, and eventually reaches the Pacific Ocean. The average annual runoff of the river basin exceeds 180 million acre-feet (2.219 x 10^{11} m^3).

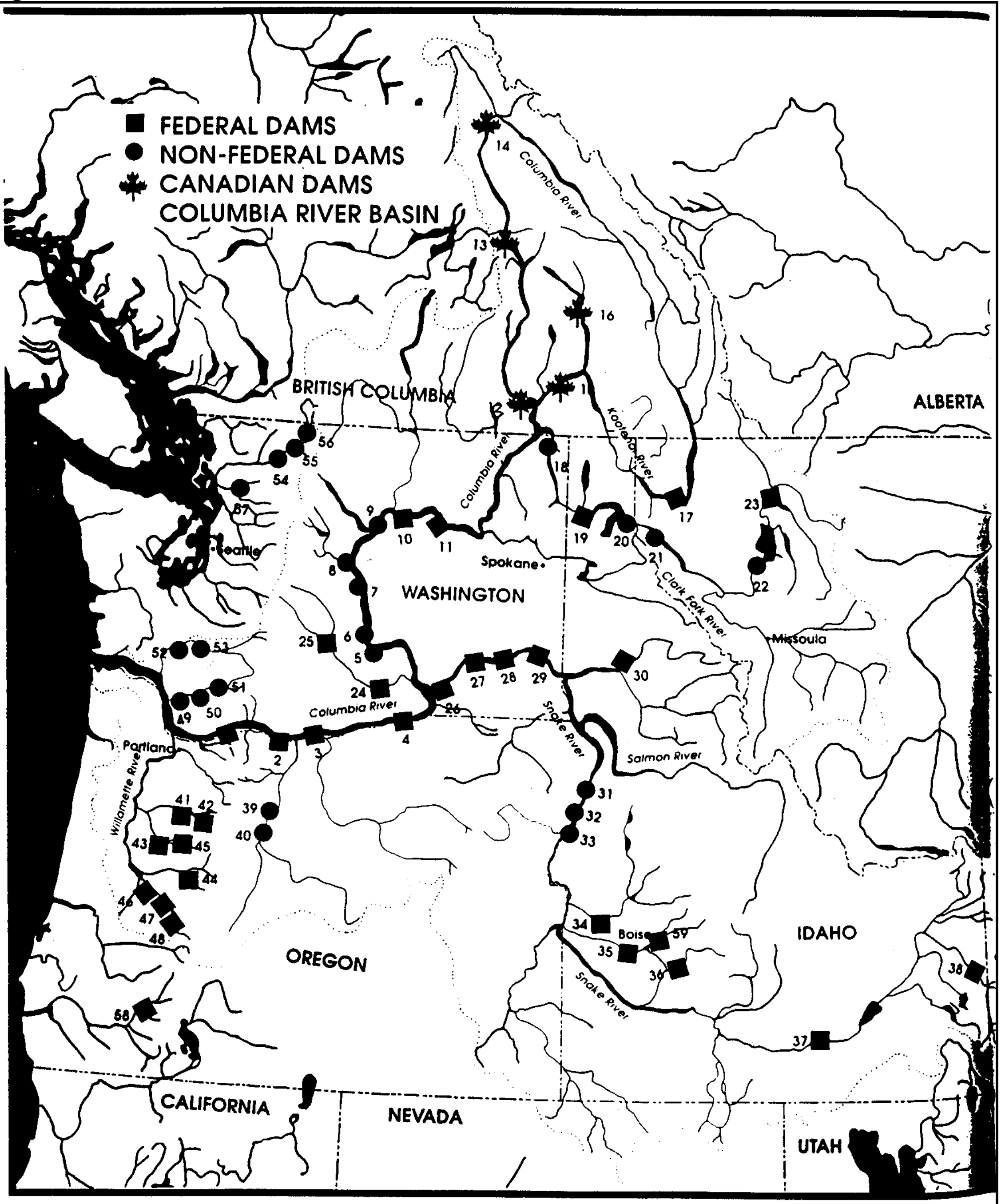
A key land feature of the basin is the Columbia Plateau, which contains the land served by the project's irrigation command area. The Plateau is a semi-arid and mostly treeless area of nearly 100 000 square miles (259 000km^2) that extends from north-central Washington to just below the border with Oregon. Land elevations in this region range from 500ft to 4 000ft (152m to 1 220m) (USDOE et al. (Main Report), 1995:2-2; USACE, 1958)

The climatic conditions of the region make the Columbia River Basin primarily a snow-fed system. Snow accumulates in the mountains from November to March, then melts and produces runoff during the spring and summer. Runoff and streamflows normally peak in early June. In late summer and fall, rivers recede. Water levels tend to be lowest during October and increase very little until April (USDOE et al. (Main Report), 1995: 2-5).

2.2 Objectives and Components of GCD and CBP

The US Army Corps of Engineers (hereafer referred to as "the Corps") and the US Bureau of Reclamation (hereafter referred to as "Reclamation") planned GCD and CBP. The Army Corps of Engineers feasibility report for the project (hereafter referred to as the "Butler Report"), officially completed in 1932, was conducted by Major John S. Butler (USACE, 1933). Reclamation released its feasibility report (hereafter referred to as the "Reclamation Report") in the same year (USBR, 1932). The plans outlined in these studies provided the background for the actual construction of the dam and irrigation project. A dominant theme in both these reports was that revenues from power generated at GCD should be used to subsidise irrigation. Without power revenues, the cost of the reclaiming the Columbia Plateau would be much too high for farmers. Both reports indicated that the irrigation part of the project should not be started until power development was well underway. As detailed in Section 5, the decision to build the project was heavily influenced by the objective of putting people back to work during the economic depression (the Great Depression) that began in the late 1920s.

Figure 2.2.1 Columbia River Basin



Source: USDOE et al., 1992.

Figure 2.2.1 Columbia River Basin (con't.)

Major Northwest Dams

1. BONNEVILLE
Columbia River, USCE
2. THE DALLES
Columbia River, USCE
3. JOHN DAY
Columbia River, USCE
4, McNARY
Columbia River, USCE
5. PRIEST RAPIDS
Columbia River, Grant Co. PUD
6. WANAPUM
Columbia River, Grant Co. PUD
7. ROCK ISLAND
Columbia River, Chelan Co. PUD
8. ROCKY REACH
Columbia River, Chelan Co PUD
9. WELLS
Columbia River, Douglas Co. PUD
10. CHIEF JOSEPH
Columbia River, USCE
11. GRAND COULEE
Columblo River, USBR
12. KEENLEYSIDE
Columbia River, BC Hydro
13. REVELSTOKE
Columbia River, BC Hydro
14. MICA
Columbia River, BC Hydro
15. CORRA LINN
Kootenoy River, WKP&L
16. DUNCAN
Duncon River, BC Hydro
17. LIBBY
Kootenoi River, USCE
18. BOUNDARY
Pend Orellle River, SCL
19. ALBENI FALLS
Pend Oreille River, USCE
20. CABINET GORGE
Clork Fork River, WWP
21. NOXON RAPIDS
Clark Fork River, WWP
22. KERR
Flathead River, MPC
23. HUNGRY HORSE
Flathead River, USBR
24. CHANDLER
Yokimo River, USBR
25. ROZA
Yokimo River, USBR
26. Ice HARBOR
Snoke River, USCE
27 LOWER MONUMENTAL
Snake River, USCE
28 LITTLE GOOSE
Snake River, USCE
29. LOWER GRANITE
Snake River, USCE
30. DWORSHAK
N F Clearwater River, USCE
31. HELLS CANYON
Snake River, IP
32. OXBOW
Snake River, IP
33. BROWNLEE
Snake River, IP
34. BLACK CANYON
Payette River, USBR
35. BOISE RIVER DIVERSION
Boise River, USBR
36. ANDERSON RANCH
Boise River, USBR
37. MINIDOKA
Snake River, USBR
38. PALISADES
Snake River, USBR
39. PELTON
Deschutes River, PGE
40. ROUND BUTTE
Deschutes River, PGE
41. BIG CLIFF
N. Santiam River, USCE
42. DETROIT
N. Santiam River, USCE
43. FOSTER
S. Santiam River, USCE
44. COUGAR
McKenzie River, USCE
45. GREEN PETER
M. Santiam River, USCE
46. DEXTER
Willamelte River, USCE
47. LOOKOUT POINT
Willamelte River, USCE
46. HILLS CREEK
Willamelte River, USCE
49. MERWIN
Lewis River, PP&L
50. YALE
Lewis River, PP&L
51. SWIFT
Lewis River, PP&L
52. MA YFIELD
Cowlitz River, TCL
53. MOSSYROCK
Cowlitz River, TCL
54. GORGE
Skagit River, SCL
55. DIABLO
Skagit River, SCL
56. ROSS
Skagit River, SCL
57. CULMBACK
Sultan River, Snohomish Co.PUD
56. LOST CREEK
Rogue River, USCE
59. LUCKY PEAK
Boise River, USCE

The Butler Report, a voluminous work that examined the entire Columbia River upstream of its confluence with the Snake River, outlined a comprehensive plan of development for this stretch of the river (USACE, 1933: 1058–64). This plan proposed the construction of six dams on the Columbia River between its confluence with the Snake River and the Canadian border. The report recommended dams at Priest Rapids, Rock Island Rapids, Rocky Reach, Chelan, Foster Creek, and Grand Coulee. At the time of the Butler Report's release, Rock Island Dam was already being constructed by a private power company (USACE, 1933: 1059). Navigation facilities were to be built up to Rocky Reach Dam. Butler determined that power generation could be increased with upstream storage, and so he also recommended regulation of Flathead and Pend Oreille Lakes and the construction of Hungry Horse Dam in Idaho and Montana.

Major Butler examined multiple methods for irrigating the basin, and his Plans 4 and 4-A proposed irrigation of the Columbia Plateau through the construction of a high dam at the Grand Coulee. Plan 4, which proposed irrigation of 1 199 430 acres (485 392ha) of land with water stored in the Grand Coulee, most closely resembled the Reclamation Report plan, and it became the model upon which the actual project was built. Plan 4-A, the plan recommended by Butler, differed in that it proposed to irrigate only 1 034 110 acres (418 489ha) from the dam, while irrigating the remainder of the irrigation lands, 140 520 acres (56 866ha), by diverting water from the Priest Rapids reservoir downstream.

Butler recognised that slight modifications in the designs and locations of the proposed structures would occur while he was developing a comprehensive plan as a broad framework for how best to use the waters of the Columbia River (USACE, 1933: 1064). His plan did not recommend any flood control provisions for this stretch of the Columbia River (USACE, 1933: 1061). In laying out his plan, Butler recommended that water for the purpose of irrigation be given a higher priority than water for power, and "that no power rights be granted which will interfere with future irrigation requirements" (USACE, 1933: 1066). Butler also recommended that "it be required that storage above power dams be so regulated as to interfere as little as possible with navigation and fish life above and below the dam" (USACE, 1933: 1067).

The Reclamation Report was much more limited in scope than the Butler Report, focusing entirely on GCD and CBP. It presented plans for constructing the dam and irrigation works. The report concluded that firm power generated at the dam could be could be absorbed within 15 years of the dam's completion, and that the financial feasibility of the project depended on the time needed to absorb the power (USBR, 1932: 81). Significantly, the Reclamation Report concluded that surplus from power revenues would be "sufficient to repay within forty years about 50 per cent of the cost of the irrigation development for the entire acreage of 1,200,000 acres…" (USBR, 1932: 81–82). The report also concluded that "the slower the irrigation development proceeds the smaller the amount of additional funds that will have to be advanced from the Treasury of the United States". Finally, the report urged that "no construction on the irrigation development should be undertaken until power revenues are assured and a suitable contract for repayment of the investment in irrigation works within 40 years has been executed . . ."

Although GCD was initiated under special executive authorities granted to President Roosevelt in 1933, it was eventually authorised by Congress in 1935 legislation that included the following language:

> *That for the purpose of controlling floods, improving navigation, regulating the flow of streams of the United States, providing for storage and for the delivery of the stored waters thereof, for the reclamation of public lands and Indian reservations, and for other beneficial uses, and for the generation of electric energy as a means of financially aiding and assisting such undertakings the projects known as . . . and "Grand Coulee Dam" on the Columbia River, are hereby authorised and adopted* . . . (US Congress, 1935: Section 2)

The objectives outlined in this law provide the legal foundation for GCD and CBP. The language of the law shows that power generation was viewed as a means of financing other project purposes.

2.3 Major Design Characteristics and Time Schedule for Implementation

2.3.1 Attributes of the Grand Coulee Dam

The principal components of the project include the following: (i) GCD with its attendant hydropower generation and pumping facilities; (ii) Franklin D. Roosevelt Lake; and (iii) the network of reservoirs, canals, and drainage facilities associated with delivery and removal of irrigation water. Key physical dimensions of the dam are as follows:

Total length of dam (axis)	5 223ft (1 592m)
Height above downstream water	350ft (107m)
Total height of dam	550ft (201m)
Spillway width	1 650ft (509m)
Total generating capacity	6 809MW

Power facilities at the dam consist of a PowerPoint on both the left and right sides of the spillway on the downstream face of the dam, and the Third PowerPoint on the downstream face of the forbear dam (See Figure 2.3.1). As constructed, the left and right powerplants contained a total of eighteen 108MW generators, nine in each powerplant. These units have been rewound to increase their capacity to 125MW each. The left powerplant contains three small station service units of 10MW each, and including these three units, the total generating capacity of the left and right powerplants is 2 280MW. The Third Powerplant has a total of six generating units: three rated at 600MW and three rated at 805MW, for a total rated capacity of 4 215MW.

The project also includes a pump-generator plant. Pumps are used to lift water up from Lake Roosevelt to a feeder canal that brings water to Banks Lake (USBR, 1976: I-62). This plant contains six pumps of 65 000 horsepower (50 300kW) each. Each pump has a capacity of 1 605 cubic feet per second (cfs) ($45m^3$ per second).

The plant also contains six pump-generators, (units capable of either pumping water or generating power). In the generating mode, two of these units have a capacity of 50MW and four of them have a capacity of 53.5MW for a total of 314MW. In the pumping mode, the six units are rated at 65 000 horsepower (48 500kW), and they each have a pumping capacity of 1 948 cfs ($55m^3$/sec). The pump-generator units are employed as follows: Pumps are used to lift water to the feeder canal during periods when the price of power is low, and water from the canal is run back down through the turbines during peak energy demand periods when the price of power is high. Collectively, all of the generators at GCD have a rated capacity of 6 809MW. Depending on the elevation of the water in Lake Roosevelt, the pumps may lift project water anywhere from 270ft to 360ft (98m to 131m) (USBR, 1976: I-62). In 1996, 2.5MAF ($3\ 100 \times 10^6\ m^3$) were diverted from Lake Roosevelt at the pump generator plant (Montgomery Water Group, 1997: 8)

Franklin D. Roosevelt Lake covers an area of 82 300 acres (33 300ha) and is 151 miles (243km) long. The Lake includes 600 miles (965km) of shoreline and it has a total capacity of 9.386MAF (11 600 million m^3). The active storage capacity of Lake Roosevelt is 5.185MAF ($6\ 400 \times 10^6\ m^3$).

Figure 2.3.1 Grand Coulee Dam Project Layout

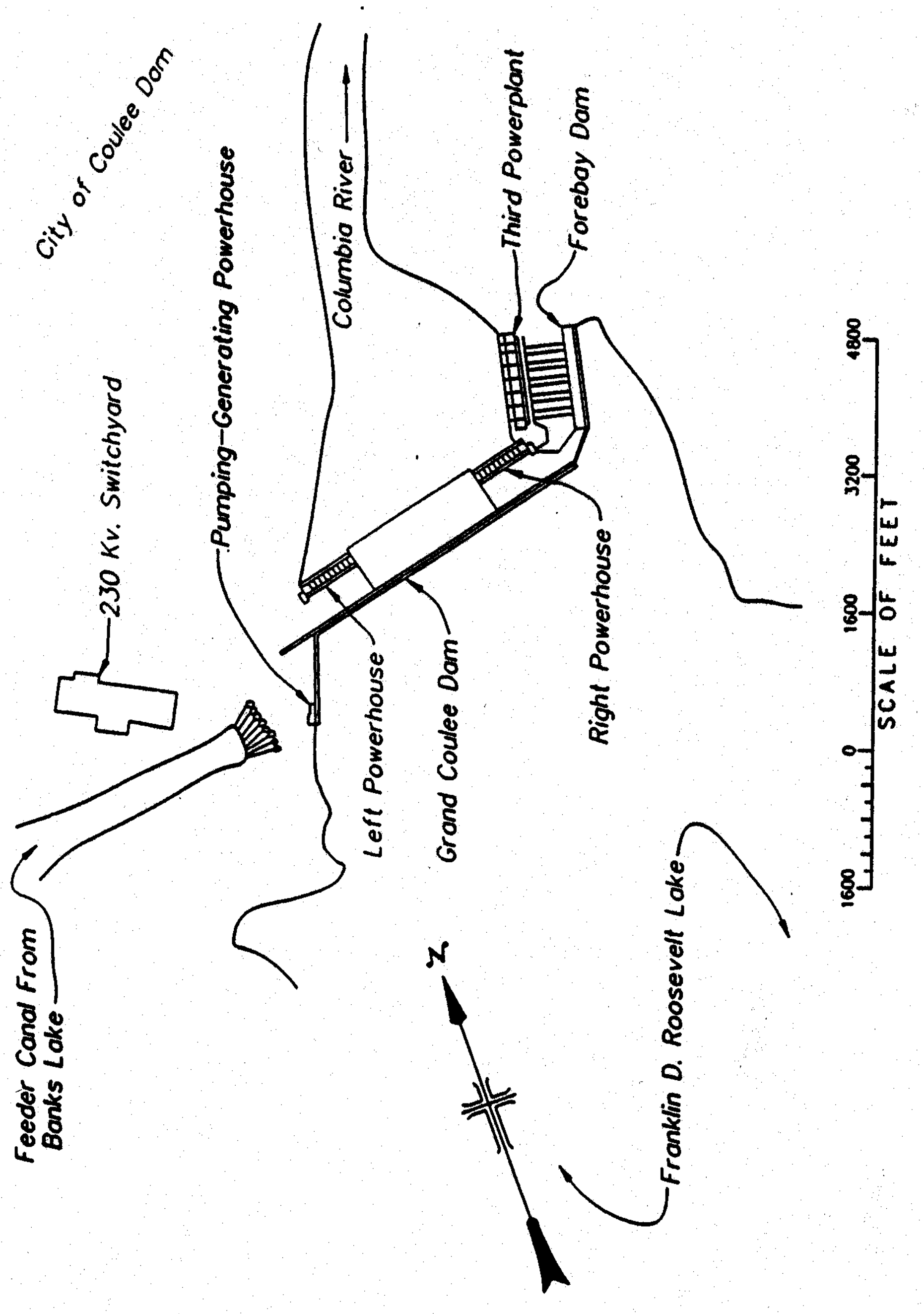


Figure 2.3.1 Grand Coulee Dam Project Layout

Figure 2.3.1
Grand Coulee Dam Project Layout

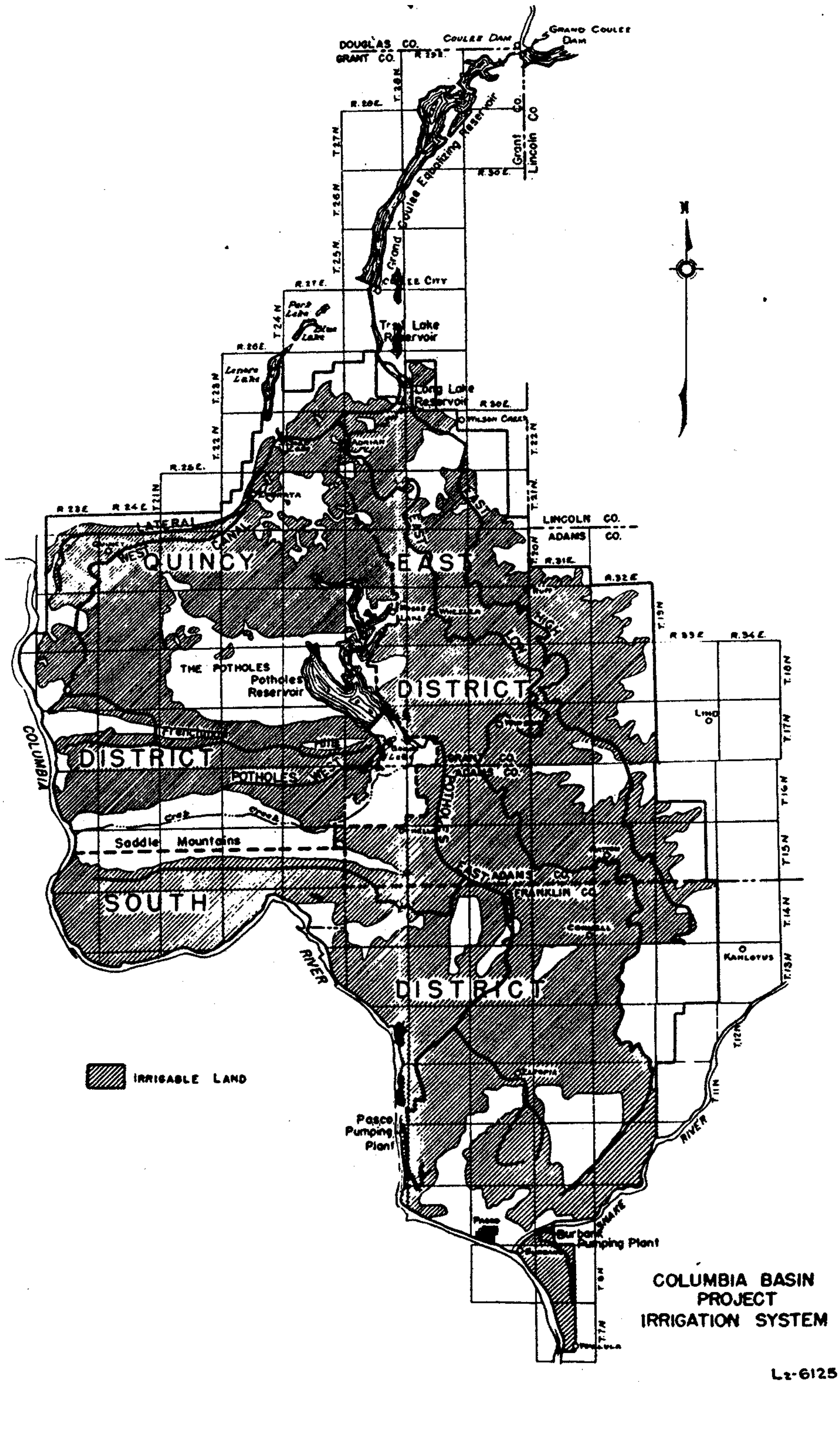
2.3.2 Description of the Columbia Basin Project[3]

CBP represents the single largest reclamation project in the United States. It currently irrigates 660 794 acres (267 414ha), with the total number of officially irrigable acres within the project area being 1 095 000 acres (443 000ha). The irrigation project consists of several sizeable dams, reservoirs, and 333 miles (536km) of main canals. There are numerous smaller features within CBP, including 1 993 miles (3 207km) of lateral canals, 3 498 miles (5629km) of drains and wasteways, and hundreds of relift pumping plants that raise irrigation water to higher land. A detailed description of CBP is contained in the Annex titled "CBP Overview". Some of CBP's major features are shown in Figure 2.3.2.

Water pumped up from Roosevelt Lake enters a feeder canal, where it flows into Banks Lake, an equalising reservoir situated in the bed of the ancient gorge known as the Grand Coulee. Irrigation pumping can be conducted during off-peak hours when power and water demands at Grand Coulee Dam are low.[4] Banks Lake was built by constructing two earthfill dams on each end of Grand Coulee – North Dam at the upper end of the Coulee, and Dry Falls Dam at its outlet. From Banks Lake, CBP water runs into the Main Canal, which begins at the east end of Dry Falls Dam. The Main Canal enters the Bacon Siphon and Tunnel and eventually empties into Billy Clapp. From there, irrigation water continues on to the Bifurcation Works.

At the Bifurcation Works the Main Canal divides into the West Canal and the East Low Canal. The West Canal flows along the north-west edge of CBP, carrying water across the Lower Grand Coulee in the Soap Lake Siphon. It then flows across the Quincy Basin to the Frenchman Hills, where it enters a tunnel that flows through the Hills. On the south side of Frenchman Hills (the Royal Slope), the West Canal splits, with the West Canal turning eastward and Royal Slope Canal extending west from the tunnel. The East Low Canal extends along the eastern edge of the developed portion of CBP.

Figure 2.3.2 Columbia Basin Project Area



An important component of CBP is O'Sullivan Dam, which forms Potholes Reservoir. Water delivered to farms on the upper part of the project, in the Quincy and East Columbia Basin Irrigation districts, flows into drains and wasteways, and many of these return flows empty into Potholes Reservoir. The reservoir also receives return flows from groundwater seepage, feed water directly from the East Low Canal, and natural inflows from Crab Creek and Rocky Ford Creek. Potholes Reservoir serves several functions in CBP. It captures return flows for reuse, thereby decreasing the diversions needed from the Columbia River. The reservoir also regulates water storage in the central part of the project, provides water early in the irrigation season for lands in the South Columbia Basin Irrigation District, and allows the storage of natural runoff to be used for irrigation purposes.

Potholes East Canal flows south from O'Sullivan Dam to the city of Othello, then it turns south-east to Scooteney Reservoir. From Scooteney, the canal runs south-west until it ends at the Pasco Wasteway, which flows into the Columbia River north-east of the city of Pasco. Potholes East Canal supplies water to two smaller canals, Wahluke Branch Canal and the Eltopia Branch Canal

There are numerous locations where CBP irrigation water returns to the Columbia River system. Among the major return flows are those from Lower Crab Creek, PE 16.4 Wasteway, and Esquatzel Diversion Canal (Michael 1999). In addition to these, there are numerous smaller outlets to the Columbia River. There is no definitive measurement of the amount of return flows to the Columbia River, although one study in the early 1970s estimated that 400 000 acre-feet (490 x 10^6 m^3) of water return to the river each year. A more recent study estimated a return flow of 571 100 acre-feet (704 x 10^6 m^3) in annual return flows (Olsen, 1996: Table 1).

Key institutions in managing CBP are the irrigation districts. There are four irrigation districts on CBP. The three primary districts are the Quincy Columbia Basin Irrigation District, which served 247 346 acres (100 100ha) of irrigated land in 1998, the East Columbia Basin Irrigation District, which served 152 000 acres (61 500ha), and the South Columbia Basin Irrigation District, which served 230,948 acres (93 500ha) (Moody 1999). The irrigation districts are governed by a board of governors elected by the district's landowners (Svendsen & Vermillion, 1994: 26–7). In addition to these three districts, which have repayment contracts with the Bureau of Reclamation, there is also the Grant County Black Sands Irrigation District, a groundwater pumping district, which had 30 500 irrigated acres (12 300ha) in 1998 (Moody 1999).

In January 1969, Reclamation transferred management of many CBP facilities to the three primary irrigation districts (ie, Quincy, East, and South). It continued to manage the "reserved works," which include the Grand Coulee Pumping Plant, Banks Lake, the Main Canal and Billy Clapp Lake, Potholes Reservoir, as well as the headworks for the West, East Low, and Potholes Canals (Svensen & Vermillion, 1994: 39). The Quincy District manages the West Canal, the East District manages the East Low Canal, and the South District manages Potholes Canal (Montgomery Water Group, 1997: 2). The districts are responsible for the operation and maintenance of the facilities they directly manage, and they pay Reclamation for these costs on the reserved works. Reclamation retains ownership of CBP (Svensen & Vermillion, 1994: 39).

In addition to managing much of CBP, the irrigation districts establish the assessment rates charged CBP farmers. These assessments cover CBP operation, maintenance, and replacement costs, the cost of generating the power necessary to lift irrigation water up to Banks Lake, and the annual CBP construction cost repayment charge, which averages $2.63 per acre per year (Kemp 1999). If CBP farmers fail to pay their assessment, the irrigation districts are still obligated to pay Reclamation the construction and maintenance costs. This is because there is an official repayment contract between the districts and Reclamation (Svensen & Vermillion, 1994: 31).

2.3.3 Timing of Construction

Table 2.3.1 contains a brief chronology of the construction of the project's principal components. It is not possible to make meaningful comparisons between the time at which different features were constructed and the times at which project planners, working in 1932, estimated that construction would be completed. This is because the Reclamation Report did not include a construction time schedule (USBR, 1932). References in the report to timing are quite general and do not allow meaningful comparisons with the actual timing of construction events.

Table 2.3.1 Construction History of the Grand Coulee Dam and Columbia Basin Project

Date	Event Description
1933	Groundbreaking ceremonies held at dam site.
1934	Contract for first phase of (low) dam and powerplant awarded.
1935	Change order authorised construction of high dam.
1939	GCD blocked Columbia River.
1940	Hatchery at Leavenworth Station on Icicle Creek completed.
1941	First service generators, LS-1[a] and LS-2 went into service; and first 108 000kW units (L-3 and L-4) went into service.
1943	Grand Coulee Fish Maintenance Project began permanent operations; generator units L-5, L-6, L-7, and L-8 went into service.
1945	Construction of pumping plant started.
1946	Construction of Dry Falls Dam, Feeder Canal, Main Canal, and West Canal started.
1947	Construction of East Low Canal and O'Sullivan Dam initiated.
1948	First farm units (ie, Irrigation Block No. 1) opened for settlement; irrigation water pumped directly from Columbia River near Pasco.
1949/ 1950	Most units in right powerhouse brought into service; construction of Dry Falls Dam and O'Sullivan Dam completed and construction of North Dam started.
1951	Generators R-7,[b] R-8 and R-9 placed into service; construction of Feeder Canal, Main Canal, and North Dam, and Dry Falls Dam completed; initial pumping of irrigation water started.
1967	Construction of Third Powerplant initiated.
1975	Generators at Third Powerplant placed into service.
1954	Construction of East Low Canal completed.
1955	Construction of West Canal completed.

[a]L is for left or West Powerhouse; [b]R is for right or East powerhouse
Sources: Downs, 1993; Simonds, 1998; USBR, undated(b).

There are also more general reasons for not drawing conclusions on how well the timing of construction corresponded to the plans laid out prior to construction. The federal government's goals changed over time as conditions changed. In 1932, while President Hoover was still in the White House, the government was under pressure not to open new lands to irrigation because of the great agricultural surplus, thus the Hoover administration directed Reclamation not to open any new land for development. However, when Franklin Delano Roosevelt was elected president in 1932, he saw construction of GCD as a mechanism for putting people to work, and he authorised a project that involved a low dam at Grand Coulee to generate power, with no provisions for irrigation.

By the mid-1930s, President Roosevelt's plans included the need for removing "Dust Bowl" refugees to the Northwest's "Planned Promised Land" that irrigation would create. Thus, there was a new emphasis on having CBP completed in a timely fashion. World War II turned plans upside down again; it slowed power development at GCD as the timeline for obtaining new generators was extended. During the war, only the generators in the left powerhouse were installed, and some of these were generators that were originally intended for Shasta Dam in California. After World War II, there was a strong push to settle veterans on CBP lands. The practicality of this idea is debatable, but it was the federal government's stated goal.

In summary, administrative pressure, congressional pressure, and changing times and conditions all affected Reclamation's construction of GCD, making its goals hard to pin down at any one time. Different personnel at top levels of Reclamation and in presidential administrations are another factor confounding any assessment of whether Reclamation followed the timeline laid out in its plans.

3. Projected and Actual Impacts of the Grand Coulee Dam and Columbia Basin Project

3.1 Irrigation

3.1.1 Predicted vs. Actual Area Under Irrigation

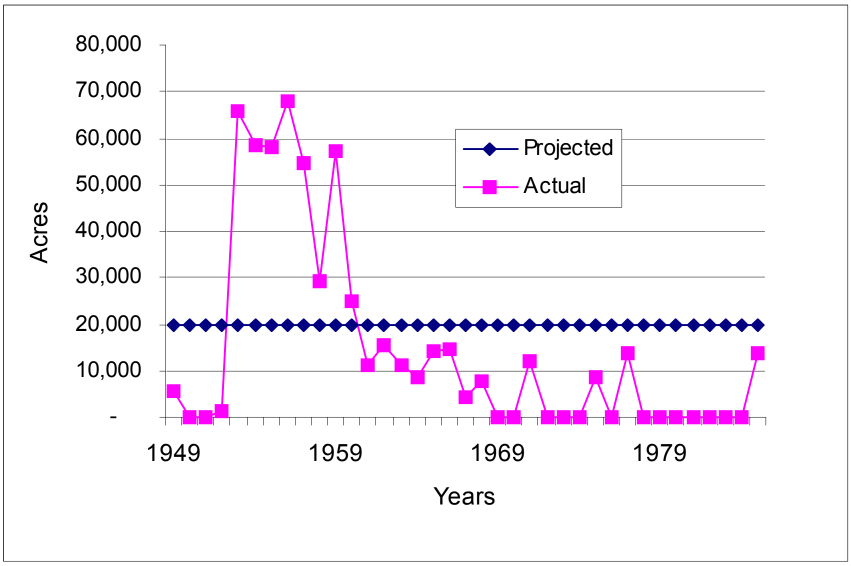
The 1932 Bureau of Reclamation Report (Reclamation Report) estimated that the ultimate size of the CBP would be 1 199 400 acres (485 400ha) (USBR, 1932: 115). This total included 981 000 acres (397 000ha) of land fed by gravity canal systems and 219 000 acres (88 600ha) irrigated by repumping water to higher elevations (USBR, 1932: 83). Additional land classification surveys in 1945 led Reclamation to revise the net irrigable acreage down to 1 029 000 acres (416 420ha) (USBR, 1945a: XIII). The estimated final size changed again when the East High Investigation of 1968 identified the total CBP size as 1 095 000 acres (443 100ha) (USBR, 1976: I-4, I-6).

There is a substantial difference between the projected size of the CBP and the area actually being irrigated. As of 1998, 660 800 acres (276 500ha) were receiving CBP water. Reclamation developed 560 000 acres (226 600ha) of this land, about 50% of the area originally proposed. The remaining 100 000 acres (40 500ha) currently being farmed have been developed largely by private individuals on lands that were previously considered unirrigable. The major reason for the shortfall in acreage developed is that the second half of the project has not been completed. The decision not to proceed with development of the second half lands is detailed in section 7.8. Currently, there are no plans to irrigate the second half of the CBP. Those areas currently irrigated and those areas not yet irrigated under the current CBP authorisation are delineated in Figure 2.3.2 of Section 2.

There is also a significant difference between the timing of the predicted and the timing of actual developments. Figure 3.1.1 shows the rate of irrigated land development predicted by the Reclamation Report and the actual acreage developed during the initial 36 years of the CBP.[5] The Reclamation Report projected a uniform development rate of 20 000 acres (8 100ha) per year, which would have resulted in 720 000 developed acres (291 400ha) after 36 years. During the same period, Reclamation actually developed 558 100 acres (225 900ha), about 30% less. During the early years of the project, Reclamation developed the CBP much more quickly than had been predicted. The Reclamation Report predicted that 200 000 acres (80 900ha) would have been brought on line in the first 10 years.[6] The actual developed acreage was substantially greater, totalling nearly 400 000 acres (161 900ha) or almost 75% of the total land developed to date.

The change in the settlement strategy that resulted in accelerated development was first proposed in the recommendations of the Columbia Basin Joint Investigation of Development Rate of Project Lands (USBR, 1945b: 2). This 1945 report cited a number of reasons for accelerating the rate of development, chief among them being the fear that the overheated wartime economy might be headed for a depression, especially with the return of hundreds of thousands of veterans. Although the Eisenhower administration, which oversaw most of this period of accelerated development, was lukewarm toward reclamation, several factors worked in favour of rapid CBP expansion during the 1950s: (i) Reclamation had learned to request more money than it needed and hence had a cushion against Congressional budget cutting; (ii) Western congressmen were committed to reclamation and provided strong political support; and (ii) reclamation continued to be a popular erosion control and soil conservation method (Pitzer, 1994: 287).

Figure 3.1.1 Projected and Actual Irrigable Acreage, 1949–1985



Sources: USBR, 1932; Patterson, 1998: Table 3

The additional 100 000 acres (40 500ha) brought under cultivation by farmers was permitted by advances in irrigation technology, primarily pressurised sprinkling and well irrigation. The CBP as planned was based on furrow or row irrigation in which water is delivered to crops by gravity flow. For this reason many areas with steep slopes were considered to be “Class 6,” unirrigable, land (USBR, 1945a: 6). Starting in the 1950s, new sprinkler technologies, such as wheel lines, were adopted by CBP farmers (Kulp 1999). Later, centre-pivot sprinklers became increasingly popular (Svensen & Vermillion, 1994: 48). With pressurised irrigation systems, many lands that originally had been considered unirrigable because of topography could be reclassified as irrigable. Between 1963 and 1991, the use of pressurised sprinkler systems increased from 40% to 70% (Montgomery Water Group, 1997: 10, Figure 3-10). While most of these lands had been irrigated prior to the conversion to sprinklers, some lands were brought under cultivation for the first time using sprinkler technology.

Rising water tables in the Black Sands area, located west of Potholes Reservoir, provided another opportunity to irrigate lands that had been predicted to be unirrigable. As a result of irrigation in other parts of the project, the groundwater table in this area rose to a level usually less than 30 feet below the surface (USBR, 1976: I-90). This has allowed the Black Sands area, originally considered to be unirrigable, to be served by irrigation based on groundwater pumping.

3.1.2 Predicted vs. Actual Agricultural Production

3.1.2.1 Increases in the Gross Value of Production

The gross value of production (GVP) has grown enormously over the course of the CBP’s development, both in aggregate and in dollars per acre. Table 3.1.1 shows the increase in output by decade. In 1962 the gross value of agricultural crops was $644 per cropped acre in constant $1998.[7] By 1992, that figure had nearly doubled to $1 210 per acre.

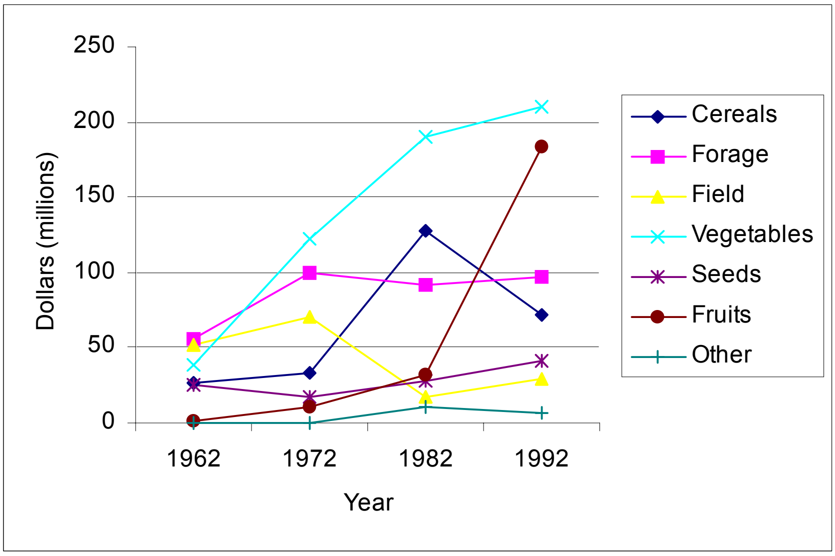
Table 3.1.1 Gross Value of Agricultural Production in the Columbia Basin Project

	Aggregate Value		Area Irrigated	GVP/acres	
	1992 ($000)	1998 ($000)	(000)	1992 $	1998 $
1962	173 100	201 000	346	555	644
1972	305 000	354 300	463	658	764
1982	429 100	498 400	5219	823	956
1992	552 300	641 500	530	1 042	1 210

Source: USBR, Crop Report Summary Sheet, Columbia Basin Project, various years, as reported in W.R. Holm and Associates, 1994.

The growth in the value of agricultural output has been, in part, the result of increases in total cropped acreage and an improvement in crop yields. But the move from traditional field crops to higher value fruits and vegetables has been even more significant. In 1992, the latter accounted for over 60% of the gross value of crops, up from 20% in 1962. Figure 3.1.2 shows some of the most important trends.

Figure 3.1.2 Trends in Crop Production



Sources: USBR, Crop Report Summary Sheet, Columbia Basin Project, various years, as reported in W.R. Holm and Associates, 1994.

- The gross value of vegetables has increased at a rapid rate throughout the entire life of the CBP. Early and late potatoes dominated the vegetable category in the initial years, accounting for 80% of the acreage in the category. In 1992, their relative importance had declined to approximately 45%. However, because of the overall increase in cropped acreage, absolute acreage increased from 27 000 acres (10 900ha) in 1962 to 41 000 acres (16 600ha) in 1992.

  Another important trend in the vegetable category is the growing importance of speciality crops, which were virtually unknown in the CBP's early years. For example, in 1992, asparagus occupied 13 100 acres (5 300ha) or 13% of the vegetable acreage. Other important vegetable crops in which the Columbia Basin has established a comparative advantage are dry onions and sweet corn for processing.

- The increase in the value of fruits has been equally notable, especially since 1980. In 1992, apples dominated this category with 27 000 acres (10 900ha), contributing roughly 80% of the value of total fruit output. They represented the largest single contribution to total farm value in the project. The second-fastest growing fruit crop was grapes, both for fresh consumption and for winemaking.

- A third of the cropped acreage is devoted to forages, down from 40% at the beginning of the project. Forages are dominated by alfalfa hay, which represents over 90% of the value in this category. Substantial acreage under forage is planted not only for its value as livestock fodder, but for its role in the crop rotations practised in the area. For reasons of soil fertility and soil disease, vegetables such as potatoes and onions must be grown in rotations that limit the number of consecutive years they can be grown on a plot of land.

The substantial crop values generated from the CBP is evidenced by the fact that it produces a significant proportion of Washington's total GVP. In 1992, the CBP produced 12% of the state's $5 328 000 000 (in $1998) GVP (USBR, 1992c; SSO Staff, 1996). For some crops, the CBP's contribution is even greater. In 1992 it provided 17% Washington's gross value of apple production, 28% of its potato value, and 32% of its hay value (USBR, 1992c; SSO Staff, 1996).

3.1.2.2 Predicted vs. Actual Cropping Patterns

The movement toward high value crops such as small grains, fruits, and vegetables was only partially anticipated by the planners of the original CBP (as the acreage figures in Table 3.1.2 indicate). Projections for alfalfa hay were reasonably accurate because of the significant role alfalfa continues to play in the project's crop rotations. On the other hand, the area predicted for pasture did not materialise; livestock have not been an important enterprise for most CBP farms. Instead, farmers have elected to grow wheat as a profitable cash crop that also fits into a sustainable crop rotation. The area devoted to both potatoes and tree crops was underestimated: these crops have turned out to be instrumental in producing the substantial growth in the gross value of CBP agriculture.

A measure of the cropping pattern effect shown in Table 3.1.2 can be obtained by comparing the gross value of production under the cropping pattern predicted by the Columbia Basin Joint Investigation study with the actual cropping pattern farmers used in 1992. This calculation, shown in Table 3.1.3, takes the Table 3.1.2 cropping patterns, normalises them to 100%, holds the cropped acreage, individual yields, and commodity prices constant, and computes a pure cropping pattern effect.

Table 3.1.2 Predicted vs. Actual Cropping Patterns

Crop	Predicted %	1972 %	1992 %
Alfalfa Hay	34.0	34.2	27.4
Pasture	23.2	5.3	2.9
Wheat	8	7.2	21.3
Corn, Grain	6.3	6.3	6.1
Barley	5.3	1.3	-
Sugar Beets	4.6	11.4	-
Clover	3.3	-	-
Potatoes	1.7	7.6	7.9
Tree Fruit	1.5	0.6	6.1
Small Fruit	1.1	-	0.7
Total Percentage	89.0	73.9	72.4

Sources: USBR, 1945a: 32-39; USBR, 1972; USBR, 1992a.

The results indicate that, other things held constant, there is a substantial difference between the GVP that the original planners predicted and what has actually transpired. If the predicted crops had been grown in the expected proportions, the 530 100 acres (214 500ha) irrigated in 1992 would have produced approximately $337.8 million (in $1998). The actual cropping patterns resulted in a GVP of $636.6 million, nearly twice as much.[8]

The sources of the difference between predicted and actual GVP have already been mentioned. Acreage that the original planners thought would be devoted to irrigated pasture, barley, and clover, prompted, no doubt, by the assumption that livestock would play a role in CBP agriculture, have instead been used to expand the acreage under wheat and, most importantly, potatoes and tree fruit.

Table 3.1.3 Predicted vs. Actual Gross Value of Production

Crop	% Predicted	% 1992	Predicted Acres	1992 Acres	GVP/acres (1998 $)	Predicted GVP (000)	1992 GVP (000)
Alfalfa	38.2	37.8	202 500	200 600	621	125 823	124 655
Pasture	26.1	4.0	138 200	21 200	167	23 110	3 551
Wheat	9.0	29.4	47 600	156 000	480	22 856	74 806
Corn	7.1	8.4	37 500	44 700	463	17 390	20 697
Barley	6.0	0.0	31 600	0.0	295	9 312	0.0
Sugar beets	5.2	0.0	27 400	0.0	1 081	29 628	0.0
Clover	3.7	0.0	19 700	0.0	621	12 213	0.0
Potatoes	1.9	10.9	10 100	57 800	2 718	27 516	157 198
Tree fruit	1.7	8.4	8 900	44 700	5 333	47 637	238 197
Small fruit	1.2	1.0	6 600	5 100	3 410	22 342	17 478
Total	*100.0*	*100.0*	*530 100*	*530 100*		*337 834 096*	*636 581*

Sources: USBR, Crop Report Summary Sheet, Columbia Basin Project, various years, as reported in W.R. Holm and Associates, 1994.

3.1.2.3 Predicted vs. Actual Crop Yields

Although changing crop composition has been the most dramatic source of increased gross production value, increases in crop yields have also played an important role in the growth of agricultural output. Table 3.1.4 shows the improvements that have taken place for a number of major crops over the years 1932, 1962, and 1992.

Table 3.1.4 Predicted vs. Actual Crop Yields

Crop	Predicted 1932 (average)	1962	1992	% change 1992 over 1962
Alfalfa	3.75t[a]	4.7 t	6.5 t	38.3
Apples		4.9 t	13.6 t	177.5
Corn	1.15 t	6.4 t	8.7 t	35.9
Early Potatoes	115 cwt[b]	349 cwt	458 cwt	31.2
Late Potatoes	110 cwt	347 cwt	533 cwt	53.6
Wheat	56 bu[c]	67 bu	100.5 bu	50.0

[a]t = ton; [b]cwt = hundredweight; [c]bu = bushel

Sources: USBR, Crop Report Summary Sheet, Columbia Basin Project, various years, as reported in W.R. Holm and Associates, 1994; USACE, 1933: 1022.

The addition of more high-value crops and improved yields were not the only technological changes taking place on CBP farms in the post-war period. Innovations in farm machinery occurred in a number of important crops, including large combines for harvesting grains, and sugar beet, potato, and onion harvesters for row crops. Larger tractors, capable of pulling plows, disks, and other farm implements with several times the capacity of older models, were introduced.

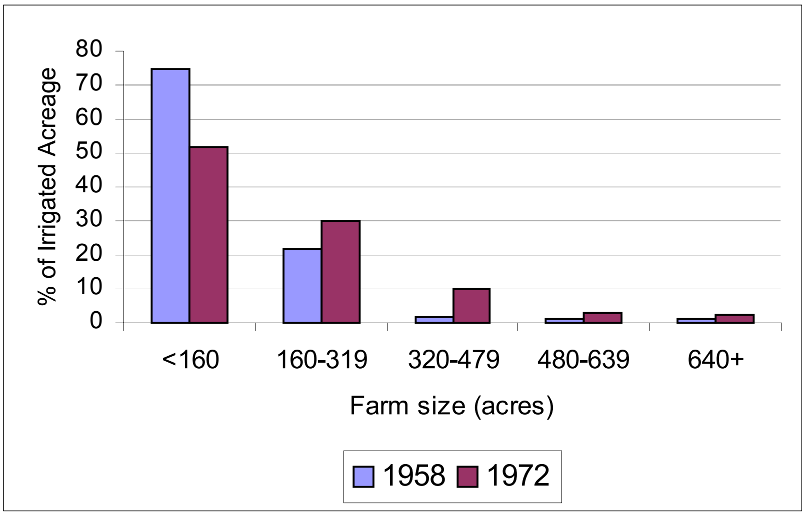
Because the capacity of the new machines increased even more than their cost, they represented powerful economies of scale and created significant incentives to increase the size of operating units. The CBP experienced much the same increases in the size of farm operations that were taking place in the rest of US agriculture. Families have continued to operate farms, but instead of a single family operating 80 acres (32ha) as they might have in the early years of the CBP, three decades later, with the application of technology, they were capable of operating four to five times that amount.

Planners working in the 1930s and mid-1940s were in no position to predict such rapid and far-reaching changes in agricultural technology. They could not have anticipated the explosion in post-war output that would produce a constant downward pressure on commodity prices, fuelling the need for non-stop innovation — the so-called "agricultural treadmill" (Cochrane, 1993: 23). Only by increasing the size of their operations, thereby reducing costs, could farmers hope to maintain or improve their standard of living. It is not surprising that "what CBP farmers wanted most in the early 1960s was to end the restrictions on land ownership" (Pitzer, 1994: 291).

3.1.3 Predicted vs. Actual Farm Size

Farm size on the Columbia Basin Project has been increasing since its inception. Between 1958 and 1973 the average farm size increased from 140 to 210 acres (57 to 86ha). Even though the data represent only the early years of the CBP, the trend toward larger farm sizes can be seen clearly (Figure 3.1.3).

Figure 3.1.3 CBP Farm Operation Size Distribution, 1958 and 1973



Sources: USBR, 1973; Doka, 1979:104.

The graph shows that, over the 15-year period, the proportion of acreage in farms greater than or equal to 160 acres (65ha) has increased while the proportion of acreage in small farms has decreased. At this time, Reclamation law allowed a husband and wife to jointly own 320 acres (130ha) (160 acres per person) and receive subsidised water rates. Any land owned over this limit had to pay the full cost of delivering water (Postma 1999). Thus, those farmers operating more than 320 acres (130ha) leased land to increase the size of their farms.

Though large non-family farms never have been widespread on the CBP, until 1982 leasing provided a way to increase farm size beyond the ownership limitations. Before Congress passed the 1982 Reclamation Reform Act (RRA), which increased the allowable acreage a farmer could own and receive subsidised water for, there was no limit on the amount of land a farmer could lease (Doka, 1979: 138). Current regulations place a limit of 960 acres (388ha) on the size of a CBP farming operation receiving subsidised irrigation water.[9]

This trend toward larger farms has continued, and today the average farm size on the CBP is about 500 acres (200ha) (Davis 1999). Despite the fact that farms have grown in size, nearly all operations in the CBP continue to be under family management (Davis 1999; Kemp 1999; Flint 1999; Cole 1999b). For the most part, these farming operations have remained within the restrictions set up under the Reclamation law. A few farmers, however, have used legal loopholes, like setting up trusts for the children in the family, to get around size limits (Postma 1999).

3.1.4 Investment Costs and Cost Recovery

3.1.4.1 Predicted vs. Actual Investment Costs

The 1932 Reclamation Report estimates for the cost of irrigation development seem fairly detailed. Table 3.1.5, for example, shows precise figures for the various project components (USBR, 1932: 108). However, the Reclamation Report's projections of year-by-year expenditures suggest that the numbers in Table 3.1.5 are largely the result of applying a dollar-per-acre formula (USBR, 1932: 114).

Table 3.1.5 Projected Capital Costs for the Columbia Basin Project

	1932 dollars (000)	1998 dollars (000)
Primary pumping plant	8 890	105 833
Repumping plants	7 525	94 062
Grand Coulee Lake	8 703	106 134
Canals	79 307	944 131
Tunnels	22 778	267 976
Siphons	37 595	427 216
Lateral system	28 516	327 770
Drainage	4 800	56 471
Buildings	1 484	17 256
Telephones	240	2 667
Wasteways	2 230	22 300
Wells	200	1 887
O and M during construction	5 997	55 528
Total	*208 265*	*2 429 231*

Source: USBR, 1932: 108.

The report predicts an expenditure of $47 million for the first ten years. This would cover both the cost of the lands of the Quincy area that are easiest to irrigate, and the cost of a substantial amount of central infrastructure (USBR, 1932: 108). Thereafter, however, each 20 000 (8 090ha) block comes with a $3.327 million price tag (USBR, 1932: 114). This continues until the 60th year when the entire 1.2 million acres (485 600ha) were predicted to have been developed.

These entries imply that there there were no detailed cost studies covering the entire area at the time the financial feasibility study was done. The data suggest that Reclamation's engineers worked out the first 150 000 acres (60 700ha) in some detail and then, combining these results with their experience in a number of smaller projects under similar conditions, simply extrapolated to the remainder of the CBP.

Table 3.1.6 shows a comparison between the predicted costs of CBP development and the actual costs.[10] Measured in $1998, the actual cost of developing that portion of the CBP that is currently irrigated is nearly three times (289%) the cost that was originally envisaged for the same area.

None of the studies done for the CBP used a discounted cash flow analysis. The numbers shown in Row 1 of Table 3.1.6 are simply the sum of investment expenditures. They do not take account of the fact that costs were planned to occur, or did occur, over time. However, the time series data that can be used to estimate a present value for investment costs do exist and the present value of costs at different interest rates are shown in rows two through to four. As expected, when viewed from the start of the project, discounting at higher interest rates decreases the present value of costs because of the relatively greater reduction in the magnitude of future costs.

Table 3.1.6 Predicted vs. Actual Construction Costs of CBP

Predicted Costs (000)		Actual Costs (000)	
Constant 1932 $	1998 $	Nominal $ (1949-85)	1998 $
(1) 105 099	1 251 178	674 000	3 615 698
Cost streams discounted at different interest rates			
(2) Discounted at 5%	767 391		2 223 901
(3) Discounted at 10%	567 202		1 470 307
(4) Discounted at 15%	469 000		1 021 230

Sources: USBR, 1932: 114–115; Patterson, 1998: Table 3.

Given the underestimate of development costs, it follows that the prediction of the subsidy required to construct the CBP would also be underestimated. According to both the Butler Report and Reclamation's feasibility study, about 50% of the irrigation construction costs would have to be covered by surplus power revenues (USACE, 1932). If direct benefits — and their associated repayment assessments — did not increase proportionately, the higher costs would necessarily be accompanied by larger subsidies.

The accelerated construction schedule also increased the level of subsidy. This is because the direct construction costs of each additional acre were substantially greater than what it returned in repayment revenues. Of the irrigation costs, only 20% were central costs (USACE, 1933: 1031).[11] The remaining 80% of the costs were incurred at the time a particular block was brought on line. By pushing irrigation development into the future, as the original feasibility study did, losses were pushed into the future.[12] For the GCD project as a whole, the effect of stringing out irrigation costs was to accumulate power revenues with minimal discounting while discounting future irrigation costs heavily.[13]

As data from FCRPS indicate, the total subsidies for construction (including drainage) have indeed been far greater than anyone had anticipated. The total cost allocated to irrigation blocks reported earlier was $674 million; the anticipated repayment from the FCRPS is $585 million or an 87% subsidy (Patterson, 1998: 7). These figures do not provide a complete description of the subsidy associated with the cost of CBP construction. The reason is that the federal government agreed to repayment in nominal dollars that are not adjusted for inflation. Thus, for example, a farmer's annual repayment costs, based on a 1962 settlement described below, are now being made in dollars that, in 1998, were worth only 18.5% of the dollars of the 1962 repayment contract.

3.1.4.2 Cost Recovery

To estimate the repayment capacity of CBP farmers, project planners used farm budgets constructed from similar irrigation projects in the West to create model "representative farms" growing potatoes, grain, corn, vegetables, and fruit. Using projected yields and prices, they calculated gross income, input costs, and net revenue (USACE, 1933: 1022). On the basis of these calculations, the Butler Report declared that a repayment cost of $6 per acre would be acceptable (USACE, 1933: 1028). The Reclamation Report estimate was slightly lower at $5 per acre (USBR, 1932: 81). These studies were trying to determine what net returns beneficiaries could expect and what repayment costs would ensure that incentives to settle were in place.

Table 3.1.7 Estimates and Actual Repayment Charges

Repayment Cost Determination	Per Acre Charges	
	Nominal	1998 dollars[a]
Butler Report (1932)	6.00	71
First Irrigation District Negotiation (1945)	85.00	773
Second Irrigation District Negotiation (1962)	131.60	711

[a]The column labelled "1998 dollars" represents the equivalent of the nominal dollar figure in earlier years inflated to $1998.
Sources: USACE, 1933: 1028; Pitzer, 1994: 299, 306.

Although repayment costs changed greatly from the estimates made in 1932, subsequent adjustments have been infrequent (Table 3.1.7). In 1945, a repayment charge of $85 per acre payable over 40 years was negotiated with the irrigation districts. This was raised in 1962 to $131.60 over 50 years as part of the overall settlement of the drainage problem. The latter amounts to an average of $2.63 per acre per year ($14.22 in $1998). This cost has remained unchanged and unadjusted for inflation since 1962.
Because there has been no link between repayment schedules and total irrigation project costs, the focus of the debate over repayment has been on what farmers could afford to pay based on their net returns exclusive of repayment costs. Olsen offers the following assessment of net returns:

> *Based on a multi-year aggregation of the Project crops, the weighted (direct) net value for 80% of the total Project acreage (crops with readily available value data) — net income return to farm management and farm holders — is about $165 dollars/acre. If net value is assumed to range between 15–20% of the gross crop values, then net value would be between $150–200/acre. This net value is based on existing Project production and operation costs to farm managers and farm holders.* (1996: 5)

Assuming that operation and maintenance assessments imposed by the irrigation districts have been subtracted from gross revenues, the Olsen estimate suggests that increases in the repayment of construction costs would be a fairly small item in a CBP farmer's total costs of farming. Congress has the power to renegotiate the repayment contracts, but it has thus far shown no inclination to do so.

3.1.4.3 Indirect Energy Subsidies

In addition to repaying a portion of construction costs, CBP farmers also pay the cost of lifting water from Lake Roosevelt to Banks Lake and into the CBP. The Bureau of Reclamation, which operates the power facilities at GCD, charges the irrigation districts for pumping, and the districts subsequently pass these costs on to CBP farmers (Olsen, 1996: 14).

CBP planners envisaged substantial indirect pumping subsidies (Gittinger, 1984). In this context, an indirect subsidy occurs when manipulation of market prices by the government yields a price lower than that which would have been received in a competitive market. (In contrast, a direct subsidy takes the form of a transfer payment from a government directly to a producer, such as a farmer).[14] The Reclamation Report projected that the price of power used for pumping would be $1 per acre, or approximately 0.5 mills per kWh. The commercial sale price was projected to be 2.25 mills per kWh (USBR, 1932: 142). Data on CBP energy use became available in 1966; since that time, CBP has used about 950 million kWh of primary and secondary power each year (USBR (GCPO), 1999). Based on this rate of power usage, the projected indirect subsidy for the irrigated areas of the CBP was approximately $19.8 million annually in $1998.[15]

The House Committee on Natural Resources Majority Staff Report of the 1994 Task Force on the Bonneville Power Administration Natural Resources (US House of Representatives, 1994) provides more information on power prices. According to this report, "Over two-thirds of the power consumed by BuRec is used in the Columbia Basin Project and is sold for 0.95 mills, less than one twenty-eighth of the 26.8 mill priority firm rate". Information on energy rates is summarised in Table 3.1.8.

Using the 950 million kWh figure, the indirect subsidy using the Staff Report number would be $27 million annually or 40% more than predicted.[16] However, not all alternative users are priority firm users, and a more conservative estimate would place the weighted average price of power at 15 mills (Hayes 1999). In this case, the annual indirect subsidy to the CBP would be on the order of $14 million annually – 40% less than the 1932 prediction when both are measured in $1998.

Table 3.1.8 Energy Rates

	Bureau of Reclamation (1932)		**Natural Resources Staff (1994)**	
	1932 $	1998 $	1994 $	1998 $
General Sale Rate (per kWh)	0.00225	0.0262	0.02680	0.02950
CBP Subsidised Rate (per kWh)	0.00050	0.0060	0.00095	0.00105
Value of Subsidy (per kWh)	0.00175	0.0202	0.02585	0.02845

Sources: USBR, 1932; US House of Representatives, 1994.

There is another form of indirect subsidy, one that is based on the power revenues foregone because water diverted for irrigation is not available to generate power at GCD. Farmers pay for the power they use, albeit less than it would be worth if sold on the market. But they do not pay for the use of water that could have been used to generate additional energy. BPA administrators have developed several alternative estimates of hydropower foregone due to irrigation (Olsen, 1996: 10-11).[17] A conservative estimate places the annual value of foregone hydropower at $39.3 million annually in $1998 (Olsen, 1996: 12).

3.1.4.4 Costs Paid by CBP Farmers

CBP farmers pay a variety of costs associated with the project. These farmers pay construction repayment costs, as specified in the 1962 repayment contract previously mentioned; this cost averages $2.63 per acre per year (Kemp 1999). CBP farmers also pay for the cost of lifting water from Lake Roosevelt up into the project area, operation and maintenance costs on both those facilities managed by Reclamation and those managed by the irrigation districts, and part of the operation and maintenance costs of GCD (Postma & Ford 1999). In 1998, CBP farmers were charged an irrigation pumping power rate of 1.206 mills per kWh (Martinez, 1998). The operation and maintenance cost assessments, which are levied on a per acre basis, vary slightly between irrigation districts. In 1998 the average assessment was $32.67 per acre in the Quincy District, $30.80 per acre in the East District, and $33.81 per acre in the South District.

3.1.5 Secondary or Indirect Benefits

It was clearly understood by project planners that repayments from farmers, the direct beneficiaries of the CBP, would be insufficient to repay the costs of constructing the irrigation infrastructure, much less repay a portion of the costs of Grand Coulee Dam. The first approach to financing the deficit was to use power revenues to pay for the dam and a substantial portion of infrastructure costs. The second was to assert that investments generated by backward and forward linkages from direct investments, ie, the increased economic activity for agri-business, banking, wholesaling, retailing, transportation, etc., should also be counted as project benefits and should be asked to contribute to cost recovery. In this regard, the Butler Report argued that “benefits to local business interests [were] precisely the same character as the benefits to the farmer” (USACE, 1933: 1042).

Of particular interest to Major Butler (USACE, 1933: 1042) was the possibility of taxing the capital gains, what he termed “assessable assets,” that would result from the implementation of the CBP. The Butler Report projected that the total increases to the value of land and franchises would be more than the cost of the project itself (Table 3.1.9). No conclusions were drawn about what portion of these capital gains should be taxed in order to help with repayment, although the report made clear that institutional mechanisms in the form of new legislation would be required.

Table 3.1. 9 Projected Increases in the Value of Land and Franchises as a Result of CBP

Item	1932 ($000)	1998 ($000)
Farm land increase	37 000	440 476
Local increase in land value	25 000	297 619
Regional increase in land value	40 000	476 190
Increase in franchise value		
Railroads	33 047	393 415
Power	81 838	974 256
Total Increase in the Value of Assets	*216 884*	*2 581 957*

Source: USACE, 1933: 1049.

For its part, the Reclamation Report did not incorporate assessments of secondary benefits into the Project's financial feasibility study, although it did suggest "applying an ad valorem tax to all property benefited" within the CBP area to reduce the repayment costs against CBP land (USBR, 1932: 117). Like the proposals in the Butler Report, these repayment schemes were never implemented.[18]

Economic conditions in the CBP area verify that the processes envisaged by the original planners have indeed occurred. Thriving agri-business concerns and the farming communities serving the agricultural sector are scattered throughout the area. In a recent study, Olsen finds that the so-called "basic sectors" of agriculture, agricultural services, and food processing, account for 30% to 50% of all income in the counties in which the CBP is located (1996: 8). Total income from the basic sectors of the CBP area, according to this study, is on the order of $617 million in $1998.

There have also been substantial multiplier effects from investments made in the basic sectors. According to the Olsen study, "these sectors generate between 1.5 to 1.7 dollars of total income within the local area for each dollar produced by the basic sectors" (1996: 8). The $617 million (in $1998) in basic sector income generates, by these computations, another $309 million in non-agricultural income.[19] At the state level, the CBP provides similar indirect benefits. These include an employment multiplier of between 1.4 and 2.5 jobs generated per direct agricultural industry job, and about 5.4 jobs per food processing job (Olsen, 1996: 8).

Another benefit of the CBP is its effect on land value, which has substantial local social benefits. Between 1990 and 1992, these increased land values have provided about $8 250 000 (in $1998) in funding to local services, such as schools and hospitals (Olsen, 1996: 9, 14). The increase in land value has been much greater than was originally expected. As indicated in Table 3.1.9, the Butler Report projected the aggregate increase in the assessed value of land to be $440 476 000 (in $1998) for the total project of 1 199 400 acres (485 400ha), or an increase in land value of about $370 per acre. Today, the increased per acre assessed value of CBP land due to irrigation is about $870 (in $1998) (Olsen, 1996: Table 7), more than double what was predicted. For the total area currently receiving CBP water of 660 800 acres (276 500ha), this represents an aggregate increased value of $574 230 000 (in $1998), 30% more value than projected on half as much land. These figures suggest that the capital gains of developing the CBP have been much greater than CBP planners envisaged.[20]

Not all the visions of the original planners, however, have been realised. Supporters of the project had hoped that CBP communities would become not only centres of agri-business, but major industrial centres as well. The incentive was to be cheap power from GCD, designated specifically for use in the CBP. This did not materialise. Through the efforts of the first Bonneville Power Administrator, J.D. Ross, GCD was linked to the Bonneville power grid. Moreover, the decision was made to employ a system of "postage stamp rates" for electricity. Under this scheme, the amount charged for electricity was not proportional to the distance from the power station or the cost of transmission. Instead, like the cost of delivering first-class mail, a uniform rate was applied for public customers such as public utility districts and rural co-operatives. In 1939, the Bonneville system was linked to the city of Portland and with the link went the hope that power generated by GCD would be earmarked for the CBP area. As

Pithier notes: "J.D. Ross, the very man Rufus Woods (a great supporter of the CBP) feared and fought, in the end, did the most to destroy Woods's dream of the agricultural/industrial empire." (1994: 238)

3.1.6 Negative Irrigation Effects

3.1.6.1 Water Withdrawal and Return Flow

Withdrawal of water from the Columbia River for irrigation purposes has had an adverse effect on the river's anadromous fisheries (USBR 1993a: 9–19). While the effect of withdrawals for the Columbia Basin Project cannot be dis-aggregated, it is one of many irrigation projects that cumulatively affect the fisheries. Irrigation water usage reduces the flexibility in providing adequate flows for juvenile fish flushes on the Columbia River during the spring (USBR, 1993a: 9-19). Irrigation water diversions for the Columbia Basin Project remove about 3% of the average annual Columbia River discharge at Grand Coulee Dam (Montgomery Water Group, 1997: 8). In recognition of the effect of water withdrawals on Columbia River fisheries, the Northwest Power Planning Council and the National Marine Fisheries Service requested that the Bureau of Reclamation stop new irrigation diversions, which it did in 1993 (Montgomery Water Group, 1997: 3). Under this moratorium, new irrigation development is prohibited.

Irrigation practices in the Columbia Basin Project have affected the quality of groundwater and surface-water return flows. In addition, there has been an increase in groundwater quantity from the application of irrigation water on the Project farms. Irrigation water has raised the water table from tens to hundreds of feet (USGS, 1998: 5). As noted in section 3.1.1, this water table rise allows groundwater pumping in the Black Sands area.

There are two primary ways in which the groundwater quality has been negatively affected. First, nitrate concentrations in many groundwater wells are elevated to the point where they exceed the Environmental Protection Agency's (EPA) maximum contaminant level (MCL) of 10mg/L. 29% of public and domestic supply wells in the CBP area have nitrate concentrations above the MCL (USGS, 1997). According to the US Geological Survey (USGS) (1998: 7), the combination of heavy application of nitrogen fertiliser and irrigation water, which increases groundwater recharge, has led to these high nitrate concentrations.[21] Deeper wells tend to have lower nitrate concentrations (USGS, 1997). In most areas within the CBP, nitrate concentrations have increased since the 1960s.

The other type of agriculture-based groundwater contaminant detected in CBP groundwater wells is pesticide. USGS samples of groundwater in the early 1990s detected only two pesticides at a concentration higher than the MCL, and this occurred in very few wells (USGS, 1996). These pesticides were EDB (1,2-dibromoethane) and Dieldrin, which have both been discontinued in use. Within the CBP area, 60% of the samples from shallow domestic and monitoring wells had detectable concentrations of pesticides and volatile organic compounds (USGS, 1998: 10). Pesticide detection are less common in deeper public supply wells, being present in 46% of the samples (USGS, 1998: 10).

Surface water quality has also decreased from irrigated agriculture. All USGS sampled surface water sites in the Columbia Basin Project area have detectable amounts of pesticides (USGS, 1998: 12). Some pesticide levels exceed standards for protection of aquatic life (USGS, 1998: 12). Furrow, or real, irrigation causes more soil erosion than sprinkler or drip irrigation (USGS, 1998: 14). DDT and other organochlorine pesticides are carried into streams through the process of erosion.[22] There are higher concentrations of p-p-DDE, a breakdown product of DDT, in areas with higher levels of furrow irrigation (USGS, 1998: 14). The degree of soil erosion, with its accompanying transport of organochlorine pesticides, has been decreasing as the proportion of sprinkler-irrigated farmland has increased (USGS, 1998: 15). Nutrient concentrations, such as inorganic nitrogen and phosphorus, have also increased from irrigated agriculture (USGS, 1998: 16–7).

3.1.6.2 The Cost of Drainage

Drainage deserves special attention because it precipitated a serious confrontation between the Bureau of Reclamation and the irrigation districts over the issue of repayment costs. Moreover, it demonstrates the enormous uncertainties involved in making predictions about the movement of irrigation return flows. Using the groundwater analysis tools available at the time, and working under severe budget constraints, the planners of the Columbia Basin Joint Investigation were not able to forecast accurately either the severity or the immediacy of the CBP's drainage problems (Pitzer, 1994: 301).

Under the assumption that 1.2 million acres (485 622ha) would ultimately be developed, the Butler Report envisioned a total drainage cost of $5 per acre or $5 997 000 (USACE, 1933: 968). The Bureau of Reclamation predicted a total drainage cost of $4.8 million, or $4 per acre (US Congress, 1932: 54). By 1945, it was already recognised that these figures were inadequate and a repayment contract was signed between the irrigation districts and the Bureau of Reclamation that provided up to $8.2 million for drainage work (Macinko, 1963: 191; Pitzer, 1994: 294).

In the summer of 1954, new lakes created by rising water tables began to appear in the CBP area (Pitzer, 1994: 293). In 1956 Reclamation predicted that the $8.2 million limit for drainage would be inadequate, and it noted that "experience to date indicates that this problem will be more difficult and costly than early estimates, which were preliminary in nature".

As drainage costs approached the $8.2 million limit, the spectre of spiralling charges for CBP farmers became imminent. All drainage works beyond the limit would be included in operation and maintenance fees. Thus, the drainage issue became instrumental in the negotiation of a new repayment contract of $131.60 per acre. Among the stipulations of the contract was an agreement that all drainage construction costs would be categorised as CBP construction costs (Cole 1999c). This arrangement, in which federal subsidies could be used to ease the debt burden, avoided what were potentially devastating operation and maintenance fees for the CBP farmer.

Reclamation recognised the need for a strict economic justification of drainage projects. Proposed projects had to demonstrate that their benefits would exceed the costs of drainage (Cole 1999c). In most cases, lands that did not meet the economic criteria became eligible for the lieu-land programme.

In the lieu-land programme owners of seeped lands that do not receive drainage facilities are offered an equivalent amount of land in another location of the CBP, which they were able to purchase at a reduced price (Postma 1999). A farmer in this situation has the option to farm this newly purchased land, which is irrigated, or sell it. In exchange for the replacement, the farmer must sign an agreement stating that the seeped land is no longer the responsibility of the federal government. Between 1968 and 1983 about 18 000 acres (7 284ha) were entered into the lieu-land programme, with little added since that time (Postma 1999).

Reclamation also began applying economic criteria to undeveloped CBP irrigation blocks (Cole 1999c). Lands with poor drainage criteria were no longer brought in. For instance, Blocks 36 and 55 on the Wahluke Slope were rejected for development because of the potentially prohibitive cost of drainage on these blocks. The process of block development became very competitive after these criteria began to be applied to undeveloped lands.

The cumulative construction costs of the CBP drainage programme to date have been $129.5 million (Bye 1999). By 1995, the programme had built 2 845 miles (4 579km) of subsurface drains, which were draining a total of 118 500 acres (47 955ha), approximately 18% of the CBP irrigated acres. (USBR, 1997a: 4). A 1997 inventory of remaining drainage problems on the CBP estimated that there are only about 550 acres (222ha) left that could be considered for drainage work (USBR, 1997a: 11).

3.1.7 Benefits from Small Scale Hydropower

In addition to producing agricultural commodities, the CBP also produces hydropower on its irrigation canals. Both the Butler and Reclamation Reports foresaw the development of such small hydropowerplants, and imagined that they would be used for supplemental pumping to lands at elevations greater than the canals. The Reclamation Report expected "power plants and transmission lines at suitable places along the canals of the distribution system for the generation and distribution of about 26 000 kilowatts of seasonal power" (USBR, 1932: 79).

There are currently seven small hydroelectric plants within the project area, which vary in size from a rated capacity of 2.2MW to 92MW (USBR, 1994b). The seven plants together averaged an annual energy generation of 546 910MWH from 1990 to 1994 (USBR, 1994b). As envisioned in the Butler and Reclamation Reports, they run seasonally, during the irrigation season (April to October) when the water is flowing through the canals.

Rather than using the power for supplemental pumping in the CBP, however, the power is being sold to the cities of Seattle and Tacoma. These cities agree to purchase the power generated and pay operation and maintenance costs during the capital repayment period (McDaniel 1999), plus an incentive of 1.6 mills for each kWh generated. The profits earned from this operation are used to reduce the operation and maintenance costs of the irrigation districts. CBP farmers receive a benefit of between $0.98 and $1.42 per acre, depending on the irrigation district.[23]

3.1.8 A Qualitative Benefit-cost Appraisal of CBP

Data in the planning documents produced in the early 1930s make it possible to develop the outlines of a contemporary benefit-cost analysis, albeit in qualitative terms. For example, the "without project" net benefits associated with dryland agriculture have been provided and accounted for in the 1932 Reclamation and Butler reports. Those reports also contain the investment costs and the net financial returns that could be expected from the irrigation project itself. The result, if organised in a cash flow format, would be sufficient to compute the net present value (NPV) or the internal rate of return (IRR) of the project in financial terms.

What is missing, in terms of a contemporary analysis, is the accompanying economic benefit-cost calculations. To economists, financial prices are the market prices used by private individuals and firms to make their business decisions. Economic prices, on the other hand, are determined by the value of resources to the economy as a whole when they are employed in their highest and best use. It is for this reason that they are sometimes called "economic efficiency prices".[24][25]

Differences between market and economic prices may arise in a variety of ways. The presence of imperfect markets in which there are major monopolistic or monopsonistic elements is one such way. Another example occurs in the presence of external effects, ie, effects are not accounted for in market transactions. External effects are especially significant in the environmental area, where there are no markets that adequately value such costs to society as groundwater pollution or the destruction of downstream fisheries.

The major source of difference between market and economic prices, however, is almost invariably public policy. Governments choose, for a variety of reasons, to distort prices from their economic efficiency values to achieve what are regarded as desirable policy objectives. What adjustments would have to be made to the market-based analysis of the CBP (in the 1932 reports) to calculate the net present values of the project from an economic efficiency perspective? Some important sources of market distortions have already been pointed out — subsidies to construction and energy costs paid by CBP farmers — and others will be described in later sections. But 1932, the Reclamation and Butler reports show that the attainment of economic efficiency was not the policy objective with the highest priority. The early planners of the Grand Coulee Dam and the Columbia Basin Project believed that the social goals served by bringing irrigation water to the Columbia Plateau were worth the subsidies to farmers that they were proposing.

Judgments about the efficacy of investments in the CBP (and the priority given in the feasibility study to market rather than economic returns) must therefore rest on an appraisal of the extent to which the social policies pursued by the government achieved their objectives. The results are mixed. A key social objective was to bring irrigation water to more than one million acres of land so that families working small plots of land could settle it. As noted above, only about half of the lands projected to receive irrigation water have actually been irrigated, about 20% of which have had significant drainage problems.

The vision of rural communities made up of small family farms also did not survive. As Section 3.1.3 indicates, changes in agricultural technology and the competitive pressures of post-war agriculture made it impossible to maintain the original acreage restrictions. Although most farms are still operated by families, their size and capital intensity generate incomes consistent with similar investments elsewhere in the economy. Pitzer comments:

> *It is fair to ask what the project might be like today had the original planners achieved their goals. It would be a collection of family farms ranging from forty to eighty acres, none of them capable of supplying their owners with a satisfactory living. The area would be a rural slum. It is for the best that this aspect of the project failed.*

Identifying the actual beneficiaries of the CBP is itself not straightforward. A 1974 Ph.D. dissertation states that CBP benefits were unevenly distributed; 25% of the tenant-operators, who both owned and rented land, received 75% of the benefits, while the bottom 10% received no net benefits (Pitzer, 1994: 366–7, 479).

The identification of true CBP beneficiaries is also complicated by the fact that, after 1968, and in practice for a decade before that, land markets in the CBP have functioned, albeit imperfectly (Pitzer, 1994: 307). As a consequence, the value of construction, drainage, and power subsidies to land owners has long ago been capitalised into the value of land, just as the Butler Report predicted. Newcomers (or those seeking to expand their holdings) have had to purchase land on the basis of its asset value, a value derived from its expected contribution to farm income. To them, and to those who rent land, there is no "benefit" from the CBP's subsidies; they have paid for the expected value of the subsidies when they purchased or rented land. Only those who owned land that appreciated as a result of the subsidies are true beneficiaries of the project in the sense that they have earned above-market capital gains. (The reverse would be true, of course, if the subsidies were removed. Land prices would decline substantially as values reflected the asset's reduced earning power. Those who purchased land in which subsidies are embedded would be hit hardest. It is only in this sense that they are beneficiaries of the continued payment of subsidies.)

The entire CBP experience illustrates the difficulties of merging an administratively managed system with a market economy over long periods of time. Pitzer notes that, in many instances, there was not enough planning to deal effectively with many of the CBP's problems, drainage being an excellent case in point (1994: 366). However, his concluding comment, given the magnitude of the unforeseen changes that would take place, is more to the mark. "Despite the unprecedented planning, the project needed more, although it is possible that there could never have been enough." (Pitzer, 1994: 366)

3.2 Hydropower

3.2.1 Projected vs. Actual Costs for Grand Coulee and its Powerplant

As mentioned previously, GCD is a key project of the hydroelectric power system in the Columbia River Basin. The construction of GCD and its associated electrical plant was carried out in two stages, separated by nearly three decades. The first stage included the dam and two powerhouses. It began in 1933 and was completed in 1951. The second stage, consisting of the so-called, "Third Powerplant," began in 1966 and was completed in 1975.

Compared to CBP, which was constructed after World War II, construction of GCD and the first two powerhouses was considerably more efficient. As shown in Table 3.2.1, the initial estimate, developed by the Corps, was for a total construction cost of $149 million in $1932 (USACE, 1933: 748). Projections made by Reclamation in its report on the cost of the dam and powerhouses increased the figure somewhat to $168 million (USBR, 1932:81). Ultimately, the government allocated $179 million to GCD and the first two powerplants, in part to compensate for the inflation of the last several years of the project.

Table 3.2 1. Cost of Constructing Grand Coulee Dam

	Predicted (millions of dollars)		**Actual (millions of dollars)**	
	Nominal	1998 $	Nominal	1998 $
Corps of Engineers (1932)	149	1 772		
Bureau of Reclamation (1932)	168	2 004		
US Government (1935-1943)	179	2 043	163	1 850

Sources: USACE, 1933: 748; USBR, 1932: 8; Pitzer, 1994: 212.

Pitzer observes:

> *In all, the bookkeepers claimed that through June 30, 1943, Grand Coulee Dam cost $162,610,943. As the government had allotted $179,477,675, the balance on hand, which went back to the treasury, was over $16 million. In post-World War II years, such an occurrence would be astounding.* (1994: 212)

This assessment may have been somewhat premature, as the cost in 1943 did not include the cost of finishing the right powerhouse, installing the nine generators that it contained, and completing the switchyard required for power distribution. But estimating the costs of building GCD turned out to be easier than assessing the cost of a settlement projects as vast and complex as CBP. Construction of GCD was nothing terribly original; it followed accepted dam building practices (Pitzer, 1994: 213). However, its size alone was sufficient to require innovative and cost-saving construction methods.

In terms of subsequent costs, GCD repairs were required almost immediately after operation commenced, revealing a series of costly design errors. Pitzer notes:

> *Workers performed other tasks at Grand Coulee through the late 40s and early 50s besides adding the generators. Despite the experiments during construction, operation revealed unforeseen design flaws.* (1994: 257)

Chief among the flaws were the large pits dug in the spillways from the force of the descending water and substantial erosion of riverbanks downstream. The cost of the repairs ran into the millions, with riverbank erosion still being a problem in the 1990s.

In 1932, Reclamation's planners estimated the cost of GCD and the left and right powerhouses to be about $2 billion in $1998. The actual cost of GCD and its power complex is carried on Reclamation's books at $270 million in nominal dollars (USBR, 1998c: 1).[26] Assuming that the additional $107 million in nominal dollars was spent evenly over ten years after the project's initial completion, the total cost in $1998 was $2 670 million or approximately 33% more than envisioned by the early designers. (The actual cost was 45% above the estimate rendered in 1943.) This suggests that, while early construction of GCD may have been done within budget, the inflation of the post-war period plus unforeseen costs raised the total cost of the project substantially beyond early estimates made by the Corps and Reclamation. GCD's Third Powerplant involved a massive remodelling of the right side of the dam. It was built in order to take greater advantage of water that was stored in Lake Roosevelt after the spring runoff and to generate power from the water to be stored upstream by the dams built as part of the Columbia River Treaty. Although it would ultimately prove to be an economic success, the Third Powerplant was plagued by cost overruns and labour disputes throughout its construction.

There is a much better basis for comparing predicted versus actual costs of the Third Powerplant than GCD and CBP because Reclamation was required to prepare a detailed benefit-cost analysis. According to the 1967 Definite Plan Report for the Third Powerplant, the cost of the project components would require the funds shown in Table 3.2.2.

Table 3.2.2 Estimated Construction Costs for the Third Powerplant

Facility	Construction Cost (millions of dollars)	
	1967 $	1998 $
Powerplant	322	1 571
Switchyard	67	325
Tour centre	1	7
Total	*390*	*1 903*

Source: USBR, 1967: ii.

On the benefit side, project analysts established that sufficient demand for the power generated by the facility existed, especially with the completion of negotiations that would permit surplus power from the Northwest to be sold to power distributors in the Southwest. By far the major portion of the benefits was to come from the sale of hydropower, but there were other, smaller, benefits in the form of flood control and recreation, as shown in Table 3.2.3.

Table 3.2.3 Benefits of the Third Powerplant

Purpose	Predicted Benefits (millions of dollars)	
	1967 $	1998 $
Power	46.3	225.7
Flood control	1.5	7.2
Recreation	0.4	1.9
Total	48.2	234.8

Source: USBR, 1967: ii.

Amortising the cost of the project over 100 years at a 3 1/8% interest rate yields an annual cost of about $66 million in $1998. When operating expenses are added, the annual cost figure is approximately $74 million. The benefit-cost ratio, assuming that the forebay would be built so as to permit future expansion, is 3.18:1.

Comparison of projected expenditures with the actual costs reported in a Reclamation financial statements suggests a significant underestimation of the costs of the project. The financial statement (USBR, 1998c) reports total expenditures of $730 million in nominal dollars. Assuming that the money was spent in roughly equal instalments over the nine years of the project's construction, the resulting cost estimate is approximately $2 930 million as opposed to the predicted $1 900 million, an overrun of approximately 55%.

In spite of the large cost overrun, if the 1967 benefit-cost calculations for the Third Powerplant had been redone using actual costs instead of estimated costs, the result would still have yielded a benefit-cost ratio of about 2:1 instead of 3.18:1. [27] The estimated benefits of additional hydropower were such that The Third Powerplant would have remained economically feasible even with substantially higher costs.

3.2.2 Influence of World War II on Hydropower

At the time construction began on GCD in 1933, the demand for power was substantially lower than the amount that would be generated by the dam. Indeed, as late as 1937, critics of the dam expressed strong doubts that the demand for power would materialise at anything approaching the rates predicted by project boosters. However, the creation of local public utility districts and rural electrification programmes during the 1930s provided markets for the power generated at the Bonneville and Grand Coulee dams, and many people expressed enthusiasm for the concept of public power sold at "postage stamp" rates (ie, low uniform wholesale rates across the entire region). It was thought that such rates would promote wide use of the abundant hydroelectric power that would soon become available. When the “Bonneville Project” (the precursor to BPA) was created in 1937 to market and transmit power from Bonneville Dam, it sold power to publicly owned utilities at these postage stamp rates. Indeed, the Bonneville Project Act of 1937 include the following major policies:

> *(1) encourage the widest possible use of electric energy; (2) operate for the benefit of the general public, and particularly domestic and rural consumers; (3) preserve the preference and priority for public bodies and co-operatives; (4) provide for uniform rates or rates uniform throughout prescribed transmission areas; and (5) set wholesale rates on the basis of actual costs as determined by specific guidelines (Norwood, 1981: 64).*

By 1938, Roosevelt had turned his attention to increasing the nation’s electric power supply in preparation for a possible war effort, and BPA played a significant role in Roosevelt’s planning efforts. In 1940, an executive order directed BPA to market the power output from GCD, as well as Bonneville Dam (Norwood, 1981: 124).

As the prospect of war became increasingly real, few had concerns about whether there would be demand for the power generated by GCD (and the Bonneville Dam which had been brought into service in 1938). As the US prepared for war, the availability of low-cost power in the US Northwest made it the obvious place to build power-hungry aluminium production facilities needed in producing warplanes. The federal government established a programme in which the Defence Plant Corporation built aluminium plants and leased them to private companies. As of mid-1942, industrial loads for war production accounted for 92% of BPA’s commitments to provide electricity (Norwood, 1981: 123). Power consumption increased in 1943, when a new “mystery load” appeared from the Atomic Energy Commission’s work in producing plutonium-based atomic weapons at Hanford Reservation in Richland, Washington. BPA also provided power for shipyards at Portland, Oregon and Vancouver and Seattle, Washington for plants that used aluminium to manufacture airplanes.

Activities of the War Production Board greatly influenced BPA’s ability to transmit power in the region and Reclamation’s ability to bring additional generators online at GCD. The Board controlled where and how scarce materials were to be used. Partly as a consequence of the board’s decisions, BPA’s transmission system expanded rapidly from about 140 circuit miles (225km) of line in mid-1940 to over 2 500 miles (4 000km) by mid-1944. However, by the end of 1944, construction of new lines had fallen dramatically. Wartime priorities for use of materials also stalled completion of the generators at GCD.

After the war, the Defense Plant Corporation sold its aluminium plants inexpensively to invite competitors to Alcoa, which had long held the dominant position in the aluminium reduction and fabrication field (Norwood, 1981: 135). As a result, four large companies came to establish a major presence in the region: Alcoa in Wenatchee and Vancouver, Washington; Kaiser Permanente in Tacoma, Washington; Reynolds in Longview, Washington and Troutdale, Oregon; and Harvey Metals at The Dalles in Oregon. During the late 1940s, these companies were able to negotiate favourable rates for both firm and “interruptible power”[28] from BPA.

During the post-war years, BPA focused on retaining electro-metal and electrochemical plants that had come into the US Northwest during the war. It also focused on responding to the accumulated demand for customer service transmission facilities, particularly for rural electrification (Norwood, 1981: 145). During the 1940s and '50s, BPA was particularly successful in responding to the key elements in its original charter, namely to "encourage the widest possible use of all electric energy that can be generated and marketed" (White, 1995: 72). The low-cost hydroelectric power marketed by BPA dramatically transformed the economy of the US Northwest.

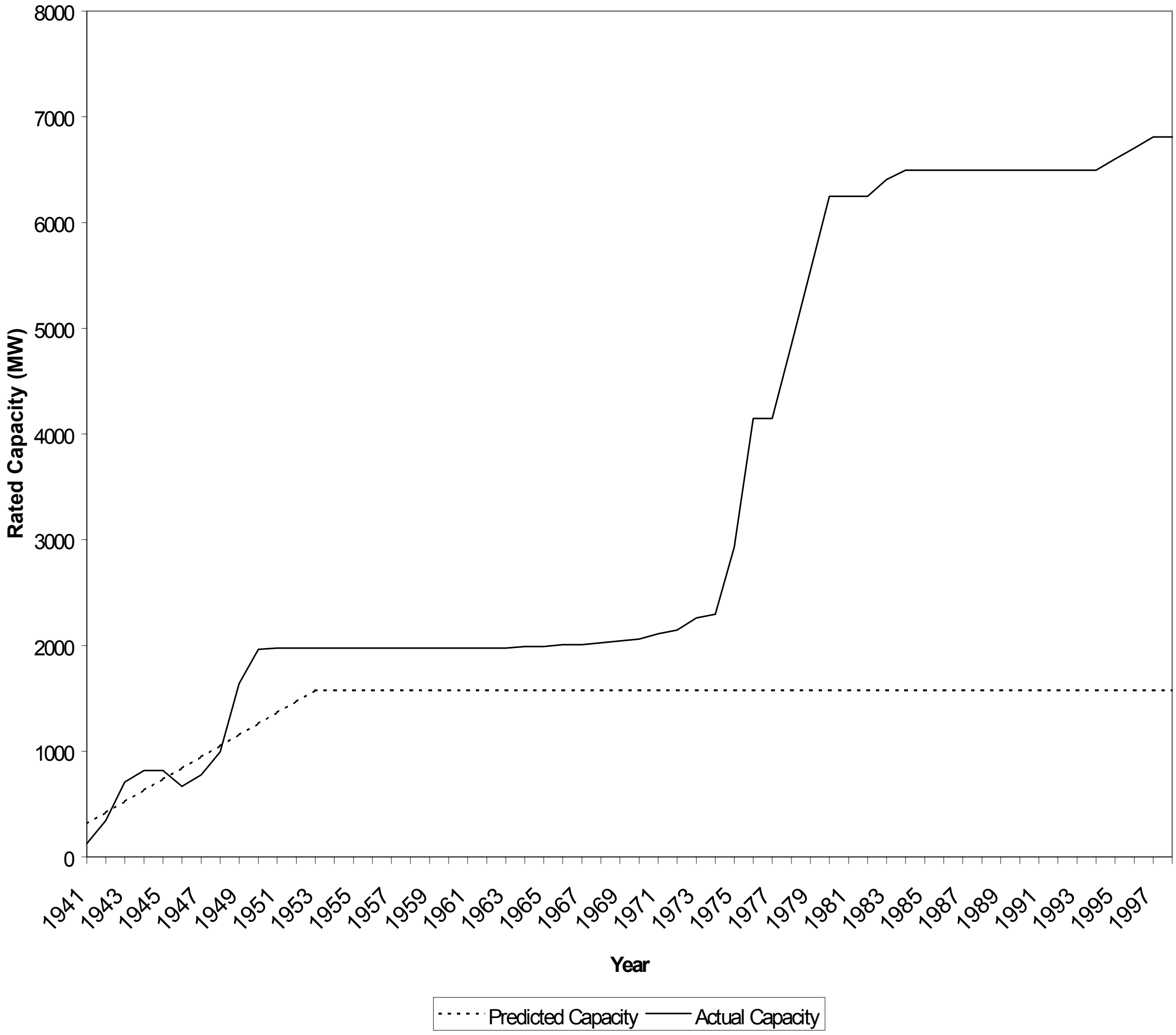
3.2.3 Predicted vs. Actual Power Generation and Capacity

The Reclamation and Butler Reports differed in their projected estimates of power output for GCD. Both reports specified that the high dam at GCD would have a powerplant with an installed capacity of 1 575 000kW (USACE, 1933: 714; US Congress, 1932: 17). The powerplant would have consisted of fifteen 105MW capacity generators. In the Reclamation Report, the estimated mean annual firm power output was predicted to be 7 008 000 000 kWh.[29] Reclamation's engineers projected 800 000 kW of continuous firm power (USBR, 1932: 79). The Reclamation Report estimated that 2 260 000 000 kWh would be the mean annual amount required for pumping (USBR, 1932: 95). This report foresaw a pumping plant consisting of twenty 33 000 hp (24 618kW) motors, each connected to a pump with 800 cfs (22.7m^3/s) capacity, for a total pumping capacity of 16 000 cfs (453m^3/s) (US Congress, 1932: 161).

The actual capacity and generation of power at GCD have far exceeded estimates. The actual rated capacity of the dam began to exceed predicted capacity from the start. This occurred because the installed generators had a capacity of 108MW, instead of the predicted 105MW. Other factors incrementally increased the dam's capacity, including the installation of six pump-generator units in the 1970s and 1980s, which added 314MW of capacity. Moreover, the stators of the original 18 units were rewound between 1966 and 1984, adding 306MW of capacity. These increases, however, are dwarfed by construction of the Third Powerplant, an addition unforeseen by both the Butler and Reclamation reports of 1932. The six units in this newer plant have added 4 215MW of capacity to the dam. Figure 3.2.1 shows the predicted versus actual increase in hydroelectric generating capacity over time at GCD.

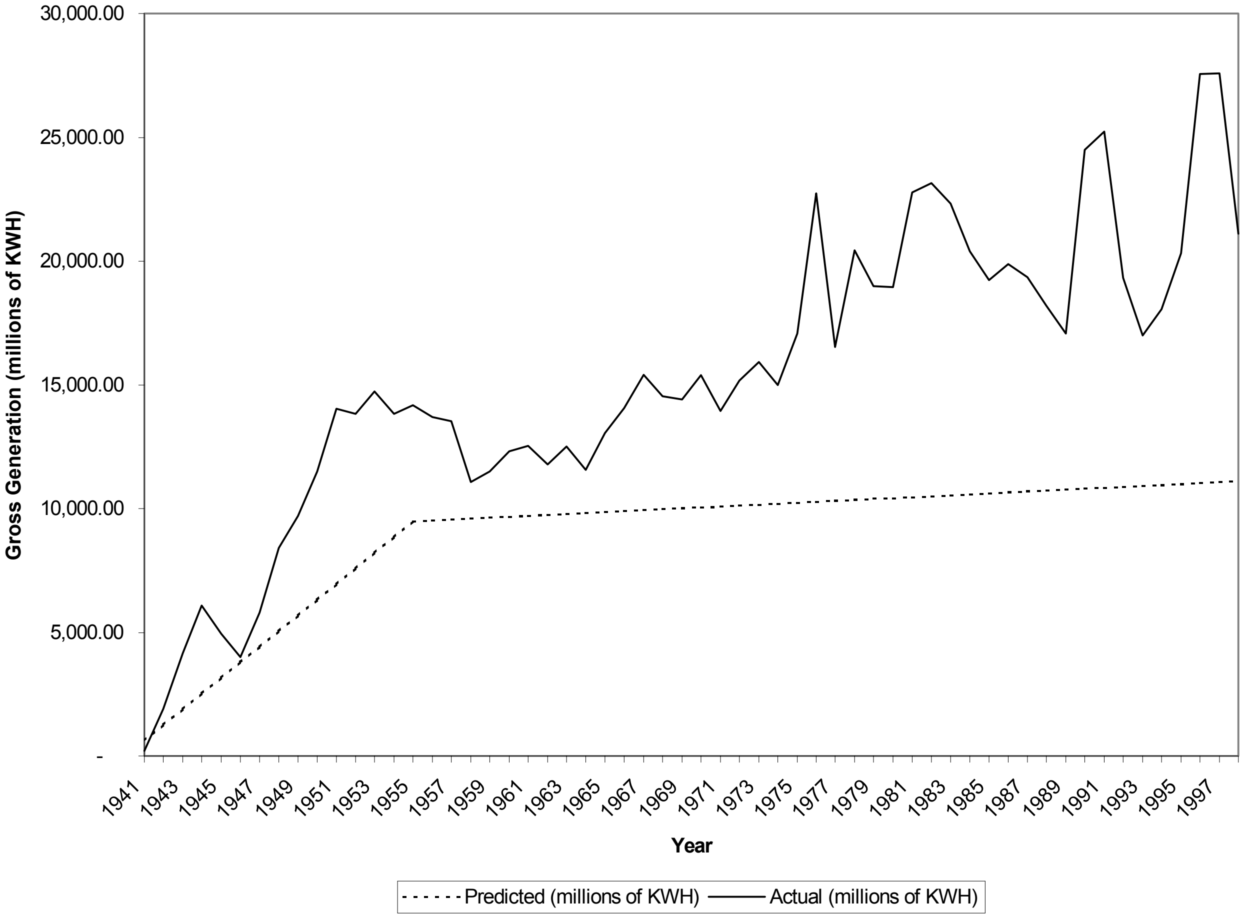
Power generation for GCD has also been much higher than expected. This increased generation is due to several factors. For example, higher capacity than predicted made it physically possible for GCD to generate much more power than project planners envisioned. However, the chief factor in these higher generation figures is that demand for power has been much greater than predicted. Both the Reclamation and Butler reports expressed concern over how quickly GCD power could be absorbed. The Reclamation Report, which had less conservative estimates of absorption, predicted that it would take 15 years after the completion of GCD for the power market to absorb the predicted annual firm output of 7 008 million kWh. (USBR, 1932: 81, 142). Planners could not have foreseen that this output would be exceeded within eight years, when GCD produced about 8 383 million kWh in 1948. As mentioned, the outbreak of World War II led to a rapid increase in power demand. The most dramatic manifestation of this demand came with the installation at GCD of two generators intended for Shasta Dam in 1943 (Pitzer, 1994: 252). The demand for power to support war-related activities in the US Northwest was great enough to justify this extraordinary measure. From 1943 onward, the combination of low rates, power-intensive industries, and population growth has provided a ready market for GCD power. Figure 3.2.2 illustrates the predicted versus actual generation of power at GCD over time.

Figure 3.2.1 Predicted vs. Actual Hydropower Capacity, Grand Coulee Dam



Sources: USBR, undated(c); Sprankle 1999a; Sprankle 1999b

Figure 3.2.2 Predicted vs. Actual Hydropower Generation, Grand Coulee Dam



Sources: USBR, 1932: 95, 143; USBR (GCPO), 1999.

3.2.4 Grand Coulee Dam in the Context of the Federal Hydropower System

The power functions served by GCD are most productively analysed in the context of the larger network of hydroelectric projects in the Columbia River Basin. In distributing electric power to users, BPA does not distinguish the electricity generated by GCD from electricity generated by other dams that feed into the BPA network. In other words, BPA transmits and sells power, not GCD power.

Of the more than 250 hydroelectric projects in the Columbia River Basin, 14 are considered to be key US projects.[30] A synopsis of these projects, which are part of the FCRPS, is provided in Table 3.2.1 Project locations are indicated in Figure 3.2.3.

Table 3.2.4 Major Federal Dams in the Columbia River Basin

Name	Date In Service	Location	Storage Capacity (MAF)	Generating Capacity (MW)
Bonneville	Jun 1938	Columbia River, OR/WA	ROR[a]	1 050
Grand Coulee	Sep 1941	Columbia River, WA	5.19	6 494
Hungry Horse	Oct 1952	Flathead River, MN	3.16	428
McNary	Nov 1953	Columbia River, OR/WA	ROR	980
Albeni Falls	Apr 1955	Pend Oreille River, ID	1.16	42
Chief Joseph	Aug 1955	Columbia River, WA	ROR	2 069
The Dalles	May 1957	Columbia River, OR/WA	ROR	1 780
Ice Harbor	Dec 1961	Snake River, WA	ROR	603
John Day	Jul 1968	Columbia River, OR/WA	ROR	2 160
Lower Monumental	May 1969	Snake River, WA	ROR	810
Little Goose	May 1970	Snake River, WA	ROR	810
Dworshak	Mar 1973	Clearwater River, ID	2.02	400
Lower Granite	Apr 1973	Snake River, WA	ROR	810
Libby	Aug 1975	Kootenai River, MN	4.98	525

[a] ROR = “run-of-the-river” dam

As shown in Table 3.2.4, GCD is the second oldest of the 14 projects, and it has the largest storage capacity and the largest generating capacity. Except for GCD and Hungry Horse Dam (both of which are operated by Reclamation), all the projects listed are operated by the Corps. Four of the projects — the ones on the Snake River — are currently being considered for possible decommissioning as a means to restore salmon populations within the basin. Interestingly, several of the projects listed were identified in the Butler Report.[31]

As indicated in Table, nine of the 14 major federal projects are characterised as run of the river (ROR) projects. In contrast to storage projects, which impound water seasonally, annually, and for multiple years, ROR dams use available inflow and a limited amount of short-term storage (daily or weekly pondage) to generate electricity. In simple terms, runoff from snowmelt is stored during the spring and summer until it is needed to generate power (typically, when the regional demand is highest in the fall and winter). Space is made available in storage reservoirs in the fall, winter, and early spring to hold runoff, and thereby prevent flooding (US DOE et al, 1994: 13).

Figure 3.2.3 Map of Key Federal Columbia River Power System Dams

Source: USDOE et al., 1995 (Main Report).

3.2.5 Power Demand and Characteristics of Power Users

Hydropower is the principal energy source used in the US Northwest,[32] and the FCRPS supplies more than half of this region's hydroelectric demand.[33] Power is delivered to customers by a network of transmission lines extending to Canada in the North, California in the South, and Montana, Utah, and Wyoming in the East. BPA's transmission grid carries the vast majority of this power, which extends over 15 000 circuit miles (24 000km), accounting for 25% of the region's transmission capacity.

Power produced at federal hydroelectric projects in the Columbia River Basin is sold to several types of customers through a variety of power sales agreements. Customers include public utility districts (PUDs), municipalities, rural co-operatives, federal agencies, and direct service industries (DSIs).

As a matter of law, PUDs, municipalities, and rural co-operatives are given first preference for power produced from federally owned Columbia River Basin hydroelectric projects.[34] BPA has long-term firm power sales contracts with over 120 publicly owned utilities. Firm power, defined as energy that can be generated given the region's worst historical water conditions, is provided on a guaranteed basis.

Publicly owned utilities are located throughout the US Northwest and provide power to individual homes in both urban and rural areas. Major metropolitan areas include Seattle, Tacoma, Yakima, and Spokane in Washington; and Portland, Salem, and Eugene in Oregon. Examples of some PUDs served by BPA include those in Grant County, Chelan County, and Douglas County. Some of the municipal utilities include Seattle City Light, Tacoma City Light, and the Eugene Water & Electric Board. BPA also sells some firm power to other federal agencies, including the Department of Defense and Department of the Interior.

Additionally, firm power is sold to some of the region's largest industries, which are called DSIs. In addition to obtaining a share of firm power, DSIs have first call on BPA's nonfirm power. Nonfirm power (ie, energy available when water conditions are better than the worst historical pattern) is generally sold on an interruptible, or non-guaranteed, basis. As of 1996, BPA had 18 DSI customers. The majority of these customers are aluminium companies (smelters), such as ALCOA; the other DSIs represent other industrial sectors, such as chemicals and mining.

The rate schedules for DSIs are complex and have changed over time. In the past, portions of the rate schedule have involved power that was interruptible. The rationale for interruptible power was as follows: at times, the Corps and Reclamation would draw down reservoir levels below normal to serve the nonfirm load in fall and winter months. However, if the probability of reservoir refill is too low in the spring, BPA would restrict its sales to DSIs in the spring, thus permitting water to stay in the reservoirs. This interruption in power delivered to DSIs was conducted to protect service to publicly owned utilities and other firm power customers.

During the period from 1981 to 1996, "full requirements service" was provided to DSIs with a four-quartile arrangement. Under this scheme, DSIs received a variety of different sources of power including the following: surplus firm energy, non-firm energy, and firm power. Under the quartile arrangement, power to the first and second quartile of the total DSI load was interruptible and could be dropped under certain circumstances. [35] However, because of a series of interruptions that occurred in the early 1990s, and the fact that the price of BPA power was higher than other power markets, the DSIs threatened to end their full-requirements power sales contracts with BPA. Though none of the DSIs terminated power sales arrangements with BPA, the four-quartile service arrangement was abandoned in 1995. Beginning that year, DSIs were able to make long-term purchases from other suppliers. For the period between 1997 and 2001, DSIs have contracts to purchase approximately 2000 average megawatts of firm requirements power from BPA; they purchase their remaining power needs from the open market.

Nonfirm power that is not used by DSIs is sold to other private customers, such as Portland General Electric, Pacific Power & Light, Puget Sound Power & Light, Washington Water Power, and Montana

Power. Hydroelectric projects in the US Northwest have also provided peaking (high demand) power to other major metropolitan areas such as Los Angeles during hot summer days.

Industries that consume large quantities of electricity are becoming a smaller part of the US Northwest economy as service industries continue to grow. As a result, the traditional dependence of the region's manufacturing and heavy industry on inexpensive electricity has declined somewhat. However, regional population is expected to increase substantially during the next decade, and thus the local population will depend increasingly upon the hydroelectric power base.

3.2.6 Economic Benefits of Hydropower Production

As noted earlier, development of the Columbia River Basin has been critical to the economic development of the US Northwest. The gross national product (GNP) of the Northwest grew to more than $300 billion in 1992. After adjusting for inflation, the personal income of citizens in the US Northwest doubled from 1929 to 1949, doubled again from 1949 to 1969, and doubled again by 1989.

Since GCD is a storage facility with a large amount of power generation capability that can be brought on line quickly, it is used primarily as a peaking facility by BPA. GCD's typical load ranges from a low of 200 to 300MW to a high of 5 000 to 5 800MW. GCD and other hydroelectric projects in the Northwest also provide peaking power to other major metropolitan areas, such as Los Angeles, during hot summer days.[36]

Revenue attributable to GCD from power sales in 1993 exceeded $412 million (BPA, 1993). This revenue not only pays for project costs attributed to power, it also pays for a large portion of federal irrigation investment in CBP. Over time, the contribution of GCD to FCRPS revenues has varied, depending on how many projects were contributing to the system. For example, from 1950 to 1953, GCD accounted for about three quarters of all FCRPS revenues (BPA, 1955). As more projects came on line, the contribution of GCD decreased, but it still remained the centrepiece of hydropower generation, accounting for 20% to 33%of total FCRPS kilowatt-hours from the late 1950s to the present.[37] On a cumulative basis, by 1993, GCD had generated over 710 million-kilowatt hours and comprised approximately 15% of total power generated by FCRPS (BPA, 1993). Cumulatively, this equates to over $2.9 billion dollars in nominal dollars. Power generation at GCD far exceeds that of other FCRPS projects. For example, GCD power generation exceeds power generation at Chief Joseph Dam, the next highest generating project, by 45% (BPA, 1993).

Hydropower in the Columbia River Basin has provided inexpensive electricity to both individuals and businesses in the region. Columbia River Basin hydropower averages $10 per MWh to generate (FWEEa, 1999). Hydropower generation costs at GCD are even lower, at $1.35 per MWh (USBR, 1996). Average generation costs at nuclear, coal, and natural gas powerplants average $60, $45, and $25 per MWh, respectively (FWEEa, 1999). Inexpensive hydroelectric power generated by GCD and other FCRPS projects in the basin has attracted many energy-intensive industries to the area such as aluminium, food processing, aerospace, defence, mining, and others. This has produced numerous jobs and increased the economic output of the US Northwest tremendously since the 1930s.

3.2.7 Unexpected Benefits of Hydropower Production

3.2.7.1 Ancillary Service and Dynamic Benefits[38]

A number of benefits of GCD relate to technical features of the process of generating and transmitting electricity commonly referred to by specialists as "ancillary services and dynamic benefits". These services and benefits were not mentioned in either the 1932 Reclamation or Butler reports; in that sense they were unanticipated. The nature of ancillary services and dynamic benefits is described in general terms below and in more complete terms in the Annex titled "A More Detailed Examination of Hydropower".

Power generators that are used to ramp up and down as the load changes from hour to hour are said to be capable of "load following". In addition to the need to meet changing power demand, generators must also provide dynamic benefits, such as frequency control and responses to minute-to-minute changes in load.[39]

Power systems must also have generating capacity available to meet contingency conditions, such as the sudden outage of a large generator or the loss of a transmission line that is importing power into a control area.[40] This type of contingency is provided for by designating an amount of capacity called "spinning reserve" (ie, the amount of generation that can be called on in a few seconds that can make up for the sudden forced outage of a large generator or a heavily loaded transmission line). Since reserve capacity must be available in a few seconds, the most responsive generators in a control area are used to provide it.

Another dynamic capability has to do with voltage support. In a power system, voltages must be kept at constant levels so that consumer appliances will operate correctly. The tolerance for voltage variation is generally within a band of plus or minus 5% of the nominal level. Voltage regulation is accomplished by controlling the supply of reactive power in the transmission and distribution system. "Reactive power" is the power that is required to create the electric and magnetic fields in transformers, transmission lines, generators and load devices. Generators and other power system facilities provide reactive power and voltage regulation.

BPA has identified the following ancillary services from generation capacity under its control, including GCD:

- Regulation/load following — According to the Federal Energy Regulatory Commission (FERC), load following is "the continuous balancing of resources with load under the control of the transmission provide . . . accomplished by increasing or decreasing the output of online generation . . . to match moment-to-moment load changes.
- Voltage support (or control) — FERC defines "reactive power/voltage control" as "the reactive power support necessary to maintain transmission voltages within limits that are generally accepted in the region and consistently adhered to by the transmission provider".
- Spinning reserve — Spinning reserve is the unloaded (uncommitted) capacity of a generator that is in operation and providing output to the power system at any time. It is an amount of generation that is available to provide additional energy as an immediate response to sudden drops in system frequency.[41]
- Non-spinning reserve — Non-spinning reserve is generating capacity that can be brought into service within ten minutes of a call for it.
- Energy Imbalance — FERC defines this as "the difference [that] occurs between the hourly scheduled amount and the hourly metered [actual delivered] amount associated with a transaction".
- Generation Dropping — generator dropping is a procedure that is occasionally used as a system stabilising technique. It can be required following the trip out of the high voltage direct current transmission line that exports power from the Pacific Northwest to Los Angeles.
- Station Service — station service is power that is needed to operate substations.[42]

GCD is operated together with the downstream Chief Joseph reregulating dam.[43] Because GCD has a large water storage reservoir and large amount of installed generation, it is operated by BPA as a peaking facility. When GCD discharges during peak load periods, water is held in the Chief Joseph reservoir and released at a later time in a controlled way so that downstream water flow requirements are satisfied. Because Chief Joseph Dam can re-regulate the water discharge from GCD, it is possible for GCD to provide dynamic functions and ancillary benefits as part of its day-to-day operations. GCD provides all ancillary services required by BPA, including load following, frequency regulation, spinning reserve, non-spinning reserve, and voltage support.[44]

The hydroelectric generators at GCD are well suited to provide dynamic services because they are robust and because they have short response times. Hydroelectric generators with minimum response times (in terms of megawatts per minute) are ideal for frequency regulation and automatic generation control. In comparison to generators operating with nuclear and fossil fuels, hydroelectric generators have the fastest response times. Hydroelectric generators are also ideal for spinning reserve service because they can deliver sustained output for an extended period of time. For example, GCD is reported to have delivered 2 000MW of reserve in response to a recent system disturbance (Flynn 1999).

The BPA control area had an estimated peak demand in 1999 of 10 167MW. GCD maintains 2.5% of capacity for spinning reserve and 2.5% for non-spinning reserve. GCD has an installed capacity of 6 809MW. GCD maintains from 240 to 280MW of generating capacity for reserve frequency regulation. It is estimated that the BPA control area average requirement for regulating reserve is 250MW.[45]

3.2.7.2 Atmospheric pollutants Avoided by Not Using Fossil Fuel Powerplants

Emissions of atmospheric pollutants avoided is another unanticipated benefit of power generated by GCD.[46] By generating electricity using hydropower, the combustion of fossil fuels, such as coal, is avoided. Although it is clear that these benefits of GCD are real, there is no widely accepted procedure for calculating the monetary value of those benefits. Moreover, even attempting to generate numerical values of tons of atmospheric pollutants avoided requires that many assumptions be made. This is demonstrated in the Annex titled “Atmospheric Pollutants Avoided,” which employs a calculation procedure developed by the WCD Secretariat to calculate a range of plausible values of benefits.

In developing a range of possible outcomes, we assumed that the power facility that would have been an alternative to GCD would have been a coal-fired steam electric powerplant. We then created five different scenarios, each of which is built on a set of assumptions related to several technical parameters, such as powerplant efficiency, the heating value of coal, and the type of boiler employed. Additional assumptions concern the quantity of power that would have been generated by the coal-fired powerplants that would have been built in the absence of GCD. This set of assumptions is required because the availability of enormous quantities of low-cost power made possible by GCD significantly influenced the demand for power in the US Northwest.

The WCD methodology includes a range for the monetary value of carbon dioxide emissions avoided from a low of $2 per ton to a high of $25 per ton. Applying this range and using the five scenarios corresponding to alternative sets of assumptions related to heating value of fuel, powerplant efficiency, power generated, and so forth, the corresponding range of values of carbon dioxide emissions avoided in 1998 varies from a low of about $14 million to a high of $541 million.[47] Again, using the five scenarios and the calculation procedures detailed by the WCD Secretariat, the range of values, in terms of tons of pollutants avoided in 1998, are as follows: sulfur dioxide, 5 66 to 17 400; oxides of nitrogen, 239 to 23 700; particulate matter less than 10 microns, 13 to 433. In each instance, the range of possible values is substantially greater than a factor of 10. Under the circumstances, we have reservations about any attempt to quantify the benefits of atmospheric pollutants avoided by building GCD instead of coal-fired powerplants.

3.3 Flood Control

3.3.1 Predicted Benefits

Flood control provided by GCD is best viewed over two different time periods: the time of project authorisation through to 1973, and after 1973, when the Columbia River Treaty projects came on line.[48] Despite the fact that the Rivers and Harbors Act of 1935, which authorised Grand Coulee Dam, begins “ . . . for the purpose of controlling floods” (US Congress, 1935), in the earliest project planning documents, it appears that flood control at GCD was only a minor consideration until after a disastrous

1948 flood. A recent Reclamation study concluded that the project's anticipated flood control benefits were small and incidental to other operations (USBR (Economics Group), 1999: 20).

Flood control was treated only briefly in the Butler Report, and Major Butler, in his testimony before the US House Committee on Irrigation and Reclamation, stated that "navigation and flood control are not important on this section of the river" (USACE, 1933: 867–71; US Congress, 1932: 17). One of the major oversights of the Butler Report relates to the way flood control was handled. The report states that the "valley of the Columbia within the United States above the Snake is not subject to inundation" (USACE, 1932: 867). However, the report did not consider the effect of upstream flood control on reducing flood damage at points below the confluence with the Snake River. This point was considered by Major Kuentz who produced a companion Corps of Engineers report on the development of the Columbia River below the mouth of the Snake River. While Major Kuentz recognised the significance of flooding in the lower Snake, he concluded that flood control was not important enough to be a major factor in the Corps' plan for water resources development.

In examining predicted flood control benefits, we looked to the Butler and Reclamation reports, but neither report treated this subject in depth. Butler's discussion of potential flood control benefits concentrates on the risk of minor flooding at upstream locations on the tributaries, not on the mainstream Columbia (USACE, 1933: 867–71). The 1932 Reclamation Report makes no mention of flood control. Little formal data exists on the projected flood control benefits of GCD for three reasons. First, both the Butler and Reclamation reports minimise the significance of flood control. Second, the project was authorised during a time when benefit-cost analyses were not required for federal water projects. Third, prior to the 1948 flood, it was generally believed that adequate flood control could be achieved solely through the construction of levees (USBR (Economics Group), 1999: 20).

A local newspaper article from 1937 estimates that annual flood control benefits were $5 million (about $60 million in $1998) and dam backers said that the dam would end downstream flooding (Pitzer, 1994: 258). An article in an issue of *Atlantic Monthly* in 1936 stated that GCD would control floodwaters "down the Columbia to 450 miles (724km) to the sea". We have found no information on projected flood control benefits that is more quantitative or more carefully detailed. Documents we have reviewed, as well as our consultations with flood control personnel at the Corps of Engineers Portland Division Office, suggest that little, if any, detailed information exists on the pre-project estimates of monetary flood control benefits provided by GCD. The argument that local project proponents did not view flood control as a major purpose of GCD during the late 1920s and early 1930s is supported by Reclamation correspondence from then Commissioner Floyd Dominy, dated 1961, which indicates that, in fact, the dam was "not designed specifically for flood control operation" (Dominy as quoted by Pitzer, 1994: 260). The estimated cost of flood control works relative to the project as a whole was modest. According to historian, Paul Pitzer, "when the government allocated the total cost of the dam to its various components, the amount indicated for flood control and navigation combined amounted to only $1 million" (about $12 million in $1998) (Pitzer, 1994: 258).

3.3.2 Flood Control Operations Before 1973

During its early years of operation, GCD was not managed with flood control as a priority. Even though the storage capacity of the project (over 5 million acre feet, or 6 170 x 10^6 m^3) seems large, it is only a small percentage of the capacity needed to control the flow of the Columbia (Brooks 1999). During the first few decades of operation, the level of the Lake Roosevelt was generally kept high to maximise power production and the potential to provide irrigation water. The limited ability of GCD to control floods became obvious when it was unable to prevent severe flooding in 1948. That year, the peak flow at the dam was 638 000 cfs (18 100 m^3/sec) (USBR, 1949).

In the wake of the 1948 flood, the city of Vanport, then the second largest city in Oregon, was completely destroyed. The disaster caused over $100 million ($730 million in $1998) in property damage and killed 51 people (USBR, 1949). The enormous amount of damage from the 1948 flood demonstrated that the projects with flood control purposes in place at that time were not capable of handling large flows. Afterwards, efforts at basin-wide flood control efforts (along with basin-wide hydropower management) received heightened attention and Congressional support (Pitzer, 1994: 334; Brooks 1999).

3.3.3 Flood Control Operations After 1973

From 1948 to 1973, significant improvements were made in flood control operations at GCD and other multi-purpose dams were brought on line to provide additional system-wide storage capability. The key event that secured flood control protection for the basin was the construction of the Columbia River Treaty projects. These projects, which became operational between 1967 and 1973, basically doubled the previously existing storage capacity of the system (USDOE et al. (Appendix E), 1995: 2-2). As detailed in Section 6, the construction of these projects followed ratification of the Columbia River Treaty between the US and Canada. These dams became fully operational in 1973. The Columbia River Treaty projects were able to store water and control releases in ways that greatly enhanced the generation of hydropower and the provision of flood control benefits basin-wide (For a detailed discussion of flood control operations in the Columbia River Basin, please see the Annex titled "System Operations — Hydropower, Flood Control, and Anadromous Fish Management Activities").

Most of the system storage capacity on the Columbia River actually resides in Canada. Out of 37 MAF (45 600 x 10^6 m^3) of available system storage, 43% (16 MAF) is provided by US facilities. GCD, with the largest reservoir on the US side, is the system's main storage dam, accounting for about one-third of the total US storage capacity and 13% of total US and Canadian storage. The dam is the gateway for 74 000 square miles (19 x 10^6 ha) of river drainage and is operated for flood control in conjunction with 13 other dams on the main-stem Columbia (USACE, 1991). Lake Roosevelt is the last major catchment for flood control on the river. Since the early 1970s, the combined operation of dams in the US and Canada has served to significantly reduce the potential of downstream flooding.[49]

Although Reclamation had responsibility for constructing and operating GCD, under the Flood Control Act of 1944, the Corps has responsibility for specific operations concerning flood control (Brooks 1999). Spring rains and melting snow generate large volumes of runoff. In anticipation of these runoff events, the level of Lake Roosevelt is lowered to accommodate high river flow, thereby reducing the risk or minimising the impact of downstream flooding. The Corps regulates the level of Lake Roosevelt based on daily, weekly, and monthly forecasts of upcoming river runoff using a storage reservoir diagram. The diagram defines how much storage must be available in any project in the system at any given time under a specific set of flow conditions (See Annex titled "System Operations—Hydropower, Flood Control, and Anadromous Fish Management Activities" for GCD's storage reservoir diagram).

The Corps estimates that monetary benefits of basin-wide flood control since 1973 have been substantial. For example, Corps calculations indicate that the value of flood control operations basin-wide for particularly wet years has been on the order of hundreds of millions of dollars (USACE, 1999). In 1974, the flood control capacity of the system was put to the test when a flood of roughly the same magnitude as 1948 occurred. This event was regulated sufficiently by upstream storage to below major damage levels (USDOE et al. (Appendix E), 1995: 2-1). Corps estimates for flood control benefits provided by the entire Columbia River system[50] since 1973 range from $500 000 (in 1973) to $378 million (in 1997) (USACE, 1999) (See Annex titled "System Operations—Hydropower, Flood Control, and Anadromous Fish Management Activities" for details on flood control benefits estimate). According to Reclamation records (USBR, 1998c), project costs allocated to both flood control and navigation[51] account for less than 3% of the total project cost.

Interestingly, there are differing opinions concerning the validity of models used to derive flood control benefits approximations for the system. According to staff we interviewed at the Corps, the benefit estimates are likely to be low, since a formal empirical study of the flood prone area has not been undertaken since 1969 (Brooks 1999). According to other analysts, estimates may be inflated because of overestimation of potential flood risks and estimates of flood damages used in the benefits estimates methodology (National Research Council et al, 1995). More generally, environmental groups, such as the Sierra Club argue that the Corps' benefits estimates are inflated because calculations of damages wrought in areas where Corps projects promoted development in floodprone areas that are later inundated are not included in estimations of a project's benefits and costs (Schildgen, 1999).

The exact flood control benefits directly attributable to GCD are difficult to gauge because the storage capacities of all the major reservoirs that provide flood control are linked and operated as a system.[52] However, a 1999 Corps study of the annual flood control benefits derived from GCD storage puts the amount to be $20 200 000 in $1998 (USBR (Economics Group), 1999: 20).

3.3.4 Unexpected Flood Control Benefits, Costs, and Impacts

The main flood control operations at GCD are: (i) drawing down reservoirs in the winter to provide enough space to store runoff; and (ii) filling reservoir space during the spring in a strategic manner to minimise downstream damages (USDOE et al. (Appendix E), 1995: 2-3). These activities are closely tied to the operation of the project for hydroelectric and irrigation purposes. Therefore, it is not possible to link unanticipated impacts of reservoir operations to flood control operations. The major unintended impacts of general project operations are discussed in Sections 3.4, 3.5, and 3.7 of the report and include adverse effects on ecosystems (particularly anadromous fish), recreational benefits, and social effects.

A phenomenon often associated with increased flood protection is increased settlement in floodplains. In the Columbia River system, the main damage potential is in the lower Columbia, which includes portions of the cities of Portland, Oregon and Vancouver, Washington, as well as extensive rural areas protected by diking districts (USDOE et al. (Appendix E), 1995: 2-4). The literature review we conducted did not yield data or studies that would allow definitive statements to be made as to whether increased flood protection in the lower Columbia River has led to a population increase in the floodplain.

While critics of federal flood control projects have not specifically attacked projects in the Columbia River Basin, they have criticised the Corps and other agencies that construct physical flood control structures (eg, dams and levees). They argue that because current federal programmes focus on structural alternatives to flood control, these programmes encourage development in floodplain areas and facilitate resettlement in floodprone areas after a disaster occurs (Schildgen, 1999; Mount, 1995). Some analysts of flood plain management posit that people commonly view flood control works as being able to prevent floods, and this mis-conception[53] has led to increased urbanisation behind levees (Schildgen, 1999; Haeuber & Michener, 1998). In fact, levees and other structural flood control works sometimes fail.

Additionally, there is a growing recognition that extensive structural flood control works affect natural ecosystems adversely by disrupting natural patterns of ebb and flow (Sparks, 1995). There is also some evidence that extensive structural works may even increase the stage of large floods, leading to higher damages associated with these rare events (Mount, 1995).

3.4 Recreation and Tourism

3.4.1 Predicted Benefits

GCD and CBP have generated a number of recreational benefits, such as the creation of wetland and riparian corridors, although project planners of the 1920s and 1930s did not anticipate them. Neither the Reclamation nor the Butler reports mentioned recreation. The 1935 Rivers and Harbors Act, which authorised the Grand Coulee Dam, did not list recreation as a primary project purpose. However, a statement in the Act that lists "providing other beneficial uses" as a purpose of the project has, over time, been interpreted to include recreational activities (NPS, 1998: 169). The Columbia Basin Joint Investigations anticipated the recreational potential of Lake Roosevelt, and the report on "Problem 26" of the Investigations, completed in 1945, deals with this issue. The Joint Investigation committee studying recreation in Lake Roosevelt saw multiple potential recreational uses of the area, including boating, fishing, picnicking, bathing, camping, hunting, and backpacking (USBR, 1945c: 4-6).

The Columbia Basin Joint Investigations report committee investigating Problem 26 noted that pleasure boaters were using the reservoir even though it was only partially filled (USBR, 1945c: 4). A fish hatchery built to replace salmon losses was expected to create fishing opportunities, and the reservoir was predicted to create increased upland game and migratory bird populations for hunting (USBR, 1945c: 4-5). The committee identified several locations where summer home communities could be built, and it discussed many educational opportunities related to history, archaeology, geology, and plant and animal life (USBR, 1945c: 7-10). The report noted that GCD received an average of 325 000 visitors annually before World War II, of which 40% were from outside Washington state. Noting the constantly changing conditions that could alter its projections, the committee predicted levels of future use of the reservoir. It foresaw a rise in visits to GCD with the end of World War II, including 200 to 400 pleasure boats with hundreds more smaller boats using Lake Roosevelt after peacetime, and a peak Sunday attendance for picnicking, bathing, and water sports of around 4 000 to 5 000 visitors (USBR, 1945c: 26-7). The committee expected these activities to increase as population increased in the surrounding areas. While no specific projections were made of potential visits to the project area, the report states "It . . . seems reasonable to conclude that, on the basis of present trends and recreational habits of people in the district, new recreational areas to provide from a capacity of at least 40,000 to 80,000 additional people will be necessary during the next two decades" (USBR, 1945c: 26).

3.4.2 Actual Recreational Facilities and Use

Recreational facilities created by GCD and CBP can be broadly divided into two categories: (i) facilities associated with the Lake Roosevelt National Recreational Area (LRNRA), which includes GCD; and (ii) facilities associated with CBP's irrigation command area. These two types of facilities are administered separately. The National Park Service (NPS) and the Colville and Spokane tribes manage recreational activities associated with the National Recreation Area; Reclamation operates recreational activities related to the dam site; and a variety of state and federal agencies manage recreational activities within the irrigation command area.[54] In 1996, total visits to all these facilities were estimated to exceed three million (Olsen, 1996). (See Annex titled "Use Statistics for GCD and CBP-related Recreational Facilities" for a list of some major recreational facilities.) Generally, recreational activity is highest during the summer. For example, visitation between June and September accounts for about three-quarters of total annual visits to the LRNRA (NPS, 1998: 68).

Lake Roosevelt National Recreation Area

LRNRA includes Lake Roosevelt, GCD, and surrounding areas. Lake Roosevelt is the largest recreational facility in LRNRA, extending 151 miles (243km) from the dam site to the Canadian border. It houses over 30 campgrounds, 10 swimming beaches, 18 boat ramps, and 28 boat docks. Six major facilities operated by the Colville Indian tribe offer houseboat and fishing boat rentals, fuel, and food. A 25-mile (40km) stretch of the shoreline along the Spokane River is also included in LRNRA.

Since 1980, the number of recreational visitors to LRNRA has increased from 800 000 visits in 1980 to 1.4 million in 1997 (NPS, 1998: 67). A 1996 visitor use survey found that most respondents (62%) were between 15 and 44 years of age. Almost three-quarters of survey respondents (74%) were from the state of Washington, and about 13% were from Canada. Only about 7% of the respondents were US residents visiting from other states, and only 1% of respondents were from outside the US (NPS, 1998: 72). The most common purposes of visits to LRNRA are camping, swimming, motor boating, and fishing (NPS, 1998: 72).

LRNRA also offers a guided tour of the dam, the Third Powerplant, and the pump-generating plant. The area houses a visitors centre, where tourists can watch a video that explains the history of the dam and view various educational displays. In 1994, almost half a million people visited the dam (Olsen, 1996).

One of the most popular attractions at the dam is a 36-minute laser light show featuring animated graphics on the downstream surface of the dam. The show is put on every evening during the summer and routinely attracts large crowds at the dam site and at surrounding areas from which the spillway is visible. According to Reclamation staff we interviewed at the dam, the majority of attendees at the light show were from Washington State, with the remaining show visitors coming from other US states (Sprankle 1999d).

3.4.2.1 Irrigation Command Area

In addition to LRNRA, there are numerous recreational opportunities in the CBP area, and many of the recreation sites were created as a result of the application of irrigation water. Some of these recreation sites have been extensively developed. In total, there are 143 785 acres (58 188ha) of land and water available for recreational use that rely on CBP water (USBR, 1992b). There are six Washington State parks and 32 other major state and federally managed recreation facilities in the project area (USBR, 1989a: III-299-300).

In 1992 there were more than 1.34 million public visits to CBP-related recreation facilities south of Grand Coulee Dam (USBR, 1992b). There are several major fishing areas, such as Banks Lake, where about 120 000 sport fish were caught in 1992, and Potholes Reservoir, where 531 000 sport fish were caught in 1992 (USBR, 1992b). There are numerous smaller sport fishing locations. Hunting is also a popular recreational activity. In 1992, nearly 60 000 ducks were taken in the project area; pheasant and geese are also heavily hunted (USBR, 1992b).

3.4.2.2 Benefits Estimate

Few comprehensive studies exist that focus specifically on recreational benefits in the project area. However, a 1996 study by Olsen[55] sponsored by the CBP irrigation districts estimates that the total direct net value (ie, economic value derived from primary activities minus the cost of provision), and secondary economic benefits of recreational purposes served by the project area. In Olsen's analysis, the total direct net value of recreational benefits was between $23 and $77 million in $1998. This estimate does not include all forms of flat-water recreational activity such as motor-boating. In addition, Olsen estimated secondary economic benefits (eg, lodging, food, gas) to be about $24 million annually in $1998. Recreation-related business is an economic mainstay for many communities located on or near the major reservoirs, including Kettle Falls, Davenport, Coulee Dam, Grand Coulee, and Electric City (Lebret 1999; Halsey et al. 1999; NPS, 1998: 62).

3.4.3 Recreational Issues

3.4.3.1 Effects of FCRPS Operations on Use of Lake Roosevelt

Project operations that alter the elevation levels of Lake Roosevelt can, and often do, impact on recreational use. Near-full reservoir levels are the best conditions for recreational reservoir use. At these levels, users can access all facilities and the water level creates an aesthetically pleasing shoreline, or beach. Drawdowns for hydropower, flood control, and fish flow augmentation can adversely affect the recreational use for two reasons. First, some activities (eg, boating) may not be feasible if water levels are too low (eg, dry boat ramps). Second, low water levels reduce scenic quality by exposing extensive areas of barren shoreline (USBR, 1993a). NPS determined that a reservoir elevation of 1 288ft (392.6m), which is 2ft (0.5m) below full pool, is ideal for the recreational use of Lake Roosevelt. At an elevation of 1 287ft (392.3m), negative affects on the use of the lake's recreational facilities occur. At an elevation of 1 285ft (391.7m), use of all recreational facilities is impaired, and at 1 280ft (390.1m), many facilities cannot be used. While typical dam operations aim for lake levels between 1 285ft and 1 290ft (391.7m and 393.1m) by July 31 of each year (USBR, 1993a), LRNRA and Reclamation staff we interviewed indicated that low reservoir levels were often problematic for recreational users, particularly between Memorial Day and 4 July (Baker et al. 1999; Sprankle 1999d).

Recreational uses of GCD and CBP are secondary to other project purposes, and lake levels are first determined to satisfy those other purposes, such as flood control, hydropower generation, and irrigation. To satisfy these requirements, operators may drop reservoir levels to below the optimal value for recreational use.[56] For example, at the Kettle Falls marina, during annual spring drawdown, the lake level can go below 1 280 feet (390.1m). When that occurs, the houseboat concessionaire must relocate his houseboats to deeper water, and rental boat docks are not available for up to six weeks during this time (NPS, 1998: 15). In addition, the 1995 Biological Opinion of the NMFS concerning the operation of the FCRPS to protect threatened and endangered Snake River salmon in the river allows as much as 10 feet (2.64m) of water to be drafted from Lake Roosevelt from time to time to augment flows for downstream fisheries. This drafting, which has taken place most often in August, can lower the lake level to near the 1 280 ft (338m) mark. At this elevation, some of the developed facilities on the lake are out of service during the peak recreation season (NPS, 1998: 15), demonstrating that recreational activities can take a back seat to other project purposes.

3.4.3.2 NPS, Reclamation, and the Tribes[57]

The management and jurisdiction of land associated with LRNRA between NPS and the Colville and Spokane tribes has been a subject of controversy since the reservoir came into existence. In lieu of reserving fishing, hunting, and boating rights on the Indian lands taken for the reservoir created by GCD, Congress mandated that approximately one-quarter of Lake Roosevelt (the “Indian zone”) be set aside for the paramount use of the Indians of the Colville and Spokane reserves. In interpreting that act in 1945, the Solicitor of the Department of the Interior stated that Indian use within their zone was not necessarily exclusive (US Solicitor, 1945). In 1946, NPS, Reclamation, and the Indian Office entered into a tripartite agreement under which the general public was permitted equal use of the Indian zone, under NPS supervision.

In subsequent decades, Washington State attempted to regulate hunting and fishing in the entire reservoir area, including hunting and fishing by tribal users in the Indian zone. The tribes strenuously objected to this. They were also dissatisfied with NPS’s management of recreational users under the tripartite arrangement. In 1974, a new opinion of the solicitor of the Department of the Interior affirmed that tribal title to the beds and banks of the Columbia and Spokane Rivers within the reservations was unaffected by legislation concerning Grand Coulee Dam. The Solicitor overruled parts of the 1945 opinion by holding that the tribes had the authority to regulate hunting, fishing, and boating by non-Indians in their zones, and that the state could not undermine or regulate Indian activities in their zone (US Solicitor, 1974). The Secretary of Interior responded by directing the federal agencies to negotiate a new agreement that included the tribes and recognised tribal sovereignty.

In 1990, Reclamation, NPS, the Bureau of Indian Affairs, the Spokane Tribe of Indians, and the Confederated Tribes of the Colville Reservation signed the “Lake Roosevelt Co-operative Management Agreement”. It outlines the roles and areas of management responsibility for the various parties. In the 1990 Agreement, NPS turned over management of recreational facilities within selected zones to the tribes. Since then, the relationship between the tribes and agencies has gradually improved, although strains remain.

In 1998, NPS issued a “Draft Environmental Management Plan/Environmental Impact Statement” for LRNRA, which outlined future options for the management of the area. While both the Colville and Spokane tribes were involved in the commenting on the plan, tribal members that we spoke with felt that their concerns were not sufficiently addressed by NPS in developing the plan (Palmer & Stone 1999).

3.4.3.3 Recreation in the Context of Changing Environmental Attitudes

Even though recreation was not among the original project purposes listed in the Congressional authorisation for the GCD, recreation-related issues have become an increasingly important factor to project managers at the dam site. In concert with the growing US environmental movement that blossomed in the late 1960s, attitudes of many in the US Northwest have changed to incorporate environmental values, for example, considering instream flows as a "beneficial" use of water and valuing rivers in their natural state (ie, not just for maintaining sports fishery purposes) (Bosse 1999). Additionally, lobbyists for sport fisherman who have an interest in preserving natural fisheries have become increasingly vocal (Mace 1999; Myron 1999). While early conceptions of recreational uses of the project were mostly limited to the immediate GCD and CBP vicinity (eg, camping and fishing), many recreators within the region are now becoming more concerned about basin-wide issues affecting their interests. For example, the Idaho Wildlife Federation, which represents sport fishermen in Idaho, has a staff member who works full time on generating support for the breaching of four lower Snake River dams to assist in the recovery of Idaho's salmon and steelhead stocks (Mace, 1999; Goodnight, 1998).

3.5 Ecosystem Impacts

At the time GCD was planned, assessing ecological effects of proposed federal projects was neither a requirement nor a priority. Thus, neither the Butler nor the Reclamation report examined this issue. Some mention of ecological concern is expressed in the Butler Report, but it is limited. Major Butler recommended that reservoirs on the Columbia River be regulated so as to have minimal interference on the river's fish (USACE, 1933: 1067). He also wrote: "The design and estimated cost of fishways have not been included, the determination of the necessity for fishways being left to the Bureau of Fisheries and appropriate State authorities." (USACE, 1933: 718) Essentially, Major Butler mentioned fish mitigation to explain that he would not discuss it. The land proposed for irrigation by CBP was widely considered to be wasteland, and no value was placed on the pre-project ecosystems on CBP land.

Although concern for Columbia River fish was not expressed in the feasibility studies, it did exist at the time the project was planned and built. This was because the Federal Power Act of 1920 required hydropower licensees on public channels either to protect migratory fish or to build hatcheries as compensation (Pitzer, 1994: 223). Eventually, after several years of inaction, government agencies adopted the recommendations of the Washington State Department of Fisheries, called the North Central Washington Upper Columbia River Salmon Conservation Project (Pitzer, 1994: 226). The experimental plan called for trapping mature salmon at Rock Island Dam, trucking them to the Leavenworth hatchery and planting hatchery fish below GCD. In 1948, after seven years of operation, Reclamation declared the plan a success (Pitzer, 1994: 229). Ownership of the Leavenworth hatchery was turned over to USFWS the following year.

The Columbia River and the Columbia River Basin were much different before the onset of GCD construction. Vegetation in the Columbia River riparian corridor upstream of the dam varied from semi-arid species to coniferous forests (USBR, 1976: II-7-8). Areas later inundated by Lake Roosevelt included habitat for whitetail deer and mule deer (USBR, 1976: II-8). Pheasants, morning doves, and bears likewise depended upon this corridor for survival (USBR, 1976: II-8).

Pre-project hydrologic conditions on CBP lands differed considerably from those after the application of irrigation water. Before the project, Lower Crab Creek, which ran dry for much of its course in the CBP area, sustained a small perennial flow into the Columbia River at Beverly (USBR, 1976: II-6). The groundwater table for the area north of the Frenchman Hills sat 150ft (45.7m) below the surface. Except along the Crab Creek corridor, the water table on the Royal Slope sat 150ft to 350ft (46m to 107m) below the surface, and it varied between 100ft and 500ft (30m and 152m) below the surface south of the Saddle Mountains (USBR, 1976: II-6).

Most CBP land is located in the big sagebrush/bluebrunch wheatgrass zonal habitat type (USBR, 1997b: 3-37). There are several other zonal shrub-steppe or steppe plant associations in small areas of the project (USBR, 1989a: III-88). The first significant disturbance to this area began in 1834 with the introduction of domestic grazing to the Columbia River Basin (USBR, 1989a: III-85). Based on available sources, we could not determine how much of this habitat had already been eliminated or degraded at the time development of CBP lands began. Vegetation in the CBP area consisted primarily of sagebrush and bluebunch wheatgrass, and other native grass species (USBR, 1976: II-7). Dryland farming, primarily of wheat, occurred in some areas. Several small private irrigation schemes had been initiated, but in most cases, they had been abandoned. The pre-project Columbia River Basin contained 8 000 acres (3 237ha) of wetlands, which were surrounded by riparian plant communities (USBR, 1984: 19).

Many bird species lived in the pre-project CBP area, including crane species, upland game birds like pheasant and grouse, and waterfowl species (USBR, 1976: II-10). The average annual mid-winter waterfowl level between 1948 and 1952, prior to the first major delivery of irrigation water, was 15 000 ducks and 7 000 geese (Parker & Lloyd, 1982: Appendix B, Table 6). Many species of waterfowl and shorebirds inhabited the region that was later inundated by Potholes Reservoir (USBR, 1976: II-9).

The most salient and direct ecosystem impact of the GCD and the CBP has been their detrimental effect of anadromous fish populations. Other significant impacts include the project's impacts on resident fish populations and the effects of the CBP on shrub-steppe and wetland habitat in the project area. Cumulative impacts of the project in conjunction with other large multi-purpose projects in the basin and other activities (eg, agricultural practices, timber, etc) are discussed in Section 4.

3.5.1 Anadromous Fish and the GCD Fish Maintenance Programme[58]

Pacific salmon and their ancestors have inhabited the rivers of the Pacific Northwest for at least five million years (Thomas, undated). It is believed that Pacific salmon survived the most recent glaciations in refuges in North America and Asia, re-colonising the rivers of the Pacific Northwest, including the Columbia River, upon glacial retreat 10 000 years ago (Thomas, undated). Previous to white settlement in the 1800s, all species of salmon were wild. Wild (or natural) salmon have been defined as those that spawn naturally in rivers and tributaries, regardless of their ancestral history (Waknitz et al, 1995). Hatchery propagation began in the Columbia Basin in 1877 (Brannon et al, 1999). Hatchery salmon are released into rivers and tributaries with the expectation that at least a small percentage will return home to spawn and bolster the number of fish available for harvest.

Salmon and steelhead have an anadromous life history pattern, that is, the fish are hatched in freshwater, spend the majority of their life cycle in salt water, and ultimately return to the freshwater environment of their origin to spawn. In the Columbia River Basin, the principal anadromous fish include five species of salmon – chinook (*Oncorhynchus tshawutscha*), coho (*O. kisutch*), sockeye (*O. nerka*), pink (*O. gorbuscha*), and chum (*O. keta*) – and two species of trout – steelhead (*O. mykiss*) and sea-run cutthroat (*O. clarki*). Other anadromous fish species also inhabit the basin, such as white and green sturgeon, smelt, and lampreys.

The species of interest with respect to GCD are those that once spawned farthest upstream, such as in the reaches of the Upper Columbia River Basin within Canada; these include chinook, steelhead, and sockeye. Coho also spawned in the reaches above GCD, but their numbers were so low by the 1930s that they were not included in mitigation planning. We introduce the anadromous fish life cycle and data on the historical abundance of anadromous species prior to construction of GCD. Then we describe the mitigation measures that were planned and implemented to salvage the runs that spawned in the reaches above the dam site. We also discuss the results of the mitigation measures and the current condition of the mitigated runs,

3.5.1.1 The Life Cycle of Anadromous Fish in the Columbia River Basin

Salmon, depending on species, race, and stock, spawn between late summer and early winter (Groot and Margolis, 1991).[59] Steelhead typically spawn in the spring (Mullan, 1987). In general, chinook use the larger main-stem sections of rivers and streams for spawning. Steelhead tend to spawn and rear in smaller and higher gradient streams, and sockeye require large lakes for early rearing and usually spawn in the tributary streams above these lakes. Female salmonids [60] select spawning sites that have suitable gravel, depth, and water velocity, among other things. Males are selected by females and defend the nest (known as a redd), which is primarily excavated by the female. The fecundity of salmon and steelhead varies with species and body size ranging from a few hundred to about 8 000 eggs (Netboy, 1980). After spawning, the adults die near the spawning site in a matter of days or weeks.[61] Free-swimming fry emerge from the redd after several months. Some species migrate downstream soon after reaching the fry stage, whereas others can spend a year or more in the river or lakes near their origin before migrating to the ocean.

Juveniles undergo a complex behavioural and physiological transformation called “smoltification” that adapts the fish to the salt-water environment of the ocean. Once this transformation has begun, the juvenile fish are referred to as smolts. Salmon and steelhead spend the majority of their life cycle in the ocean environment, typically 18 months to five years depending on the species. When spawning season nears, maturing salmon migrate, sometimes thousands of miles, to the freshwater stream of their birth.

The timing of runs of salmonid species varies. salmonids may be classified by the time of year they enter the freshwater environment for their upstream spawning migration. There are two distinct types of chinook salmon: ocean-type and stream-type. Stream-type chinook typically begin their migration in the spring and summer and are referred to as spring and summer chinook. Ocean-types begin their migration in the fall, and are referred to as fall chinook. The various chinook runs in the Columbia River overlap, giving the overall distribution of the number of fish a bell-shaped curve with a peak in June.[62] Steelhead are typically designated as either winter or summer races; they have a more distinct separation between the two runs than that of the chinook.

Prior to the construction of GCD, the upper Columbia River stocks spawned above GCD, middle Columbia River stocks spawned in the main-stem and tributaries located between the confluence of the Snake River and GCD, and lower-Columbia stocks spawned in the main-stem and tributaries below the Columbia River confluence with the Snake River. After completion of GCD, upper Columbia River stocks were categorised as the fish that were relocated to the tributaries between Rock Island and GCD by the Grand Coulee Fish Maintenance Programme (GCFMP) (see Figure 3.5.1).

3.5.1.2 Estimating Historical Upper Columbia Salmon Runs

The Pacific salmon and steelhead runs had experienced substantial decline prior to the construction of GCD. Reasons for this decline include over-harvesting, grazing, timber harvesting, mining, dams on tributary rivers, roads, highways, railroads, and destruction of estuarine and freshwater wetlands. Table 3.5.1 shows estimated run sizes in the Columbia River Basin and the upper Columbia River at key points in history. Prior to white settlement in the 1800s, the Columbia River Basin supported a population of 7 to 30 million salmon and steelhead (ISG, 1999). The wide range in population estimates represents the uncertainty associated with estimating historical abundance levels. Estimates of the range from various sources are as follows: 10 to 16 million (NRC et al., 1995; NPPC, 1986), 12 to 16.3 million (Scholz et al., 1985), and 7.4 to 12.5 million [63] (CRITFC, 1995). Salmon populations had decreased to approximately 5 to 6 million before large dam construction began on the Columbia River, and to about 2.2 million by 1938, the year Bonneville Dam was completed. The runs that spawned in the upper Columbia River (ie, above the location of GCD) experienced similar decreases.

Table 3.5.1 Estimated Basin-Wide and Upper-Columbia Fish Run Numbers

Time Period	**Basin Wide**	**Upper Columbia**
pre-1850	7 000 000 to 30 000 000 [a]	500 000 [b] to 1 300 000 [c]
1930 (pre-Rock Island Dam)	5 000 000 to 6 000 000 [d]	--[e]
1938 (pre-Grand Coulee Dam)	2 200 000 [f]	25 000 [f]

[a] ISG, 1999; [b] Haas, 1975 as cited by BOR, 1976. 500 000 sockeye and chinook, steelhead and coho populations were not estimated; [c] Scholz et al., 1985; [d] Corps, 1994; [e] An estimate was not determined; [f] Calkins et al., 1939b; WDFW, 1992

Sources: ISG, 1999; Haas, 1975; Scholz et al., 1985; USACE, 1994; Calkins et al., 1939b; WDFW, 1992.

Salmon populations above GCD fluctuated widely in the pre-settlement era of the 1800s. Kettle Falls, a primary Native America fishing area upstream of GCD provided a catch of as much as 40 000 (Mullan, 1987) to 90 000 (Scholz et al., 1985) salmon in the early 1800s. However, during several seasons in this era (such as 1811, 1826–1829, and 1831) the catch was too low to sustain Native American populations; some tribal members starved to death and others relied on horse meat for survival (Mullan, 1987; Scholz et al, 1985). These early variations in salmon populations may have resulted from unfavourable ocean conditions and adverse climate conditions that produced periods of low flow impeding downstream migration at Celilo Falls or at other natural low-flow barriers.

3.5.1.3 Conditions Prior to Construction of Grand Coulee Dam

The most significant early human influence on the salmon populations was the commercial fishing industry. The first cannery opened in 1866 with a production of about 240 000 pounds, and by 1883 more than 59 canneries were supported by Columbia River fisheries with peak catches in the late 1800s of 43 million pounds (Mullan, 1987; NRC et al, 1995). The huge annual catches not only affected the number of fish returning to the river, but also their reproductive success (Mullan, 1985). As early as 1875, business and political leaders became alarmed because harvesting had caused a decline in the fish runs that served the canning industry. When consulted in 1875, United States Fish Commissioner Spencer Baird said the salmon were being destroyed by habitat destruction, dam construction, and over-fishing. Baird advised officials in the Northwest to invest $15 000 to $20 000 in artificial propagation in order to avoid restrictive fishing regulations (Baird, 1875; Bakke, 1998). The Oregon and Washington Fish Propagating Company (OWFPC) built the first hatchery in the Columbia River Basin in 1877 [64] on the Clackamas River (Brannon et al., 1999; Dietrich, 1995). The hatchery was closed by OWFPC in 1882 and reopened in 1888 by the State of Oregon (Brannon et al, 1999). From that point, on hatcheries became an important part of salmon management in the Columbia River Basin.

The Native American fisheries at Kettle Falls, and along tributaries such as the Colville, Spokane, and Sanpoil rivers began to experience a steady decline in salmon around 1878 and collapsed around 1890 when the salmon runs virtually disappeared (Mullan, 1987; Scholz et al, 1985). Although salmon continued to spawn in these rivers after the turn of the century, the populations remained far below the abundant levels that sustained the Native American fisheries prior to 1878. The decline in the upper Columbia stocks (above GCD) was reportedly due to the development of commercial fisheries in the lower Columbia River (Koch 1976 as cited by Scholz et al, 1985). Because salmon habitat in the upper Columbia River Basin had not changed significantly over this time period, some analysts believed that a cessation of commercial fishing would have restored the upper Columbia River stocks to their previous levels of abundance (Scholz et al, 1985).

Concern for declining fish runs throughout the basin prompted sporadic, but often ineffectual, conservation measures (Mighetto & Wesley, 1994: 26). The most common conservation measure in the late 1800s and the early 1900s was the banning of certain types of fishing gear. However, bans that occurred in Washington as early as 1871 were not implemented by Oregon until almost two decades later and vice versa (Dietrich, 1995: 335). Co-ordination between the two states was limited, and the ineffectiveness of co-ordination caused President Theodore Roosevelt to comment in 1908 on the inability of the two states to agree on adequate protection of the fisheries (Dietrich, 1995: 335).

Several hatcheries were built in the early 1900s, but even with widespread artificial propagation in the period from 1887 through 1931, Pacific salmon catch numbers continued to decline. By the early 1930s, the catch had been reduced to approximately 25 million pounds, with an estimated run size of 5 to 6 million fish (USACE, 1994). All the hatcheries were closed by 1931 because of disease problems and low numbers of returning adults. No hatcheries operated between 1931 and 1939 (Myers et al, 1998). The runs continued to decline after the completion of Rock Island and Bonneville Dams.

3.5.1.4 Developing Fish Mitigation Measures

Reclamation had taken control of the GCD project in 1933, but it had been unable to reach an agreement with the US Department of Fisheries and the State of Washington regarding the preservation of the fish (Pitzer, 1994). When groundbreaking for the dam took place in 1933, no resolution had been reached regarding the fate of the anadromous fish runs that spawned above the dam site. In 1937, the dam's foundation was completed and the anadromous runs were effectively blocked. Reclamation commissioned the construction of temporary fish ladders that would allow the 1938 runs to reach their natural spawning areas, but by 1939, the dam had reached its full height and fish ladders were no longer a feasible method for passing fish over the dam.

At the time that fish mitigation measures were being considered, no consideration was given to the cultural significance of salmon to indigenous tribes in either the US or Canada. The Minister of Fisheries in Canada was not much concerned with the potential loss of salmon and steelhead because there were no commercial salmon fisheries on the Columbia River in Canada (Pitzer, 1994: 25).

The main emphasis of the mitigation efforts was on maintaining, and possibly increasing, the fish runs based on their economic value for commercial and sport fishing. Prior to completion of Rock Island and Bonneville dams, the run size was estimated based on the size of the commercial catch in pounds. After Bonneville and Rock Island dams were built, the enumeration switched from pounds to numbers of salmon. With these dams in place, the size of fish runs could be easily measured by counting the fish as they passed through fish ladders. Because the fish were valued according to their commercial value, fisheries managers strove to maintain a commercial catch as measured in pounds. They were concerned with maintaining a certain number of fish and not necessarily in preserving specific runs.

Because of the state of knowledge of ecosystems at the time, virtually no attention was given to genetic, biodiversity, or evolutionary issues. Little effort was made to preserve the genetic integrity of hatchery stocks. Hatchery efforts sometimes relied on eggs from other river systems to supplement propagation efforts. Poorly performing hatcheries were frequently subsidised with excess eggs. This was usually a situation in which eggs produced at lower river hatcheries augmented the egg supplies at upper river hatcheries.

Prior to completion of GCD, the sockeye populations had been reduced to a remnant run by over-harvesting and damming of rearing lakes; the coho had been driven to near extinction,[65] and the summer and fall chinook populations were severely diminished (Chapman et al, 1982; Mullan, 1987).

3.5.1.5 The Grand Coulee Fish Maintenance Programme [66]

In January 1939, Secretary of the Interior Harold Ickes stepped in and appointed a Board of Consultants to review the plan proposed by the Washington State Department of Fisheries, and more generally, to investigate and report on migratory fish problems in the upper Columbia Basin (Pitzer, 1994: 226). The Board of Consultants, herein referred to as "the Board," was comprised of R. D. Calkins, Professor of Economics at the University of California of Berkeley, W. F. Durand, Professor of Mechanical Engineering (Emeritus) at Stanford University, and W. H. Rich, Professor of Biology at Stanford University. The Board developed a mitigation plan for the anadromous fish runs based on a general plan proposed by the Washington State Department of Fisheries in co-operation with the State Department of Game and the United States Bureau of Fisheries.

The Board's plan entailed trapping all of the fish runs at Rock Island Dam downstream of GCD and transporting them to the four tributaries between the two dams for natural propagation and to four hatcheries located on these tributaries for artificial propagation. The four tributaries were the Wenatchee, Entiat, Methow and Okanogan Rivers (see Figure 3.5.1). This process was to be repeated for several years until the fish that once spawned above GCD were retrained to spawn in the four tributaries. The concept behind the plan was that the commercial value of the runs could be maintained by simply shifting the runs below GCD. The Board recommended that the fish maintenance project be approached as a scientific experiment, with the hope that improvements would be made both to achieve greater success and to reduce overall cost. A salvage programme of this magnitude had not previously been attempted, and at the time, the proposed artificial propagation programme was the largest of its kind in the world (Netboy, 1980).

The overall plan for anadromous fish was based on several estimates and assumptions. The Board estimated the number of salmon and steelhead spawning above GCD at approximately 25 000 based on an average of six years of runs at Rock Island Dam (ie, runs from 1933 to 1938). The Board recognised that some of the fish that would be trapped at Rock Island were not native spawners to the tributaries above GCD. A fraction of the trapped run spawned naturally in the four tributaries, but because the entire run was trapped at Rock Island Dam, it would be impossible to separate out these runs. The Board estimated that only 2 500 spawned naturally in the four tributaries, a number not considered important when compared with the total number of fish involved (ie, 25 000). The 25 000 fish being mitigated were only a small fraction of the estimated 1 300 000 anadromous fish that spawned in the upper Columbia River before the arrival of white settlers.

Because the main hatchery facility was not completed in time to accept the 1939 fish run, temporary measures were used to care for the run. A portion of the run was transported above GCD, and the remainder of the fish were transported directly to the four tributaries that were slated to become their new spawning grounds. This was to be the beginning of the transplantation process. Smolts hatched from the 1939 run that were transplanted above GCD were expected to pass GCD without harm on their downstream migration because the turbines and irrigation pumps linked with the dam would not yet be in place.

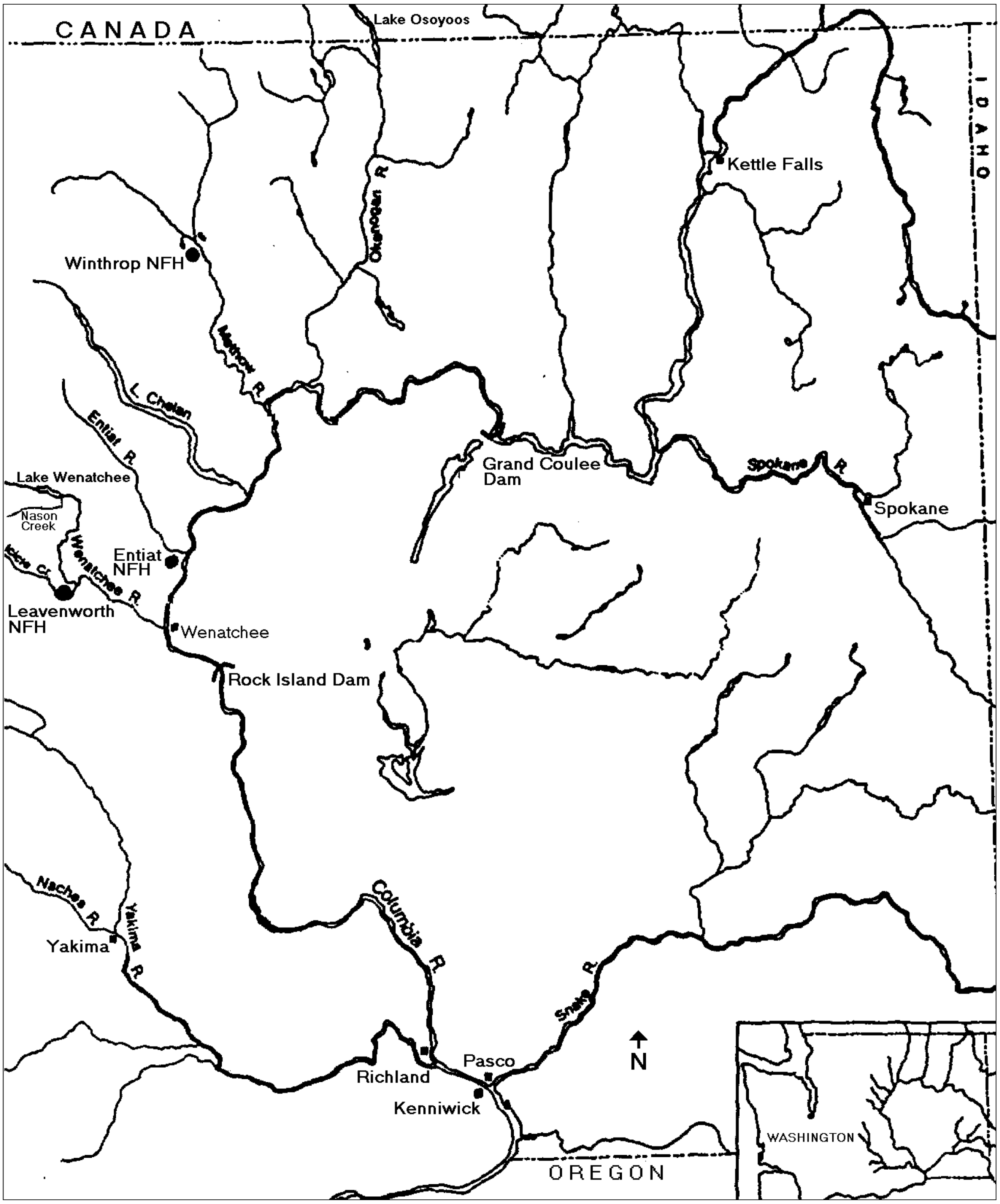
The locations of the hatcheries are shown in Figure 3.5.1. The main hatchery was located on Icicle Creek, a tributary of the Wenatchee River near Leavenworth. The hatchery was to have a production for salmon and steelhead that corresponded to a run of 36 500 fish at Rock Island Dam. Auxiliary hatcheries were also planned for the Methow, Entiat, and Okanogan Rivers. After one or two hatching cycles, it was anticipated that the released hatchery fish would return to the four tributaries to spawn naturally, and the hatcheries would remain in operation merely to augment the run to populations larger than could be hoped for from the natural runs alone (Calkins et al, 1939b: 8).

At the time of the Board's analysis, stricter fishing regulations were under consideration. The two regulations brought to the Board's attention were the elimination of fishing above Bonneville Dam and the elimination of all fishing on the river during portions of June and July (Calkins et al, 1939b). If either, or both, of these regulations were implemented during the course of the trapping and transportation programme, the Board's plan could be infeasible. The Board recognised the importance of their estimate, and argued that if the commercial fishery catch were reduced substantially, their plan would be compromised.

The number of trucks, the size of the hatcheries, the size of the auxiliary facilities, and the anadromous habitat targeted as new spawning areas were all designed to accommodate approximately 36 500 adult fish. If a substantial reduction in commercial fishing occurred, the number of migrating adults could be much greater than the estimated 25 000. Indeed, the Board estimated that without commercial fishing, the number of adult spawners could have been increased several fold (Calkins et al, 1939b). If such a situation were to occur, the Board felt GCD and CBP should not be responsible for dealing with it.

The Board's plan was projected to cost about $322 000 annually (in 1937, $3 659 091 in $1998). The Board judged this to be a good investment given that the economic value of the recreational and commercial fishing adversely affected by the GCD was estimated between $250 000 and $300 000 annually (in 1937 dollars). The Board expected to increase the run size (from 25 000 to 36 500) and thereby increase the value of the fisheries.

Figure 3.5.1 Map of the Middle and Upper Columbia River in the US



Source: Adapted from Mullan, 1987

3.5.1.6 Implemented Mitigation Plan and Results from 1939 to 1947

The Board's plan was implemented with the exception of the proposed plan for the Okanogan Basin. The only suitable hatchery sites found were in Canada, and international complications coupled with the onset of wartime building restrictions forced a delay in construction until the need became more apparent. The hatchery proposed for the Okanogan River was never built. Only sockeye salmon were transplanted in the Okanogan River Basin (specifically Lake Osoyoos, see Figure 3.5.1). The Okanogan River was not used for transplanting chinook and steelhead because, based on stream surveys, it was considered to have an insignificant portion of the runs (Fish & Hanavan, 1948: 4). The natural holding areas chosen on the other tributaries were considered to have a higher probability of success in the programme (Fish & Hanavan, 1948: 4). At no time during this endeavour were chinook salmon planted in the Okanogan River, thereby virtually eliminating the native population. It is possible that 6-year-old adult chinook that escaped the trapping and transportation programme returned in 1944, but this cannot be substantiated.

The natural propagation holding areas consisted of a 16-mile (26km) stretch in Nason Creek for summer steelhead and spring chinook, an 18-mile (29km) stretch of the Wenatchee River for the large summer chinook and steelhead, and a 15-mile (24km) section on the Entiat River for summer chinook. The sockeye salmon were transported to Lake Wenatchee on the Wenatchee River and Lake Osoyoos on the Okanogan River, with racks constructed at the outlets to prevent escape.

The natural propagation programme encountered problems, such as high adult fish mortality due to disease infections resulting from mechanical injury (such as that received in hauling) followed by exposure to high water temperatures. The disease infections were most pronounced in the Entiat River, and this holding area was abandoned after the 1940 season because of complaints from local residents. Additionally, the fish encountered difficulties passing low water barriers in the tributaries. This resulted in a high concentration of spawners in the lower-reaches of the rivers.

Dead fish were collected throughout the natural propagation programme to monitor whether or not they had successfully spawned. Only a small fraction of the original fish release was ever recovered because bears and other wildlife consumed a portion of the dead fish. During high water periods, dead fish were difficult to locate, and some live fish escaped the holding areas. Of the fish that were recovered, the majority had spawned successfully. For example, of the 2 600 fish that were released into the river holding areas in 1941, approximately 28% were recovered. Of those recovered, nearly 60% had spawned. In the lake holding areas, approximately 95% of the fish recovered had spawned.

Hatcheries were completed at Leavenworth on Icicle Creek in 1940, in Entiat on the Entiat River in 1941, and in Winthrop on the Methow River in 1941 (see Figure 3.5.1). The programme for trapping fish at Rock Island Dam and transporting them to the middle Columbia River tributaries began in March 1940, and the Leavenworth holding ponds began receiving fish a few months later (Pitzer, 1994: 227). Several problems were encountered with the original hatchery designs in the early years of operations, the most notable being the lack of fish ladders and the lack of adult holding ponds at the Entiat and Winthrop substations.[67] Freezing temperatures and the lack of a sufficient and suitable wintertime water supply interfered with the ability to rear fish during the winter. In addition, the water supply was inadequate to operate near full capacity during the summer. The hatcheries consistently operated at less than 10% of their original design capacities.

Several studies were undertaken at the hatchery facilities in order to improve the success rate of the artificial propagation programme (eg, by lowering mortality rates throughout the rearing process), and to improve the knowledge regarding fish culture for anadromous species. Studies included pathological investigations, nutritional studies, and investigations of hatchery techniques. The most serious problem at the hatcheries was the pre-spawning mortality of adult fish. When the fish were collected at Rock Island Dam, they had not reached sexual maturity, and thus the fish were held at the hatcheries until they reached sexual maturity. Sockeye and summer chinooks required two to four months of holding, and summer steelhead required six to nine months of holding. During this time, the fish suffered high rates of fungal illness and the pre-spawning mortality rates were often higher than 50% (Fish, 1944; Table 2).

Experiments conducted by the Division of Fish Culture [68] showed that it was not one factor alone that resulted in high mortality rates in the adult fish, but rather a combination. The most plausible explanation was trauma and injury (such as occurred when the fish traversed the Rock Island Dam fish ladder, and when they were trapped and hauled) followed by exposure to high water temperatures. Injured fish offer an excellent medium for the growth of pathogenic microorganisms, and the high water temperatures increase their growth rate (Fish, 1944). Based on the Division of Fish Culture's empirical findings, the best approach to minimising pre-spawning mortality was to eliminate fish trauma and injury prior to spawning (Fish, 1944: 24).

The trapping and hauling programme was eliminated in 1944, and after that the hatcheries were unable to increase production. Egg collections were limited to those collected from adult salmon that returned to the hatcheries to spawn. Several of the stocks were supplemented with eyed eggs from other river systems, such as Lake Quinault sockeye and McKenzie River chinook in 1941, Big White Pond chinook and Lake Chelan kokanee in 1942, and Carson NFH chinook and sockeye in 1943 and 1944.

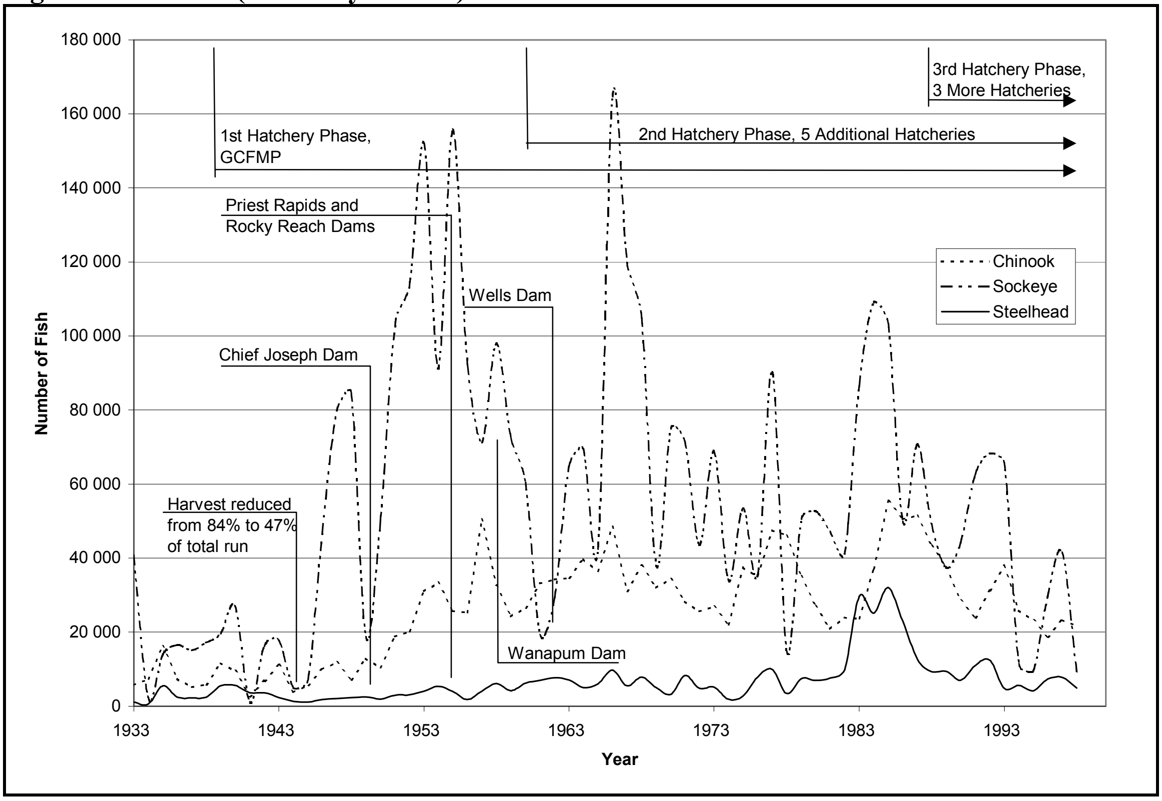
Although the hatchery programme operated at only 10% of its designed capacity, the natural propagation programme was thought to be more successful. Recorded escapement counts at Rock Island Dam from 1938 to 1947 indicated that the returns from the relocated runs generally exceeded early expectations (Fish & Hanavan, 1948: 48). For the sockeye, a discernible increase in the population was observed between 1938 and 1947, showing that the sockeye runs increased over the course of the programme. However, Mullan (1987) reports that the marked increase in the sockeye populations after 1945 was because of a reduction in the commercial catch that brought the catch “more nearly into balance” with escapement. The spring chinook runs experienced a slight decline, but they were well within normal fluctuating ranges. The summer chinook experienced the largest decline. Adequate counts of steelhead were not kept during this period because they were considered to be of minor importance, averaging less than 3% of the total number of salmonids passing Bonneville Dam (Fish & Hanavan, 1948: 49).

3.5.1.7 Upper Columbia Salmon Run Conditions to Present

The Columbia River and the commercial fisheries have experienced significant changes since the implementation of GCFMP, and these changes are reflected in the number of fish passing Rock Island Dam as shown in Figure 3.5.2. In the mid-1940s, the in-river commercial harvest was reduced from 84% to 47% of the total run, which resulted in a marked increase in the salmonid populations, most notably in the chinook and sockeye (Mullan, 1987). In-river commercial fishing has experienced increasing levels of regulation; examples include shortened fishing seasons, decreased catch limits, intermittent closures of entire seasons, and complete fishing closures for non-Indian fisheries above Bonneville Dam. Currently, virtually no non-Indian commercial fishing exists in the Columbia River.

Ocean fishing still exists for Columbia River stocks and it can account for a significant portion of the potential chinook runs. In the 1960s and 1970s, the level of ocean harvest increased significantly as in-river restrictions increased (Chapman et al, 1982). Thus, the numbers of fish caught in the ocean were increasing as the level of in-stream harvest was decreasing. Chapman et al. (1982) estimated that from 1970 to 1974, over 70% of upper Columbia River fall chinook were caught in the ocean by US and Canadian commercial and sport fisheries, compared with less than 20% caught by in-river commercial, sport, and Indian fisheries. As a result of the combined ocean and in-river harvest, less than 10% of the total upper Columbia River fall chinook run managed to escape the fisheries and return to the middle Columbia River. Sockeye and steelhead, however, were not subjected to the same level of exploitation. Mullan (1987) asserts that sockeye are rarely caught in the ocean, and steelhead are subject to only minor ocean exploitation. When in-river harvest was scaled back, the exploitation rate for sockeye dropped considerably.

Figure 3.5.2 Total (Hatchery + Wild) Fish Counts Past Rock Island Dam



Source: Mosey & Murdoch, 2000: Appendix 5

The construction of additional hydropower dams and their associated fish mitigation efforts in the middle Columbia River also had an effect on the upper and middle Columbia River fish populations. Chief Joseph Dam was constructed below GCD between 1950 and 1955, eliminating 50 miles (80.5km) of main-stem spawning habitat. Rocky Reach Dam was constructed above the mouth of the Wenatchee River between 1956 and 1961, adversely affecting fish passage to and from the Entiat, Methow, and Okanogan Rivers. Priest Rapids Dam was constructed above the confluence with the Yakima River between 1956 and 1959. Wanapum Dam was constructed between 1959 and 1964 above Priest Rapids Dam. Finally, Wells Dam was constructed between 1963 and 1967 just below the mouth of the Methow River, further affecting fish passage to the Methow and Okanogan Rivers. The construction of these dams eliminated an additional 149 miles (240km) of main-stem habitat between Chief Joseph and Priest Rapids dams (Brannon et al., 1999). Three additional dams were constructed in the lower Columbia River that interfered with fish passage for the upper and middle Columbia River stocks: McNary Dam (1957), The Dalles Dam (1957), and the John Day Dam (1968).

Major fish mitigation efforts were associated with the increasing dam construction. These took the form of additional hatcheries and increased hatchery releases. Between 1961 and 1967, four hatcheries (Rocky Reach, Chelan, Priest Rapids, and Wells Hatcheries) and one satellite facility [69] (Turtle Rock Hatchery) were constructed. Another phase of mitigation was instigated in 1989 with the construction of the Methow Hatchery and two satellite facilities, Eastbank Hatchery and five satellites, and the Cassimer Bar Hatchery. This phase was intended to mitigate for the juveniles lost in passage at Wells and Rock Island dams (Brannon et al, 1999). The fish counts shown in Figure 3.5.2 include both wild salmonids and the increasing numbers of hatchery fish that returned to the hatcheries located above Rock Island Dam. The distribution of fish between hatchery and wild has changed dramatically over the past several decades. In the 1930s and 1940s, the majority of fish were wild. Currently, the majority of fish are of hatchery origin; in some cases more than 80% of the salmonids are from hatcheries (Busby et al., 1996).

The Leavenworth, Entiat, and Winthrop National Fish Hatcheries have continued producing fish for the anadromous runs in the four middle Columbia River tributaries below GCD. In 1945, control of the hatcheries shifted from Reclamation to USFWS. Nearly fifty years later, in 1994, Reclamation resumed funding the hatcheries. During the 1950s and 1960s, the hatcheries associated with GCFMP (ie, Leavenworth, Winthrop, and Entiat) shifted away from rearing sockeye, steelhead, and chinook and toward rearing resident trout. This continued until the early 1970s, when changing social values and increasing scientific knowledge led biologists and fisheries management agencies to see that the fish stocks were important over and above their commercial value. At this point, the GCFMP hatcheries were upgraded and shifted back to rearing the stocks originally under consideration by GCFMP, namely chinook, steelhead, and to a much lesser extent, sockeye.

The Wenatchee River Basin currently supports wild runs of spring chinook, sockeye, steelhead, and the majority of the summer chinook found in the middle Columbia River Basin (Mullan, 1987). The Entiat River Basin continues to support a small wild run of spring chinook and a possible remnant of wild summer chinook (CRITFC, 1995: 74). Fall chinook may also be spawning in the Entiat River; this may be due to straying[70] from Turtle Rock Hatchery releases. Sockeye have been reported spawning in the Entiat River near Brief, but are likely strays from the Wenatchee or Okanogan river systems (CRITFC, 1995: 74).

The Methow River Basin continues to support wild spring chinook runs in the Twisp, Chewuck, and upper Methow rivers and some minor tributaries; there is also a wild summer chinook run in the main-stem of the Methow River and wild steelhead runs throughout the basin (CRITFC, 1995). A remnant wild run of summer chinook presently exists in the main-stem of the Okanogan River and the Similkameen River. A small wild sockeye run uses Lake Osoyoos. Wild steelhead are found throughout the Okanogan River Basin (CRITFC, 1995: 89).

The four middle Columbia River tributaries (ie, the Wenatchee, Methow, Entiat, and Okanogan rivers) have experienced continued degradation as a result of forestry activities, shoreline development, irrigation withdrawals, and riparian (shoreline) vegetation removal. The Entiat River watershed suffered forest fires in 1988 and 1994 that burned much of the watershed and adversely affected in-stream rearing habitat and sediment load. As a result of the presence of upstream dams, irrigation diversions and warm irrigation return flows, the Okanogan River suffers from extreme summer temperatures, and sediment [71] and low flow problems (Gustafson et al, 1998).

GCFMP, along with the later hatchery programmes associated with other Columbia River Basin dams (mentioned above) has been successful at maintaining relatively stable salmonid populations and in maintaining genetic diversity to some unknown degree (Mullan, 1987). The various stocks that once spawned above Rock Island Dam experienced a significant level of homogenisation because of the trapping and transplanting process, so although specific stocks were not preserved, it is likely that some of the genome [72] was saved. Increasing development and hatchery production has further stressed the wild salmonids, and although the populations of wild chinook salmon were stable from the 1950s through the 1980s (Mullan, 1987), these populations have declined in recent years (Myers et al., 1998). The wild upper Columbia River spring chinook runs were listed as endangered by NMFS in 1998.

The upper Columbia River sockeye stocks were revived after 1945 when the commercial catch was lowered (Mullan, 1987). Today, Lake Osoyoos supports a highly variable sockeye population, with a current five-year average of 11 100 sockeye, and Lake Wenatchee supports a more stable population with a five-year average of 19 000 sockeye (Gustafson et al, 1997). While there are concerns regarding the health of the Lake Osoyoos system because of lake eutrophication and high water temperatures, both Lake Osoyoos and Lake Wenatchee sockeye populations are considered healthy and not in danger of extinction (Gustafson et al, 1997).

The wild steelhead populations in the four middle Columbia River tributaries are all considered at risk of extinction. The annual steelhead counts remained fairly stable from 1938 through 1980, and a marked increase of 300% to 400% was seen in the early 1980s (Mullan, 1987; Busby et al., 1996). However, the increase occurred because of major hatchery supplementation programmes and the steelhead populations returned to their previous levels in the 1990s, despite continuation of the hatchery supplementation programme; hatchery fish comprise 65% of the spawning escapement in the Wenatchee River, and 81% in the Methow and Okanogan rivers (Busby et al., 1996). The runs of wild upper Columbia River steelhead are severely depressed, and the upper Columbia River steelhead stocks were listed as endangered in 1997.

3.5.1.8 Effectiveness of GCFMP and Irreversible Impacts of GCD

The total fish population target for the four middle Columbia River tributaries chosen by the Board, namely 36 500 salmonids, has been met. The total number of fish passing Rock Island Dam (based on the five-year average from 1994 to 1998 in Figure 3.5.2) is estimated at 48 700. A simple comparison of the Board's target with today's population sizes may lead one to believe that GCFMP has been widely successful, the target has not only been met but has been exceeded. However, because of the changes that have occurred over the past 60 years, a meaningful comparison between the present populations and targets set in the late 1930s is difficult, if not impossible.

Table 3.5.2 highlights the major differences between the factors affecting salmon runs in the mid-1930s and those influencing salmon runs today. Before GCD was constructed, commercial fishing, limited fish passage at Bonneville and Rock Island dams, habitat destruction, and other factors had reduced the upper and middle Columbia River runs above Rock Island Dam to only 25 000. However, the Board estimated that over 75 000 salmonids destined for the upper Columbia River were caught in lower Columbia River commercial fisheries, bringing the size of the potential run to over 100 000 fish. The upper and middle Columbia River runs were also subjected to sport and Indian fishing; the absence of these takes would increase the total potential run size even further. In 1999, virtually no in-river commercial, sport, or Indian fishing is allowed for the upper Columbia River stocks to assist salmonid restoration efforts. A more meaningful comparison of past and present run sizes needs to remove the effects of fishing. A crude comparison leads us to conclude that the total salmonid population migrating above Rock Island Dam since the 1930s has been roughly reduced by 50%. This estimate is based on comparing 101 300 salmonids (ie, the Rock Island Dam count of 25 000 plus the 76 300 salmonids taken in the lower river commercial fishery) in the 1930s with 48 700 today.

Table 3.5.2 Comparison of 1930s and 1999 Upper Columbia River Salmonid Conditions

1930s – pre GCD	**1999 – the present**
25 000 wild salmonids at Rock Island Dam	48 700 salmonids, 60% to 80% from hatcheries
76 300 wild salmonids caught in lower-Columbia commercial fisheries	No in-river commercial harvest
Unregulated sport fishing	No sport fishing for wild or ESA listed fish ("catch and release" only)
Unregulated Indian fishing	Managed Indian fishing to avoid catching ESA listed species
Extensive available habitat for spawning and rearing above GCD site	Relatively scarce habitat for spawning and rearing in four middle Columbia River tributaries
Main-stem spawning habitat accessible	Virtually no main-stem spawning habitat
2 Main-stem Dams (1 complete and 1 under construction)	11 Main-stem Dams (including GCD and Chief Joseph)
No operating hatcheries	Extensive hatchery supplementation

Aside from limitations on run size from harvest and ocean conditions, habitat carrying capacity is typically the bottleneck, or limiting factor controlling run size. In 1934, extensive habitat areas were available above GCD. Much of the habitat above GCD had not changed significantly since the late 1800s, and Scholz et al. (1985) believed that a cessation in commercial fishing could have restored the upper Columbia River runs to much more abundant numbers. The same was not true for the four middle Columbia River tributaries. The Wenatchee, Entiat, Methow, and Okanogan Rivers had experienced significant degradation before the 1930s. Stream rehabilitation and fish passage improvements were necessary to bring the tributaries to the point where they could adequately support GCFMP's proposed 25 000 to 36 500 fish.

The upper Columbia River habitat, over 1 100 miles (1 770km), was irreversibly blocked by GCD. And another dam, Chief Joseph, was built just downstream eliminating an additional 50 miles (81km) of main-stem spawning habitat. In 1985, when Mullan (1987) reviewed strategies for further increasing the runs, a possible option was to release smolts from the hatcheries earlier in their life cycle for short term rearing and outplanting in middle Columbia River tributaries. He felt this might result in better quality smolts and higher smolt-to-adult survival rates. However, Mullan rejected the option when he determined that the middle Columbia River streams lacked suitable habitat for outplanted hatchery juveniles (Mullan, 1987). While habitat is limiting in the middle Columbia River tributaries, habitat restoration would be very expensive because of the size of the rivers. The rewards from such an endeavour would be expected to be limited by losses incurred at downstream dams and by inherent ecological factors. For example, these four rivers have very cold winter and high summer water temperatures, which can limit salmonid survival.

The Columbia River has also undergone substantial development for its hydropower potential since the 1930s, and this development has created an unnatural environment for anadromous fish. Before the construction of GCD, only two dams existed on the Columbia River's main-stem (Bonneville and Rock Island). Although both dams had fish passage facilities, fish mortality occurred during both the upstream and downstream migrations through the dams. Considerable research and development has been conducted over the past 60 years to reduce the high mortality rates during passage and assist salmonids in their migrations. Although these efforts have improved fish passage, the number of dams migrating salmonids must traverse to reach the four middle Columbia River tributaries has increased. For example, salmonids that spawn in the Wenatchee River must traverse seven main-stem dams, while those that spawn in the Entiat River must traverse eight; and those in the Methow and Okanogan rivers must traverse nine. This hydropower development was under consideration before GCD was constructed, but development impacts on the future success of GCFMP were largely ignored.

In order to mitigate for the increasing development, extensive hatchery programmes have been instigated, and these programmes release hundreds of millions of young smolts into the river system each year (Waples, 1999). While substantial controversy exists over the effect of these hatchery fish on their wild counterparts, virtually all who have studied the subject agree that there has been some effect. Based on the sheer number of hatchery programmes on the Columbia River, it is not surprising that hatchery fish currently comprise a sizeable portion of the upper Columbia River stocks. In the 1930s, the Board was not concerned with distinguishing between wild and hatchery fish. The primary goal was reaching a target population size; the origin of the fish was immaterial. However, today's scientific norms recognise the differences between hatchery and wild fish, and only wild salmon are of concern under the ESA. Since hatcheries formed the basis of early recovery efforts, other options were not necessarily left open for future efforts. In view of the current regard for hatcheries, recovery is problematic. Currently 60% to 80% of the current populations size (ie, 48 700) is attributable to hatchery stocks. Therefore, wild fish populations are currently in the range of 10 000 to 20 000 salmonids — a population that is only 10% to 20% of our estimate of the 1930s potential runs size of 101 300. Several of the upper Columbia River stocks have been listed under ESA because of their severely depressed numbers, and the role hatcheries can play in the required recovery strategies is uncertain.

Table 3.5.3 shows the current escapement counts for the four middle Columbia River tributaries and the current risk level of the stocks based on ESA listings and the Nehlson rating system (Nehlson et al, 1991). The summer and fall chinook counts have been combined into the summer classification since these races are no longer considered genetically unique because of the extensive homogenisation that occurred under GCFMP [73] (Myers et al, 1998). Two chinook stocks (the Okanogan spring chinook and Entiat summer chinook) have gone extinct since GCFMP's implementation.

The Board could have anticipated how different the development of the Columbia River System hydropower would be today because the Butler Report and the Major Kuentz Report were available

(USACE, 1933). These reports laid out extensive development plans for the entire main-stem of the Columbia River within the US, and GCD was only one component of a much larger scheme. However, the Board could not have anticipated the extent of the current hatchery mitigation efforts. At the time of the Board's analysis, no operating hatcheries existed on the middle or upper Columbia River. Today, there are multitudes of hatcheries throughout the entire Columbia River Basin, including additional hatcheries built to support the four middle Columbia River tributaries. And while in the past hatcheries were an acceptable mitigation effort for lost habitat and/or natural populations (Waples, 1999), the Board could not have anticipated the changing sentiments towards hatcheries. There has been growing appreciation that long-term sustainability of salmonids requires conservation of natural populations and their habitats (NRC et al., 1995). Increasing levels of scientific knowledge have caused more weight to be placed on the ecological importance of specific stocks and the vast array of genetic and biological diversity they contain. The foundation of GCFMP was to homogenise the upper and middle Columbia River stocks by trapping all the runs at Rock Island Dam. If ecological significance and biodiversity had been an issue at the time, it is unlikely that this large-scale homogenisation would have been undertaken.

The Board could not have anticipated the importance that present day society is placing on wild salmon. (Only wild salmon are protected under the ESA.) How could they have known that there would be people today that want to restore salmon runs back to their historical abundance? How could they have anticipated the level of controversy that has arisen surrounding the Columbia River salmon? The Board could not possibly have anticipated the inherent value that many US Northwest citizens attach to simply knowing that salmon exist in the Columbia River. While this attachment of inherent value to wild salmon in the Columbia River is probably strongest in the Columbia River Basin's large coastal cities (eg, Seattle, Tacoma, and Portland), it has been a major factor in the politics of salmon recovery.

Increasing scientific knowledge, changing social values, as well as the differences between the 1930s and 1990s listed in Table 3.5.2, are not the only factors that make it difficult to compare the salmonid runs of 1930s and 1990s. Such a comparison is also difficult because of three significant irreversible effects that GCD and GCFMP have had on the middle and upper Columbia River anadromous fish. First, GCD blocks 1 100 miles (1 770km) of habitat, making it a practical impossibility to significantly increase the number of salmonids in the upper Columbia River Basin. This change is virtually irreversible since the likelihood that GCD will ever be removed is practically nil because the dam is of central importance to the Columbia River hydropower system. Second, the Board's plan makes it a practical impossibility to substantially increase the population sizes of the upper Columbia River stocks in the middle Columbia River tributaries because GCFMP was developed around a habitat area that cannot support significant population increases. And third, GCFMP made it absolutely impossible to ever recover the original stocks of the four middle Columbia River tributaries. These stocks, considered insignificant at the time of the Board's analysis, were completely subsumed within the upper Columbia River stocks through the trapping and transportation programme in the late 1930s and early 1940s.

Table 3.5.3 Current Status of Wild Anadromous Salmonid Stocks in the Entiat, Methow, Okanogan, and Wenatchee River Basins

River Basin	Stock	Status	Data Years	5-Year Average
Entiat	Summer chinook	Extinct [a]		
Methow	Summer chinook	Moderate risk of extinction [a]	1963-1996	666
Okanogan	Summer chinook	Special concern [a]	1977-1996	491
Wenatchee	Summer chinook	Healthy [a]	1975-1995	7 012
Entiat	Spring chinook	Endangered [b]	1977-1995	89
Methow	Spring chinook	Endangered [b]	1977-1995	355
Okanogan	Spring chinook	Extinct [a]		
Wenatchee	Spring chinook	Endangered [b]	1977-1995	328
Lake Osoyoos	Sockeye	Healthy [c]	1960-1996	11 100
Lake Wenatchee	Sockeye	Healthy [c]	1961-1996	19 000
Entiat	Steelhead	Endangered [b]		
Methow & Okanogan	Steelhead	Endangered [b]	1982-1993	540
Wenatchee	Steelhead	Endangered [b]	1962-1993	800

[a] Myers et al, 1998; [b] NMFS, 2000; [c] Busby et al, 1996;
Sources: Myers et al, 1998; NMFS, 2000; Busby et al, 1996.

3.5.1.9 Total Dissolved Gas

An important aspect of GCD operations (and FCRPS operations generally) affecting anadromous fish is total dissolved gas (TDG). TDG is the level of atmospheric gases dissolved in water. The normal maximum amount is 100% and is affected by water temperature. During uncontrolled flood events, when water must be released from spillways, or when dams release spill for flow augmentation, the plunge of large spill volumes can drive the levels of TDG to 150% of normal. TDG levels above 120% cause fatal gas bubble disease trauma in adult and juvenile fish.

Operations at GCD affect TDG in two ways. First, the dam carries on TDG generated by upriver dams. Second, spill (ie, water not released through turbines) released through spillway drum gates or outlet works at the dam increases TDG content composition downriver (USBR, 1998a). Although GCD powerplant releases do not increase downstream dissolved gas levels, releases from the dam consistently exceed the Washington State standard of 110% dissolved gas standard between May and August of most years, even with no spill (USBR, 1998a). Concentrations of already high TDG are further increased when spill releases are discharged through the dam's outlet works or spillway drum gates (USBR, 1998a).

Operators at GCD try to minimise spill as much as possible to keep TDG levels at or below 110%. However, in many cases, dams downstream have had to seek variances of 120% in order to meet flow augmentation requirements.[74] The FCRPS project sometimes use spillway modifications called flip lips to reduce plunge and TDG, but not all TDG can be eliminated (Mighetto & Wesley, 1994).

The system-wide problem of TDG reflects the conflicts sometimes inherent in anadromous fish recovery efforts. On the one hand, spill benefits outmigrating anadromous fish by helping speed their journey to the ocean and by helping them to pass through dams. On the other hand, too much spill increases the concentration of dissolved gas in the water, and TDG concentrations that exceed 120% can be lethal to fish.

While the dissolved gas problem has been linked to 'gas bubble disease' for decades, it was not until recently that specific actions were taken at GCD to abate gas levels. Under the NMFS 1998 Biological

Opinion, Reclamation was given the task of investigating operational and structural gas abatement measures at the project (USBR, 1998b). The biological opinion states: "The Action Agencies, in co-ordination with NMFS and the Regional Forum, shall jointly investigate operational and structural gas abatement measures at Grand Coulee and Chief Joseph Dams as part of a system-wide evaluation of gas abatement measures . . . The Action Agencies shall seek congressional authority and funding, as necessary to implement the selected preferred alternatives . . . Lower dissolved gas levels from the Grand Coulee and Chief Joseph Dams would reduce background TDG levels caused by those projects, which may limit the duration of exposure of adult steelhead to high dissolved gas concentrations. Further the passage survival of juvenile steelhead would be improved because increased spill would be allowed at downstream projects . . ." (NMFS, 1998, as cited in USBR, 1998b).

To offset the effects of TDG, several operational changes have been implemented at GCD, including alteration of spill cap procedures[75] (for spillway and outlet works); increased used of turbines for water passage (with or without power production); prioritised use of spillway releases over outlet works releases; and modification of outlet works releases to minimise generation of dissolved gas (USBR, 1998a). Reclamation is also working with other federal operating agencies and non-federal project operators in the basin to investigate more systematic operational changes that will reduce dissolved gas concentrations.

In response to the 1998 NMFS biological opinion, Reclamation is also considering five structural alternatives for GCD (USBR, 1998b): (i) extending mid-level outlet works to obtain a submerged discharge into the tailwater pool; (ii) and (iii) constructing a new pipeline to transfer water from the forebay to the tailrace of the dam (with and without a gas stripping drop structure);[76] (iv) adding deflectors on the downstream face of the spillway; (v) adding deflectors below the expanse of the mid-level outlets to redirect flow. The range of implementation times for these projects is between three to five years and the construction costs range from $39 million to $293 million (USBR, 1998b).

3.5.1.10 Fish Mitigation Costs

Fish mitigation measures have had a direct effect on power generation, not only at GCD, but also for all major projects throughout the Columbia River Basin (USACE, 1996). Since ESA listings began in 1991, the FCRPS has taken increasingly drastic measures to prevent extinction. Right now the FCRPS operations are increasingly driven by fish mitigation needs, and the costs are considerable. Since 1996, $435 million has been budgeted by BPA annually to pay for: (i) capital expenditures of improved fish facilities, including the past debt load; (ii) foregone generation from volitional spill and storage release to aid salmon migration; (iii) operation and maintenance of fish facilities; and (iv) research and development programmes for fish and wildlife affected by the dams.

When water supply (runoff) is average, $182 million is lost each year in hydropower revenues, primarily from releases of storage and spill for fish migration. Add this to the cost of implementing all mitigation measures (ie, capital improvements, such as fish ladders, hatcheries, screens, and habitat restoration, plus $127 million annually to the NPPC's fish and wildlife programme), and the total annual cost of fish mitigation averages $435 million (NPPC, 1998).[77] Plans for further mitigation are underway including the possibility of dam removals, which could raise the annual cost of fish mitigation to over $700 million.

3.5.2 Resident Fish

Prior to construction of GCD, many native fish species, both anadromous and resident, were present in the Columbia River. After the project blocked upriver spawning grounds, resident fisheries, which include both native and introduced species, became increasingly important (DOE, et al. (Appendix K), 1995: 2-1). Lake Roosevelt, home to 30 species of resident fish,[78] has become one of the main non-anadromous fisheries in the Columbia River system (DOE et al. (Appendix K), 1995: 2-4-2-8). Key species within the lake include kokanee, walleye, and rainbow trout. Lake Roosevelt is a popular fishing destination for sport anglers.

GCD has had two main effects on resident fish populations. First, it provided the impetus for stocking Lake Roosevelt with native and introduced species. Second, project operations have affected and continue to affect the health and productivity of the resident fishery.

The three federal hatcheries of GCFMP added rainbow trout to their production programme. In the 1950s and 1960s, walleye were introduced in Lake Roosevelt. That species has done well, but it is an aggressive predator. The 1984 amendment to the Northwest Power Act allowed some money from hydropower generation to go to resident fish substitution. Both the Spokane and Colville tribes now operate kokanee and trout hatcheries funded by BPA, and they co-operate closely in fish monitoring and studies. The two kokanee hatcheries were constructed as mitigation for the loss of anadromous salmon to the region and to replenish the decreasing kokanee population in Lake Roosevelt (DOE et al. (Appendix K), 1995: 2-26). However, a number of problems remain, and few fish are caught as a result of these programmes. Late 1990s harvest levels of kokanee were only 10% of the goal (See Annex titled "Native Americans for details).

Optimal reservoir conditions for resident fish in Lake Roosevelt include water retention times of 30 days or greater, high reservoir elevations, decreased drawdowns, and improved refill probability (DOE et al. (Appendix K), 1995). When the reservoir is drawn down beginning in the summer or early fall, the reduced volume and surface area of the reservoir limit fall food supply and alter water temperatures during critical growth periods (eg, for trout). Deep drafts reduce food production and concentrate prey fish (eg, trout) with predators (eg, northern sqawfish) (DOE et al. (Appendix K), 1995: 1-9). Releases for flow augmentation from May to July to assist in the outmigration of anadromous smolts adversely affects resident fish by reducing the probability of refill. Also, lack of stored water in the reservoir can compromise the system's ability to maintain critical flows needed for resident fish species to spawn in tributaries (DOE et al. (Appendix K), 1995: 1-9). Some tribal fishery managers fear that the increased emphasis on native species and anadromous fish spurred by the Endangered Species Act may eliminate the limited progress made on resident fish programmes (Underwood 1999; Peone et al. 1999).

Water retention times in Lake Roosevelt below 30 days in the spring often result in the entrainment[79] of fish, such as kokanee and rainbow trout, through or over the dam. Entrainment increases with decreasing water retention time (DOE et al. (Appendix K): 2-26). According to Beckman et al. (1985), annual spring drawdowns for flood control and additional release to augmentation flow for anadromous fish migration affect nutrient levels in Lake Roosevelt, decreasing phytoplankton and zooplankton production in the reservoir and decreasing water retention times. Because kokanee, [80] walleye, and perch rely on zooplankton as a food source, having a water retention time of 30 to 35 days in the spring appears to be of critical importance to the Lake Roosevelt fishery throughout the year (Griffith & Scholz, 1991; Peone et al, 1990). In practice, average water retention time in the reservoir ranges between 15 and 76 days. Retention time is shortest in spring (Beckman et al., 1985), when the resident fish often need longer retention times. Because of short retention times, nutrients and plankton are rapidly flushed through the reservoir. (DOE et al. (Appendix K), 1995: 2-24). Spring drawdowns also force hatchery managers to move rainbow trout fishery net pens deeper into the reservoir and have, on occasion, necessitated the premature release of fish (DOE et al. (Appendix K), 1995: 2-26).

New integrated rule curves have been developed to improve conditions for all resident and anadromous fish species in the Columbia River system within the "realities of flood control and power production". (DOE et al. (Main Report), 1995: 1-9). Integrated rule curves were identified as tools for balancing the needs of fish with flood control and hydropower generation objectives as a result of a System Operation Review conducted in the mid-1990s by BPA, Reclamation, and the Corps (DOE et al. (Main Report), 1995: 1-9).

3.5.3 Transformation of Ecosystems on CBP Land

By developing land for irrigated agriculture and applying water to the land, CBP has caused enormous change in the ecosystems of the Columbia Plateau. A major conversion in habitat took place with consequent changes in the type of vegetation and wildlife that exist in the project area.

One of the largest changes has been the loss of hundreds of thousands of acres of shrub steppe habitat (Hill 1999). About 40% of the original shrub-steppe habitat that existed in the project area prior to human settlement and CBP development currently remains (USBR, 1997b: 3-39). The highest quality shrub-steppe habitat was converted first. Areas with deeper soils, among the most desirable for farmland, were also the best habitat; shrubs grew taller there than on areas with shallower soils (Hill, 1999). Deeper soils are also important for species like the pygmy rabbit, and the loss of this habitat has decreased the populations of these animals, as well as Washington ground squirrels and burrowing owls (Hill 1999). There were 17 predominantly shrub-steppe-dependent animal species of concern known to be associated with the CBP's shrub-steppe habitat in 1997 (USBR, 1997b: 3-67).

Lower Crab Creek has also been altered by the project. It now maintains a constant flow except during severe flood events. Native willow trees, which are adapted to regenerate under conditions of changing flow along riparian corridors, have not been regenerating on Crab Creek (Hill 1999).

CBP has also created large areas of wetlands, reservoirs, and riparian corridors. As a result, CBP lands have become very significant to migratory birds in the Pacific Flyway. As much as 10% of the wintering population of mallards remains in the CBP area due to the habitat conditions resulting from the irrigation project (Hill 1999). There are also several bird species that breed in CBP wetlands. Throughout the year, more than 500 000 ducks, geese, and other waterfowl species use the CBP area. The wetlands are used by many non-game bird species as well as heavily hunted game birds (USBR, 1989a: III-164).

As a result of the increase in many wildlife species on CBP land, several state and federally run wildlife management areas have been established. The Columbia National Wildlife Refuge, which was planned simultaneously with CBP, now encompasses 23 200 acres (9 389ha), consisting of approximately 18 000 acres (7 284ha) of shrub-steppe, rock cliff, and grassland habitats, and 5 000 acres (2023ha) of wetland and riparian areas (Hill 1999; USFWS, 1992). The Washington State Department of Fish and Wildlife owns or manages a total of 229 283 acres (92 789ha) in the CBP area (Parker & Lloyd, 1982: 1).

Two irrigation wasteways created by CBP have also assumed ecological importance. Recent studies have documented that chinook salmon are spawning in them, and there have also been reports of steelhead spawning in one of the wasteways (Bowen et al, 1998: 9-18).

Unexpected changes in the newly created habitat have tempered the benefits to waterfowl and other bird species dependent on wetlands and open water. One of the characteristics of the new habitats, such as artificially created wetlands, is their need for maintenance (Hill 1999). Artificially created wetlands fill quickly with vegetation, which reduces their use by wetland birds like waterfowl and passerines (Creighton et al., 1997: 216). To reverse these conditions in CBP wetlands, the Washington Department of Fish and Wildlife has been excavating wetlands since 1987; their goal is to create more wetlands with open water (Creighton et al, 1997: 216-7). Man-made lakes and reservoirs on CBP land have also undergone similar physical changes, and they are no longer as productive as they once were (Hill 1999). This is reflected by a decreased use of project lands by waterfowl since the early years of the project (USBR, 1984: 5). For instance, between 1966 and 1970, there was a wintering population of 314 000 ducks and 23 000 geese. This dropped off to an average of 98 241 ducks and 13 462 geese between 1976 and 1980 (Parker & Lloyd, 1982: 1).

3.6 Social Effects: Non-indigenous Peoples

3.6.1 Construction-related Employment

In keeping with one of President Franklin Roosevelt's original motivations for promoting and supporting the project, GCD and CBP provided jobs for thousands of workers. Pitzer (1994: 181) estimates that the number of people employed by the project ranged from 2 000 to 8 000 workers, and the size of the community in the vicinity of GCD grew as large as 15 000 (Gold Historian, 1983). When large-scale construction of GCD began, men — mostly young, unmarried, and white — arrived in droves to take advantage of this opportunity for work during the Great Depression. Higher-level engineers and government inspectors earned between $1 600 and $2 300 (19 000 to 27 000 in $1998) annually, while day labourers made between fifty cents to a dollar per hour (Pitzer, 1994: 183). During GCD's major early construction (from 1934 to 1941) local communities, such as Coulee Dam and Electric City, prospered. However, the prosperity was short-lived, as many of the workers did not eventually settle in the project area. For example, of those who began working at the dam in 1934, only 10% were still working there as of 1937 (Pitzer, 1994:191).

The *Wenatchee Daily World* reported that 20% of the men working at the site were from out of state. The observations below, written by a journalist for *Esquire Magazine,* helps illustrate the employment effects of the project and the characteristics of the workers in May 1941:

> *There are over fifteen thousand people at Coulee today, and not one is a farmer. Coulee is like a boom town like those of the gold rush days . . . The Coulee towns are fairly affluent places, as might be expected where 6 000 men are employed, day and night, at wages averaging 90 cents* [about $10.50 in $1998] *an hour . . . The men come from every state in the union and almost every foreign country, but the majority are white citizens of Anglo-Saxon origin. The married men and the unskilled labour from the poor dry-land wheat farms near by [sic] are inclined to save their money. Most of the builders, however, are unattached migrant toolhands who like to make money fast and don't mind spending it faster.* (Weller, as reprinted in The Gold Historian, 1983)

Employment benefits to persons of other ethnicities are not well documented, but the town of Grand Coulee did house a small black and Hispanic population (Pitzer, 1994: 186). During the early period of project construction, the government did not employ women, stating that the community lacked suitable quarters. Later, however, women were hired for administrative and clerical work (Pitzer, 1994: 180). There was no significant Native American presence in the construction work force. In fact, it was difficult for Colville tribal members, whose reservation bordered the dam site, to obtain construction work on the project (Fredin 1999).

3.6.2 Commercial and Sport Fishing

GCD, constructed with no fish passage facilities, formed an impassable barrier for fish that traditionally spawned upstream of GCD. Consequently, the project had an adverse effect on upstream commercial and sport fishing. Early estimates of the economic value of anadromous fish that would be lost due to the project are presented in Table 3.6.1 below, which shows a total estimated loss of between $250 000 to $300 000 in 1937 dollars (approximately $2.84 to $3.41 million in $1998).[81] This number does not include consideration of the project's effects on downstream fishing.[82]

Table 3.6.1 Total Estimated Value of Anadromous Fish Lost due to GCD per Annum

Category	Wholesale Price (1937 $)	Wholesale Price (1998 $)
Chinook	178 200	2 025 000
Sockeye	43 200	491 000
Steelhead	4 950	56 000
Recreation/Sport Fishing	25 000 to 75 000	284 000 to 852 000
Total	**250 000 to 300 000**	**2 856 000 to 3 424 000**

Source: Calkins et al., 1939b.

3.6.3 Displacement and Resettlement of Non-indigenous People[83]

Although the land area to be inundated by the reservoir created by GCD was sparsely populated, Reclamation had to acquire more than 2 000 pieces of property,[84] and this required displacing between 3 000 and 4 000 non-indigenous people.[85] Reclamation paid for all acquired land but provided no resettlement assistance for those displaced. The reservoir formed by GCD covered 151 miles (243km) of the main-stem Columbia River, as well as substantial portions of tributaries including the Spokane, Kettle, and Sanpoil rivers, among others. Lake Roosevelt inundated approximately 70 500 acres (28 500ha) of land in addition to the original riverbed (USBR, 1976: I-57).

Lake Roosevelt's creation displaced both rural residents and inhabitants of at least ten towns.[86] The following ten towns were flooded: Boyds, Daisy, Keller, Kettle Falls, Gerome, Gifford, Inchelium, Lincoln, Marcus, and Peach (Luttrell & Bruce, 1994: 10.8). In addition to these ten towns, Lake Roosevelt inundated several other communities that were smaller and not necessarily incorporated (Luttrell & Bruce 1994: 10.7). Although less than 15% of the area inundated was being cultivated prior to dam construction (USBR, 1976: V-2), the riverine corridor, with its good soil and access to water, supported economic activities, with agriculture, particularly orchard husbandry, predominating.[87] Lake Roosevelt inundated between 400 and 600 farms (Stoffel, 1940: 14; WDW, 1941: 17).

3.6.3.1 Notification

We did not find any documentation of any formal notification procedure used by Reclamation for informing non-indigenous settlers (or Native Americans) about the imminent creation of Lake Roosevelt.[88] Between 1933 and 1936, the Columbia Basin Commission surveyed and appraised all the land (including Native American land) that would be needed for the lake (Pitzer, 1994: 104, 215–216; Luttrell and Bruce, 1994: 10.4). As a result of the Commission's activities, many people in the reservoir area were aware of the project and the fact that their land was scheduled to be taken by the end of 1936.[89] Lake Roosevelt began forming in June 1937 when the dam's foundation was spanned (Pitzer, 1994: 150; Downs, 1993: 95). In 1939, rising reservoir levels inundated the town of Keller, the first to be inundated. Lake Roosevelt reached its maximum height in June 1942 (Pitzer, 1994: 211–212). According to articles in the *Wenatchee Daily World*, a local newspaper, Reclamation nailed moving notices on hundreds of farm and community homes and gave people more than a year to move (Stoffel, 1940: 14; WDW, 1939b: 7).

3.6.3.2 Compensation for Land

Reclamation spent $10.5 million ($125 million in $1998)[90] making purchases in the reservoir area. They acquired land, buildings, improvements, and other facilities, such as telephone lines, telegraph lines, roads, bridges, and railroad track (USBR, 1976: I-57). Between $2 million and $2.5 million (roughly $24 and $30 million in $1998) of the $10.5 million, was used to purchase land.[91]

Five appraisers working for the Columbia Basin Commission assessed and assigned values to parcels and their improvements. Appraisers were to consider the physical value of the land, buildings, and business. They also included the value of the parcel as a means of earning a living and the suitability of the parcel as a residence (Luttrell & Bruce, 1994: 10.2). When appraisals were being made, the understanding was that the easements were reserved for the owners, thus enabling owners adjacent to Lake Roosevelt to use the reservoir without constraints. Severance damages for riparian easements were not included in the app–raisers' valuations and Reclamation did not compensate for losses of riparian easements (USBR, 1976: I-26; Lebret 1999).[92]

To acquire a parcel owned by a settler, Reclamation would make an offer on the property. Compensation was based on land values in the immediate vicinity. If the owners felt the government's offer was to low and rejected it, the government pursued condemnation to gain title to the land. If the owner was not satisfied with the compensation received, he could file suit against the government. By 1938, contracts of purchase had been signed or were in the process of being negotiated for all but less than 1% of the property owned by settlers (Luttrell & Bruce 1994, 10.1). In addition to purchasing farms and town lots, Reclamation had to acquire a variety of businesses in the reservoir area.[93]

When the federal government initially offered to buy the land of settlers residing in the location of the future dam and reservoir site, many landowners refused, arguing that proposed compensation amounts were too low. In response, the government exercised its “taking” rights and the courts had to eventually settle the issue of compensation. In one case, several local residents joined together to file suit against the government, alleging unfair taking of about 1 100 acres (450ha) of land. The government had appraised the property at approximately $15 000 ($178 000 in $1998), but the plaintiffs argued that their land was worth much more — $15 million ($178 million in $1998). The case was first heard in 1935 and in the end, the jury awarded the plaintiffs $17 000 ($202 000 in $1998), even though estimates of lawyers fees were $10 000 ($119 000 in $1998). Outraged, the settlers appealed — first to the Circuit Court of Appeals, and then to the Supreme Court — but the ruling held (Pitzer, 1994: 218). Negotiations for land upstream of the dam and reservoir site were not as contentious, but most farmers who lost their land also felt that were inadequately compensated (Pitzer, 1994: 218219).

3.6.3.3 Resettlement

During the 1930s, Reclamation lacked legislative authority to assist in the relocation of people displaced by Lake Roosevelt (USBR, 1976: App 296, App 298, App 301). It was not until about 30 years later that Reclamation gained authority to assist displaced persons (USBR, 1976: App 296). Reclamation cited its lack of legislative authority as the reason that it provided no resettlement assistance to the people and communities displaced by reservoir creation (USBR, 1976: App 296, App 298, App 301).

When Reclamation acquired the land needed for the reservoir, it purchased all improvements on the land, such as homes and other structures. Before filling, the reservoir area had to be cleared of all structures, trees, and brush which could cause damage or obstruct any part of the dam or navigation on the Columbia River. In order to avoid having to demolish or burn all the acquired structures in the reservoir area, the federal government auctioned off structures that were movable (Luttrell and Bruce, 1994: 10.2). Many homes and buildings were bought by their original owners, at a nominal cost of around $50 to $75 (Luttrell & Bruce, 1994: 10.2). Purchasers were responsible for moving the structures out of the reservoir area by May 1, 1939.[94] In the end, purchasers, not the government, moved over 5 000 structures (WDW, 1941: 17; Downs, 1993:94). Reclamation burned structures remaining in the reservoir area. Farmers and other reservoir oustees had to find either property they could afford or move in with relatives. Most relocated to nearby areas.

Although Reclamation did not assist in the resettlement of families and towns, it rebuilt or replaced 25 miles (40km) of railroad track, 180 miles (290km) of highway, 72 miles (116km) of primary roads, and 54 miles (87km) of secondary roads (Pitzer, 1994: 223; USBR, 1976: I-57). Replacement of 14 bridges and track alone cost Reclamation $2 million (Pitzer, 1994: 223; Columbian, 1938: 3). Also, some telephone lines, telegraph systems, power line facilities, and fences were moved to higher ground (Pitzer, 1994: 223; WDW, 1941: 17).

Communities did not receive government assistance in finding new home sites. Each of the inundated communities had its own relocation experience. Some towns, for example Daisy and Kettle Falls, were more successful than others in relocating; other towns, such as Peach, were never re-established.[95] The largest town inundated by Lake Roosevelt, Marcus had a population of 531 in 1939.[96] In February of that year, just months before the 1 May relocation deadline, the residents of Marcus and the residents of Lincoln had yet to find relocation sites for their towns (WDW, 1939d: 7).[97] Because Reclamation had no authority for resettlement, records concerning where settlers eventually relocated are not readily available.

3.6.4 Development within the Columbia Basin Project Area

The 1932 Reclamation Report did not have much to say about the influence of CBP on the development of the Columbia Plateau. To the extent that the report considered development effects, those considerations revolved largely around the market for power. For example, the report detailed all the main users of electric power in the region, and it made projections of the future growth in load. Reclamation planners were concerned about how long it would take before the regional demand for power would be large enough to absorb the power generated at GCD (USBR, 1932: 121–23).

Reclamation's principal efforts at social planning in the context of CBP involved its work in assembling the Columbia Basin Joint Investigations. In 1939, the Commissioner of Reclamation, John C. Page appointed Harlan Barrows, a professor of geography at the University of Chicago, and William Warne of Reclamation, to lead an inquiry concerning planning for the use of the 1.2 million acres (486 000ha) of land to be irrigated by CBP (McKinley, 1952: 139). This inquiry, the Columbia Basin Joint Investigations, yielded a vision of development that involved a large number of small (40 to 80 acres, 16ha to 32ha) family farms.[98] Although some project planners estimated there would be as many as 80 000 families on 10 000 farms in CBP, the actual results were far different. For example, in 1973, there were 2 290 farms operating in the project area (Pitzer, 1994: 364). Additionally, as the analysis in Section 3.1 indicates, the average farm size today is approximately 500 acres (202ha), and there are a small number of very large farms.

Notwithstanding the differences between what was planned and what actually occurred, there is no denying that the Columbia Plateau is an economically viable farming community that contributes significantly to the state's economy. This is consistent with the concept promoted by project advocates who saw the use of irrigation water to develop CBP land as a way to lure industry and stimulate economic growth in the Columbia Plateau. As detailed in Section 3.1, project supporters, including Major Butler (author of the 1932 Butler Report), imagined that the businesses that would grow up to support the farmers would play an important role in regional economic growth, and this phenomenon has indeed taken place. In this respect, the 1933 testimony of Major Butler before the US House of Representatives was prescient:

> *The farmer as a primary producer is not necessarily the main beneficiary of irrigation development. Local retailers of every kind, banks, public utilities (both power and railroads), labour, wholesalers, jobbers, manufacturers, and the general public are to a surprising degree dependent upon agricultural production, not only because of the food produced for direct consumption and the raw materials supplied to manufacturers, but because of the general business activity which is created.* (Butler, as quoted by Pitzer, 1994: 365)

One effect on the local economy that was not considered by Major Butler, but that was anticipated by the Columbia Basin Joint Investigations, is the important role that project-related tourism has come to play. Tourism, like farming, has created its own set of economic multipliers, which contribute significantly to the overall prosperity of the region.

3.6.5 Social Tension in the US Northwest: the Symbolic Value of Salmon

During the past few decades, a social tension has developed between CBP supporters in eastern Washington and critics of FCRPS in Seattle, Portland, and other urban centres west of the Cascade

Mountains. This social tension, which revolves around the symbolic (and ecological) significance of salmon, evolved gradually as these metropolitan areas grew in size and as the adverse effects of hydropower on salmon runs became more widely known. This social tension is complex; even critics of the FCRPS acknowledge the benefits of low electricity rates and plentiful, high-quality agricultural products tied to GCD and CBP. We elaborate on these tensions created by the loss of salmon by adopting a historical perspective.

Over the past century, changes have occurred in how people and institutions value salmon. In the 1800s and early 1900s, salmon were valued primarily for their commercial worth. There is an important exception to this: as explained in Sections 3.7 and 3.8, Native Americans and Canadian First Nations valued salmon in non-commercial terms. Chinook runs were seen as more significant more than sockeye and steelhead runs because of their greater commercial importance. During this early period, the emphasis was on "pounds" of salmon — the size of the catch. Hatchery efforts were initiated in order to increase the size of catch (as measured in pounds), or to prevent the decline of catch (as measured in pounds).

By the 1930s, when large dam construction began changing the main-stem of the Columbia River, people began measuring salmon runs in terms of numbers of salmon, as well as pounds of fish. The presence of the dams provided an easy way to measure the size of the fish runs by counting the fish as they passed through the fish ladders. With the US' second major environmental movement, which began in the 1960s[99], another shift occurred: instead of solely valuing salmon as a commercial product, people also began to value salmon for their genetic biodiversity and intrinsic value as distinct species. This shift was brought about by a combination of a growing environmental awareness among the US public and advancing scientific knowledge.

Pacific salmon still possess commercial value, but they are not valued by that standard alone. They also possess indirect value, what economists term, "existence value" (ie, the value people place on salmon by simply knowing they exist in the Columbia River). For many residents of the region, salmon have become a symbol of the US Northwest that must be protected and preserved.

Some indication of the symbolic significance of salmon is provided by media coverage. Our search of the *Seattle Times* on-line archive of newspapers generated 2 325 articles related to salmon during the 44 month period from 1 February 1 1996 to 1 October 1999—an average of about 1.8 articles per day. Headlines read: "Salmon plight: Can we still turn the corner?" (21 October 1999), "Budget talks endanger salmon programme" (19 October 1999), and "How much are Snake River salmon worth?" (17 October 1999). This last article discusses the existence value of salmon to the people of the Pacific Northwest. The article asserts that economists' concept of existence value is hard to quantify, but that "it is both large and meaningful" in the case of the salmon (Verhovek, 1999). Other newspaper accounts come from the *Oregonian*, the US Northwest's largest newspaper. The *Oregonian* reported that salmon protection is the number one environmental concern in the state; and that 86% of Oregonians want to preserve salmon runs in the Columbia and Snake Rivers (Lansing, 1999).

3.7 Effects on Native Americans in the US[100]

Native Americans and Canadian First Nations tribes felt the most significant social impacts of GCD and CBP. In many respects, these two social groups shared similar experiences. This section focuses on impacts to Native American tribes; the following section discusses GCD's impacts on Canadian First Nations.

The Columbia Plateau tribes in the US most significantly affected by the project are shown in Figure 3.7.1. Direct and indirect effects of the project were felt primarily by the Colville and Spokane tribes, whose reservations overlapped with the project area. Other tribes that were significantly affected were the Coeur d'Alene, Kootenai, Kalispel, Nez Perce, Umatilla, Warm Springs, and Yakama. With the loss of all or most of the anadromous fish, these tribes lost the centrepiece of their economy and culture.

GCD, Lake Roosevelt, and CBP also damaged livelihoods by destroying or limiting access to gathering and hunting grounds both on and off the reservations. Inundation of the river valleys above the dam took much of the best reservation farm land and forced half or more of the Colville tribe's population and a number of Spokanes to move from their homes with what they viewed as minimal compensation.

3.7.1 Pre-Project Conditions

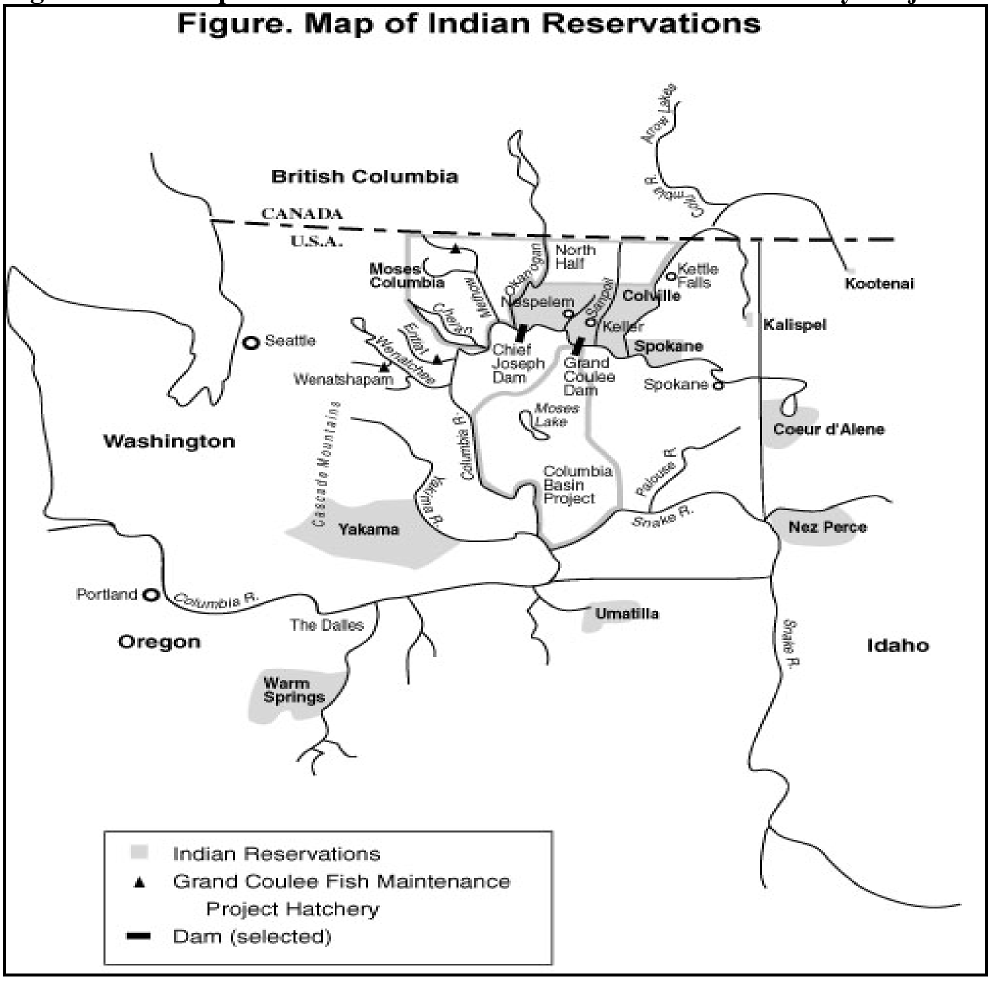
Through the middle of the 19th century, the Native American peoples most significantly affected by GCD lived along the Columbia River and its major tributaries between the Rocky and Cascade Mountains, in what are known today as British Columbia and the states of Washington, Oregon, Idaho, and Montana. Anthropologists today identify the tribes of this inter-mountain region as belonging to the "Plateau" cultural group.

Archaeological evidence shows that, for at least 10 000 years, humans had occupied the river valleys, fishing, gathering roots, hunting, and trading with coastal tribes (Walker, 1998: 73, 103; Chance, 1986). Thousands of people from many tribes came together annually at the major root grounds and the principal fisheries. Despite the arid climate of much of the region, nature was bountiful and resources were shared generously and distributed equitably. People developed a rich spiritual life; they believed that animals, plants, and inanimate objects had spirits and powers that could protect and nourish the respectful human (Ray, 1954: 26; Hunn, 1990: 230–40).

As detailed in the Annex titled “Native Americans” the political world of the Plateau cultural groups changed radically between 1850 and 1940, but the economic and cultural life of its native people changed only moderately. Most tribal people lived on reservations by the 1930s. A few families had adopted a largely farming or cash economy, but others still lived almost entirely in the traditional way.[101] For most families, traditional foods and materials continued to provide their basic diet and a significant portion of their material possessions. People continued to rely on access to open land beyond their family's allotment and tribe's reservation to supply their daily needs. Salmon runs had declined markedly, but the frequent reports from the late 19th and early 20th centuries of few fish reaching Indian fishing grounds must be understood from the perspective of people who remembered literally millions of fish in former times. Fishing by individuals and family groups continued in all the rivers and streams that still supported runs. Every year until the construction of GCD, Indians from all the reservations of the region gathered at Kettle Falls, the town of Keller on the Sanpoil River, the mouth of the Okanogan, and other principal fisheries of the upper Columbia.

White residents of Spokane and other cities gathered also as tourists to watch the colourful display of Indians fishing, racing, playing games, and the carrying out of the salmon ceremony (Scholz et al, 1985: 36). Anthropologist Verne Ray later reported that when he first began doing field work on the Colville Reservation in 1928, every household he visited offered him salmon as part of the meal. Boys still learned to hunt from their fathers and grandfathers. Children of the 1930s learned to gather and prepare foods and medicinal plants, travelling and camping with their families for weeks at a time into the mountains or onto the Columbia Plateau, following a pattern that has existed for thousands of years (Ray, 1972; Ackerman, 1988).

Figure 3.7.1 Map of US Native American Reservations Affected by Project



Sources: USDOI, 1916; Kappler, 1904.

Traditional culture remained constant in other ways as well. Several generations often lived together in one household. The reservations had been divided up in the early 20th century into individual allotments, but extended families continued to cluster their dwellings in the pattern of traditional villages, rather that adopting the Anglo-American custom of each nuclear family living on its own piece of land. People chose their allotments and built their houses in the sheltered river valleys and along creek beds, where water, wood, and food supplies were close at hand. Tribal people also continued to follow Plateau gender patterns by considering the house and household goods to belong to the wife rather than the husband, despite the patriarchal assumptions made by Indian agents and other whites.[102] The emphasis on sharing resources with everyone in the community remained strong. Those who could fish, hunt, and gather brought food to the elders and the sick, and those who earned cash helped purchase items for other family members. Some people had adopted Christianity, but even they, along with those who continued to follow native religions, often held to beliefs in spirits, and everyone joined in the first food ceremonies (Seyler 1999b; Flett 1999; Sampson 1999).

3.7.2 Centrality of Salmon to Economic, Cultural, and Spiritual Life

The bountiful salmon and steelhead runs of the Columbia River provided the Plateau people with their chief means of subsistence, and they occupied a central place in their cultural and spiritual life. Each tribe had a narrative of how, in an earlier time, Coyote brought salmon to the people. Tribes eagerly awaited the first arrival of fish in the spring, and marked the first catch of the season with five days of ceremony and elaborate ritual behaviour. In practising the first salmon ceremony, the people assured the yearly return of the fish — both by following the laws laid down by the Creator, and by allowing sufficient fish to escape to spawn the next generation. Nineteenth-century white visitors to the Plateau described with awe the tens of thousands of pounds of fish harvested and prepared by the Indians at their principal fisheries (Lewis & Clark, 1953: 353, 358; Wilkes, 1845: 431, 438; Parker, 1967: 298).

Salmon and other fish were caught in all the rivers and streams of the region. Each tribe had its own fishing locations, and also shared in the harvest at the large intertribal fisheries, following the anadromous fish in their course upriver. The Dalles and Celilo falls on the middle Columbia River, and Kettle Falls on the upper Columbia River were the most important sites, but 19th-century observers also reported 1 000 or more Indians gathered to fish at the Wenashapam (near present-day Leavenworth) on the Wenatchee River, the mouth of the Okanogan River, and Spokane Falls and Little Falls on the Spokane River (Scheuerman, 1982: 25, 79; Scholz et al, 1985: 66).

The tribe that controlled a particular fishery appointed a salmon chief to oversee the harvest, distribution, and proper observance of ritual. Each man got his turn at the fishing stations, and each woman received a share of the catch to dry for winter use. Mourning Dove, born in 1888 and the granddaughter of a Colville chief, wrote: "Everyone got an equal share so that the fish would not think humans were being stingy or selfish and so refuse to return." (Miller, 1990: 101) In most years there was a surplus that could be traded for materials and crafts not found in their own territory, such as shells and baskets from the coast. Games, horse racing, gambling, and trade took place at the camps surrounding the fisheries.

Salmon nourished the Indian people physically, providing one-quarter to one-half of caloric needs for most of the Plateau tribes.[103] The annual salmon ceremony and the salmon stories told throughout the year were central to spiritual life; they reflected the reverence native peoples held for all life forms. The distribution of fish to all members of the community and to all visitors reinforced core cultural values of egalitarianism and generosity. The intertribal gatherings that accompanied the salmon harvest promoted reciprocal and peaceful relationships across the Plateau.

Gathered plants and game animals also had cultural and spiritual value. First root and first huckleberry ceremonies were held annually, although these were not as elaborate as the salmon festivals (Ruby & Brown, 1970: 21; Hunn: 128). The Plateau people relied on large and ecologically diverse territories to provide their subsistence and shelter. Each tribe had access to rivers, arid plateaus, and forested mountain slopes, either within their own territory or that of a friendly neighbour. Areas along the riverbanks were particularly important because they supported a rich diversity of plant and animal life. Juniper berries, choke cherries, seeds, reeds, medicinal, and other plants could be gathered; waterfowl, deer, and small game could be hunted; and shellfish, suckers, and other fish foods could be acquired (Spier, 1938; Walker, 1998).

3.7.3 Pre-Construction Consultation with Tribes

The Colville and Spokane tribes were informed that GCD would be constructed, and at least one meeting was held on the Colville reservation (US House, 1994: 11; Sam 1999; Seyler 1999a). The reservation superintendent, or Indian agent, was the major conduit of information from the government to the tribes, and from the tribes to Washington, DC. Surveyors were at work on the Spokane and Colville reservations through the mid-1930s, marking the eventual height of the reservoir. Members of the Colville and Spokane tribes whose individual allotments were to be flooded by the reservoir were notified in 1939 and 1940, in some cases both in person and in writing (see Section 3.7.4.2 below).

However, according to practices of the time concerning "executive order reservations," the US pursued no formal process of involving the tribes in decision-making or gaining the tribes' consent for the taking and inundation of lands or the destruction of the tribes' fisheries.[104]

The dam was constructed during an era when the US government maintained a highly paternalistic attitude toward tribes. Although the Indian Reorganisation Act (IRA) of 1934 slowed the stripping away of tribal resources and sovereignty that had characterised the previous century, administrators in the Indian Office continued to make decisions with little consultation with individual Indians or tribes. Many of the elder generation at that time spoke no English, and few could read (Herman 1999; Sam 1999). Moreover the pressure the IRA placed on tribes to abandon their traditional leadership and adopt representative forms of government hampered the ability of tribes of the US Northwest to respond to the crisis the dam presented.

The 1930s was also a period when attitudes toward preserving salmon were decidedly mixed. The Washington State and US departments of fisheries were strong advocates for preservation, but officials in those and other government agencies viewed Indian fishing as a threat to salmon survival (Washington Dept. of Fisheries, 1939; White, 1995: 100; Cone & Ridlington, 1996: 206–207). Reclamation placed priority on irrigation and economic development, and had already built other projects in the region that seriously harmed fish runs, including a project on Salmon Creek in the Okanogan watershed (USFWS, 1948). The US Indian Office charged with protecting the interests of the tribes, advocated for preservation of tribal fisheries, but it also favoured tribal members abandoning traditional life styles, and shared the general Anglo-American attitude supporting development (Upchurch, 1924a; Upchurch, 1924b). Thus the tribes did not have the power to defend their rights and interests in the Columbia River fisheries, nor did they have a forceful ally.

The tribes urged the federal government to act to protect their fisheries before construction of GCD, and the administration was well aware of the tribes' dependence on fish. In 1924, the Colville tribe protested a proposed dam at Priest Rapids (Upchurch, 1924). GCD was first undertaken as a project of the state of Washington. After a preliminary permit was issued to the state in 1932, the tribe protested vigorously, especially fearing the loss of their major fisheries on the Sanpoil River and at Kettle Falls. Under terms of the 1920 Federal Power Act and the original permit, the state would have been required both to construct fish ladders and to make annual payments to the Colville and Spokane tribes for the land flooded by the dam reservoir. Agents of the United States assured the tribe that their rights in both lands and fisheries would be considered. Early correspondence between the Commissioners of Indian Affairs and Reclamation, endorsed by Secretary of Interior Harold Ickes, expressed the understanding that if the federal government took the project over, the US would pay the tribes a share of power revenues generated from tribal lands. However, after the project was federalised in 1935, high government officials concluded (erroneously, according to 1978 findings of the Indian Claims Commission (ICC)) that the Colvilles, Spokanes, and other upper river executive order tribes had no greater rights to fish than any other citizens. For several decades thereafter, fish mitigation efforts were oriented exclusively for others' benefit.[105]

3.7.4 Project Impacts on Native Americans

Construction of GCD devastated the way of life of upper Columbia River tribes. The loss of anadromous fish, destruction of wildlife habitat, loss of access to gathering grounds, and loss of prime agricultural lands and homes eliminated the economic base of many members of the Colville and Spokane reservations. Those who lost land received a small cash compensation, but the government made no serious effort to mitigate resource losses or assure that relocated towns had basic utilities until over 40 years later. Cultural practices and community life were also affected in both the long and short runs. The immediate economic and cultural damage to other upper Columbia River tribes and the four middle Columbia River (Indian) treaty tribes was less profound, but also severe.

3.7.5 Anadromous Fish

The dam blocked all anadromous fish runs to the Spokane, Coeur d'Alene, Kalispel, and Kootenai reservations, and to their traditional off-reservation fishing locations. The Colvilles lost a significant portion of their runs, including communal fisheries at Kettle Falls and on the Sanpoil River. Those living on the eastern half of the reservation now had to travel long distances over rough roads to reach the depleted fisheries of the Okanogan River, if they continued fishing at all.[106] The immediate effect on the livelihood and health of the people was severe, and the loss of cultural practices was painful. Fishing was a spiritual as well as economic activity. Members of the Spokane reserve and other upper Columbia River tribes could no longer hold the first salmon ceremony, and the Colvilles had difficulty obtaining enough fish (WDW, 1945; Sam 1999). The position of salmon chief disappeared, along with parts of the language and crafts associated with fishing. Fishing had been a communal activity that bound families and tribes together, with elders transmitting the values and history of the tribe to children while teaching them to catch and preserve fish. In June 1941, Indians from throughout the Northwest gathered at Kettle Falls for a three-day Ceremony of Tears, mourning the loss of that great fishing ground. Within the month, the rising reservoir had completely covered the ancient falls (CCT, 1977: 50; Pitzer, 1994: 227). The upper Columbia River tribes stopped gathering annually at Kettle Falls and Keller once the fish stopped running. Powwows have replaced the inter-tribal fishing festivals to some extent, but nothing could replace salmon in the lives of the people. Some have attributed cases of alcoholism and support for tribal termination in the 1950s and '60s to the cultural despair resulting from loss of salmon (Harden, 1996: 100, 113; CCT, 1975: 307).

While the dam itself totally eliminated runs above it, GCFMP further damaged the Colvilles' fishery below the dam. The capture and transplantation of most adult fish into the Wenatchee, Entiat, and Methow rivers destroyed much of the remaining wild run that spawned in the main-stem Columbia River and in the reservation streams between the Okanogan River and GCD.[107] Some Okanogan River fish did escape capture at Rock Island Dam, however, and so a natural run survived the genetic weakening that resulted from the mingling of upper Columbia River fish at the three federal hatcheries (Peone et al. 1999; Washington Dept. of Wildlife et al., 1990; Fish & Hanavan, 1948).

By largely eliminating anadromous fish above the Okanogan River, GCD and GCFMP set the stage for the subsequent decision not to provide for fish passage at Chief Joseph Dam, constructed a short distance above the mouth of the Okanogan by the Corps and completed in 1955. An additional 50 miles (80km) of the Columbia River along the Colville Reservation boundary was thus lost to future efforts to restore anadromous fish habitat (ICC, 1978: 592; Peone et al. 1999; NPPC (Appendix E), undated). Chief Joseph Dam has become the major fishing station for members of the Colville Tribe since its completion, although the fishery was damaged by the backwaters of Wells Dam (constructed in 1967 by the Douglas County PUD). As late as 1977, Colville Indians caught an estimated 2 000 chinook here, but in the 1980s, the tribal catch at the base of the Chief Joseph Dam averaged under 300 fish annually (WDW et al., 1990: 39; Mullan, 1987: 57, 65).

The tribes of the four middle Columbia River Indian treaty reservations — the Yakama, Nez Perce, Umatilla, and Warm Springs — experienced a decline rather than a complete loss of salmon. The GCFMP did mitigate, to some extent, the losses. The government has also granted the four tribes rights to fish on the Wenatchee, Entiat, and Methow rivers where GCFMP hatcheries are located, in lieu of usual and accustomed fishing sites lost with other hydroelectric development in the basin. However, the serious fish survival problems the hatcheries had in their early days, the loss of the fish that spawned in the furthest upper reaches of the Columbia River, and the genetic weakening through mixing stock all made it much more difficult for tribal members to survive economically by fishing, even before the Dalles Dam flooded the last great tribal fishery at Celilo Falls in 1956. Moreover, much of the joint fish mitigation for Bonneville Dam and GCD was designed to benefit the commercial fisherman at the mouth of the Columbia River, not the tribes. Of the 25 hatcheries funded through the Mitchell Act of 1938, 23 were below Bonneville Dam, where they did not benefit the tribes. Consequently, the four middle Columbia River Indian treaty tribes all suffered in their ability to continue providing for themselves, and to practise religious ceremonies dependent on salmon (Sampson 1999; FWEC, 1999; Cone & Ridlington, 1996: 105).

Fish losses and government mitigation efforts associated with GCD have greatly exacerbated tensions between members of treaty and executive order reservations. From the perspective of the treaty reserve tribes, their lieu fishing rights on the rivers included in GCFMP are not sufficient to make up for what they have lost from other development; and while tribes once shared each others' fisheries, such reciprocity is no longer possible (Sampson 1999). However, for the Colville tribe, the governments' refusal during much of the 20th century to recognise Methow, Chelan, Entiat, and Colville-Wenatchi claims to fish their ancestral rivers, while transplanting upper river fish into those same streams and granting treaty reservation members lieu fishing rights there, has compounded their suffering (Gooding, 1994).

3.7.6 Inundated Homes and Communities

In the 1930s, most of the people of the Colville and Spokane reservations lived, as in the past, along the rivers. The upland areas of both reservations are mountainous, rocky, and arid. The river valleys were milder during the winters: land was flatter, the soil was richer for gardening; wood and a variety of foods and medicines could be gathered easily from the rich riparian habitat. The riverfront land inundated on the Colville and Spokane reservations by Lake Roosevelt displaced many families and communities, destroyed valuable wildlife habitat, and made it significantly harder for people to earn their livelihoods.

On the Colville reserve, inundation most significantly affected members of the Colville-Scheulpi, Lakes, Sanpoil, and Nespelem tribes who were clustered on the east side of the reservation. On the Spokane reserve, mostly west-end homes were affected. Early in 1939, the Office of Indian Affairs and Reclamation signed an agreement for acquiring lands below the 1 310ft (400m) line. Surveyors identified 54 Indian allotments with a total of 4 607 acres (1 700ha) in the Keller district of the Colville reservation, below and along the Sanpoil River, which would be flooded during the first year the reservoir began filling. Government agents, with the assistance of local residents and interpreters, assessed the value of land and improvements for each property, and sought the written consent of each owner for sale of the land. According to the aforementioned agreement, once deeds to all the properties had been acquired, the government would transfer payment into trust accounts that were controlled by the Indian agent for the benefit of the individual owner. Surveyors identified an additional 227 tracts that would eventually be flooded, including 149 lots with 7 814 acres (3160ha) on the Colville South Half, 32 lots with 889 acres (360ha) on the North Half, and 46 lots with 1 723 acres (697ha) on the Spokane reserve. In addition to those allotments, the Colville towns of Inchelium, Klaxta, and Keller would be inundated (USBIA, undated). The Colville Tribe later estimated that the reservoir displaced 2 000 of its members (CCT, 1975: 363). Between 100 and 250 Spokanes were also displaced.[108]

By the summer of 1940, water covered all 54 of the first tracts, but the federal government had acquired deeds to only 43 of them and none of the owners had been paid. Meanwhile the government was clearing the other 227 allotments, including burning some houses (Louie 1999; Brisboys et al. 1999). The Colville agent reported that the Indians were growing resentful. They needed money to build new homes and improve their remaining property, and they knew that white owners across the river had already been paid (Balsalm, 1940a; Balsalm, 1940b). On 29 June 1940, Congress enacted legislation entitling the US to all Indian lands needed for the Grand Coulee reservoir, and providing that at least one-quarter of the reservoir be set aside for the paramount use of the Indians of the Colville and Spokane reserves for fishing, hunting, and boating purposes (54 Stat. 703). The Department of Interior then abandoned the policy of acquiring Indian consent. Thereafter, the government simply notified landowners by mail of the lands to be taken and the price they would be paid. Although the new policy still gave people the right to appeal their assessment, they had no encouragement or support to do so, and many people later claimed that their property had not been fairly appraised. Some people lost personal possessions when the waters rose more quickly or higher than they had anticipated (CCT, 1975: 363-365; Fredin 1999). By early 1941, all the Indian owners had been paid, except for Albert Louie of the Colville reserve who refused to accept his $483 (Gross, 1941). Those furthest down river, in the first 54 tracts, on average lost

85 acres (34ha) and received payment of $930. Those allotted land on the Colville North Half, furthest upriver, on average lost about 28 acres (11ha), and received payment of $570. Spokane allottees lost on average 38 acres (15ha) and received $655 (USBIA, undated).

Because of erosion of the reservoir's banks, and the need to acquire right-of-way for relocated roads and utilities, the federal government later purchased an additional 1 534 individually owned acres (620ha) on the Colville reserve for $76 006, and 132 acres (53ha) on the Spokane for $7 065. Floodwaters also covered some tribally owned lands. The Colville Tribe received $67 530 payment for 3 359 acres (1 360ha), and $750 for gravel used in dam construction. The Spokane Tribe received $17 265 for 1 045 acres (423ha). Indian-owned land flooded on both reserves totaled 34 413 acres (13 930ha) (CCT, 1975: 296).

The tribal towns of Keller and Inchelium were relocated and still exist today, but other smaller settlements were lost with the inundation. Inchelium residents split, with some locating high above the Columbia River where the town is today, others remaining closer to the Columbia in an area called Skunk Flats, and some leaving the area altogether (Arnold et al. 1999). The towns lost a number of services with the move, and Congress did not provide Reclamation with the authority to finance new water, electrical, or telephone services (USBR, 1976: 296). Inchelium had no source of water at its new site, and it was 30 years before its residents regained phone service. The government auctioned off buildings on land it purchased, including the Inchelium school. A member of the school board, Joe Kohler, later testified that he took out a personal loan to buy the buildings, but they were not able to move them to higher ground until after the floodwaters rose, then receded again. Keller had no municipal water until 1973 when Congress authorised drilling a well, and the town got phone service that same year (CCT, 1975: 298-90, 368; Arnold et al. 1999).

A number of tribal members we interviewed stated that government officials told them they would receive free electrical service from the dam. However, most parts of the Colville and Spokane reserves only acquired electricity later, and usually at a much higher price than typical off-reservation residents paid.[109] Tribal members were well aware of the contrast between their relocated towns and the modern, well-serviced towns the government built for dam workers (CCT, 1975: 371, 375; Herman 1999; Fredin 1999; Flett 1999).

3.7.7 Burial and Archaeological Sites

For centuries, Indian peoples of the Plateau had buried their dead near their homes and villages, on the banks of the rivers that provided the necessities of life. Reclamation planners gave low priority to relocating tribal graves. In April 1939, Reclamation contracted for the reopening, removal, and reburial of graves at 27 sites along the Columbia and Spokane rivers. Many of the sites were small family plots with fewer than 15 graves, but several were larger including the San Poil Mission Cemetery with 106 identified graves, the Whitestone Tribal Cemetery with 58, and the Hall Creek Cemetery with 194. The funeral home of Ball and Dodd managed the work and hired a number of young tribal men to assist (Arnold et al. 1999; Brisboys 1999; USBR, 1939).

As reservoir waters rose, relocation work became rushed. Some gravesites were identified too late to be removed (Pitzer, 1994: 220). In the decades since, as reservoir levels have fluctuated and the banks have eroded and slumped, many additional burial sites have been exposed. Both the tribes and Reclamation have attempted to prevent artifact hunters from desecrating the remains, with limited success. Reclamation now provides the Colville and Spokane tribes with some funds to patrol the area during low water periods, and to relocate burial sites as they are exposed. However, from a tribal perspective, neither the NPS nor Reclamation has been willing to accept full responsibility. For many tribal members the flooding and disruption of their ancestors' remains continue to be distressing (Seyler 1999b; Fredin 1999; Sam 1999).

As the primary habitation of tribal peoples for over 10 000 years, the river valleys and banks contain numerous culturally and archaeologically significant sites that have been lost or seriously damaged by inundation. In the 1930s, preservation of these sites was not a high priority for the federal government. The fluctuation of reservoir depth has provided some opportunities for documentation in more recent decades. NPS contracted for archaeological assessment of the reservoir area in the early 1960s. Both NPS and Reclamation have supported some continued work since, particularly at Kettle Falls (Chance, 1986; Larrabee and Kardas, 1966). The agricultural development of the Columbia Plateau has also destroyed culturally significant sites there (GCD Bicentennial Assoc., 1976; Marchand, 2000).

3.7.8 Riparian Habitat

Creation of Lake Roosevelt destroyed much wildlife habitat, particularly low elevation winter range. The Colville and Spokane tribes have hunting rights on a considerable portion of the approximately 80 000 acres (32 300ha) flooded in the US. The Spokanes lost habitat in the 10 miles (16km) of Columbia River bank on their west side and 31.5 miles (51km) on both sides of the Spokane River. The Colville tribes have recognised hunting and fishing rights along the west bank of the Columbia River, extending to the Canadian border. In the 1930s, tribal people continued to rely on deer and elk for meat, as well as some clothing and ornamentation, and hunted smaller game and waterfowl near the rivers. With salmon gone, the other resources became more critical, but the lost habitat resulted in a decline in game as well.

Attention to game habitat is a late development. The 1980 Northwest Power Act, which mandated the protection, mitigation, and enhancement of habitat losses from hydropower development and provided for the active involvement of tribes, initially did not address wildlife losses. In 1989, consideration of wildlife was amended into the Act. The Colville and Spokane tribes and the State of Washington now have a joint wildlife plan. Under that plan, the Colville tribe has been able to acquire 20 000 mitigation acres (8 100ha) on the reservation since 1993.[110] BPA funds the purchase of land from ratepayer dollars. However, the replacement lands are not of the same quality as the riparian lands lost. The tribe estimates it needs three times as many upland acres as the riparian habitat lost, and the land needs to be enhanced, particularly by planting native plant species, before it begins to mitigate the losses. Even then, full mitigation is not likely. No wildlife surveys were conducted prior to construction of the dam (Peone et al. 1999).

3.7.9 Loss of Access to Columbia Plateau

Prior to construction of GCD, tribal members of the Colville, Spokane, Yakama, and Umatilla reservations were still able to gather food and medicinal plants on the thinly populated Columbia Plateau. The irrigated agriculture of CBP and the additional development spurred by GCD's hydropower destroyed much native plant life on the Plateau. Private land owners put up fences and no trespassing signs, discouraging Indians from gathering the plants that remained (Flett 1999; Sam 1999). The creation of Lake Roosevelt also made crossing the Columbia River far more difficult. Before the dam, small ferries operated all along the river. The river could be easily crossed in a canoe in most seasons, and the river sometimes froze. Crossing the reservoir requires larger, sturdier, and more expensive boats and far more energy. In this regard, the lake created a hardship for members of the Colville and Spokane tribes during the first decade or two after construction of the dam by cutting off their access to food supplies, jobs, and each other's reservations (Arnold 1999; Fredin 1999).[111] Economic development on the eastern third of the Colville reserve and on the Spokane reserve have also been constrained by the limitations on transportation (Marchand, 2000).

Tribal members are still able to gather on public lands off their reserves. Since the 1970s, the Bureau of Land Management, National Forest Service, and other federal managers of public lands have gained increased awareness of Native American rights and respect for cultural values, and they have often been willing to facilitate gathering (Flett 1999; Fisher, 1997).

3.7.10 Tribal Health

The traditional diet and active lifestyle of Plateau tribes promoted long and healthy life. A number of tribal elders in the first third of the 20th century lived over 100 years, according to both written reports and the memories of today's elders. Native medicines treated everything from headache and diarrhea to cancer. As mentioned, salmon played a central role in the diet of tribal members. Construction of GCD forced a drastic change in diet. As a result of moving to foods high in fat, sugar, and salt, rates of heart disease, diabetes, and other diet related illnesses have increased significantly on the reservations (Flett 1999; Arnold 1999; Louie 1999; FWEC et al., 1999).

3.7.11 Timber and Mines

The government cleared brush and timber from the banks of what eventually became Lake Roosevelt before the waters rose. Spokane elders report the wood from reservation land floated downriver and was taken by a white mill owner, without compensation to the Spokane people (Brisboys 1999; Pitzer, 1994: 216).

Placer gold mining was common during the late 19th century on beaches all along the Columbia River; this mining was particularly common among Chinese immigrants (Hackenmiller, 1995: 91). Spokane elders recall non-Indians mining gold on Spokane reservation land during the 1930s, under permit from the Bureau of Land Management. The reservoir covered mines on both the Spokane and Colville reserves, which might have become resources for the tribes in later times (Brisboys 1999; Marchand, 2000).

3.7.12 Modern Tribal Economies

All of the reservations of the Pacific Northwest have high rates of unemployment and poverty (Beaty et al., 1999). The construction of Grand Coulee Dam, and the ways in which the reservoir have been managed have contributed to the poverty of tribal people. The people of the Colville and Spokane reservations and the other northern tribes suffered a sudden and drastic change in their economies with construction of the dam. In the decades since, the reservoir has continued to be a major obstacle to transportation for the Colville and Spokane reservations. Limited bridge and ferry access has both restricted commercial and resource development on the reservations and posed a barrier to tribal members seeking jobs off the reservation. Tribal leaders maintain that the ways in which NPS has managed the recreation district have also limited the kind and extent of facilities the tribes could develop, while the annual fluctuation in the reservoir level prevents recreational use and tourist activity for much of the year (Marchand, 2000; Seyler 1999b).

3.7.13 Claims Cases

In 1951, the Colville Confederated Tribes filed suit against the US on several grounds, including claims arising from construction and operation of GCD. The ICC separated GCD claims into two cases. [112] One case, Docket 181-C, dealt with two main issues: (i) fishery losses resulting from general development and US inaction prior to 1939; and (ii) the elimination of fish runs above the mouth of the Okanogan River because of construction of dams and other actions since the 1930s. The Colville Confederated Tribes in this case acted as representative of the Colville (Scheulpi), Lake, Sanpoil, Nespelem, Okanogan, and Methow tribes. The Commission did not issue an opinion until 1978. At that time the Commission held that implicit in the creation of the Colville Indian Reservation, defendant [the United States] undertook an obligation to claimants [the tribes] to assure them the right to take fish in the waters on and adjacent to the reservation for their subsistence . . . [and] was required to protect claimants' fishing right against all infringement (ICC (Docket 181-C), 1978a and 1978b).

The ICC ruled that the tribes were entitled to be paid the difference between the fish they were able to catch between 1872 and 1939, and the value of what their normal subsistence catch would have been.

Nevertheless, it awarded no damages for that period. The Commission did award the tribes $3 257 083 for the subsistence value of fish lost to the six claimant tribes since 1940 (about $13 million in $1998).[113] Commissioner Blue, dissenting in part, termed such a small compensation to the Colvilles “winning the case but still losing it” (43 ICC 505).

In a second case, Docket 181-D, the Colville made claims for compensation for water-power values of the lands taken in construction and operation of GCD and Lake Roosevelt. After rulings in federal courts in 1990 and 1992 (20 Ct.Cl. 31; 964 F. 2nd 1102), the United States and the tribe reached a negotiated settlement. Congress approved the settlement in 1994, in effect recognising the unfulfilled promise of 1933 to pay the tribe an annual share of power revenues (108 Stat 4577). For the first time, the US provided significant compensation to the tribe for part of the damages suffered from the dam. The tribe received a $53 million lump sum settlement ($58 million in $1998) for previous years, from funds appropriated by Congress, and not reimbursable by BPA. That money was distributed per capita: each tribal member received $5 937. The act also provided that thereafter, BPA would make annual payments to the tribe of approximately $15 million. In a hearing shortly before passage of the bill, Colville tribal chairman Eddie Palmanteer testified:

> *Is it a full compensation for our loss? The answer has to be no. You have to understand that we have looked at Grand Coulee Dam for a long time. We realise that for the Pacific Northwest the Grand Coulee Dam has made development and prosperity possible. But for us, it has been a disaster. How much is reasonable compensation for the loss of our fishery, our way of life, our towns where our elders lived? How much must be paid for the destruction of our mother's and father's graves. For some of our members no amount of money can fairly compensate the Tribes for this loss* (US House, 1994).

The Spokanes were not covered by the negotiated settlement, although the tribe suffered in similar ways and participated in lobbying Congress for passage of the Colville's act. The Spokanes, with a tribal government only two months old at the time of ICC’s deadline, and with neither attorneys nor proper advice from the Bureau of Indian Affairs, had not filed a claim in 1951, and so did not have the threat of a law suit to spur the US federal government to take action. In 1999, Representative Nethercutt and Senator Murray filed bills in Congress to provide compensation and annual payments to the Spokane tribe, equivalent to 39.4% of that paid to the Colvilles (Spokane Tribe, 1995; US House, 1999).

The *United States v. Oregon* decision (302 F. Supp. 899) in 1969 marked a major turning point for Columbia River Indian treaty tribes. The ruling was an outgrowth of the long struggle by Northwest tribes to assert and protect their rights. In the late 19th and 20th centuries, the right of treaty tribes to fish at usual and accustomed places off the reservations in common with other citizens came under repeated assault. Private property owners sought to block tribal members' access to the rivers, commercial fishers blamed the tribes for declining runs, and the states of Oregon and Washington attempted to regulate tribal fishing in the name of conservation. The federal government generally supported the tribes in these disputes, but usually not aggressively, and did little to prevent the continued decimation of anadromous fish runs. The courts consistently upheld the rights of tribal members to fish on private land without state licenses and with minimal state regulation (Parman, 1984). Finally the cases of *United States vs. Oregon* in 1969 and *United States vs. Washington* in 1974 (384 F. Supp. 312) settled outstanding issues. Under these rulings, the states' conservation measures and other regulations must be managed in such a way that an equitable share of fish reach the upstream tribal fisheries, and treaty tribes are entitled to 50% of the harvestable fish destined for traditional fishing places. The rulings also assured the four middle Columbia River Indian treaty tribes an ongoing role in the management of Columbia River fisheries.

The Court in *United States v. Oregon* has retained jurisdiction and has required the states of Oregon, Washington, and Idaho to agree to harvest plans with the Nez Perce, Umatilla, Warm Springs, and Yakama tribes.[114] The Columbia River Inter-Tribal Fish Commission (CRITFC) represents the four treaty tribes in this process. Subsequent court decisions have affirmed the rights of treaty tribes to regulate tribal fishing on and off their reservations, and the obligations of the federal government to regulate ocean fishing and protect habitat that affect treaty catches (CRITFC, 1999). In 1988, after five years of negotiation, the states, tribes, and federal entities agreed to a ten-year Columbia River Fish Management Plan, setting harvest levels and a fish production process. As a result, hydroelectric fish mitigation efforts have been much more equitably distributed between commercial and treaty tribe fisheries. However, when that plan expired in 1998, the states and tribes were unable to come to a new agreement. Harvest levels have been set season by season, and must be approved by the judge who continues to rule on issues arising under *United States v. Oregon* (Underwood 1999; Peone et al. 1999).

In 1989, the Colville Confederated Tribes intervened in *United States v. Oregon* as representative of the Wenatchi and Pisquouse signatories of the Yakama Treaty. Although courts had ruled in earlier cases that Colville was a legitimate representative of the Wenatchi, Entiat, Chelan, and Columbia tribes for the purposes of land compensation, Judge Marsh denied the Colvilles a voice in the Columbia River Fish Management Plan. Many Colvilles viewed that decision as a bitter defeat (Gooding, 1994).

In 1999, the Colville Confederated Tribes intervened again, based on their recognised role in managing habitat and harvest in the Okanogan River. The tribe claimed that middle Columbia River escapement levels for Okanogan sockeye are not sufficient to rebuild the run to the level that the watershed could support. CRITFC has opposed this intervention as well. In the eyes of many members of the treaty reservations, the Colvilles sold out their fish and their culture with the ICC decision of 1978 and the Settlement Act of 1994 (Sampson 1999).

Besides litigation, several other major policies that have influenced the project affect Native Americans. Among these are the tri-party and multi-party agreements concerning jurisdiction over lands comprising the Lake Roosevelt National Recreation Area, which is discussed in Section 3.4. The Northwest Power Act and the Endangered Species Act, which are aimed at anadromous fish recovery, are tied to larger issues of hydropower development basin-wide and the trade-offs that need to be taken among the competing uses of the Columbia River's water. Details on how these policies affected decision-making are provided in Section 6.

3.7.14 Benefits of GCD for Tribes

When asked if they benefited in any way from GCD, tribal members interviewed for this study mentioned electricity, roads, and jobs. Electricity came to the reservations later than to surrounding areas, and usually at a significantly higher cost, but reservation members still appreciated its benefits (Andrews 1999).

Men from the Spokane and Colville reservations were hired to help with grave relocation in 1939 and 1940, and Indians from throughout the region worked on dam construction itself. According to tribal members we interviewed, most were hired under a permit system that allowed Indians to work without joining the unions, and this led to some resentment from white workers. Roads were also built and improved on the Spokane reserve, making travel much easier (Arnold 1999; Sam 1999; Brisboys 1999).

Since passage of the Northwest Power Act in 1980, BPA has funded employment of tribal members from both Spokane and Colville tribes in the fish hatcheries, to work on fish and wildlife assessments and studies, and seasonally to do patrols and grave relocations during periods of low water. Recreational facilities directly connected with Lake Roosevelt also employ small numbers of tribal members and may expand in the future, particularly with the Spokane Tribe's planned resort (Underwood 1999; Peone et al. 1999; Palmer & Stone 1999). However, these jobs account for only a fraction of the 2 000 people the Colville tribe employs, and the 650 individuals employed by the Spokane. According to some tribal leaders, NPS policies restrict the extent of commercial recreation facilities the tribes can develop, and annual fluctuation of the reservoir level limits the season for recreational use. Forestry and casinos are the main generators of income and jobs for these tribes. Tribal casinos, begun in the late 1980s, benefit from the tourism draw of the dam and reservoir (Knapton 1999; Seyler 1999b).

3.8 Effects on First Nations in Canada [115]

Canadian Columbia River Basin First Nations are also part of the Plateau cultural complex described in Section 3.7, but there are some important differences. In the early spring, some Canadian First Nations groups, such as the Ktunaxa moved to locations to harvest trout at spawning areas and along migration routes. This was followed, later in spring by the shift to root-digging grounds. The root-harvesting period was followed for some tribes (eg, the Ktunaxa) by the early summer communal move to the eastern slopes of the Rocky Mountains for bison hunting (Schaeffer, 1940). Mid- to late-summer was the time for both salmon and berry harvesting within the Canadian portion of the Columbia River Basin. Salmon populations migrated to upriver spawning areas after the snowmelt freshet had passed.

Archaeological evidence indicates at least 10 000 years of continuous aboriginal occupation of the Canadian portion of the Columbia River Basin. Salish-speaking tribes (eg, the Shuswap, Okanagan, and Sinixt-Lakes) lived in the western part of the Columbia River Basin in Canada, while the linguistically isolated Ktunaxa (aka, Kutenai) occupied the eastern portion. Okanagan, Sinixt-Lakes, and Ktunaxa tribes joined with other tribes at the Kettle Falls salmon fishery, which was also an important site for trade and celebration.

3.8.1 Pre-Project Conditions

As with the US Columbia River Basin tribes, salmon were also central to the economic, cultural and spiritual life of the Columbia River Basin First Nations in Canada. These First Nations marked the first salmon harvest with special ceremonies and rituals to confirm the relationship between humans and salmon, thereby ensuring the annual return of the salmon. Salmon were particularly important to Canadian First Nations since they created opportunities for communal gathering and group action.

Prior to construction of GCD, chinook and sockeye ascended the Columbia River to its headwaters at Columbia Lake, approximately 1 240 miles (2 000km) from the mouth of the river. Principal fishing locations along the migration route were at Fairmont Hot Springs (aka, Kɫaqakinuknana) immediately downstream of Columbia Lake, Athalmere (aka, Kwataqnuk) at the outlet of Windermere Lake, Brisco, near the confluence of the Columbia and Jordan rivers, at the south end of the Arrow Lakes, and at and below the confluence of the Columbia and Kootenay rivers. Salmon could only ascend the Kootenay River to Bonnington Falls and into the Slocan River system. Upstream fisheries usually involved individuals or small groups at fishing locations; those downstream of the Columbia-Kootenay rivers confluence more typically involved entire bands or groups of bands of tribal members.

While the Canadian First Nations share many cultural attributes with US tribes in the Columbia River Basin, the experiences that followed the imposition of non-native governments are markedly different. First contact between Europeans (fur traders) and Canadian First Nations did not happen until early in the 19th century in the Canadian portion of the basin. Early contact was established in the context of the "Royal Proclamation of 1763," which acknowledged Indian ownership of lands not ceded to or purchased by the Crown (ie, the colonial government). The Oregon Treaty of 1846 and subsequent surveying settled the boundary between Canada and the US west of the Rocky Mountains. The establishment of this boundary had profound effects on the Okanagan, Lakes-Sinixt and Ktunaxa Nations since it separated groups north and south of the border. Tribes that were previously united in the border area became divided after the establishment of this international border.

British Columbia colonial and subsequent (ie, post-Confederation) policy was largely defined by then governor Joseph Trutch, despite the fact that the British North America Act (the British law that established the Canadian federation in 1867) accorded power over Indian matters and lands reserved for Indians to the federal government. In most of the rest of western Canada, colonial and then federal governments entered into treaties with First Nations. This was not the case in British Columbia, where Trutch's government refused to acknowledge aboriginal title and rights and to enter into treaties with First Nations. Most of the Indian reserves in the Canadian portion of the Columbia River Basin were established in the 1880s by "Order-in-Council," which is roughly analogous to the executive order process used in the US where reserves were not mutually agreed upon by means of treaties. The importance of fishing in general and salmon fishing specifically is demonstrated by the locations of current and former reserves at important fishing locations, including the confluence of the Kootenay and Columbia rivers and Invermere (aka, Kyanuqɨi?it).The "Oatscott" reserve along lower Arrow Lake reverted to the government in the mid-1950s because the Arrow Lakes band no longer had any enrolled members. The members of Arrow Lake dispersed to other communities largely because of the loss of the salmon fishery along the Columbia River. The salmon fishery was the principal reason for the initial establishment of the reserve. The size of many reservations was substantially reduced in the early 1900s following the decision of a joint federal-provincial "Royal Commission" on Indian affairs.

Indian policy from establishment of the Canadian confederation (1867) to the 1970s was assimilationist. A law passed by the government of British Columbia in 1875 prohibited Indians from voting to prevent First Nations from attempting to advance their rights through the electoral process. In 1876, the federal Indian Act was passed. In it, the Canadian Prime Minister spoke explicitly of the assimilationist objectives of the Act. Amendments to the federal Indian Act were passed in 1884 to prohibit Indian cultural and religious ceremonies, like the first salmon ceremonies. Later Indian Act amendments prohibited First Nations from raising funds or hiring lawyers to promote aboriginal rights and interests.

The assimilationist Indian policy was not dropped by the Canadian federal government until the 1970s. Abandonment of the policy at that time was a result of important "aboriginal rights and title" decisions at the Supreme Court of Canada (eg, *R. vs. Calder* and *R. vs. White and Bob*) and the associated Indian rights movement. The federal and British Columbian provincial governments agreed to negotiate modern day treaties with British Columbia First Nations in 1991. Fisheries issues in general, and fisheries restoration in particular are key issues for Columbia Basin First Nations.

The description of the economies and cultures of US Columbia Basin tribes in the 1930s presented in Section 3.7 applies equally well to Canadian First Nations. However, in contrast to the situation in the US, Canadian First Nations were unaware of the plans to construct GCD. The dam was partially completed when the US applied to the International Joint Commission for approval of the dam. There is no evidence that either the Canadian government or the International Joint Commission consulted with Canadian First Nations prior to IJC approval of the dam. Indeed, when GCD construction was being considered in the US in 1934, the Deputy Minister of the Department of Fisheries advised the Canadian embassy in Washington that "…the assumption that there is no commercial salmon fishery on the Columbia River in Canada is correct, and hence Canadian interests in that respect will not be affected if the dam at Grand Coulee is not equipped with fishery facilities" (Pitzer, 1994: 224).

3.8.2 Project Impacts on First Nations

As was the case for US Native American tribes, GCD also caused major adverse effects for Canadian Columbia River tribes. Salmon runs to the upper Columbia River provided an important foundation for the subsistence economies of the Canadian tribes, particularly the Ktunaxa and Lakes/Sinixt. The construction of GCD was the final blow, in addition to commercial overharvest in the lower Columbia River and the construction of Rock Island and Bonneville dams, which virtually extinguished the livelihoods of these tribes. While the Columbia River Basin in Canada provided spawning, rearing, and migration habitat for a large number of spring, summer, and fall chinook, sockeye and steelhead populations, completion of GCD left only one chinook and one sockeye population remaining in the Canadian portion of the basin within the Okanagan sub-basin.

The near elimination of Canadian-origin salmon populations caused by construction of GCD had major adverse effects on Canadian First Nations. For example, the almost complete loss of access to salmon had severe dietary, health, and economic consequences for Canadian First Nations. Salmon had formerly provided a foundation for the subsistence economies of First Nations, and, at the time GCD was built, these economies were far more important than the wage or commercial economy to First Nations. The loss of salmon also had severe cultural and spiritual consequences, including the elimination of traditional social and communal practices, and celebrations integral to First Nations' way of life.

GCD blocks all anadromous fish runs to the Ktunaxa, Shuswap, and Lakes-Sinixt territories. Because of dam construction, the following fish populations or stock aggregates became extinct:

- Arrow, Slocan, and Whatshan sockeye populations (Fulton, 1970);
- Columbia and Windermere Lake sockeye populations (Bryant & Parkhurst, 1950);
- Spring/summer chinook populations, which spawned downstream of the Columbia/Kootenay confluence, in the lower Pend d'Oreille River and the tributary Salmon River, in the Slocan River downstream of Slocan Lake, downstream of Bonnington Falls in the Kootenay River, between the Arrow Lakes, intermittently upstream in the Columbia River main-stem between Upper Arrow Lake and Radium Hot Springs, and heavily downstream of Windermere and Columbia Lakes (Fulton, 1970; Scholz et al., 1985); and
- Fall chinook populations that spawned in the lower Pend d'Oreille River, intermittently downstream of the Columbia/Kootenay confluence, in the lower Kootenay below Bonnington Falls, in the lower Slocan River and in the Columbia River downstream of lower Arrow Lake (Fulton, 1968).

Salmon consumption levels before and during the early period of white settlement in First Nations in Canada have been estimated at 300 pounds per capita per year for the Ktunaxa, and 400 pounds per capita per year for the Okanagan and Lakes (Hewes, 1947) These estimates, of course, apply to a period when salmon were far more abundant than they were in the period immediately prior to the construction of GCD.

Effects of GCD on First Nations are important not only because the dams provided the final blow to salmon runs that had already been decreasing because of other factors, but also because it eliminated the ability to restore these populations in the future (at least with the dam in its present configuration, and with the pre-existing genetic attributes) to levels of abundance that might sustain similar harvest levels. GCD represented an irreversible change: the pre-existing genetic attributes of certain salmon species cannot be regained.

The complete loss of salmon from the diets of Canadian First Nations has had substantial negative impacts on health conditions. As discussed in Section 3.7, for Native Americans in the US, the shift in diets of tribal members away from "country foods" (including salmon) has contributed to significant increases in illnesses like heart disease, diabetes and arthritis.

GCD does not block the salmon populations that return to spawn and rear in the Canadian portion of the Okanagan River Basin. However, the Okanagan River sockeye population has been adversely affected by GCFMP because of the harvesting of Okanagan fish for hatchery broodstock, the genetic mixing of wild and hatchery stocks (and resultant reduced fitness), and ineffective hatchery practices.

In contrast to the mitigation efforts for Native Americans in the US, there has been no mitigation for the impacts of GCD on First Nations salmon fisheries in Canada. First Nations are not party to *US v. Oregon*, and until 1999, the NPPC had not supported funding for projects to mitigate for the impacts of US dams on Canadian fish or wildlife populations. Unlike their counterparts in the US, Canadian First Nations have not had access to the legal mitigation and compensation mechanisms and funds. Canadian First Nations are actively pursuing mitigation and compensation for their salmon losses, particularly through efforts to achieve their long-term goal of salmon restoration.

4. Basin-Wide Impacts and Operations

As the preceding sections make clear, GCD cannot be analysed in isolation. Notwithstanding that some early project advocates in eastern Washington were not thinking in terms of basin-wide planning, the definitive appraisal of GCD, the 1932 report for the Columbia River above the Snake prepared by the Corps, was conducted as part of a basin-wide planning effort. One indication of the significance of this early basin-wide planning effort is whether or not projects detailed by the Corps in 1932 were actually constructed.

4.1 The 1932 Butler Report as a Plan for the Upper Columbia Basin

In examining whether the Corps' 1932 comprehensive plan for development for the Columbia River above the Snake River was implemented, it is useful to review the primary components of this plan. The scheme outlined in the Butler Report called for construction of six dams on the Columbia River: Priest Rapids, Rock Island Rapids, Rocky Reach, Chelan, Foster Creek, and Grand Coulee. Major Butler recommended that navigation facilities be built up to Rocky Reach Dam, and he also recommended the regulation of Flathead and Pend Oreille Lakes and the construction of Hungry Horse Dam, with its accompanying reservoir. Finally, the Butler Report advocated adoption of a plan for irrigation of the Columbia Plateau.

In terms of hydropower projects on the Columbia River above the Snake, every one of the dams the Butler Report recommended for construction was eventually built. The Corps built Chief Joseph Dam at the Foster Creek site, and the Douglas County PUD constructed Wells Dam at the Chelan site. Rocky Reach and Rock Island dams were built by the Chelan County PUD, and Priest Rapids Dam was built by the Grant County PUD. Moreover, Reclamation followed Butler's recommendation of a high dam at Grand Coulee.

The major exception to implementation of Major Butler's plan for the upper basin is the case of Priest Rapids and Wanapum dams; the latter is located 18 miles (29km) upstream from Priest Rapids. Major Butler compared the potential power possibilities under two different scenarios for Priest Rapids. In one scenario, he examined the power potential with a low dam at Priest Rapids and another dam 25 miles (40km) upstream, at the vantage site (USACE, 1933: 1003-1004,1007). The other scenario envisioned a high dam at Priest Rapids that would inundate the Vantage site and create a reservoir back to Rock Island. Since Butler concluded that the low dam-Vantage scenario would lose 18,000kW of power 100% of the time, he recommended the high Priest Rapids Dam (USACE, 1933: 1004). This recommendation was not implemented. Instead, the low dam was built at Priest Rapids, and another dam, Wanapum, was constructed not far from the Vantage site. As in the case of Priest Rapids, Wanapum was constructed by the Grant County PUD.

Not all of the other elements of Major Butler's plan were implemented. The navigation facilities proposed for Priest Rapids and Rock Island dams were never built. Also, the plan implemented at Grand Coulee represented a modest departure from the scheme outlined in the Butler Report. Reclamation employed the pumping plan Butler advocated. However, Butler's recommendation for "Plan 4-A," with part of the project supplied with irrigation water from Priest Rapids, was not followed. Instead, Reclamation's plans for GCD and CBP adhered closely to Butler's "Plan 4," with the vast majority of irrigation water for CBP coming from Lake Roosevelt.[116]

The Butler Report recommended regulation of Pend Orielle Lake through the construction of a dam at Albeni Falls, and that recommendation was followed: the Corps completed Albeni Falls Dam in 1955. Reclamation built Hungry Horse Dam, which went online 1952. Private groups constructed Kerr Dam at the outflow of Flathead Lake.

In summary, the comprehensive plan of development in the Butler Report was not implemented in its entirety, but most of the main hydropower and irrigation features recommended by Major Butler were eventually built by various public and private entities. Interestingly, when the chief of the Corps submitted the Butler Report to the Secretary of War in 1932, he recommended that the hydropower and irrigation projects for the Columbia River Basin be undertaken by parties other than the US government.

4.2 Influence of GCD on Decisions to Build other Water Projects in the Basin

Given that so many of Major Butler's general plans for projects in the Columbia River above the Snake were implemented, there is a clear link between GCD and many other dams on the Columbia River. However, some projects in both the US and Canada are particularly noteworthy because of the way the existence of GCD influenced decisions pertaining to these projects.

4.2.1 Effect of GCD on Projects in the US

Two specific examples of how GCD affected the construction and design of other dams in the basin are Libby Dam (located upstream), and Chief Joseph Dam (located immediately downstream). Construction of Libby Dam is closely tied to the Columbia River Treaty, which, among other things, authorised the US to build a dam on the Kootenay River, near Libby, Montana. The project was built and is operated by the Corps; its significance in controlling floods is reflected in the following statement: "Libby Dam is the culmination of years of effort on the part of both the United States and Canada to develop a flood control plan for the Columbia River Basin." (USACE, 1996)

Libby Dam, completed in 1973, provides over 5 MAF (6 165 million m^3) of storage to the basin-wide system. The dam's reservoir, Lake Koocanusa, is a total of 90 miles (145km) long and extends 42 miles (68km) into BC, Canada. Without GCD and the Columbia River Treaty, it is highly unlikely that Libby Dam would have been built the way it was, since all the storage projects in the Treaty take into account the flood control capacity of GCD (USACE, 1972). The presence of GCD was a major factor affecting the design and operation of Libby (Brooks 1999).

Chief Joseph Dam, built by the Corps in 1958, has also been influenced by GCD. This run-of-the-river project lies 51 miles (82km) immediately downstream of GCD and is one of the Corps' largest power-producing dams in the basin. When all 27 generators are operating, the dam can produce over 2.6 million kilowatts. Currently, the value of electricity produced at Chief Joseph Dam exceeds $200 million annually (USACE, 1998). To produce more power for the US Northwest, the Corps raised the height of Chief Joseph Dam by 10ft (2.64m) and installed 11 additional turbine generators in 1980 (USACE, 1998). After the dam was raised, the Corps raised the level of Rufus Woods Lake (the reservoir created by the dam) by 10ft (2.64m), bringing the lake level to 956ft (254m) above sea level. With the higher lake level and a total of 27 generating units, Chief Joseph Dam is now the second largest hydropower producer in the US — second only to GCD. The powerplant at the dam produces enough power to supply the electrical needs of over 1.5 million people (USACE, 1998).

The ability of the Chief Joseph Dam to generate this much electricity is directly tied to the upstream regulation of flow by GCD. The operation of the two dams is closely linked. As stated by Reclamation, "The water levels between Grand Coulee Dam and Chief Joseph Dam are a complex function of the operation of both dams and their powerplants" (USBR, 1976: I-105). Since the Chief Joseph Dam is run-of-the-river, it is not designed to control large amounts of water flow.[117] Therefore, power generation activities at the dam are closely synchronised with activities at GCD.

Another major influence of GCD on Chief Joseph Dam concerns its lack of fish passage facilities. As mentioned in Section 3.5, GCD was built without fish passage facilities. This condition set the stage for the subsequent decision not to provide fish passage facilities at Chief Joseph Dam. While there are no major spawning tributaries between GCD and Chief Joseph, the fact that Chief Joseph Dam was built without fish passage facilities eliminated the possibility of using the area between the two dams as spawning habitat (ICC, 1978a; ICC 1987b; Peone et al 1999; NPPC, undated; Bosse 1999).

4.2.2 Influence GCD on projects in Canada[118]

As detailed in the Annex titled "Negotiating the Columbia River Treaty," the perceived need to increase power output at GCD led to discussions in 1944 about the prospect of building water storage facilities in Canada. After nearly two decades of negotiation, the Columbia River Treaty was ratified in 1964. The Treaty led directly to the development of three new storage dams in BC, Canada, and to the US development of Libby Dam on the Kootenay River in Montana. Significantly, in the absence of financial benefits provided by the Treaty, Canada would not have built the three "Canadian Treaty dams" — currently named Duncan, Hugh Keenleyside, and Mica Creek. The Treaty requires that these dams be operated to prevent downstream flooding and to increase downstream power generation. As the stored water flows through generators at the Canadian dams, Canada retains all the electricity produced at those sites. As the same stored water flows through generators at US dams, it increases the production of electricity at downstream sites. Using calculation procedures specified by the Treaty, the downstream energy production benefits of the water stored in Canada can be calculated, and Canada is entitled to 50% of these benefits. These funds are commonly referred to as "downstream power benefits".

According to Gordon MacNabb, one of the advisers to the Canadian Treaty negotiators, had downstream benefits not been negotiated, Canada would have met its energy needs by building coal-fired powerplants to generate electricity. These plants represented a less expensive alternative to independent development (by Canada) of the hydropower projects on the portions of the Columbia River within Canada. In other words, the three Canadian Treaty dams would not have been built in the late 1960s and early 1970s if the Columbia River Treaty had not provided the additional power and monetary benefits.[119]

As the previous observations suggest, the indirect effects of GCD on the course of water resource development in British Columbia have been profound. The existence of GCD led directly to the negotiation of the Columbia River Treaty, and the benefits provided by the Treaty led Canada to develop three major water resource projects in BC. This chain of indirect effects extends even further when the following three facts are considered. First, storage provided by the Canadian Treaty dams led to additional electricity generation capacity for the Mica project. Second, the Treaty dams led to the development of the Revelstoke Dam (downstream of Mica in Canada). Third, the Treaty dams led to the construction of the Kootanai Canal Plant (downstream of both the Duncan Dam and Libby Dam in Canada).

4.3 Effects of the Treaty Dams on Canadian Resources and People

4.3.1 Environmental and Social Impacts of the Treaty Dams

Construction of the Columbia River Treaty dams created a new reservoir (Kinbasket, behind Mica Dam) and enlarged two lakes — Arrow and Duncan. In addition, Libby Dam created Koocanusa reservoir, which lies in both the US and Canada. Table 4.3.1 summarises storage and generation capacities for the Treaty dams.

Table 4.3.1 Storage and Generation Capacity of Columbia River Treaty Dams

Dam	Lake	Completion Date	Generating Capacity (MW)	Treaty Storage (MAF)	Treaty Storage (million m^3)	Non-Treaty Storage (MAF)	Non-Treaty Storage (million m^3)
Duncan	Duncan	1967	None	1.4	1 727	None	None
Keenleyside[a]	Arrow	1968	None	7.1	8 758	0.25	308
Mica	Kinbasket	1973	1 740	7.0	8 624	5.0	6 167
Libby	Kookanusa	1973	640	5.0	6 167	None	None

[a] Keenleyside dam was previously referred to as the Arrow Lakes project; hydroelectric power generators are currently being installed at Keenleyside.

The advantages of the Columbia River Treaty projects to Canada go well beyond the downstream power benefits and flood control payments from the US detailed in the Treaty. For example, Duncan and Libby produce power benefits downstream in Canada on the Kootenay River that are retained entirely by Canada.[120] They also create flood control benefits within Canada on both the Kootenay and Columbia rivers, and these benefits are not shared between the US and Canada. (The Treaty did not require Canada to pay the US for the flood protection in Canada provided by Libby Dam in the US.) In addition, Mica Dam produces large amounts of power both on site and downstream at Revelstoke Dam. Power-generating capacity is also currently being added to Keenleyside Dam. All of these benefits from the Treaty projects are retained by Canada. Because of the Treaty dams and other hydroelectric projects in the Canadian portion of the Columbia River Basin, people in British Columbia enjoy one of the lowest power rates in North America.

While there is substantial agreement about the nature of the flood control and power benefits within Canada, there are differences of opinion about the adverse environmental and social effects of the Treaty dams within Canada. Although we were unable to conduct an extensive study of the divergent opinions, the observations below give some sense of how views differ. The source of these observations consists of opinions expressed by citizens and officials from communities affected by the Treaty dams as contained in reports prepared for the Columbia River Treaty Committee,[121] an organisation created by local governments in 1994 to negotiate on behalf of the Canadian region affected by the Treaty dams with the province of British Columbia. Another important source of information consists of comments made at a workshop held on 4 October 1999 in Castlegar, Canada to discuss the influence of the GCD on people and resources in BC.[122]

The Columbia River Treaty projects have had numerous adverse effects, including the displacement of residents forced to relocate because of reservoir-filling, and reductions in community population with consequent reductions in the provision of core community services and community and social infrastructure. Although the total number of people displaced is disputed (estimates vary from 1 600 to 2 200 residents), the number of people involved is significant. At the time the Treaty was ratified, the region was dependent on agriculture, lumber, and mining in sparsely settled, steep, mountainous terrain. The region's bottom lands are extremely important for human habitation, agriculture, wildlife wintering areas, migratory bird rest areas and habitat, as well as transportation routes. Some of these relatively scarce bottom lands were inundated by the Columbia River Treaty projects, and compensation was paid to the affected people at that time. In the opinion of some current residents of areas affected by the projects, landowners who had their properties expropriated were not compensated adequately. Moreover, because lengthy litigation faced those who were forced to relocate, some people with grievances related to land expropriation could not afford to press their claims.

The Canadian Treaty projects caused significant disruption to aquatic ecosystems in the region. The dams separated individual populations and caused the local extinction of specific fish stocks. Moreover, bank sloughing caused by fluctuations in reservoir water levels have damaged natural spawning areas and wildlife habitats. In addition, the reservoirs have caused significant fragmentation of wildlife habitat; Kinbasket reservoir was particularly damaged in this regard.

The Columbia River Treaty projects also led to a loss of forestlands in Canada and the jobs associated with those lands. However, estimates of those losses vary. The range of values for total land area losses (including grasslands, forests, agricultural areas, and so forth) varies from a low of about 150 700 acres (61 000ha) to a high of about 192 200 acres (77 800ha).[123] According to Josh Smienk, executive director of the Columbia Basin Trust, a conservative estimate of land flooded by Mica and Duncan dams would be 110 000 acres (44 500ha) and most of that would be in forestlands (Smienk 1999a). In addition, about 52 700 acres (21 000ha) would have been in some type of agricultural use, mainly in the area flooded by Lake Koocanusa and the expansion of Arrow Lakes. Notwithstanding the differences of opinion about the number of acres inundated, there is no question that the land area involved was substantial. The aforementioned reports detailing opinions of residents in affected communities contained numerous examples of forestry jobs lost, ranches flooded, livestock production eliminated, agricultural activities disrupted, and so forth.

Recreational activities were also transformed by the Columbia River Treaty projects. For example, there was interference in guiding and other tourist-related activities tied to hunting and fishing in pristine wilderness. This was of particular significance in the area affected by the Kinbasket reservoir. At the same time, however, there is ongoing, extensive recreational activity on portions of the new lake areas created by the Treaty dams, and the highway systems have been improved significantly.

One aspect of the operation of Columbia River Treaty dams that has been in particularly troublesome to many local residents is the wide fluctuation in reservoir levels. During the first years after ratification of the Treaty, reservoir operations focused exclusively on the generation of electricity and flood protection. Reservoirs were full in late spring and summer, and lower during the coldest months of the year — November to March. However, during the past few years, operations at Libby Dam have been modified by US authorities to release water for fish mitigation purposes, and this has created circumstances where the Kookanusa reservoir has experienced significant drawdowns during the summer and fall months, thereby seriously affecting use of the reservoir in Canada and creating unsightly conditions around the shoreline. [124]

In a November 1994 report on the "Effects of the Mica Dam and Kinbasket Lake on the Economy of Golden and Area (prepared for the Columbia River Treaty Committee)," Hambruch (1994: 10) makes the following observations:

> *The water level in Mica [ie, Kinbasket] reservoir fluctuates by up to 53 m (175 feet).*[125] *The effects of these fluctuations include:*
>
> - *Sediment brought in by glacier-fed rivers that settles out on the reservoir bottom becomes exposed and creates a dust problem.*
> - *Access for log transport is greatly complicated or made impossible.*
> - *Boating access is next to impossible at certain times of the year.*
> - *Fishery enhancement programmes are greatly affected or made impossible.*

Moreover, it is a common perception in the region that the fluctuations in Lake Koocanusa are so great as to leave the lake empty part of every year (Smienk 1999a). (In fact, however, Mica reservoir is always a long way from empty because it needs a minimum head for power generation purposes. (MacNabb 1999a). Low water levels reveal a wide valley that is barren gravel and a silt bed with a relatively narrow river running through it. Changes in reservoir and lake levels are particularly dramatic in drought years. During those periods, some homeowners who are normally situated lakeside might have a shoreline in front of their houses in May, but their houses might be as far as 35 miles (56km) from the water in July.

Another set of issues about which local residents are concerned centres on local tax base. The new dams that were built as a result of the Columbia River Treaty enjoy a special exemption from property taxes in the region. This exemption, provided by the Province of British Columbia, is specific to the Columbia River Treaty projects. However, BC Hydro, owner of the projects, pays a grant-in-lieu of taxes.[126] This equals about 7% of what the tax assessment on the lands would otherwise be if they were owned by private utilities. Some local residents estimate that if the dams and transmission lines were taxed at a similar rate to private utilities, the local tax base would increase by 25%.

Overall, some local residents have felt a sense of betrayal over the difference between what they thought they were getting in 1964 and what actually occurred. For example, residents of the Village Valemount area recall government promises that Kinbasket would be managed as a lake with relatively stable water levels and subsequent uses that depended on minimal lake fluctuations. In 1964, the Minister of Lands and Forests and Water Resources indicated that "only 14 miles [23km] out [from Valemount] will be formed one of the greatest man-made lakes in the world". (Hon. Ray Wiliston as quoted in Townsend, 1994: 16).[127] Instead, Kinbasket is a managed reservoir that has drawdowns as great as 150ft (46m), approximately four times the amount that local residents expected. Moreover, some people in the region feel they had little opportunity to participate in the decision processes associated with the Columbia River Treaty. Although there may have been many exceptions to the rule, local hearings that were held in connection with the Treaty required the public to speak only to the issue of the engineering of the structures involved, not about social impacts affecting local communities.[128]

4.3.2 Programmes to Compensate Communities Adversely Affected by Canadian Treaty Dams[129]

Most hydroelectric development by BC Hydro in the Columbia Basin occurred between 1960 and 1985. Some of the projects are Columbia River Treaty dams and others are not, while some of the impacts of the new dams were obvious immediately (eg, the Seven Mile Dam projects flooded prime white-tailed deer habitat in the Pend d'Oreille Valley), other impacts became evident slowly. An example is the decline in Kootenay Lake productivity, which took up to 25 years to become obvious.

The Columbia Basin Fish and Wildlife Compensation Programme (CBFWCP) is a non-profit entity separate from, but not independent of, its BC Hydro and BC Environment partners. CBFWCP, which was created in 1994, evolved from existing Mica, Arrow, Duncan, Revelstoke, and Pend d'Oreille compensation programmes. The mandate of CBFWCP is to deliver projects to conserve and enhance fish and wildlife populations affected by BC Hydro dam-related activities throughout the Canadian portion of the Columbia River Basin. CBFWCP receives $3.2 million a year from a perpetual fund established by BC Hydro as part of the requirement under the crown corporation's water license agreement.

A key component of CBFWCP's mandate is consultation and communication with the public. The objective is to build involvement in the programme among residents, community groups and other key stakeholders including First Nations, local governments, resource users, government agencies and the media. CBFWCP work led to 325 fish and wildlife projects with 276 partners between 1995 and 1999.[130]

Other efforts to ameliorate the adverse effects of the Canadian Treaty dams involve activities of the Columbia Basin Trust (CBT).[131] In 1995, the Province of British Columbia recognised that "the People of the Canadian Columbia River Basin were not adequately considered in the original negotiations of the Columbia River Treaty" (Bill 5, 1995 Columbia Basin Trust Act) and created the CBT as a form of local empowerment to address past injustices. CBT has broad powers and was created to ensure that benefits derived from the Columbia River Treaty help create a prosperous economy with a healthy, renewed natural environment in the region impacted by the Canadian Treaty dams.

The region, through the CBT, was given approximately $300 million Canadian ($321 million in $1998) and investment opportunities in the form of ownership and development rights at existing dams in the region. One objective in creating these opportunities is to have more localised control over the region's water resources. Trust directors reside in the Canadian portion of the Columbia River Basin, and the majority of the Trust's Board of Directors is appointed by local government. CBT operates within a plan that has been developed with broad community input.

CBT's mandate is to invest the region's share of "downstream benefits" created by the Columbia River Treaty and to spend the income earned from these investments to deliver social, economic, and environmental benefits to the basin and its residents. Activities of CBT do not relieve governments of their obligations. CBT also has a number of other legislated responsibilities including the following: participating in a review of the Columbia River Treaty when that opportunity arises in 2014; providing input into water licenses issued in the basin; and playing an advocacy role in water management issues in the basin.

4.4 Cumulative Impacts of Projects on Ecosystems

4.4.1 Basin-wide Factors Affecting Anadromous Fish

In addition to project-specific factors (eg, lack of fish passage facilities at GCD), anadromous fish populations have also been affected by basin-wide factors. In recent years, the major factors affecting salmon populations have been categorised under "the four H's:" harvest, hatcheries, hydropower, and habitat. These categories are not mutually exclusive (eg, a dam can cause effects through its passage facilities as well as affect salmon habitat). Moreover, it is typically very difficult to determine the extent to which one factor (eg, hydropower) is responsible for a specific percentage of fish population decline. Nevertheless, the four H's form a useful framework for introducing the many different issues that affect salmon and steelhead in the Columbia River Basin.

4.4.1.1 Harvest

The impact of harvest on salmon and steelhead is straightforward — overharvest impairs the ability of a species to maintain a self-sustaining population. Overfishing during the heyday of the salmon canning industry, for example, is widely cited as a primary reason for salmon declines prior to the construction of large dams in the basin. Similar to the other "H's," harvest effects are cumulative. When fish populations decrease for other reasons, even if catch levels remain constant, the percentage of fish harvested from a run has a much more significant effect (Bennett 1999). The harvest of Columbia River salmon has been regulated by state,[132] federal, and international[133] law. However, these laws and treaties can be difficult to implement and enforce.[134]

4.4.1.2 Hatcheries

The influence of hatcheries on anadromous fish is widely debated. Proponents view hatcheries as a necessary measure for augmenting wild populations, whereas critics see hatcheries as exacting negative effects on fish via genetics[135] and disease.[136] Some scientists also contend that the release of hatchery fingerlings, which tend to be larger than their wild counterparts, contributes to increased mortality of wild fish.[137] Hatcheries are a large component of fish recovery plans, not only for GCD itself, but for the system of multi-purpose projects in the Columbia River Basin. Numerous hatchery facilities have been built in the middle Columbia River and its tributaries. Table 4.4.1 presents descriptive information on some of the major ones. Hatchery operations are generally managed by state and federal agencies and operations and maintenance costs are often paid by the operators of multi-purpose projects (eg, Reclamation, the Corps).

Table 4.4.1 Selected Hatchery Facilities in the Middle Columbia River and Tributaries

Facility	Species	Capacity in Millions of Smolt	Year in Service	Agency	River
Ringold	Fall Chinook Spring Chinook Steelhead	4.0 1.0 0.18	1962	WDFW[a]	Mid-Columbia
Hanford	Fall Chinook	4.0–5.0			Mid-Columbia
Priest Rapids	Fall Chinook	6.7–7.7	1963		Mid-Columbia
Wells	Summer Chinook	4.4	1967	WDFW	Mid-Columbia
Eastbank	Summer Chinook Steelhead Sockeye	1.816 0.25 0.2	1989	WDFW	Wenatchee
Turtle Rock	Coho	1.0	1990	WDFW	Mid-Columbia
Chelan	Summer Chinook Steelhead	4.4 1.05	1965	WDFW	Mid-Columbia
Methow	Spring Chinook	0.738		WDFW	Methow
Winthrop	Spring Chinook	1.0	1941	USFWS	Methow
Leavenworth	Spring Chinook	3.0	1941	USFWS	Wenatchee
Entiat	Spring Chinook	0.8	1941	USFWS	Entiat
Okanogan	Sockeye	0.2			Okanogan
Yakima River	Fall Chinook Spring Chinook Summer Chinook Coho Steelhead	3.6 1.125 0.2 2.0 0.6			Yakima
Oak Springs	Steelhead	0.14	1923	ODFW[b]	Deschutes
Round Butte	Spring Chinook Steelhead	0.3 0.16	1974	ODFW	Deschutes
Warm Springs	Spring Chinook	0.7		USFWS	Deschutes
Irrigon	Steelhead	1.677	1984	ODFW	Mid-Columbia

[a] Washington Department of Fish and Wildlife; [b] Oregon Department of Fish and Wildlife
Sources: CRITFC, 1995: Appendix B; Busby et al., 1996: Appendix C

4.4.1.3 Hydropower

GCD is one of many major dams in the US portion of the Columbia River Basin. Table 4.4.2 lists a number of these dams and indicates whether or not they have fish passage facilities. As physical barriers, dams present challenges to both adult salmon spawning upstream as well as smolts during outmigration to the sea. Adult salmon must be able to locate and have the strength to traverse fish ladders.[138] Some mortality occurs at each dam the fish must pass. Mortality rates of adult fish migrating upstream are generally estimated at 5% per dam (NPPC, 1986: 3). For example, the NPPC estimated that cumulative impacts of dams (as physical barriers to passage) over a series of nine dams as physical barriers would result in an overall adult mortality rate of 63% (NPPC, 1986: Appendix E). The range of mortality rates for juveniles migrating downstream varies considerably and is the subject of much debate. Recent estimates range from 5% to 15% per dam.

Table 4.4.2 Fish Passage Facilities at Major Dams of the Columbia River Basin

Dam	Year Dam Completed	River	Fish Passage	
			Adult	Juvenile
Rock Island	1933	Mid-Columbia	Yes	Yes
Bonneville	1938	Lower-Columbia	Yes	Yes
Grand Coulee	1942	Upper-Columbia	No	No
Chief Joseph	1955	Upper-Columbia	No	No
McNary	1957	Lower-Columbia	Yes	Yes
The Dalles	1957	Lower-Columbia	Yes	Soon
Brownlee	1959	Snake	No	No
Priest Rapids	1959	Mid-Columbia	Yes	Yes
Rocky Reach	1961	Mid-Columbia	Yes	Yes
Oxbow	1961	Snake	No	No
Ice Harbor	1962	Snake	Yes	Soon
Wanapum	1964	Mid-Columbia	Yes	Yes
Hells Canyon	1967	Snake	No	No
Wells	1967	Mid-Columbia	Yes	No
John Day	1968	Lower-Columbia	Yes	Yes
Lower Monumental	1969	Snake	Yes	Yes
Little Goose	1970	Snake	Yes	Yes
Lower Granite	1975	Snake	Yes	Yes

Source: University of Washington, 1999.

In addition to their effect as physical barriers, the numerous dams in the Columbia River Basin impact salmon and steelhead habitat in a number of ways. First, reservoir creation often eliminates prime spawning habitat. Second, the system-wide operation of multi-purpose water projects in the basin has been geared towards maximising hydropower generation and flood protection. This has changed the river's natural flow regime. The end result is a set of conditions that have adverse effects on juvenile outmigration. For example, dams slow river velocities, thus impeding the ability of the river to "help the fish along" in their passage to the sea. Delays during outmigration can have major effects on smoltification, the complex biological transformation that enables the fish to survive in a marine environment. If smoltification does not take place within a particular timeframe, the fish will not be able to survive in the ocean. Third, because of thermal storage in reservoirs, salmon and steelhead in the Columbia River system, which are cold-water fish, are exposed to higher than normal temperatures.[139]

4.4.1.4 Habitat

Habitat quantity and quality are both important in salmon and steelhead production. Dams in the basin have contributed significantly to habitat degradation, but they are not the only cause. Other practices, such as timber harvesting, wetland destruction, agricultural practices, and irrigation continue to decrease the availability of habitat. Table 4.4.3 lists important components of salmon and steelhead habitat.

In addition to inland habitat, climate and ocean conditions also have a significant influence on salmon and steelhead health. In the past decade, scientists have become aware of the effect of El Nino-like climate shifts that can persist for several decades. These shifts, which increase seawater temperatures and interfere with upwelling, wind, and current transport, can have major effects on the marine food-web, thereby influencing salmon survival at sea. Because of these ocean effects, the number of fish are produced in the rivers may be less influential than is widely believed, as these climate effects may preclude, and even confound, a lot of what are perceived to be fish recovery problems in rivers (Bennett 1999).

Table 4.4.3. Components of Salmon and Steelhead Habitat Quality

• Water quality	• Pool quality	• Large woody debris supply
• Water quantity	• Habitat diversity	• Water temperature, availability of shade
• Flow regime	• Sediment loading	• Water velocity
• Gravel quality	• Instream cover	• Bank stability
• Gravel quantity	• Overhead cover	• Presence of under cut banks
• Pool quantity	• Riparian vegetation	• Fish passage

4.4.2 Larger Ecosystem Effects

The role of salmon and steelhead in transferring nutrients from the Pacific Ocean to the Columbia River Basin is a relatively new subject of study. In the context of GCD, the nature of this nutrient transfer is summarised here.

Before construction of GCD (and the two main-stem dams that preceded it, Rock Island Dam and Bonneville Dam), salmon migration to the upper basin involved a nutrient transfer because salmon were an important food source for other animals. Spawning and spawned-out salmon comprised an important source of nutrition for animals such as bears[140] and eagles, effectively transferring nutrients from the ocean to the relatively sterile rivers and streams where the fish ultimately spawned. Bears ate the salmon, and they also recycled salmon-derived nutrients important to plant growth (eg, nitrogen and phosphorus) through their faeces (Olsen, 1998). Additionally, decaying salmon formed a nutrient base for organisms lower on the food chain that fed on decomposed fish bodies. The presence of an extensive dam system, including GCD and the other major projects in the basin, has severely compromised the traditional flow of nutrients to ecosystems in the upper basin region. Scientists are only beginning to unravel the implications of this alteration in nutrient flow.

4.5 Cumulative Socioeconomic Impacts

In the context of the Columbia River Basin, the significance of cumulative socioeconomic impacts of water resource development projects is undeniable. Indeed, the notion of cumulative effects is implicit in the Corps' "308 Report," which turned out to be the initial version of a master plan for water resource development projects on the main-stem within the US portion of the basin. The 308 report, which was named after House Document No. 308 of 1926 (US Congress, 1926) mandating detailed studies of the Columbia River Basin (among others), included two principal parts: a report by Major Butler for the portion of the Columbia River above the Snake, and one by Major Kuentz for the portion of the Columbia below the Snake (USACE, 1933). These reports paid a great deal of attention to the overall development of industry and agriculture within the US portion the basin.

The significance of the reports by Butler and Kuentz is undeniable, particularly in light of the projects actually built.[141] Indeed, the Corps modified and updated the original 308 report during the 1940s to maintain its viability as a long-range planning document.

Manifestations of the cumulative socioeconomic impacts of water resources development in the Columbia River Basin are not difficult to find. Indeed, the timing of both irrigation developments and hydroelectric projects were intentionally sequenced to match the increasing demands for agricultural outputs and electricity. Collectively, these additions of hydroelectric power and irrigated acreage had an extraordinary impact on the overall development of the US Northwest.

Another set of cumulative effects involves the influence of the CBP's agricultural outputs on farming activities in other parts of the US. While we were unable to identify studies of how subsidies for irrigation water to CBP growers allowed them to out-compete growers of similar crops in other parts of the country, several people we interviewed during the course of the study raised the issue. In particular, it appears to be common knowledge in Idaho that many potato farmers in that state — once one of the leading producers of potatoes in the US — shifted to other crops in the face of very stiff price competition from potato growers receiving CBP irrigation water.

In addition to effects on US farmers outside the CBP area, the availability of subsidised irrigation water on the Columbia plateau has also affected farmers in BC. An analysis by W.R. Holm and Associates (1994: 84-90) examines the shift to growing higher valued crops on CBP lands in the period from 1962 to 1992. In the investigation, the following five crops were considered: apples, potatoes, asparagus, onions, and grapes. According to Holm's analysis, the shift to higher valued crops in this period meant increased competition for farmers in British Columbia who produced the same crops without the advantage of subsidised irrigation water.

Relationships between cumulative socioeconomic impacts and cumulative ecosystem impacts are also notable. Consider, for example, the links between incremental dam construction, effects on salmon migration, and consequent social and cultural impacts on upstream Indian tribes. As noted in Section 3.5, Rock Island and Bonneville dams were both completed before GCD, and the negative effects of Rock Island and Bonneville dam on salmon and steelhead migrations were notable. Debates on the impact of GCD on fisheries were influenced by the cumulative effects of these two earlier dams. In particular, during the mid-1930s, James O'Sullivan, executive secretary of the Columbia River Development League, countered critics of GCD concerned about salmon migration by referring to effects of the two earlier dams. O'Sullivan argued that as a result of the combined effects of Bonneville and Rock Island dams, only one half of one percent of the Columbia's salmon run would probably remain by the time those salmon that survived reached the Grand Coulee. He also argued that the commercial value of the salmon fishery was a small fraction of the value of outputs from dam construction on the Columbia River. As noted in previous sections, the decision to eliminate the upstream migration of salmon by constructing GCD had major cultural and social impacts on Native Americans in the US and First Nations in Canada.

4.6 System Operations

System-wide objectives, laws, and policies affecting all major projects in the Columbia River Basin largely govern GCD operations. Historically, the two dominant functions of the reservoir system, including GCD, have been hydropower and irrigation. After 1972, flood control was added as a major purpose of the project. Beginning with the 1980 Northwest Power Act, the major operational changes for GCD and other projects in the Columbia River system focused on the need to more adequately address requirements for maintaining and enhancing anadromous fish populations. In 1995, the NMFS biological opinion concerning the 1991/92 ESA listing of three species of endangered Snake River salmon heralded another change in project operations. According to interviews that we conducted with Reclamation and BPA staff (Jaren 1999; Rodewald 1999; McKay 1999), the NMFS biological opinion is the dominant factor now driving system operations.

4.6.1 Major Changes in Operations Over Time

Four major stages, characterised in Table 4.6.1, mark the evolution of GCD operations in its basin-wide context. At the time GCD was completed, the major focus of operation of federal dams in the Columbia River Basin was on power generation at the project level. Over time, more and more projects and project purposes were added, and operations moved from the individual project level to the system level.

Between 1942 (the time of GCD completion) and 1948, GCD was operated primarily for hydropower-generating purposes; no significant flood control was provided during that period. Between 1948 and 1972, GCD was relied on more heavily for flood control, and power management in Columbia River system began shifting from a project specific to a system-wide focus; CBP also came on line. During this time, GCD was one of the major sources of power generation on the US side of the Columbia River Basin. The ability of GCD to play a role in significantly protecting against floods was limited until the Columbia River Treaty dams became operational in the early 1970s (Brooks 1999). Additionally, the completion of the Treaty dams in the US and Canada made significant hydropower optimisation possible.

After 1973, power generation and flood control activities were managed at a basin-wide level. The environmental aspects for individual projects were managed under requirements for federal agencies to conduct environmental impact assessments under the National Environmental Policy Act (NEPA) of 1969. The Northwest Power Act of 1980, the creation of the NPPC, and its 1983 fish and wildlife programme, marked the addition of anadromous fish concerns as a major basin-wide management issue (Rodewald 1999).

Table 4.6.1. Stages of GCD Project Operations

Time Period	Characteristics
1940s to 1950s	- Power generation at the project level
1950s to early 1970s	- Power generation at the project level - Flood control at the project level - Irrigation
Early 1970s to early 1980s	- Power generation at the system level - Flood control at the system level - Irrigation - Environmental impact mitigation at the project level
Early 1980s to present	- Power generation at the system level - Flood control at the system level - Irrigation - Environmental impact mitigation at the system level (particularly for anadromous fish)

In 1990, BPA, the Corps, and Reclamation used the environmental impact statement process under NEPA to conduct a joint review of 14 major projects in the basin (including the GCD) to develop an overall system operating strategy that would balance the varied, and sometimes conflicting, needs of all water users in the basin (see Table 4.6.2). For example, flood control requires reservoirs to be drawn down in early spring, whereas resident fish require stable reservoir levels year round. The final report, the *Columbia River System Operation Review Final Environmental Impact Statement*, was issued in 1995 and outlines the general system operating strategy for GCD that is used today (Jaren 1999; Rodewald 1999; MacKay 1999).

Table 4.6.2. Optimal Conditions for Different Types of River Uses

River Use	Description
Anadromous Fish	Streamflows as close to “natural” river conditions as possible, with main-stem reservoirs well below spillway levels.
Cultural Resources	Stable reservoir elevations year round
Flood Control	Reservoirs drafted in early spring to capture snowmelt inflows
Irrigation	Full reservoirs during the growing season (March to September)
Power	Reduce or eliminate non-power operating constraints on the system
Resident Fish	Stable reservoirs year round, with natural river flows
Recreation	Full reservoirs during the summer (May–Oct) and stable downstream flows
Water Quality	Natural river flows with minimum spill

Source: USDOE et al., 1995 (Main Report): 4-2.

Because GCD is a large storage project relative to other projects in the basin, it plays a key role in system-wide operations concerning both power generation and flood control. The natural flow of the Columbia River is not well correlated with the temporal pattern of power demand. In the US Northwest, power demand is highest in the winter and lowest in the summer, whereas the natural flow pattern of the river would have high flows in the spring and summer and low flows in the winter. Thus, the purpose of large storage projects like GCD is to adjust the river's natural flow pattern to mirror power demand more closely (DOE et al, 1992). This entails storing spring and summer snowmelt in reservoirs for eventual release in the fall and winter. For the most part, this pattern of reservoir operation is also compatible with flood control requirements, which require capturing spring and early summer runoff. However, at times, this operating strategy can be in direct conflict with operating requirements for other project purposes, such as recreation and flow augmentation for the maintenance of anadromous fish.

Details of how GCD operates in relation to specific project purposes (eg, flood control, hydropower generation, and anadromous fish) are discussed in other sections of this report and in the Annex titled "System Operations — Hydropower, Flood Control, and Anadromous Fish Management Activities". The discussion below concerns the general approach to operating GCD in light of all the project's various purposes.

4.6.2 Current GCD Operations

Current GCD operations reflect trade-offs among various project purposes. For example, recreational users want reservoir elevation to be high in the summer, but this may conflict with flood control needs, which can call for elevations to be low in the summer to accommodate incoming runoff. For GCD, Reclamation develops operating requirements specific to irrigation at CBP, and BPA requests reservoir levels for power within those limits, given flood control constraints and anadromous fish needs.

The three main functions that are managed on a system-wide basis in the Columbia River Basin are hydropower operations, flood control, and anadromous fish enhancement measures. The specific details of operations that pertain specifically to these functions are discussed in the Annex titled "System Operations — Hydropower, Flood Control, and Anadromous Fish Management Activities".

Besides power generation, flood control, irrigation, and anadromous fish, other major operational components of the project include resident fish and recreation. For irrigation, reservoir levels must be at a minimum level (1 240ft, or 327m) so that irrigation works function properly. While only about 3% of the river's flow is withdrawn for irrigation at GCD, the combined effect of these withdrawals, along with other water uses, is important. Storing water in reservoirs to meet irrigation demands alters river flow for other uses (eg, flow augmentation) Irrigation activities for projects in FCRPS are managed on a project-by-project basis, however, certain irrigation system requirements are taken into consideration when planning for system-wide operations.

Table 4.6.3 illustrates the various constraints that determine how GCD is operated. For example, from January to April, flood control criteria dominate. Irrigation pumping runs from March to September, and the reservoir must be at or above a certain level to satisfy irrigation requirements. From May to September, the "Technical Management Team" (TMT), an interdisciplinary group representing the operating agencies (ie, the Corps, Reclamation, and BPA), NMFS, the tribes, and other groups working on anadromous fish conservation, convenes by teleconference weekly to determine how GCD operations might be conducted so as to enhance conditions for anadromous fish. Over the summer months, recreational interests desire the reservoir level to be around 1 285ft (339m). And in September and October, reservoir levels are supposed to be between 1 283ft (339m) and 1 285ft (339m) to enhance kokanee spawning.

Table 4.6.3. Grand Coulee Dam Operating Constraints

Month	General Operating Constraints for Power
January	• Operate to higher of 1 260ft (333m) reservoir elevation or 85% confident of refill to flood control rule curve by 10 April
February	• Operate to higher of 1 260ft (333m) reservoir elevation or 85% confident of refill to flood control rule curve by 10 April
March	• Draft to higher of 1 240ft (327m) or 85% confident of refill to flood control rule curve by 10 April • Begin irrigation pumping
April	• Operate to flood control rule curve • Continue irrigation pumping • Inchelium Ferry out of service if reservoir elevation level less than 1 225ft (323m)
May	• Target 1 240ft (327m) reservoir elevation level for irrigation pumping • Begin work of TMT • Spill Memorial day through 30 September for laser light show
June	• Refill to 1 285ft (339m) for recreation (can be overruled by TMT) • Continue TMT • Continue irrigation pumping • Continue spill for laser light show
July	• Operate to maintain reservoir elevation of 1 280ft (338m) to 1 290ft (341m) • Continue TMT • Irrigation pumping continues • Continue irrigation pumping • Continue spill for laser light show
August	• Must reach reservoir elevation level of 1 280ft (338m) by end of August (10ft (2.64m) draft from July elevation required by TMT for anadromous fish) • Continue TMT • Irrigation pumping continues • Continue spill for laser light show
September	• Maintain reservoir elevation at 1 283ft (339m) for kokanee spawning • Continue TMT • Irrigation pumping continues • Continue spill for laser light show
October	• Maintain reservoir elevation of 1 283ft (338.7m) to 1 285ft (339.2m) for kokanee spawning • Beginning mid-October operate to meet requirements of Vernita Bar (ie, minimum flow between 80 and 100 kcfs)
November	• Operate to meet requirements of Vernita Bar (ie, minimum flow between 80 and 100 kcfs) through Sunday prior to Thanksgiving
December	• Provisionally draft reservoir elevation level to 1 270ft (335m) to 1 280ft (338m) • NMFS biological opinion draft limit of 1 265ft (334m) reservoir elevation level if cold snap occurs

Sources: BPA, 1999; McKay 1999.

4.7 Evolution of Basin-wide Planning Institutions[142]

As detailed in the Annex titled “Attempts at Comprehensive Planning for the Columbia River Basin,” a valiant effort was made during the 1930s and 1940s to create a new institution for comprehensive planning in the Columbia River Basin: the Columbia Valley Authority (CVA). Despite the efforts of its promoters, CVA never became a reality. Failure to create CVA ended any hope of a comprehensive basin-wide planning body for the region.

BPA was initially created in 1937 as a temporary entity (then called the “Bonneville Project”) to market power from Bonneville Dam. It became a permanent agency charged with marketing the power generated at all federal dams on the Columbia River, including that produced at GCD. World War II — which accelerated so much economic development in the US Northwest, and which made the power from the Bonneville and Grand Coulee dams so vital to aluminum production, not to mention the atomic works at Hanford, Washington — created the circumstances that forced BPA into existence. Once in place, BPA made itself, if not indispensable, at least vital in the overall power picture. As historian Richard Lowitt writes, "The Bonneville Power Authority [sic], a temporary expedient, by default remains to this day the primary federal authority promoting regional interests" (Lowitt, 1984: 170).

Long term squabbles between Reclamation and the Corps, and the reluctance of US Northwest residents to surrender the economic future of their region to some unknown and untested body also helped kill the CVA idea. Post-war fear of communism tainted centralised planning in general and caused many to repudiate what they had seen as so necessary in the 1930s. The Korean War shifted attention away from the CVA issue. (Richardson, 1973; 37-38.) All of these factors conspired to end any hope that a long range, co-ordinated regional planning vehicle, or even a lesser agency to deal in a comprehensive way with only power issues, could be created.

BPA has emerged as it exists today, out of the ashes of the CVA concept, along with the often-confusing collection of other state and federal agencies that share the sometimes-overlapping responsibilities for the health and economic welfare of the US portion of the basin. Between World War II and the ratification of the Columbia River Treaty in 1964, BPA, Reclamation and the Corps dominated in terms of decision-making for hydropower. Once the treaty was in force, a fourth powerful agency, BC Hydro, played a key role, and the focus on hydropower in operations was broadened to include flood control. As fisheries-related issues became more prominent in the 1980s and ’90s, other actors, such as the NPPC and NMFS gained influence over the decision-making process, and decision-making became much more open than it had been in the past.

This sketch of historical developments only hints at the institutional complexity that exists today. Concurrently and separately, the Federal Power Commission, the Washington State Department of Public Works, the Washington State Department of Conservation and Development, the State Planning Council, the Northwest Resources Association, Washington State College, and the University of Washington, not to mention the numerous federal agencies, are all taking a hand in planning and developing the US Northwest, and they are only a sampling of the many national, state, and local bodies with intertwined jurisdictions (Mitchell, 1967: 39).

This ongoing proliferation of agencies has inevitably resulted in duplication of effort and cases where agencies, unable to work together and unco-ordinated, have missed or ignored cautions presented by others. The most striking example might be the current plight of the salmon. The USFWS warned in the 1940s that without proper planning, the dams proposed by the Corps would seriously endanger the annual salmon runs (McKinley, 1952: 385-388).[143] Also, in 1946, local agricultural agencies, through the Columbia Basin Inter-Agency Committee, warned that proposals by the Corps were made without much study of or knowledge of the agricultural agencies that would be affected. (McKinley, 1952: 416-420) In 1952, Reed College Professor Charles McKinley outlined the benefits that might come from increased co-operation and co-ordinated regional development: “Unified planning, programming, and control of investment in basic drainage-basin development must be provided in the interest of financial prudence and maximum financial and economic return on the large outlay required.” (McKinley, 1952: 448)

Concerns about salmon, however, were hardly new and had been expressed as early as the turn of the 19th century (Netboy, 1980: 28). Despite the severe depletion of the runs long before the advent of any Columbia River dams, little attention was paid to the salmon, except by some fishermen and scientists. And the history of salmon mismanagement is only one example of an issue where co-ordination and long-term vision might have yielded a more favourable outcome. Other notable planning and management failures in the US Northwest concern the unsatisfactory handling of issues related to Indian tribes whose lands and fisheries were affected by dam construction, inefficient and costly duplication of studies and development plans (eg, both agencies conducted comprehensive basin-wide studies during the 1930s), and increased pollution in all its forms.

The history of the failed attempts to plan effectively the long-term use and development of the Columbia River demonstrates, if nothing else, the evanescent nature of goals and priorities, let alone conflicting economic and political interests and jurisdictions. For example, the very nature of "conservation" has changed from "best and wisest use" to "preservation of biological diversity" over the last nine decades. While the plethora of federal, state, and local agencies that operate in the US Northwest can be inefficient because of duplication and contention, there is no proof that a unified planning agency, given rapidly changing values and conditions over time, would have produced a more satisfactory long-term result. There are, after all, limits to what planning can accomplish, given the unpredictable nature of major socioeconomic events like economic depressions and wars. The influx of "dust-bowl" refugees to the US Northwest during the 1930s, and the greater migration of workers brought by World War II dramatically altered the economy of the region in ways hardly predictable.

Despite the lack of a CVA or anything like it, federal and local agencies co-operated when conditions forced it. There was growth and development beyond anything predicted in the 1920s or 1930s. And CBP produced a viable economy that balanced agriculture and industry. What difference centralised planning would have made is both debatable and unascertainable.

5. Distribution of Benefits and Costs

5.1 Anticipated Beneficiaries and Cost Bearers

Having detailed the projected, actual, and unintended effects of GCD and CBP, we now examine those affected by looking at predicted and actual beneficiaries and cost bearers. The Butler Report provided a comprehensive discussion of the predicted beneficiaries (and to a lesser extent, cost bearers) of GCD and CBP. Since the Butler Report was completed prior to the passage of the Flood Control Act of 1936, which introduced the requirement that benefits must exceed costs for Corps projects in order to be authorised by Congress, a strict benefit-cost analysis was not undertaken (Eckstein, 1958: 47). In terms of distribution of costs and gains, Major Butler made it clear that power revenues would have to subsidise irrigation. He reiterated this point in a 1932 hearing of the US House of Representatives by indicating that the costs of irrigation development were so high that without the subsidy from power revenues irrigation could not bear the costs of development (US Congress, 1932: 46). Although the Butler Report does not include a benefit-cost analysis, it does provide a very detailed economic analysis that incorporates direct and indirect benefits (USACE, 1933: 1037-49).

In his economic analysis, Butler placed the benefits of the Columbia Basin irrigation project into three general categories: (i) direct benefits in the form of profits to farmers and local and regional businesses; (ii) indirect benefits in the form of increased farmland, urban land, and franchise values; and (iii) public benefits in the form of an increased supply of produce for consumption and processing, as well as reduced food prices. Butler argued that the first and third types of benefits are worthy of federal subsidy while the second kind "forms an assessable asset upon which an estimate of the economic feasibility of the project may depend" (USACE, 1933: 1049). Butler valued these benefits at $217 483 875 ($2 600 000 000 in $1998) (USACE, 1933: 1049), [144] $33 million more in 1932 dollars (390 million in $1998) than the estimated cost of construction. He recommended a land tax in order to assess beneficiaries other than CBP farmers (USACE, 1933: 1050).

Similarly, the Reclamation Report called for assessments to be charged to beneficiaries, stating that "it will be necessary that the State of Washington, municipalities, and all interests benefiting within the irrigation district contribute toward the direct cost in proportion to such benefits" (USBR, 1932: 81). The Reclamation Report recommended an ad valorem tax on all properties that benefited (USBR, 1932: 117). Owners of properties that benefited were expected to bear costs in proportion to the benefits they received.

The Butler Report discussed briefly the people upstream that would be relocated because of reservoir creation. Three bridges (one rail and two highway) that cross the Columbia River upstream would need to be torn down with construction of the dam. In addition, "a number of small towns, several miles of highway and railroad, and a considerable area of tillable land would be inundated". (USACE, 1932: 747). Butler also reported that during periods of low flow, the head of the Washington Water Power Company's Little Falls Dam would be reduced 10ft to 12ft (3 to 3.7m). In addition, the Fish Hawk power site would be completely submerged. In an earlier part of his report, Butler stated:

> *The high dam would submerge the city of Marcus and about 15 miles* [24km] *of the Great Northern Railway Company's branch lines, as well as above mentioned power sites. The flowage area would include isolated tracts of cultivated land closely adjacent to the river and principal tributaries and also some higher areas that could be irrigated economically by pumping. Otherwise, damage to agricultural interests would be sligh.t* (USACE, 1933: 612)

Neither the Butler nor the Reclamation reports mention the effect GCD and CBP would have on the Colville and Spokane tribes.

Existing farmers were also predicted to be disadvantaged by CBP. Major Butler discussed the possible effect of an increase in cultivated land on farmers: "Farmers as a class receive no direct benefit. They are, in fact, damaged by the increased competition, particularly if the increased production of new land is sufficient to reduce prices. This fact forms the basis for opposition to any plan for increasing production." (USACE, 1933: 1039) Butler tried to address this concern by recommending that CBP only be approved when the demand for land and agricultural products required the development of new farmland.

5.2 Major Project Beneficiaries and Cost Bearers

The effects of GCD and CBP on major beneficiaries and cost bearers are summarised in Tables 5.2.1 and 5.2.2. A matrix graphically depicting the distribution of benefits and costs of the project is presented in the Annex titled "Distribution of Benefits and Costs".

Table 5.2.1 Major Project Beneficiaries

Group	Main Project Benefit(s)
Irrigators and associated agribusiness	• Subsidised water, power, and land
BPA ratepayers (eg, public utilities, DSIs)	• Inexpensive power
Downstream residents	• Flood control protection
Recreators who use project-related facilities and recreation-related commerce	• Use of recreational facilities • Tourism-based commerce • Augmentation of resident fishery resources
US Northwest economy and residents	• Socioeconomic development of US Northwest • Growth of regional industry • Creation of metropolitan cities
BC Hydro ratepayers	• Inexpensive power

5.2.1 Major Beneficiaries

5.2.1.1 Irrigators and Associated Agribusiness

As planned, irrigators and the agricultural sector in Washington State were primary project beneficiaries. As of 1998, there were 660 794 acres (267 400ha) receiving some form of project water (including groundwater). Section 3.1 provides details on gross crop values returned to these lands. Farmers have benefited from the project by receiving water and power at subsidised prices. Farming communities have also benefited from the infrastructure created as a result of the project, including roads and educational systems. The crops produced in the project area have also supported a major food-processing industry. All this activity would not have been possible without a tremendous investment by the federal government (ie, the US taxpayer). BPA ratepayers through the "irrigation assistance" programme discussed later in this section will eventually pay for a large portion of project costs allocated to irrigators for the capital costs of the project.

5.2.1.2 BPA Ratepayers

The project has also been a boon to BPA ratepayers, which include public utilities and select industrial customers (DSIs). The FCRPS, of which the GCD is a key component, supplies roughly 75% of the US Northwest's power needs at rates well below the national average.

5.2.1.3 Downstream Residents

A substantial number of Oregonians and Washingtonians enjoy increased flood protection from the upstream series of 14 dams that provide storage capacity in the Columbia River system. GCD is the largest source of active storage in the US portion of the basin. In conjunction with an extensive system of levees, FCRPS dams and the Columbia River Treaty projects provide substantial flood control protection to population centres of Portland, Oregon, and Vancouver, Washington. Additionally, GCD also provides for local flood protection in the immediate vicinity of the project area.

5.2.1.4 Recreators and Recreation-related Commerce

Many recreators — engaging in activities such as boating, fishing, hunting, and wildlife viewing—have benefited from facilities provided by the Lake Roosevelt National Recreation Area, the GCD, and the multitude of seep ponds and wetlands within CBP's irrigation command area. A major recreational activity enjoyed by anglers is fishing for certain species of resident fish that are now plentiful in the project area. While recreational uses of the facilities do not receive the same priority as other project purposes, the net benefits to recreators in Washington State as well as visitors from other US states and other countries have been significant. Annually, project-related recreational facilities generate approximately three million visitor days. Extensive use of recreational facilities in the project area also supports recreation-related commerce in towns such as Grand Coulee, Coulee Dam, Davenport, Quincy, Moses Lake, and Kettle Falls.

5.2.1.5 US Northwest Economy and Residents

GCD and CBP have been instrumental in the socioeconomic development of the US Northwest. During dam construction, the project provided jobs to thousands of workers. After the project was completed, low-cost power attracted important industries to the area, such as aluminium processing, shipbuilding, weapons development, and aeronautics. The defence industry that sprang up in the region contributed to employment and technology helped the Allied Forces emerge victorious from World War II. Additionally, inexpensive power supplied to publicly owned utilities has facilitated the growth of regional hubs such as Seattle, Washington and Portland, Oregon.

5.2.1.6 BC Hydro Ratepayers

Electricity in the Canadian portion of the Columbia River Basin that is sold by BC Hydro is less expensive than it would be otherwise because of Canada's participation in the Columbia River Treaty. Canada used the payments it received from the Columbia River Treaty to build major water resource projects in British Columbia. If Canada had not received the financial benefits from the Treaty, it was prepared to construct coal-fired powerplants in British Columbia.

5.2.2 Major Cost Bearers

Table 5.2.2 presents the project's major cost bearers, which include Native Americans and First Nations tribes, individuals concerned with maintaining the integrity of ecosystems, commercial and sport fishing interests (for anadromous fish), non-indigenous people forced to resettle, US taxpayers, farmers outside the CBP area, and upstream residents and businesses.

Table 5.2.2 Major Project Cost Bearers

Group	Main Project Cost(s)
US Native American and Canadian First Nations Tribes	• Loss of anadromous fish and associated impacts • Loss of land and homes because of inundation • Inconvenience of resettlement
Individuals concerned with maintaining ecosystem integrity	• Loss of anadromous fish and associated aquatic and riparian ecosystems • Loss of river in its natural state
Commercial fishing interests in the US and Canada	• Adverse affects on commercial salmon industry
Sport fishing interests	• Loss of anadromous fisheries
Non-Native Americans forced to resettle	• Loss of land and homes because of inundation • Inconvenience of resettlement
US taxpayers	• Paid for construction of much of CBP
Some US farmers outside CBP area	• Increased competition from CBP farmers
Upstream residents and businesses	• Loss of land and forest resources, jobs, and tax revenues • Indirect effects via impact of Canadian Treaty dams • Increased competition from CPB-supported agriculture

5.2.2.1 Native Americans and First Nations Tribes

The groups of people that bore the major cost of the project were US Native Americans and Canadian First Nations tribes whose livelihood and culture were permanently and significantly altered by the project. The project's main direct effect was the inundation of lands and the elimination of anadromous fish runs upstream of the dam site. The creation of this physical barrier resulted in the termination of spawning that had traditionally occurred in the Columbia River Basin upstream of GCD.Tribes dependent on catching salmon upstream of GCD, such as the Colville, Spokane, and Nez Perce, were forced either to go elsewhere to fish or to cease fishing for salmon and steelhead entirely. This change caused adverse economic, cultural, and social changes because salmon had previously played a central role in the cultural, religious, economic, and social activities of the tribes. Additionally, the construction of the reservoir forced the relocation and resettlement of approximately 2 000 members of the Colville tribe and between 100 and 250 members of the Spokane tribe.

Some adversely affected tribes have shared in the benefits of the project. For example, the Spokane and Colville tribes receive income from recreational users of Lake Roosevelt, but the compensation amount has been small.[145] While some reparations have been made to affected tribes (eg, a 1994 US government settlement with the Colville tribe), many tribal members feel that monetary reparations cannot make up for the adverse effects of GCD on their livelihood and culture. Types and levels of compensation has also varied among the tribes (eg, thus far, the Spokane have only been compensated for the taking of their land, and not for other adverse effects), and this has contributed to inter-tribal tensions. First Nations in Canada are planning to take actions to receive compensation for their losses, but those actions have not yet been initiated.

5.2.2.2 Ecosystem-related Impacts

Major aquatic and terrestrial ecosystems have been adversely impacted by the project. The physical barrier and large reservoir created by GCD have resulted in significant adverse environmental effects, the most salient of which are negative impacts on anadromous fish populations in the upper Columbia River Basin. While not the sole cause of anadromous fish decline in the upper basin, the construction and operation of GCD exacerbated already poor conditions. Ongoing operations of the dam, in conjunction with other projects on the Columbia River system, add to the problem (eg, by reducing downstream outmigration flows and increasing in-stream dissolved gas concentrations). Natural seasonal fluctuations of the river have been altered to better meet some human needs, particularly those associated with power production, flood control, and irrigation. It was not until the mid-1980s that changes were made in system-wide project operations to address increasingly serious fish recovery issues. Although a GCD-related hatchery programme (the GCFMP) was initiated in the early 1940s, the programme assumed that future losses of salmon and steelhead to the region could be remedied artificially by a programme based on hatcheries and fish transplantation. There are divergent views on the extent to which hatcheries have been able to compensate for the loss of wild salmon and steelhead, but there is wide agreement that biodiversity has been reduced by GCFMP.

The ecosystem that now exists in the vicinity of GCD and CBP, as well as the entire Columbia River Basin, is markedly different than the original, pre-project landscape. The Columbia River is no longer a natural, flowing river with distinct seasonal fluctuations in flow. GCD, along with other large dams constructed along the river have transformed the nature and type of the flow regime, affecting factors such as river flow rates, temperature, and nutrient content. Large storage reservoirs, like Lake Roosevelt, also create a very different set of conditions for aquatic and riparian biota. Terrestrially, high desert has been replaced with irrigated farmland and seep ponds. Individuals who value the aquatic, riparian, and terrestrial ecosystems in their natural state can also be considered major cost bearers in the sense that the natural conditions that existed before the project can no longer be enjoyed.

5.2.2.3 Sport and Commercial Fishing Activities Related to Anadromous Fish

Because it was constructed without fish passage facilities, GCD formed an impassable barrier for fish that traditionally spawned in the upper Columbia River Basin. Consequently, the project clearly had an adverse effect on commercial and sport fishing that occurred upstream of the dam. In 1937, annual losses to commercial and sport fishing were estimated to be between \$250 000 and \$300 000, the equivalent of \$2.8 to \$3.4 million in \$1998.

5.2.2.4 US Taxpayers

US Treasury funds were used to construct the initial structures for the GCD and CBP in the 1930s and 1940s. To date, 24% of the total project cost has been paid for, mostly from hydropower revenues. Since there is no interest on money used to construct irrigation works and there is a 50-year repayment period (that starts 10 years after initial development of an irrigation block), no money for this portion of the project has yet been repaid. BPA will begin making payments to the US Treasury for a portion of the construction costs allocated to irrigation beginning in 2009.

5.2.2.5 Non-Native Americans Forced to Resettle

The construction of the project resulted in the inundation of over 70 000 acres (28 300 hectares) and displaced between 2 000 and 4 000 non-Native American settlers. Those forced to resettle were not provided any relocation assistance by the federal government, and many were dissatisfied with the amount of compensation they received for their land.

5.2.2.6 Some Farmers Outside the CBP Area

While the CBP project clearly benefited project area farmers, it had adverse effects on other farmers in the region (eg, wheat farmers in Idaho) because subsidies to CBP irrigators made their operating costs lower. These lowered operating costs have enabled CBP farmers to accept a lower price for their crops, giving them an advantage over farmers growing the same crops, but not receiving the same assistance.

5.2.2.7 Upstream Residents and Businesses

GCD was instrumental in the development of the Columbia River Treaty, and the Treaty called for the construction of three dams in Canada (Duncan, Mica, and Keenleyside). Canadians in British Columbia and Montana residents in the area affected by the Canadian Treaty dams were adversely affected in terms of loss of land, forest resources, jobs, tax base, and disruption of agricultural activities. These dams also affected recreation and fisheries. These effects were indirect outcomes of the GCD. While the reservoirs behind the Treaty dams provide new recreational opportunities, there are divergent views on this subject. Many residents of BC believe the Canadian Treaty dams caused significant adverse effects on regional recreational activities. Also, as mentioned, Canadian First Nations tribes were directly adversely affected by GCD, primarily because of loss of salmon in the upper Columbia River Basin.

5.3 Stakeholder Perspectives

From July to October of 1999, we conducted 21 structured interviews with stakeholders representing various interests in GCD and CBP (see Annex titled “Stakeholder Interviews” for list of interviewees). People interviewed included Native American tribal elders, CBP farmers, local government officials, and the staff of environmental organisations. Because the sample is small and was not selected at random, we make no claims regarding the representative nature of the views we heard. Nevertheless, results from these interviews provide some insight on how different groups view GCD and CPB’s costs and benefits, and they help to identify areas of convergence and divergence on the development effectiveness of the project as a whole.

Our analysis of the interview data indicates two areas of apparent convergence among all interviewees. First, most interviewees identified the primary beneficiaries of the project as irrigators (and the associated agricultural sector), power users, and the residents of the US Northwest generally. Second, most interviewees identified Native Americans as the project’s primary cost bearers. Interviewees’ opinions diverged on whether or not the overall benefits of GCD and CBP justified their costs. They also had divergent views about other groups (aside from Native Americans) that shouldered project costs, and about who else (besides irrigators, power users, and US Northwest residents) benefited from GCD and CBP. Further explanation of the interview results is presented below according to the two sub-groups of respondents that shared similar views.

5.3.1 Tribes and Environmental Organisations

Generally, the nine interviewees we spoke with who represented tribal entities and environmental groups had similar perspectives on the benefits and costs of the project. In aggregate, they viewed the major beneficiaries as irrigators, power users (ie, public utilities, citizens, and large aluminum companies), and residents of the US Northwest who gained from the overall socioeconomic development of the region. They saw the Native American tribes, sport and commercial fishing interests, and the US citizens generally (from an ecosystem loss perspective) as the primary cost bearers. Additional stakeholder input from the Canadian perspective was captured during a WCD meeting held in Castlegar, British Columbia. Attendees at this meeting voiced the opinion that First Nations tribes that had traditionally depended on upstream salmon spawning also suffered many of the same adverse impacts as Native American tribes in the US.

When asked if, on the whole, GCD and CBP's negative impacts were acceptable given the benefits generated, there was no consensus. Responses ranged from considering the project totally unacceptable, to viewing the project as "a wash," to seeing the project as providing a net gain. Native American tribal elders we interviewed viewed the project as totally unacceptable, regardless of gains.

As the following observations of a Colville tribal elder demonstrates, the impacts on many Native Americans and Canadian First Nations members were adverse, severe, and irreversible.

> *The dam really did affect us. The Sanpoil lost their fishing grounds and their land, their traditional ways. I was brought up that way . . . It hurt us in a lot of ways . . . We lost Kettle Falls. My family used to go fishing there . . . Our traditional ways, fishing, land, pretty much everything we did for survival was hurt by the dam . . . What we got from the claims payments was just peanuts compared to what we lost. We have to go to the Coast hatcheries to get salmon for our dinners here . . . Losing our land was what really hurt. The first time they came and bought some, then they came back to buy more. A lot of people said, 'when's it going to stop? We're always giving and get nothing.' They gave us a little money and took a lot.* (Sam 1999)

Further insight on the views of Native Americans is given by the following remarks made by a Spokane tribal elder.

Our ceremonies and spirituality were based on the rivers. When the dam went in it changed everything. It changed our way of life from hunters and gatherers to farming. It changed our spirituality and cultural realm . . . We hardly had time to relocate graves. Thousands of our ancestors went floating down the river and lots of historical sites were inundated. Farms and homes were destroyed. If they had done this to another groups of people, the mindset would have been different. The tribes were looked down upon and not given any consideration . . . Promises were made that everything would be taken care of for us . . . [but] *we never received compensation for that dam.* (Seyler 1999b)

Some interviewees representing environmental groups viewed the project as a net positive, but emphasised that there were significant negative environmental impacts of the project. They also felt that some groups, such as irrigators and large aluminum companies received a disproportionate share of the project's benefits, while others, namely Native Americans and US citizens generally, bore most of the costs associated with ecosystem damage. The selected quotes below demonstrate a variety of these views.

On balance, I think the gains from low cost power were not worth the loss of the fisheries. It was a net negative. We are now trying to undo those effects. Our efforts reflect changing values, changing technologies, and changing relationships with water and land. (Ransel 1999, American Rivers)

How can you balance [project benefits] against an irreplaceable loss? The genetic makeup of salmon has changed and in this sense the damage to salmon cannot be reversed in our lifetime. Citizens of the Pacific Northwest lost because salmon is part of the culture here . . . Losing the salmon is like cutting off a piece of one's self. There is an existence value to salmon, even to people who do not actually use the river. Salmon is an icon. (Patton 1999, Northwest Energy Coalition)

Looking at the big picture, the region would not have developed the way it did without the Grand Coulee Dam, but the fish runs were decimated. The project had both good and bad effects (Myron 1999, Oregon Trust).

The project has brought net economic benefits to the Pacific Northwest, even in retrospect, it seems like a worthwhile endeavor from the power perspective, but not for irrigation . . . The Columbia Basin Project is the poster child for subsidized agriculture in the Pacific Northwest. It was a signal that agricultural development would not be market-based, but involved heavy federal intervention . . . Irrigators got subsidized power, subsidized water. They [the irrigators] *made out like bandits. I can't see* *any costs that they incurred . . . The aluminum companies didn't locate here for the bauxite, they located themselves near dams because of cheap power. One-third of the power in the Federal Columbia River Power System goes to them. The tribes were most adversely affected. They lost their traditional fisheries. Their culture was destroyed.* (Bosse 1999, Idaho Rivers United)

5.3.2 Local Governments, PUDs, and CBP Irrigators

The other main sub-group of interviewees represented governments of communities near GCD and Lake Roosevelt, a public utility district, and CBP farmers. Generally, the 12 individuals we spoke with shared many similar perspectives on the benefits and costs of GCD and CBP. In aggregate, they viewed the major beneficiaries as irrigators and associated agribusiness, power users (ie, public utilities, citizens, and large aluminum companies), residents of the US Northwest who gained from the overall socioeconomic development of the region, local towns, and recreators. They saw the Native American tribes as the primary cost bearers, but felt that the tribes also benefited from the project (eg, through tourism) and that the tremendous net positive impacts of the project far outweighed the costs to this one group. The following observations help illustrate the views of these stakeholders.

> *If you look at the positive benefits* [of the project] *— power, flood control, fish, agriculture, wildlife — every one of those is impacted in a positive way. Steamboat Rock and Potholes [Reservoir] are highly used. There is upland hunting game for birds. There is fishing in Banks Lake and Potholes, too. There are recreational activities and wildlife. The project has stabilized the agricultural economy. It gave a base load for power production, and it was redesigned so it can handle peak loads. It has the ability to reduce flood damage in Portland. It added $650 million in crops per year to the Columbia Basin. It affects employment for the Northwest. It made agriculture the number one industry in Washington. Without the CBP, you would have a completely different picture.* (McDaniel 1999, South Columbia Irrigation District)

> *We would not be here if it was not for Grand Coulee Dam. Essentially, this was a wasteland before the project was here. The only thing here before was jackrabbits and coyotes . . .* [The project has definitely had a positive effect on me] *. . . I started to see the transformation of this wasteland into viable agricultural farms. I started to see communities grow. I started to see wildlife habitat develop. I started to see the desert bloom and all the benefits that came from Grand Coulee Dam to development.* (Tom Flint 1999, CBP farmer)

> *The project has had a major positive effect [in an area] that otherwise would not have any economic base. The Columbia Basin Project has generated income for the economy. Without the water to grow crops, there wouldn't be anything here . . . .In a majority of cases, 90% or more, people have been positively affected by the project . . . Even the tribes have been impacted positively. The tribes have casinos;* [without GCD and CBP] *they wouldn't have the population base to support their services. On the other hand, people will say Grand Coulee Dam has no fish ladder and yes, there has been some loss of salmon runs. If we look at the overall benefits versus costs, you can't say this would be a salmon economy* [without GCD]. *In 85% to 95% of cases it's been positive. In a few cases it's been negative. The greater social and economic good has come* [from GCD]. *We can have a strong economy and allocate resources to help salmon. Without a strong economy, we can't recover the salmon. The tribes are aware of that — the funds* [for salmon mitigation programmes] *come from hydropower revenues . . . The negative impacts are small compared to the positive impacts. We need to look at the overall benefit of the project. There's always going to be costs. In this case, the overall impact has been positive.* (Staff[146] 1999, potato farming organisation)

> *I'm sure the loss to Indians that were affected was severe, but on a nationwide level, the benefits of the project were significant. Over history, from the big picture perspective, the irrigation and direct and indirect benefits of the project were enormous. The defense industry and the aluminum companies wouldn't have developed here if it weren't for the dam.* (local government official[147] 1999)

5.3.2 Cost Allocation and Repayment

The total cost of the GCD and CBP in nominal dollars (dollars in the year they are spent) is approximately 1.875 billion (USBR, 1998c). [148] Repayment costs are allocated to a variety of different purposes, with some of the costs categorised as “reimbursable” and others categorised as “non-reimbursable”. Reimbursable costs are those that are to repaid by the project’s beneficiaries. For GCD and CBP, the main categories of reimbursable costs are for power and irrigation. Non-reimbursable costs are those borne by the federal government because certain purposes of the project are viewed as national in scope (USGAO, 1996). For the project, the main categories of non-reimbursable costs are navigation and flood control, which are grouped together.[149]

5.3.3 Cost Allocation

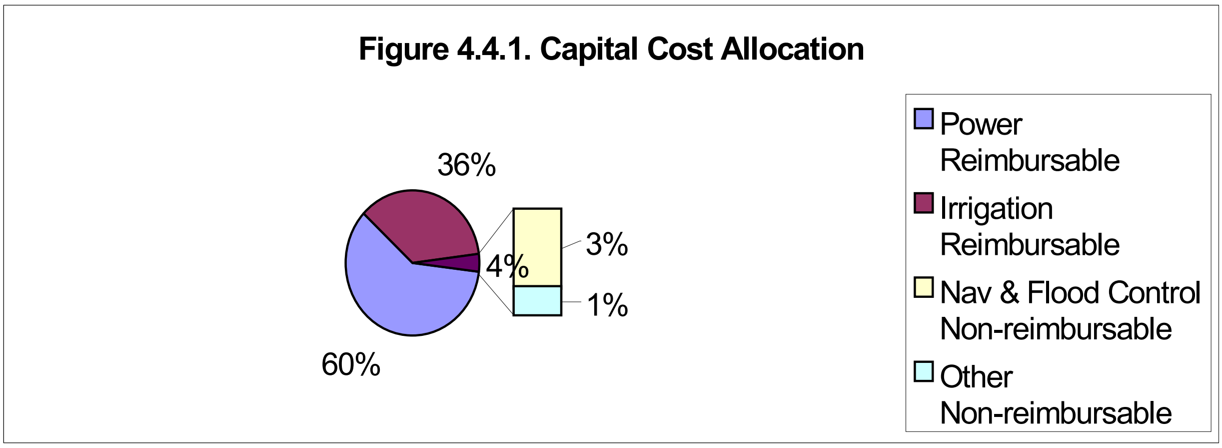
Under federal reclamation law, the amount of reimbursable costs a water user must repay varies by the type of user. For CBP, as in many water resource development projects in the US, irrigators — irrigation districts that have contracted with the federal government to repay the costs of constructing a project — are responsible for repaying their allocated share of a project’s construction costs. Under what are called Section 9(d) contracts, irrigators are only responsible for their share of the project’s estimated construction costs, as determined by their “ability to pay,” and they are not required to repay interest that accrues either during construction or the repayment period (USGAO, 1996; Reiners 1999).

Repayment obligations for power generation include the cost of constructing hydropower-related facilities and interest during construction, interest during the repayment period, and what is known as “irrigation assistance” (USGAO, 1996). “Irrigation assitance” is defined as the difference between the irrigators’ allocated share of a projects construction costs (including interest) and the amount the irrigators actually repay. In the case of GCD and CBP, BPA will use FCRPS revenues to augment payments made by the irrigators to make up for the difference in capital construction costs for the irrigation portion of the project. Non-reimbursable capital project costs are paid for by the US Treasury (ie, the US taxpayer).

The major categories of cost allocation for the capital portion of the GCD and CBP are presented in Figure 5.4.1. The figure shows that the vast majority of project costs, 96%, are allocated to reimbursable expenses, with 60% ($1.126 billion) allocated to power, and 36% ($670 million) to irrigation. About 4% of the project’s capital costs are allocated to non-reimbursable categories, with navigation and flood control accounting for 3% (USBR, 1998c).

Total annual operation and maintenance (O&M) costs are currently about $43 million dollars. Of that, about $29 million (67%) is allocated to power, about $2.7 million (6%) is allocated to irrigation, about $3.6 million (8%) is allocated to non-reimbursable flood control, and about $3.3 million (7.6%) allocated to non-reimbursable land resource management (USBR, 1998c). In contrast to capital costs, project beneficiaries for reimbursable O&M costs pay for their own share (ie, no direct subsidies exist) and beneficiaries pay the O&M costs they are allocated. In the case of power usage for irrigation, however, power prices paid for pumping water through the irrigation works is well below market cost (Bolin 1999; Patterson, 1999).[150] Non-reimbursable O&M expenses are paid using US Treasury funds and they are paid off annually.

Figure 4.4.1 Capital Cost Allocation



Source: USBR, 1998c.

5.3.4 Repayment

Thus far, about $445 million (24% of the total project cost in nominal dollars)[151] has been paid to the US government (USBR, 1998c). As of 1998, irrigators had paid in about $51 million (less than 3% of total project cost, about 12% of total repayment) of the total project cost (USBR, 1998c). Revenues collected by BPA from power sales had repaid about $389 million (about 20% of total project cost, and about 88% of total repayment) (USBR, 1998c).

Irrigation assistance, as of 1997, was to be approximately $585 million, which is 87% of the project cost allocated to irrigation (USBR, 1997c). This means that irrigators will eventually pay 13% of their allocated project cost. Since there is no interest on these payments, the revenues will be deposited lump sum in the US Treasury according to the date specified in the contract for each irrigation block.

For any particular block, repayment must be complete 60 years after the first year in which development to deliver water to that block begins. The repayment period is 50 years, but the repayment period does not start until 10 years after the first development year. Irrigation water development first began in CBP "irrigation block No. 1" in 1949. Thus, the 50-year repayment period for this block began in 1959. The last blocks to receive irrigation water (blocks 26 and 461) started receiving water in 1985. Payments for irrigation assistance will be deposited in the US Treasury from BPA on behalf of the irrigators beginning in 2009 and continuing through to 2045 (USBR, 1997c). Thus, in the case of CBP, federal funds were used to pay for the construction costs of the irrigation works, and repayment will not begin until the end of the 50-year repayment period for each irrigation block. This type of repayment plan has further monetary implications when the opportunity cost of money is considered. Money used to construct these facilities cannot be used for other federal investment purposes. Moreover, when the costs are eventually repaid, they will not represent the total net present value of the investment because they are repaid in nominal dollars with no interest. The difference between the net present value of the investment and what is actually repaid will never be recovered by the US Treasury, and some economists would consider this an additional subsidy to irrigators (Patterson, 1999).

The case of GCD and CBP exhibits characteristics similar to other federal irrigation projects in the US. For example, in a GAO (1996) examination of 133 water projects, when the repayment obligation is adjusted through irrigation assistance and charge-offs, many irrigators were only scheduled to repay a small fraction of construction costs. In the case of CBP, 87% of irrigators' construction cost allocation has been shifted to other beneficiaries, namely FCRPS ratepayers and US taxpayers. Another general conclusion reached by the GAO study was that because irrigation assistance is for capital costs at no interest and because costs are scheduled to be repaid at or near the end of a project's repayment period, few power revenues have been transferred to the federal government to date for this purpose. In the case of GCD and CBP, BPA will not begin to deposit irrigation assistance monies into federal government coffers for the project until 2009. Thus, prior to 2009, the US Treasury will have paid for a substantial fraction of expenditures for the project, and those Treasury outlays will be repaid without interest.

5.3.5 Basin-wide Accounting

All projects in FCRPS are grouped together as part of a basin-wide accounting system. Under this type of system, the revenues and costs generated by projects in the system are pooled into a common fund, in this case, the FCRPS. Reclamation's rationale in creating this kind of system has been described as follows:

> *By the late 1930s, the high cost of projects made it increasingly difficult for Reclamation engineers to meet economic feasibility requirements. In the early 1940s, the Bureau devised the plan of considering an entire river basin as an integrated project. It enabled the agency to derive income from various revenue-producing subfeatures (notably power facilities) to fund other works not economically feasible under Reclamation law. Thus, by offsetting construction and development costs against pooled revenues the Bureau was able to demonstrate the economic feasibility for the entire, pooled programme*. (Michael Robinson, as quoted by Reisner, 1993: 135)

The basin-wide accounting system has been criticised for obscuring "bad projects" (ie, projects that are not economically feasible). By being lumped together with more economically viable projects, irrigation projects that are not economically feasible can be made to appear feasible by using revenues generated by hydropower (Reisner, 1993: 134-137). For example, of the 23 hydroelectric projects that comprise the FCRPS, power-generating costs for the GCD are the fifth lowest.[152] If GCD were a single purpose hydroelectric project, it probably would have paid for itself long ago. However, since GCD is part of a linked system, that includes both profitable and non-profitable projects, power revenues generated by GCD are often used to cover the costs of other projects in the system. The practice of basin-wide accounting is widespread among Reclamation projects, including systems of projects in the Colorado, Missouri, and Bighorn river basins (Reisner, 1993).

6. Options Assessments and Decision-making Processes

6.1 Decision to Build a Dam at the Grand Coulee[153]

Serious efforts to promote construction of a dam at the Grand Coulee started in 1918 when Rufus Woods, publisher of the *Wenatchee Daily World*, printed an article trumpeting the merits of an irrigation scheme for the Big Bend area based on diverting water into the Grand Coulee from a nearby dam on the Columbia. During the same year, Elbert Blaine, chairman of the Washington State Railroad Commission, detailed an alternative approach, one that involved bringing water from the Pend Oreille River at Albeni Falls in Idaho and carrying it through 130 miles (209km) of channels, tunnels, and reservoirs to the Big Bend area. This scheme came to be known as the "gravity plan," while the proposal supported by Rufus Woods and his associates was often called the "pumping plan". The plans were competitors, and each had a number of enthusiastic supporters in eastern Washington.

Between 1918 and the early 1930s, there were frequent debates over the merits of the gravity plan in comparison to the pumping plan. Among the principal advocates of the gravity plan was a Spokane-based group whose members were opposed to the provision of public power, particularly power generated by the federal government that would be sold at rates below the price of electricity generated by private companies. Promoters of the pumping plan included boosters from the CBP area, led by, among others, Rufus Woods, James O'Sullivan, and a small group from the Ephrata area. They envisioned GCD and CBP as a locally controlled project that would serve as the linchpin of an agro-industrial empire in the Big Bend region.

Serious opposition to both the gravity plan and the pumping plan came from two significant sources: farmers nationally who decried extending irrigation onto new land during a time of oversupply, lost markets, and low prices; and congressmen from outside the western states who opposed the federal irrigation programme to reclaim arid land. Other potential opponents, particularly sports and commercial fishermen, and spokespersons representing Native American and Canadian interests, were largely absent from debates on the gravity and pumping plans.

Advocates of the gravity plan were dealt a serious blow in 1932 when the Corps released its voluminous study of a general plan for the Columbia River Basin. This document, often called the "308 report," after house Document No. 308 of 1926 authorising the Corps to prepare plans for the Columbia and numerous other river basins, dismissed the gravity plan because of its high cost per irrigated acre. In contrast, the Corps' report found that a high dam at the Grand Coulee could provide irrigation water at prices that farmers could repay, provided that most of the costs of delivering irrigation water was paid for by those who consumed the electricity to be generated by the proposed dam.

The portions of the 308 report concerning the Columbia River above the Snake River had been prepared under the supervision of Major John Butler of the Seattle district office of the Corps. Most of Major Butler's report focused on power and irrigation. Flood control was dismissed in a few pages because Butler felt that floods would not pose a problem on the Columbia River above its confluence with the Snake River. Consequently, his investigation did not pursue the idea of using upstream storage to prevent flood control in the lower basin. The companion report on the Columbia River below the Snake River, which was prepared by Major Oscar Kuentz of the Portland district office, did consider flood control. It concluded that, "the regulation of the flow from storage in the upper part of the stream (ie, the upper Columbia, Clark's Fork, and Kootenai River Basins) would be difficult and the costs involved would not be justified by savings in probable flood damages" (USACE, 1933: 1737). The report by Kuentz recommended use of levees to control flooding in portions of the Columbia River below the Snake River that were subject to flooding.

In the more than 1 800 pages that comprise the 1932 Corps reports on the Columbia River, only a few pages concern fisheries. These pages, which are in the portion of the report concerning the Columbia River below the Snake River, concentrate on commercial fishing resources and a probable need to construct "fishways" to allow migrating fish to get past dams above 75 feet (23m) in height.[154]

Following normal Corps procedures, the reports prepared by Butler and Kuentz were reviewed by the Army's Board of Engineers for Rivers and Harbours. In commenting on the proposed dam at the Grand Coulee, the Board felt that Major Butler significantly overestimated the rate at which electricity generated at the dam would be absorbed. The Board was also impressed by the opinion of the US Secretary of Agriculture, who opposed the introduction of new agricultural lands because farm surpluses were high, prices of agricultural commodities were low, and farmers throughout the US were struggling badly.

The Board's analysis was accepted by the Chief of Engineers who, in reporting to Congress, did not propose federal development of a dam at the Grand Coulee. Instead, the Chief of Engineers made the following recommendation:

> *That the power developments on the Columbia River shall be made on application of local governmental authority or private interest under restriction of the Federal Water Power Act.* (USACE, 1933: 5)

The Chief of Engineers concluded that no license for construction of hydropower projects on the Columbia River should be issued unless those projects were consistent with the general plan for combined development of navigation and power as recommended by the Board of Engineers for Rivers and Harbours, subject to modifications by the Chief of Engineers and the Secretary of War.

Reclamation, which up to that point had been conducting its own, far less comprehensive studies of a dam at the Grand Coulee, took exception to the pessimistic view of the Chief of Engineers.[155] Elwood Mead, Commissioner of Reclamation from 1924 to 1936, indicated that it would take decades to complete all of the engineering works needed to bring irrigation water to farms. In the interim, sufficient demand would exist for both electricity generated at the dam and crops produced on the newly irrigated lands. The Commissioner reasoned as follows:

> *It will require at least ten years after the works are authorized, to build the dam and a powerplant, and another 10 or 15 years to absorb the power thus made available. These things must precede the large expenditure to build the works required for irrigation. By that time the increasing population of the cities of Spokane, Seattle, Tacoma, and Portland, and all the other cities and towns of the Northwest, will provide a local market for the products of these farms. They will be an essential element in the economic and prosperous development of this region.* (USACE, 1933: 5)

In the end, the 1932 reports prepared by the Corps and Reclamation and the congressional debates on the merits of GCD were not the deciding factor. Instead, it was Franklin Delano Roosevelt, the newly elected president in 1932, who managed to move the project forward. Roosevelt had run on a campaign to bring the country out of economic depression, and the prospect of putting thousands of people to work building dams like GCD was an important component of the president's programme. Moreover, Roosevelt and his advisors were eager to reduce price gouging by private power companies and make electricity more widely available at low cost. For both these reasons, in July 1933, the Roosevelt administration allocated $63 million in Public Works Administration money for a low dam at Grand Coulee to be built by the state of Washington. This dam would generate hydroelectric energy, but it would not provide sufficient storage for irrigation water. In November 1933, the low dam was made a Reclamation project with costs to be repaid by revenues from hydropower generation. Although some preliminary construction had started in 1933, the first major contract — in the amount of $29.3 million — was awarded in July 1934.

As a result of the often enigmatic and convoluted political, engineering, and economic events described in the Annex titled "Shift from Low Dam to High Dam at Grand Coulee" the Roosevelt administration amended its original plan and in July 1935 directed Reclamation to proceed with a high dam at Grand Coulee, one that would permit storing enough water to irrigate over one million acres in the Big Bend region. Roosevelt was convinced that a high dam at the Grand Coulee could meet his administration's goals of providing relief to unemployed workers, cheap public power, and a planned relocation of farmers who were struggling to eke out a living on poor farmlands in other parts of the county. The high dam would provide the basis for the project originally detailed by Major Butler: irrigation of the Columbia Plateau using revenues from hydropower to offset the otherwise excessively high cost of irrigation.

Although Roosevelt attempted to have the high dam at the Grand Coulee paid for using Public Works Administration funds (thereby short-circuiting the Congressional authorisation process), a Supreme Court decision in 1935 forced a change in plans. Based on the Court's decision, the Roosevelt administration moved to have the high dam at the Grand Coulee, along with numerous other dams, authorised by Congress in the Rivers and Harbors Act of 1935 (US Congress, 1935). In enacting this law, Congress, authorised GCD for purposes of flood control, navigation, stream flow regulation, storage for and delivery of stored waters, and reclamation of public lands and Indian reservations. The generation of electric energy was to be used "as a means of financially aiding and assisting such undertakings”.

6.2 Early Attempts to Compensate Native Americans for Expected Losses[156]

Native Americans in the upper Columbia River Basin recognised that GCD would cut off the salmon runs on which they depended for subsistence and other purposes, and they took the steps available to them in an attempt to mitigate the loss. Their principal interventions occurred before 1935, at a time at when GCD was still a Washington state project. Following federal law, the state of Washington had applied for a permit as required by the Federal Power Act 1920. In response to vigorous protest by the Colville tribe, that federal permit contained provisions requiring the state of Washington both to construct fish ladders and to make annual payments to the Colville and Spokane tribes for tribal lands flooded by the reservoir.

Circumstances changed dramatically after GCD was made a federal project because Reclamation was not required to obtain a permit under the Federal Power Act. According to Reclamation’s interpretation of statutes existing at the time, no law required it to compensate the tribes.

Notwithstanding Reclamation’s legal position, early correspondence between the Commissioners of Indian Affairs and Reclamation, endorsed by Secretary of the Interior Harold Ickes, expressed the understanding that the federal government would pay the tribes for a share of power revenues generated from water on tribal lands. Indeed, in a letter dated 22 December 1933, Ickes instructed Reclamation to make sure that the interest of the tribes in the dam “be given careful and prompt attention to avoid any unnecessary delay.”(Ickes as quote by Harden, 1996: 144, 250) By the late 1930s, however, high government officials had concluded that the Colvilles, Spokanes, and other executive order upper Columbia River tribes had no greater rights to fish than any other citizens.

6.3 Columbia Basin Joint Investigations

Because of the fundamental importance of power revenues in the overall scheme to repay the federal government for the cost of the dam and irrigation works, it was always anticipated that irrigation facilities would not be built until after the powerplant at the GCD was in operation. World War II delayed initial construction of the irrigation works. However, as the war progressed in the early 1940s, the federal government engaged in an elaborate process of planning for the irrigation within CBP lands. The Reclamation Act of 1939, which applied to CBP, called for the kind of orderly and systematic planning advocated by New Deal leaders.

As part of this orderly planning process, the Columbia Basin Joint Investigations were launched. These studies explored 28 potential problems that fell into 16 categories. From 1941 to 1943, over 300 people representing about forty agencies, as well as private sector organisations (eg, railroads and chambers of commerce) pursued questions, such as the following:[157]

- What types of crops and crop programmes are best suited to the project area?
- How can excessive use of irrigation water be prevented?
- What is the optimum size of farm units, and how should farms be laid out?
- Should downstream activities, such as power projects below the GCD and Columbia River navigation, be assigned an "equitable share" of the cost of the dam?
- At what annual rate should lands be brought into the project?
- How many new villages should be created, how should they be designed, and where should they be located?
- What other infrastructure services (eg, roads, railroads, and electricity), recreational resources, community centres, and so forth, were required for the area?

6.4 Acreage Limitations and Anti-Speculation Statutes

Even as GCD was being constructed, the Roosevelt administration had become concerned that word of the planned irrigation in the project area would cause individuals to buy up land with hopes that land prices would rise and windfall profits could be made by selling at inflated prices. In response, the Interior Department sponsored the Anti-Speculation Act, which was passed by Congress on 27 May 1937. This statute limited each project farm in CBP to 40 acres (16ha) for an individual, and 80 acres (32ha) for a husband and wife. Holders of land exceeding those limits could sell their land, but only after the government appraised the land based on its value before irrigation water had been delivered. The price for excess holdings had to be set at or below this appraised value.

In recognition of the continuing difficulties that farmers had in repaying their debts to Reclamation, the Reclamation Act of 1939 granted irrigators on new projects a ten-year grace period before having to start what was, by then, a forty-year repayment schedule with an interest rate of zero. The Anti-Speculation Act passed two years earlier also contained provisions concerning repayment. Two major conditions were that: (i) some CBP costs could be charged off to flood control and navigation; and (ii) farmer's obligations were to be based on their ability to repay, rather than actual construction costs.

The Columbia Basin Joint Investigations provided the basis for the Columbia Basin Project Act, which Congress passed in 1943, and then soon amended (in response to settler concerns about powers granted to the federal government). This law and its amended version (signed 10 March 1943), was sponsored by Reclamation and the Interior Department, and it replaced the Anti-Speculation Act of 1937. The Act also reauthorised the CBP and brought it under provisions of the Reclamation Act of 1939.

The Columbia Basin Project Act stipulated that the government could not deliver water until contracts were signed by Reclamation and irrigation districts. (By 1943, three irrigation districts had been formed in the project area: Quincy, South, and East districts.) Significantly, the Columbia Basin Project Act allowed farm units to range in size from 10 to 160 acres (4ha to 64ha), depending on land quality, and it allowed owners of record before 1937 to retain up to 160 acres (64ha) regardless of the quality of their land.

Speculation was controlled with the following provision: for five years after irrigation water first arrived, a farm owner could not sell land for more than the value of the land before water had been provided. The shift in the maximum size of holdings from 80 acres (32ha) in 1937 to 160 acres (64ha) reflected a concern that if land holdings were too small, settlers would be unable to make a living off their farms. The 160-acre (64ha) limit, while thought to be adequate, was low enough to maintain the vision of CBP as a means to support small family farms, not the large corporate farms that have come to be referred to as “agribusiness”. As time progressed, however, further relaxation of maximum farm size requirements became necessary because of changes in farm technology that made it impossible for farm families to survive on 160-acre (64ha) plots.

7. Criteria and Guidelines: Policy Evolution and Compliance

This section examines the evolution of policies affecting GCD and CBP in the period following construction of CBP in the mid-1950s. In general, we introduce these policies in chronological order. However, in some cases there is an overlap in time. In order to eliminate any confusion, Table 7.1 lists the order of topics considered in this section.

Table 7.1 Evolution of Project-related Policies After the Mid-1950s

Policy	Date(s)
Columbia River Treaty	1944–1964
Pacific Northwest Co-ordination Agreement	1964
Authorisation and construction of Third Powerplant	1966–1975
National Environmental Policy Act	1970
Northwest Power Act	1980
System Operation Review	1989–1995
ESA Listings of Snake River salmon	1991–1995
Decision not to irrigate CBP second-half lands	1984–1994
BPA-Reclamation direct funding agreements	1993–1996

7.1 Columbia River Treaty

During the early 1940s, discussions began on the possibility of using storage of the Columbia River within Canada to enhance the ability of GCD to generate power and control floods. In March 1944, the US government referred the matter of increased storage on the Columbia River to the International Joint Commission (IJC), a body created in 1909 under the Boundary Waters Treaty between the US and Canada. The International Joint Commission created an International Columbia River Engineering Board (with two members from each county) to analyse the situation.

The IJC had not made much progress on the matter until after the massive flood of May 1948. In the wake of the enormous damage caused by this flood, the key US agencies in charge of managing the Columbia — the Corps, Reclamation, and BPA — were eager to push ahead with upstream storage projects. This extra storage could be used to capture excess flow during wet periods and make it available during periods when the river lacked sufficient flow to turn all the generators at GCD. These three agencies produced a 1948 report demonstrating that new storage in the US and Canada would, once and for all, solve downstream flooding problems.

Work on the upstream storage issue progressed slowly, as the US and Canada differed on how much the US should compensate Canada for the increased water that would be supplied to US generators. Canada also sought compensation for the reduction in flood damages that would result from storing wet weather flows behind dams in British Columbia. It took over 20 years to move the IJC from the initial 1944 referral to the point at which the US and Canada could agree on how the benefits from storage facilities on the Columbia River in Canada would be allocated. As detailed in the Annex titled "Negotiating the Columbia River Treaty," numerous stumbling blocks along the way involved domestic politics in both countries as well as the normal complexities of international treaty negotiation.

On 16 September 1964, an exchange of diplomatic notes between the US and Canada had the effect of bringing the Columbia River Treaty and Protocol into force. These documents included provisions for the following:[158]

- Canada would complete Duncan Dam by 1968, Arrow Lakes (later named Hugh Keenleyside Dam) by 1969, and Mica Creek Dam by 1973, to provide a total of 15.5 MAF (19 100 million m^3) of storage; the dams were to be operated for power and flood control in the US. (These three dams are referred to hereafter as the "Canadian Treaty dams".)

- To compensate Canada for its costs, Canada would be entitled to receive one half of the additional power and flood control benefits produced downstream in the US. The US paid Canada a one-time sum of $64.4 million (about $340 in $1998) upon completion of the Canadian Treaty projects for one half of the present worth of the estimated US flood damages prevented through 2024.
- Canada and the US agreed to determine the downstream power benefits based on the estimated increase in dependable capacity and average annual usable energy in the US from the operation of the three Canadian Treaty dams; these increases are calculated relative to the US reservoir storage system operation that existed in 1961, and assuming that all downstream US projects are operated for optimum power and flood control.[159]
- The Treaty permitted the parties to operate the Canadian Treaty dams in ways that would produce additional benefits to both parties.[160]
- The Treaty allowed the US to build Libby Dam in Montana and inundate associated land in Canada; the 4.98MAF (6 100 million m^3) of storage was to be operated for flood control and other purposes.

When the Treaty was implemented, the Canadian province of British Columbia (BC), which had accepted the treaty benefits and obligations on behalf of Canada, decided to build projects on the Peace River in northern BC at the same time that it built the required projects on the Columbia River. Since there was no immediate need for all this power, British Columbia elected to sell the Canadian entitlement for the first 30 years of each project, and it negotiated a deal with a consortium of companies in the US. This sale specified full payment up front, and BC used this payment to cover a significant portion of the construction costs associated with the Canadian Treaty dams.

The Columbia River Treaty had specific plans for only two water uses: hydropower and flood control. The central idea was to use upstream storage to change the shape of the Columbia River's hydrograph: the magnitude of the peak flows, which typically occur in May and June, were to be reduced, while the relatively low flows occurring in fall and winter were to be increased. With a more uniform flow regime, more power could be generated and the potential for flood damage reduced. Three agencies were charged with implementing the Columbia River Treaty: BC Hydro, BPA, and the Corps.

A provision of the Treaty permits the parties to agree to any real operation that produces additional benefits for both parties compared to the basic operation for power and flood control. This provides considerable flexibility in implementation. The main requirements of joint operations are that agreement between the two nations is required and that both parties benefit. This condition has sometimes been interpreted to mean that accommodating water quality enhancements (and other uses aside from hydropower and flood control) cannot take place unless payments are made by beneficiaries of these other uses. However, this view is not necessarily true. In fact, there are many examples in which Canada and the US have agreed to an operation for fish mitigation, and both countries have lost small amounts of hydropower. In these cases, agreement was reached because both parties considered the modest hydropower loss to be more than offset by the other benefits of the revised operation. (The US and Canada generally agree to several such non-power operations each year.) Flood control is still considered to be of primary importance, and flood control operations are not compromised for other project purposes, including hydropower.

7.2 Pacific Northwest Co-ordination Agreement

The co-operation in river operations in the US envisioned by the Columbia River Treaty is reflected in a 1964 accord called the Pacific Northwest Co-ordination Agreement (PNCA). This agreement takes the form of a contract that defines obligations for BPA, Reclamation, the Corps, and most major US Northwest hydropower project owners. These obligations concern system-wide operations planning, exchanges of power between utilities, and the determination of headwater benefits owed to upstream reservoir owners. No project owner is required to operate its facility according to the plan, but deviations from the plan incur power obligations. The agreement is founded on the notion that the Columbia River power system is connected in terms of both hydraulics and electric power: upstream storage influences downstream hydroelectric power generation. By co-ordinating operations of dams as if they were owned by a single organisation, the overall benefits to co-operating parties can be much greater than if each party operated as an independent, self-optimising entity.

PCNA defines “firm power” by assuming that flows will be at the lowest level recorded in the past half century. These flows are translated into firm power projections used in meeting each party’s obligations. Each year, an Annual Operating Plan is drawn up for the entire US portion of the Columbia River Basin, and the parties co-ordinate their operations to maximise power production after satisfying non-power water uses. The Agreement also includes provisions concerning payments for upstream water releases that benefit downstream generators and compensation (in the form of “in lieu” energy payments) when water held at one dam decreases energy generation at a downstream dam.

7.3 Authorisation and Construction of Third Powerplant

The Columbia River Treaty cleared the way for the addition of GCD’s Third Powerplant.[161] It also guaranteed the additional power needed by BPA to create a power "intertie," in which BPA sold Canada’s share of the Columbia River Treaty power in the Southwest during periods when the power was an unwanted surplus in the Northwest.

Although Congress appropriated $125 000 in 1952 for a feasibility investigation of the Third Powerplant, plans for the facility could not be implemented until adequate upstream storage was developed. Although 2.98 MAF (3 646 million m^3) of additional upstream storage had been created by Hungry Horse Dam in 1954, and another 1.1 MAF (1 346 million m^3) was created by the Albeni Falls Dam ten years later, it was only the prospect of 15.5 MAF (18 964 million m^3) of usable power storage provided by the Canadian Treaty dams that made it feasible to go forward with the Third Powerplant (Norwood, 1981: 247). On 14 June 1966, Congress authorised the Third Powerplant at GCD (US Congress, 1966), and construction began in 1967. The first unit in the powerplant started generating electricity in 1975, and the sixth and final unit was completed in 1980. The total cost of constructing the Third Powerplant (in $1998 dollars) was approximately $2 934 000 000 (USBR, 1998c).

7.4 Environmental Impact Assessment Requirements

On 1 January1970, President Nixon signed into law the US National Environmental Policy Act (NEPA), which is best known for its requirements related to the preparation of environmental impact statements (EISs). Under the Act, agencies of the federal government are required to prepare EISs when their proposed actions will have “a significant impact on the quality of the human environment”. Citizen participation is an important feature in the process of preparing EISs. Indeed, citizens must be notified of the decision to prepare an impact statement, and they must be invited to participate in the preparation of the scope of work to be performed in preparing the statement. In addition, citizens have opportunities to review and comment on a draft version of an EIS, and they have opportunities to challenge the adequacy of the final version of an EIS using the federal courts.

The first application of NEPA in the context of GCD and CBP occurred in 1975, when Reclamation issued a draft EIS for CBP. At the time, the Third Powerplant was under construction, and about 8 750 acres (3 540ha) were being brought under irrigation in block 251 of CBP. Notwithstanding that these actions were already in progress, Reclamation was required to prepare an EIS because NEPA did not exclude from its requirements projects already under construction. The 1975 draft EIS provided an overall review of the entire project, beginning with the initiation of construction of GCD in 1933, and continuing on to the development of irrigation works and the Third Powerplant. Although the draft elicited numerous comments from non-governmental organisations and agencies, it is not clear from a reading of the final EIS (USBR, 1976) that Reclamation took (or was required to take) any action as a follow on to the exercise of preparing the EIS.

7.5 Northwest Power Planning Act of 1980

Beginning in the 1970s, the US Congress began enacting legislation that would, directly or indirectly, have significant consequences for how GCD and other dams in the Columbia River Basin would be operated. One of these laws, the Northwest Power Act of 1980 (US Congress, 1980) required that planning for the energy future of the US Northwest involve public participation in a process that considered the full environmental and economic cost of energy alternatives. The Act also required the establishment of a fish and wildlife programme based on recommendations of the region's fish and wildlife agencies, Indian tribes, and others.

Planning under the Northwest Power Act was to be guided by NPPC, a compact composed of representative from four states in the US Northwest. The Act requires that NPPC's programme for offsetting the effects of dams on salmon and other fish and wildlife populations be financed by BPA hydropower revenues and by the federal agencies controlling the dams producing hydropower. BPA pays for mitigation and compensation projects approved by NPPC from power sales revenues. In the late 1990s, 70% of funds were designated for anadromous fish projects, and 15% each for resident fish and wildlife.

The Northwest Power Act of 1980 was a turning point for tribes affected by GCD. The Spokane, Coeur d'Alene, Kalispel, and Kootenai tribes formed Upper Columbia United Tribes (UCUT) in 1982 to represent the executive order tribes above the GCD in dealing with NPPC. The Colville tribe joined UCUT in 1999. The Columbia River Inter-Tribal Fish Commission (CRITFC) represents the treaty tribes in the context of NPPC's work. As mentioned in Section 3.7.5 (and detailed in the Annex titled "Native Americans"), Native American tribes have filed several suits against the US government on matters related to GCD, and they have prevailed in a number of them. During the late 1990s, all the Columbia River tribes came together to create a joint Tribal Vision, calling for the protection and restoration of fish and wildlife habitat throughout the basin, the reintroduction of anadromous fish above Chief Joseph and Grand Coulee dams, and increased respect for the sovereignty and spiritual values of native peoples (CRITFC & UCUT, 1999).

7.6 System Operation Review

As mentioned in Section 3.2, BPA, the Corps, and Reclamation operate what is known as FCRPS (ie, GCD plus thirteen other federal dams that dominate in hydroelectric power production on the Columbia and Lower Snake rivers). During the 1990s, these three agencies teamed up to use the EIS process (established by NEPA) to develop a "system operating strategy" for the co-ordinated operation of FCRPS by conducting a System Operation Review (SOR)[162]. As stated in the SOR final report, the review is the "environmental analysis required by . . . NEPA to consider changes in the Columbia River system operations and the effect of those changes on users of the system and the environment" (DOE et al. (Main Report), 1995:1-1).

The SOR was also to be used to examine issues tied to a new PNCA and a new Canadian Entitlement Allocation Agreement (CEAA) (Hyde 1999). The original PNCA and CEAA were signed in 1964 and will expire in 2003. Replacement agreements extending through 2024 were completed in 1997. The CEAA concerns obligations of owners of the middle Columbia River non-federal dams to deliver a portion of the downstream power benefits owed to Canada under the Columbia River Treaty. Canada sold a portion of the downstream benefits to a consortium of US Northwest utilities in 1964; that sale will also expire in 2003. An updated CEAA was needed to meet the Treaty requirements. The middle Columbia River project owners needed PNCA to assure their ability to meet CEAA obligations. The PNCA assured the owners of non-federal projects downstream of GCD that they would receive either streamflows similar to the optimum power operation assumed in the Treaty operating plans or exchanges of power with BPA that compensate them for the difference.

The SOR departed from traditional environmental management practices in the Columbia River Basin in several ways. According to interviews we conducted with federal agency staff, the SOR was a pivotal event in FCRPS operations, marking the first comprehensive, programmatic, and holistic review of all major environmental impacts of system-wide project operations (Brooks 1999; McKay 1999; Rodewald 1999; Jaren 1999). Preparation of the SOR also involved an unprecedented amount of public involvement.[163] Another major difference in approach was that the SOR was geared towards developing adaptive environmental management strategies, as opposed to “one time only” solutions to environmental problems (Jaren 1999).

Conducting the SOR proved to be an enormous undertaking. When completed, the final EIS (ie, the main report) was a document several hundred pages in length, and it was accompanied by over 20 technical appendices.[164] In total, the SOR took about six years to complete. The scoping process alone (ie, the process used to identify the issues the study would investigate) took one year (Jaren 1999). Although exact dollar amounts are not available, the total cost of conducting the SOR is estimated at $20 million ($23.5 million in $1998), with BPA contributing the majority of the funding (Jaren 1999).

Notwithstanding the multiple goals of the SOR, issues related to salmon passage and habitat began to overshadow the review process as the prospect increased that certain species of salmon would become listed as an endangered species under the Endangered Species Act (ESA). This shift was clearly indicated in the final EIS, which makes the following statement about how the need to address anadromous fish issues received increasing priority over the course of the review process:

> *The ESA listings and associated events have had a significant effect on the SOR. While one of the primary goals of the SOR is to decide on a co-ordinated operating strategy to balance conflicting demands on the system, the reality is that the need to help conserve endangered salmon, specifically, and all salmon, generally, has taken precedence over other considerations . . . In short, the single most immediate and salient issue in the SOR is the recovery of endangered runs of wild salmon on the Snake River.* (DOE et al (Main Report), 1995:1-1)

The preferred system operation strategy that was ultimately adopted was driven by the 1995 NMFS Biological Opinion, a plan designed to recover the three species of threatened and endangered Snake River salmon. The overarching goal of this plan was to store more water during the fall and winter to meet spring and summer flow augmentation targets and to manage other detrimental effects by establishing maximum summer draft limits. Actions specific to GCD included ensuring availability of water for summer flow augmentation and drafting during July and August to meet flow targets at Priest Rapids Dam (see Annex titled “System Operations — A Closer Look at Hydropower, Flood Control, and Anadromous Fish Management Activities” for details).

Some observers believe the SOR has had a positive impact on salmon recovery efforts. For example, according to one policy analyst, the SOR “allowed the federal agencies to play a much more constructive role in the salmon debates than they would have otherwise”. (Volkman, 1997: 83). Some federal agency staff we interviewed also believed that the process helped different stakeholders understand the complexity of the system and better understand trade-offs among the various system functions (Jaren 1999; Rodewald 1999; Brooks 1999). One staff member also saw the SOR as providing useful information for guiding future decision-making (Jaren 1999).

However, not all stakeholders were satisfied with the SOR’s process, content, and use. For example, some have criticised the SOR for not using data generated by the project as the basis for decision-making. In the opinion of some federal agency staff we interviewed, some SOR critics felt that, in the end, all the analyses conducted to assess alternative operating strategies were abandoned in light of the pressure to address the 1995 NMFS Biological Opinion (Jaren 1999; MacKay 1999; Brooks 1999). Additionally, some groups, most notably, Native American tribes, environmental NGOs, and agencies with environmental protection responsibilities, were not satisfied with the results of the SOR. For example, in EPA's comment letter to the draft environmental impact statement, the agency makes the following assertions.

> *In our view the draft environmental impact statement (DEIS) fails to comply with the dictate of the National Environmental Policy Act . . . The DEIS lead agencies . . . assert that Appendix C-2 (Juvenile Fish Transportation Program Technical Appendix) constitutes the required "hard look" at the transportation program. We do not agree . . .* [For example] *the analysis fails to adequately consider the negative impacts of transportatio . . . The appendix does not rigorously explore and objectively evaluate all reasonable alternatives to fish transportation . . . Furthermore, Appendix C-2 considers alternatives to transportation in isolation and independent of each other. No discussion of possible combinations of alternatives is included.* (DOE et al (Appendix T), 1995: O-7, O-10)

In commenting on the draft EIS, the Sierra Club also roundly criticised the SOR for, among other things, failing to include other major federal projects in the Snake River Basin above Hells Canyon and all Canadian water in the Columbia under the Non-Treaty Storage Agreements. In addition, the Sierra Club argued that the preferred alternative was not consistent with the system operation strategy recommended by the region's fisheries agencies and the tribes (DOE et al, (Appendix T), 1995: O-14 to O-23).

The Spokane and Colville tribes also lodged serious criticisms concerning the SOR process itself. The following extracts from letters of comment on the SOR are illustrative:

> From the Spokane Tribe of Indians:
> *Throughout the SOR process we have watched the focus of the federal agencies shift with the political winds until, at this late stage in the Review, we observe the agencies with diligence pointing toward a SOS [system operating strategy] that favours compliance with the ESA to save endangered salmon, despite reliable forecasts of ill effects to other resources if ESA considerations are not modified to accommodate other considerations of equal or greater importance. For the Spokane Tribe, the SOS [system operating strategy] alternative that is being pushed forward threatens to decimate our resident fisheries . . .*
>
> *We cannot continue to participate in a process that has a predetermined outcome . . . The agencies appear to be "railroading" the NEPA review to accommodate closure on the EIS, and seem to be unwilling to open up the process to full participation by the tribes.* (Letter from the Spokane Tribe of Indians in DOE et al (Main Report Exhibits), 1995)

> From the Colville Confederated Tribes:
> *Along with 13 other tribes included in the SOR EIS, the CCT* [Colville Confederated Tribes] *is concerned and offended that Native Americans were not meaningfully included in the early stages of the process . . . The CCT [Colville Confederated Tribes] feels that the Federal government established the boundaries of the "playing field," made the rules, and then reluctantly invited us into the game. This was not done in a spirit of cooperation.* (DOE et al (Appendix D Exhibits), 1995: D-2)

7.7 Endangered Species Act Listings and NMFS Biological Opinions

By the mid-1980s, concern was growing about dwindling populations of wild salmon and steelhead in the Columbia River Basin (see Section 3.5 for details). The pervasive weakness in wild runs prompted several petitions to list certain salmon populations under the Endangered Species Act (ESA), a national policy that protect endangered species and requires the establishment of a species recovery plan. The listing of three species of Snake River salmon (and to a lesser extent Snake River steelhead) has had a dramatic effect on project operations. Table 7.2 presents key dates in the listing timeline.

Table 7.2 Key Events in Snake River Salmon and Steelhead ESA Listings

Date	Event
November 1991	• Snake River sockeye listed as endangered by NMFS
April 1992	• Snake River spring/summer run chinook listed as endangered by NMFS • Snake River fall run chinook listed as endangered by NMFS
August 1994	• Snake River spring/summer run chinook listed as endangered by NMFS • Snake River fall run chinook listed as endangered by NMFS
March 1995	• NMFS issues Biological Opinion concerning recovery of endangered Snake River salmon runs
August 1997	• Snake River Basin steelhead listed as endangered by NMFS

Sources: NMFS (Northwest Region), 1995; NMFS, 2000

Collectively, these rulings require that the federal operating agencies (ie, Reclamation, BPA, and the Corps) consult with NMFS on annual river operating plans. This, in turn, led to a number of interim operating changes.

During the early 1990s, federal agency responses to species listings were governed by a series of Biological Opinions released by NMFS. The Opinions outline what is required for species recovery. For example, in light of the events in 1991 and 1992, at a system-wide level, flow augmentation of up to 3 MAF (3.7 billion m^3) on the Columbia River was added to be stored in the winter and released in the spring during low runoff years.

In March 1995, NMFS presented a set of revised measures aimed at species recovery over the 1994 to 1998 time period (NMFS, 1995). After NMFS issued its March 1995 Biological Opinion, the federal operating agencies strove to adopted NMFS' general recommendations in determining a preferred system operating strategy. The overarching goal of this plan was to store more water during the fall and winter to meet spring and summer flow augmentation targets and to manage other detrimental effects by establishing maximum summer draft limits. (See Section 3.5 for details.)

7.8 Decision Not to Irrigate Second-Half Lands

On 2 August 1994, Reclamation sent out a public letter to stakeholders interested in the fate of the EIS process related to the continued development of irrigated farmland on the Columbia Basin Project (USBR, 1994a).[165] In this letter, James Cole, Manager of the Upper Columbia Area Office, stated that a decision had been made "to defer further action on the DEIS [Draft EIS] until more information concerning" the new emphasis on water conservation by Reclamation and the uncertainty regarding flow requirements for threatened and endangered species was available. Cole's letter resolved one of the most debated issues related to CBP in the last 30 years. Described below is the decision-making process that led to the shelving of plans for continued development of CBP.

As noted in Section 3.1, CBP development proceeded rapidly during the 1950s. By the 1960s, the rate of irrigation block development slowed down because of a number of factors, the most important of which was that the irrigation facilities were operating at full capacity, making it impossible to irrigate new land (Pitzer, 1994: 314). The next step toward expanding CBP required construction of the Second Bacon Siphon and Tunnel. During the late 1960s and early 1970s, Congress appropriated funds for construction of the siphon and tunnel, but the Bureau of Budget cut them. Finally, in 1976, funding was secured and the way was cleared for construction.[166] The Second Bacon Siphon and Tunnel was completed in 1980, and this provided the additional capacity in the canal system to fully irrigate the remaining CBP blocks (Pitzer, 1994: 322; USBR, 1976: I-127).

Reclamation started work on the EIS process for developing the second half lands in January 1984. At scoping meetings held that month, Reclamation presented five action alternatives, including a "no action” alternative (USBR, 1989a: vi). Reclamation selected the consulting firm of CH2M Hill to undertake the study. In November 1986, after consultations with the State of Washington, Reclamation delayed the EIS process while a special Water Conservation Steering Committee reviewed the existing alternatives and issues of water conservation (USBR, 1989a: IV-4). The committee's recommendations led Reclamation to retain three alternatives: Alternative 1, full development of the second-half lands; Alternative 2, enlargement and extension of the East Low Canal; and Alternative 3, no action (USBR, 1989a, vii). Alternative 2, which ended up being the preferred alternative in the September 1989 Draft EIS, would have irrigated 87 000 acres (35 208ha), mostly in the East District. Reclamation advised expansion proponents that there were three prerequisites to further expansion. First, it wanted an expression of local interest and support, in the form of cost sharing, from the State of Washington. Second, it wanted a higher repayment from the irrigators of the expansion lands than is being paid by irrigators of first half lands. Finally, it wanted to include an enhancement plan to ensure fish and wildlife would be an integral part of any project expansion.

The economic feasibility of continued development came up as a major issue during the EIS process. Professor Norman Whittlesey of Washington State University, Pullman, who had already established himself as opposed to the continuation through his testimony in 1984 Washington House of Representatives hearings, was a prominent figure in the debate during the period prior to the issuing of the Draft EIS (Whittlesey 1999; Pitzer, 1994: 328; Erickson 1999). Whittlesey's calculations indicated that the project had an unfavourable benefit to cost ratio. Although Whittlesey and CBP proponents debated the economic issues extensively, the two sides were unable to agree on the economic feasibility of expansion.

Effects of development of the second half on the environment were also contentious in the EIS process. To address environmental concerns, Reclamation developed a fish and wildlife plan. Had the plan been implemented, it would have created several wildlife benefits in the CBP area with very minimal negative impacts. Less than 10 acres (4ha) of native shrub-steppe habitat, most of which was already degraded, would have been lost (USBR, 1993a: 8-1). By comparison, the plan would have created 1 487 acres (602ha) of new wetlands, permanent protection for 11 285 acres (4 567ha) of native shrub-steppe and grasslands, and planting of 7 398 acres (2 994ha) of dry farmland with native shrub-steppe vegetation (USBR, 1993a: 5-5, 8-2).

Issues pertaining to expansion of CBP were complex and often controversial. Numerous groups were either for or against the notion of irrigating the second half lands, and many agencies and organisations were faced with lack of agreement internally. The State of Washington did not take an official position either endorsing or opposing the project. With unresolved cost sharing and environmental issues, including the salmon controversy, state agencies and officials were not able to agree on the propriety of continued development. Staff members within the USFWS, BPA, and even Reclamation itself held divergent views and struggled with the challenge of formulating a consensus. Although environmental groups largely opposed expansion of CBP, members of these groups worked with Reclamation during the EIS process to address environmental concerns. For instance, consistent with its national policy, the Audubon Society officially opposed expansion of CBP; however, members of local chapters provided valuable input in drafting Reclamation’s Fish and Wildlife Plan (USBR, 1993b). In September 1989, Reclamation released the Draft EIS and solicited comments on the document.

By 1990, when three species of Snake River salmon began to be considered for listing under ESA, many of the other issues had been resolved. There was wide agreement on the advantages of Reclamation’s Fish and Wildlife Plan. By using existing facilities, the cost of expanding irrigation had been decreased so that cost sharing options were viable. Although farmers who would potentially receive CBP water had once objected to the high repayment costs, many of those farmers came to view the repayment costs as acceptable. This occurred because as the groundwater supplies continued to be depleted, pumping costs became greater than the cost of repayment.

As the significance of economic and other previously contentious issues began to diminish, the focus shifted to salmon. The debate around salmon became so heated that one irrigation district manager blamed the abandonment of the project on the salmon listings and the political atmosphere surrounding the salmon issue. Comments on the Draft EIS emphasised the need for mitigation plans for anadromous fish. This led Reclamation to prepare a supplement to the Draft EIS. To move the process forward, the irrigation districts made a major concession: they would dedicate 1.6MAF (1 973.5 million m^3) of the CBP water right for in-stream Columbia River fish flows. These flows would be used for spring flow augmentation. This move led NMFS and USFWS to support the plan. In September 1993, Reclamation released its supplement to the Draft EIS, which addressed concerns that had been raised over anadromous fish. However, the anadromous fish plan in the supplemental document did not satisfy some critics who argued that irrigation of the second-half land would still be detrimental to anadromous fish.

Reclamation did not to issue a Final EIS for several reasons. First and foremost, given the widespread concern expressed by stakeholders during the EIS process, Reclamation felt that it was not timely to move forward with a final decision regarding CBP expansion. Reclamation considered the lack of resolution on several major issues: the uncertainty in the US Northwest about issues related to endangered species, and potential contractual and legal problems that could result from the selection of any of the alternatives. Concerns existed among irrigators and within Reclamation that continuation of the process would likely lead to Congressional involvement. If this happened, decisions about CBP expansion might then be further complicated by national issues such as the budget deficit and shifting priorities away from irrigated agriculture, as well as the possibility that Congress might have decided to re-negotiate the CBP repayment contracts on existing developed lands. Because Reclamation was intent on honouring the terms of existing contracts, it wished to avoid this result. Even environmental groups expressed concerns about the proposed dedication of water for the recovery of salmon. While enthusiastic about the offer from the irrigators, environmentalists were uncertain as to the value of spring flow augmentation and the benefits that would ultimately be derived from the proposal.

Another consideration in Reclamation's decision was the likelihood that the complex legal and contractual issue of declaring CBP complete would be raised if the Final EIS resulted in the "no action alternative". Project irrigators did not want CBP to be declared complete until the full acreage was served because when the project is declared finished, the total repayment obligation will be distributed among the existing developed acres. The financial burden per acre is smaller if more acreage is brought into production. Thus, while the South and the East Districts would have benefited the most from project expansion, all three districts will benefit in the long run if more land is developed.

Significant water rights issues that would have been of great concern to the State of Washington as well as water users further complicated the question of declaring the CBP complete. As long as the CBP remains incomplete, it continues to hold the water rights for the entire project. Under Washington state law at that time, if the right to unused CBP water returned to the state, it would have been allocated to other water users. The implications of this complex matter were discussed among various groups and agencies, including officials from the state. The consensus at the time was that Reclamation should not take any action that would lead to a reallocation of water rights and thereby complicate efforts to resolve salmon recovery efforts. Reclamation's decision not to issue the Final EIS eliminated the need to address the issue of CBP completion, and it also left open the possibility of further project expansion at some time in the future.

7.9 Direct Funding Agreements between Reclamation and BPA

Two recent Memorandums of Agreement (MOA) between Reclamation and BPA have markedly affected financial management of the project are. These documents enable specific Reclamation projects, like GCD, to obtain much of their necessary capital and O&M budgets directly from BPA, instead of having to rely on the process of Congressional appropriations. Among Reclamation and BPA staff, these MOA are referred to as "direct funding agreements".

Prior to the MOAs, project budgets were subject to an annual Congressional appropriations process, which could be lengthy and arbitrary (Kent 1999; Clark 1999). BPA, which pays for costs related to hydropower generation at Reclamation projects in FCRPS, did so indirectly, by reimbursing the US Treasury (Kent 1999). In 1993, BPA and Reclamation signed an MOA that allowed BPA to "directly fund authorised additions, replacements, and improvements allocated to power at Reclamation facilities in the Pacific Northwest" (MOA, 1993: 2). This agreement enabled BPA to directly fund equipment replacement and major capital investments at projects like GCD (Kent 1999). Several years later, another MOA was signed between BPA and Reclamation, this time focusing on O&M costs. Under the terms of this MOA, BPA is authorised to directly fund day-to-day O&M costs and small equipment replacements or additions using annual and five-year power budgets to guide estimates of funding (Kent 1999; MOA, 1996).

Reclamation staff we interviewed concerning direct funding included the Director of the GCD Power Office and a Reclamation regional manager (in Boise, Idaho) who helped broker the agreement between the BPA and Reclamation. Both interviewees felt that there were many advantages to this financing arrangement. The observations below provide insight on how the GCD Power Office Director views changes brought about by the agreement.

> *This way* [ie, using direct funding], *it's more efficient. It enables us to act more like a business and takes us out of the political arena. Congressional appropriations are a three-year process. Who can predict what kind of machinery you are going to need in three years? Now, we can make decisions more like a business, from more of a utility standpoint*
>
> *For example, as an improvement, we wanted to replace eighteen old turbines with ones that were more efficient. We showed that this would increase our power production by 400 000 megawatts per year, resulting in an increase in revenues of 10 million dollars annually. It would save us 40 million dollars in seven years. Under the direct funding, this proposal has already gone through with BPA. Under the old practice of having to get Congressional approval, it would have been a much more difficult and lengthy process* (Clark 1999).

Management at Reclamation's regional headquarters in Boise, Idaho echoed the project manager's sentiments.

> *Direct funding allows us to be more responsive. We can also move money around when we need to . . . Previously it was use it* [by the end of the appropriations period] *or lose it. Also, the agreement helps our long-term planning perspective. Now, we are able to look at projects with longer term payback periods . . . Ultimately, the* [memorandums of] *agreement took the politics out of decision-making, which is better for* [BPA] *ratepayers. There is still a check on BPA's budget, which includes the money that they directly fund to us.* (Kent 1999)

8. Lessons Learned

One of the main objectives of the WCD in conducting case studies is to identify what can be learned from past experience with large dams. In this section, we set out the principal lessons learned from our analysis of GCD and CBP. For each lesson, we highlight divergent views held by some stakeholders. The Annex titled "Consultative Meetings and Comments" contains a more complete compendium of the convergent and divergent views expressed in response to the draft version of this report. It includes correspondence we received from stakeholders and statements made at a stakeholder meeting held in Portland, Oregon on 13 January 2000.

8.1 Open Planning Process

Issue:	Stakeholder participation in planning
Components of Project Cycle:	Planning and operations
Lesson:	An open planning process facilitates identifying and resolving conflicts among stakeholders; a closed process serves the opposite purpose.
Evidence:	Inadequacies in opportunities for Native Americans and Canadian First Nations to participate in decision-making has fostered conflicts over GCD for several decades.
Views (divergent):	If you include everyone in the planning process, you can't make a decision. Also those unaffected by a proposed action may claim to be stakeholders and interfere with the process of reaching decisions.

The decision to go forward with GCD was not made in a way that allowed all concerned stakeholders to participate in the planning process. In particular, tribes of indigenous people, both in the US and Canada, had virtually no opportunity to influence the decision to build the dam. This is particularly notable, since the adverse effects on Native Americans and First Nations have been quite significant and many of those effects were predictable.

The case study of GCD and CBP also demonstrates how failure to involve key stakeholders in decision-making can lead to ongoing attacks on aspects of a water resources project long after the project has been constructed. From the very earliest days of the project, Native Americans tribes in the US and First Nations in Canada have been distressed at the ways in which the loss of salmon in the upper Columbia River have affected social, cultural, and economic dimensions of their lives. Given the strength of their feelings, it is not surprising that these previously excluded groups have used every means at their disposal to try to redress what they consider to be a great injustice. In some cases, as described in Section 3.7, tribes have been at least partially successful. Indeed, court decisions in favour of Native Americans on questions related to anadromous fish runs in the upper Columbia River have been extraordinarily influential in changing the way GCD and other FCRPS dams are operated.

The advantages of an open planning process are well demonstrated by procedures used to include stakeholders in the decision on whether or not to expand irrigation to 87 000 acres (35 210ha) of CBP second half lands. In this instance, EIS reporting requirements established by NEPA were used to solicit the views of all affected parties. As detailed in Section 7.7, there were divergent views. However, all stakeholders had an opportunity to be heard, and decision-makers were able to balance stakeholder interests. While the final decision to shelve the proposed CBP expansion onto 87 000 acres (35 210ha) was controversial, it has not been contested.

Some people attending the stakeholder meeting in Portland on 13 January 2000 (see Annex titled "Consultative Meetings and Comments") felt that if the planning process includes everyone with an interest, it will be impossible to reach any decisions. In addition, those individuals felt that people unaffected by the project might claim to be stakeholders and interfere with the process of reaching decisions.

One stakeholder sent us correspondence taking exception to our use of the EIS for expansion of 87 000 acres (35 210ha) of CBP land as an example that demonstrates how stakeholder views can be considered in decision-making. In his opinion, Reclamation's decision to shelve the proposed CBP expansion ignored the citizens affected by the proposed irrigation.

8.2 Managing Debates on Project Operations

Issue:	Managing debates on project operations
Component of Project Cycle:	Operations
Lesson:	In a multipurpose water project, it is common for project purposes (eg, flood control and recreation) to conflict. Because conflicts among various purposes are practically inevitable, a process for managing stakeholder contributions to debates on project operations should be institutionalised on future projects.
Evidence:	Operation of GCD has changed in response to shifts in social values and changing political and economic circumstances. Some stakeholders concerned with resident fish and recreation feel that they lack a productive forum for advocating their interests related to project operations.
Views (divergent):	

The need for a process that encourages stakeholders to participate in planning does not end with project construction. The history of operations at GCD provides ample evidence supporting the existence of continual debates about operations on long-lived water resources projects. In the early stages of GCD, the project was operated primarily for hydropower and irrigation. After the Columbia River Treaty was in place, flood control was given top priority in overall operations of FCRPS. At that point, GCD was operated according to a system-wide scheme that optimised hydropower and flood control, while meeting CBP irrigation requirements. In subsequent years, flow augmentation and spill control to mitigate damage to anadromous fish received increasing attention.

Some of the above-noted project purposes interfere with uses related to recreation and residential fish. During our interviews, individuals concerned about recreation and residential fish frequently complained about the lack of priority given to these project purposes. Broadly speaking, debates on how much priority should be given to each of the principal project-related activities — hydropower, irrigation, flood control, anadromous fish, recreation, and residential fish — have been going on for many years. Shifts in priority for different project purposes are inevitable in the context of a long-lived water resources development project, and it would be beneficial to have a structured process for integrating stakeholder perspectives into the process of deciding which uses to prioritise in project operations over time.

8.3 Incorporating Changing Social Values into Operations

Issue:	Changing social values
Component of Project Cycle:	Operations
Lesson:	For future projects, periodic, planned re-evaluations can provide a mechanism for incorporating temporal changes in social values into project operations. To meet social policy objectives, it might be necessary to reduce uncertainties for stakeholders whose decisions would be influenced by results of re-evaluations.
Evidence:	Support for the social goal of having small family farms located in the semi-arid Columbia Plateau has faded, but long-term contracts with subsidised prices for irrigation water persist; support for maintaining wild salmon and steelhead in the upper Columbia River is much stronger today than it was when the project was planned.
Views (divergent):	Issues related to uncertainty are of critical importance; re-evaluation procedures need to be workable.

As the experience of GCD and CBP demonstrates, changes in social values and political context can be expected during a water resource project's useful life. For projects built in the future, periodic re-evaluations and adjustments would allow decision-makers to accommodate changing political contexts and social values. Support for this finding is given by the experience with aspects of the project related to irrigation. During the 1930s, when CBP was first authorised, the idea that irrigation of arid lands was necessary to provide food for growing populations in the US Northwest, while controversial, at least had some credibility. Today, in the face of the international trade in agricultural commodities, this notion would be difficult to defend. During the past half-century, technological changes in everything from tractors to computers have resulted in extraordinary gains in output per acre of farmland. These productivity gains, coupled with the rise of international trade, have caused the number of farmers in the US to fall since the 1930s. Whereas a century ago, a notable percentage of all Americans lived on farms and ranches, only a very small fraction of the US population is engaged in farming today. The provision of irrigation water to the Columbia Plateau highlights the danger of making long-term commitments to support certain project operations without specifying a fixed future time for re-evaluating those initial commitments. If the farm families on the Columbia Plateau knew many years ago that their ability to obtain subsidised, low-cost irrigation water was going to change at a particular point (or at least that it was going to be seriously re-examined with the possibility that it would change), those farmers would have made very different decisions along the way. Under circumstances that now exist, farmers would feel betrayed by a change in the rules related to water pricing. A significant increase in price might cause enormous social disruption in the CBP area because many families have invested themselves and their futures in farming.[167]

The prospect of future re-evaluations will introduce uncertainties for those making investments based on the current distribution of a project's benefits and costs. Consequently, it may be necessary to introduce contractual mechanisms that reduce uncertainties for stakeholders. The nature of these uncertainties is well illustrated by the circumstances surrounding CBP. Putting a fixed timeline on subsidies to irrigators would have provided flexibility for federal decision-makers, but it would also have introduced much uncertainty to the decision processes of CBP settlers. The result might have been that farmers would have decided not to settle on CBP land or, if they did settle, to make smaller investments to enhance productivity. A case could be made that, in the context of the original CBP objectives, the additional uncertainty would have been undesirable from a social policy perspective.

If the uncertainties associated with periodic re-evaluations might interfere with attainment of social policy objectives, contractual mechanisms could be designed to offset the effects of uncertainty. In the case of CBP, the federal government might have agreed to compensate farmers adversely affected by the results of future re-evaluations as part of the costs of retaining policy flexibility. For example, the initial contracts with settlers might have included provisions for the government to compensate CBP irrigators for part of their capital investments if changes resulting from re-evaluations made it financially infeasible for irrigators to continue farming CBP lands. As another method of reducing uncertainty, the government might have specified, at the outset of a contract, the maximum change the government would be permitted to make at particular future dates.

Issues related to anadromous fish also demonstrate that periodic, planned re-evaluations of a project can be beneficial in accommodating changing social values. During the 1930s, the majority of people in the US Northwest did not rise up in protest over the loss of salmon caused by the first three dams on the main-stem of the Columbia River: Rock Island, Bonneville, and Grand Coulee. And not many people (other than Native Americans and First Nations) seemed preoccupied with the fact that native salmon runs were being reduced and being replaced by runs supported by hatcheries. Moreover, many agricultural and industrial interests viewed water from the Columbia River that flowed to the sea as being a waste of natural resources. Contrasting the situation in the 1930s with the situation today reveals a much different scene. Large numbers of people now feel that wild salmon should run in the Columbia River. Moreover, there is increasing political support for the view that maintaining in-stream flows to support ecosystem functions is a legitimate, beneficial use of water. While these changes in social values have been reflected in changes in FCRPS operations, many of the changes in operations occurred long after significant damage to ecosystem functions and salmon runs had already taken place. Perhaps, if systematic and periodic project re-evaluations had been undertaken, interventions to restore salmon and steelhead and maintain ecosystem functions on the Columbia River could have come sooner, with less cost, and with a higher likelihood of success.

The following were among the divergent views expressed at the stakeholder meeting of 13 January 2000 in Portland: the only way this lesson would make sense is if those entering an agreement would be compensated if they made investments predicated on there being no change in arrangements and then changes were made later. Implementation of the proposed lesson would introduce too much uncertainty. For example, if CBP farmers thought their financial arrangements would be re-evaluated after 10 years, the resulting uncertainty would have been sufficient to keep irrigators from making investments and the goal of the project to settle farmers in the area would not have been attained.

Another concern registered at the stakeholder meeting in Portland centred on the workability of re-evaluation procedures. The periodic reassessment of licenses conducted by the Federal Energy Regulatory Commission (FERC) was cited as an example of a periodic re-evaluation process that was useful in theory, but highly bureaucratic and cumbersome in practice. The individual citing this example felt that periodic re-evaluation was a valuable concept, but that great attention needed to be given to the workability of the re-evaluation process.

We also received correspondence from a CBP irrigator who took exception to our use of subsidies to CBP farmers as an illustration of the value of periodic re-evaluations to incorporate temporal changes in social values into project operations. In his view, an evaluation of monetary costs and gains would find that the government has benefited from CBP in excess of expenditures.

8.4 Incorporating Changes in Science and Technology into Operations

Issue:	Changes in science and technology
Component of Project Cycle:	Operations
Lesson:	For future projects, periodic, planned re-evaluations provide a mechanism for incorporating changes in science and technology into project operations. To meet social policy objectives, it might be necessary to reduce uncertainties for stakeholders whose decisions would be influenced by results of re-evaluations.
Evidence:	Biologists' views on native versus hatchery fish have changed; and changes in farm technology have increased pressures for larger farms than anticipated by CBP planners.
Views (divergent):	Issues related to uncertainty are of critical importance; re-evaluation procedures need to be workable.

This lesson is closely related to the previous one, and the discussion above concerning uncertainty also applies here. We chose not to combine sections 8.3 and 8.4 into a single lesson because we felt there was value in separating issues tied to changing social values from those related to changes in science and technology.

Rapid scientific and technological changes were a hallmark of the 20th century, and there is no reason to expect the rate of change in science and technology to decrease in the future. Periodic, planned re-evaluations of project operations can provide a basis for accommodating changes in technical and scientific knowledge. A forceful demonstration of this is given by the way changes within the scientific community surrounding the significance of genetic biodiversity have affected biologist's views on native versus hatchery fish. During the 1930s, when the fish maintenance programme for GCD was being created, the biologists designing the programme did not favour runs of native salmon and steelhead over runs that involved fish propagated via transplantation and hatchery operations. Today, many biologists view hatcheries and fish transplantation in very different ways, and they would distinguish among ecologically significant units of salmon (and steelhead). The goal for the GCFMP — to maintain the aggregate size of the anadromous fish runs and not the individual ecologically significant units — would be untenable today.

Periodic project re-evaluations would also allow decision-makers to account for changes in technological conditions associated with project operations, such as changes in technology that affect economically viable farm sizes on CBP lands. From the earliest days of the planning for CBP, maximum farm size was an issue. Reclamation planners knew that if farm sizes were too small, settlers would go bankrupt. At the same time, they wanted to ensure that the irrigation water was used on small family farms, since the creation of family farms was a policy objective of the project. As noted in section 3.1, there have been numerous changes in irrigation technology, earth moving equipment, and other aspects of modern farming, and these changes made the original constraints on farm size untenable. Reclamation made several adjustments in the maximum CBP farm size over time, but these changes were based on modifications in federal reclamation law. The process of changing CBP farm size could have been carried out more systematically if there had been opportunities for regular project re-evaluations that considered the changing technological context in which irrigated agriculture took place on CBP lands.

The call for systematic project re-evaluations is based not only on the need to accommodate changes in science and technology, but also on opportunities to monitor project outputs systematically and to respond to monitoring results expeditiously. In 1978, Professor Holling and his colleagues at the University of British Columbia introduced the term "adaptive environmental management," and they urged that this form of management be practised on projects that (like GCD) had the potential to change ecosystems in extraordinary ways.[168] Holling recognised the limitations on data and scientific knowledge available for pre-project impact assessment activities. He and his colleagues argued that impact assessment specialists should view a project as an experiment with uncertain outcomes that need to be monitored carefully. Results from monitoring a project's ecosystem impacts could be used to determine unacceptable effects. Using this information, project officials could implement mitigation activities to offset adverse outcomes as quickly as possible.

8.5 Sensitivity Analysis of Economic Parameters

Issue:	Sensitivity analysis and the evaluation of project robustness
Component of Project Cycle:	Planning
Lesson:	Substantial inflation-corrected cost overruns in GCD and CBP reflect the uncertainties that surround large construction projects. These uncertainties underscore the need for wide-ranging sensitivity analyses to ensure that project goals and objectives are robust and can be met with available resources. Implicit or indirect subsidies need to be evaluated under alternative market conditions to ensure that the subsidies are in line with a project's social objectives.
Evidence:	Inflation-corrected Third Powerplant costs were approximately 55% above planned costs. CPB costs were nearly three times those projected with the result that repayments by beneficiaries is roughly 15% of construction costs rather than the planned 50%. Indirect energy subsidies of the CPB have increased over time as the value of firm power to BPA's non-agricultural customers has increased.
Views: (convergent/divergent)	

Undertaking projects in support of non-market social objectives, such as providing opportunities for small farmers, fostering national food security, and developing sparsely settled regions, could be the outcome of legitimate political processes. However, for administrators and politicians to make informed judgments about the trade-offs that are invariably involved in such decisions, they need to be aware of a project's uncertainties. Projects whose acceptance hinges on best-case outcomes in terms of technical and economic parameters should be viewed with more scepticism than projects that look promising even when technical and economic parameters are varied. An example of the latter is GCD's Third Powerplant. The original planned benefit-cost ratio was 3:1. A sensitivity analysis that simulated the substantial cost overruns that actually occurred would have produced a benefit-cost ratio greater than 1, giving planners and politicians confidence in their decision to build the powerplant.

In a sensitivity analysis, technical and economic parameters are varied over the range of possible values to investigate the extent to which different estimates of parameters might lead to a change in a proposed action. Sensitivity analysis of parts of the project other than the Third Powerplant might have produced a different outcome. For example, construction of CBP ultimately cost nearly three times the estimates made by early planners. The result of the cost overruns is that only about 15% of the project construction cost is being repaid by CBP irrigators rather than the anticipated 50%. No one can say in hindsight whether the decreased percentage repayment associated with a much higher construction cost would have influenced the final outcome had this information been available to the politicians who made the construction decision. What can be said, however, is that no such analysis was ever done.

Assessing the impact of potential changes in overall economic conditions should also be an objective of sensitivity analysis. Conventional project appraisals assume, for example, that inflation can be neglected because inflation is likely to influence all elements of a project in approximately the same way. However, where contractual arrangements do not provide for inflation adjustments, the impact of these arrangements needs to be examined explicitly. For example, the decision not to index the repayments by CBP cultivators to inflation has meant that a farmer's annual repayment costs, based on a 1962 settlement, are being made in dollars that, in 1998, were worth only 18.5% of the 1962 dollars. Thus the real cost to irrigators, and by implication, the real value of repayments to the project, has declined over time.

Lastly, sensitivity analyses need to include an examination of alternative assumptions about the direction of key markets on which indirect or implicit subsidies are based. According to Gittinger (1984: 500-501), “An indirect subsidy may occur when manipulation of the market produces a price other than that which would have been reached in a perfectly competitive market”. For example, in the case of the market for energy, the indirect subsidy is the difference between the price at which the government (ie, BPA) provides energy to users and the price determined by the functioning of supply and demand.

Because the indirect subsidy is the difference between the contract and the prevailing market price, possible changes in market prices must be explored. In the case of energy, prices have varied over time. In recent years, for example, natural gas from Canada has reduced alternative generation costs and placed a downward pressure on energy prices. The result is to reduce the indirect subsidy to public power utilities and their customers by reducing the difference between market prices and the regulated below-market costs provided through BPA.

The indirect energy subsidy to CBP irrigators has also varied over time. The indirect subsidy for irrigation results from a contractual arrangement that provides pumping power for CBP at roughly the cost of production at GCD, substantially below the market price and well below the firm power price that BPA charges its other customers. The difference between the CBP price and the subsidised BPA firm power price provides a lower-bound estimate on the size of the indirect subsidy. With approximately constant production costs, the indirect subsidy has increased substantially as BPA firm power prices have gone from 0.33 cents per kWh in the early part of the project to between two to three cents per kWh in recent years.

The examples of unexpected economic consequences given above are not intended as a criticism of government policy. Rather, our intention is to emphasise that the future may yield parameter values that are very different than the expected values on which decisions to proceed with such large scale projects are based. A robust project is one that has the following characteristics: when parameters (eg, technical co-efficients and prices) that could affect the decision are varied, the project still meets its economic and social objectives. For robust projects, those responsible for the ultimate outcome can make their decisions with some degree of confidence.

8.6 Developing a Shared Conceptual Framework for Project Appraisal

Issue:	Disagreements frequently arise because stakeholders and planners do not share a common conceptual framework and vocabulary for project appraisal
Components of Project Cycle:	Planning
Lesson:	Stakeholders and planners involved in an open planning process need to work with a common conceptual framework and vocabulary in making formal project appraisals. Of particular importance is the distinction between private and social (economy-wide) perspectives. Failure to develop a shared conceptual framework and vocabulary can lead to unnecessary acrimony.
Evidence:	Interviews with and letters from stakeholders indicate that numerous disagreements and misunderstandings resulted because of the absence of a shared framework and vocabulary for appraising projects. Particular sources of difficulty include the distinctions between financial and economic prices and between direct and indirect benefits.
View: (convergent/divergent)	

Discussions among stakeholders (and between stakeholders and planners) are sometimes acrimonious because of differences in conceptual frameworks for project appraisal. These differences centre on two aspects of appraisal: (i) the concept of a subsidy; and (i) the use of a national, social accounting perspective as opposed to a private accounting perspective. The first has to do with the distinction between market and economic prices that underlies the presence of implicit or indirect subsidies. The second is related to the role of secondary benefits and how they should be counted in evaluating a project's economic benefits. Disagreements about outcomes often arise among stakeholders who view the project from different perspectives. For communication to be effective, these differences need to be confronted explicitly by individuals and groups involved in an open planning process.

In a formal project evaluation, a distinction is made between the project's *financial* appraisal in which market prices are used to value goods and services, and its *economic* appraisal, in which the prices used reflect the value of goods and services to the society as a whole. In competitive markets, the two are the same. However, government policy interventions often generate differences between the two in the form of direct or indirect taxes and subsidies. In the case of subsidies, individuals, who see only the market prices with which they are confronted, understandably interpret project results in those terms. For example, a CBP irrigator took the position that there was no energy subsidy because "the [irrigation] districts pay for 100 percent by contract of the amount that they were expected to pay". Another asserted that "there is no measurable value to leaving Columbia River irrigation water in the river". In both cases, these private, individual perspectives are at odds with the economic notion that resources must be valued in their best alternative use if they are to be allocated efficiently from a social or economy-wide perspective. A better understanding of these differing perspectives by all parties would go a long way to reducing the disputes that otherwise arise around the word "subsidies".

A similar (and perhaps even more important) difference in perspectives is present in the discussion of direct versus indirect (secondary) benefits. The original GCD and CBP planners, as well as some of the current stakeholders, have repeatedly referred to the non-farm processing, supply, and service industries that have sprung up in the area as a "benefit" of the project. Seen from the perspective of residents of the CBP area, whose efforts have produced its thriving economy, this conclusion is understandable. However, from a national, economy-wide perspective, a different conclusion can be reached. In the absence of economies of scale associated with locating in the area, and in the presence of reasonably competitive capital and labor markets, the increase in economic activity resulting from resources flowing into the CBP area is more or less offset by a lack of economic growth in areas where project monies could otherwise have been spent. This issue was intensely debated in the early 1950s and, as far as US Government agencies are concerned, was resolved with issuing of Circular A-47 by the Bureau of the Budget (Committee, 1995). This document forbade the inclusion of secondary benefits in an assessment of a water resource development project's economic benefits.

The Bureau of the Budget circular makes clear, however, that banning the inclusion of secondary benefits as an economic benefit in the appraisal of project's contributions to net national income does not preclude consideration of the role of secondary benefits in attaining other policy objectives such as regional settlement, small farmer development, and national food security. Groups involved in the planning process therefore have ample opportunity to argue for the inclusion of objectives in which they have a particular stake. However, it is important that stakeholders, as well as project planners, appreciate that there is often a trade-off between their particular interests and maximisation of the project's returns to the national economy as a whole.

If stakeholders and project planners adopt a common vocabulary and framework for discussing project appraisal concepts, including the distinctions between market and economic prices and the differences between private and social accounting perspectives, communications would be much improved. With a common basis for discussing traditional objectives related to maximising net national income as well as other social objectives such as regional economic development, stakeholders and planners can identify more easily areas of agreement and disagreement. In short, disagreements that stem from a lack of common appraisal framework and terminology could be minimised.

8.7 Mechanisms for Ensuring Just Compensation

Issue:	Compensation for adversely affected parties
Components of Project Cycle:	Planning and operations
Lesson:	In large water resources projects, those who bear the costs may not receive many benefits. Therefore, mechanisms for ensuring just compensation are important. In a project that has impacts that cross international borders, the usual forums for allowing parties to make compensation claims — for example, the judicial system in the US — may not be satisfactory, and alternative forums should be considered. Alternative dispute resolution mechanisms may also be able to speed up the settlements of claims normally brought using the court system.
Evidence:	Inadequate opportunities for Native Americans and Canadian First Nations to obtain compensation for project- related losses in a timely fashion.
Views (divergent):	

A striking feature of GCD and CBP is the long-standing bitterness of those who felt wronged by the project. Individuals who were significantly disadvantaged by the project include settlers and Native Americans forced to relocate by the creation of Lake Roosevelt, and members of Native American tribes and Canadian First Nations who were adversely affected by the loss of anadromous fisheries above the dam. On the US side of the Columbia River, some of those who felt unjustly compensated for their losses took their cases to court, but the process was lengthy and slow. Moreover, individuals without adequate resources to bring suit were effectively denied the opportunity to have their claims heard in court.

The situation for members of Canadian First Nations is different than that of Native Americans because of the international dimension of the problems they faced. First Nations have not been able to benefit from various fish mitigation programmes implemented on the US side of the basin. Moreover, they do not have a mechanism for making claims against the US government for damages they believe they incurred. While the GCD case does not suggest an alternative dispute resolution mechanism that such claimants could use, it does point to the need for one.

The adequacy of monetary compensation to individuals forced to relocate because of reservoir creation is a common issue, and it certainly was a factor in the case of GCD. Because of the long passage of time, and because of the absence of systematic records on payment for those whose property was expropriated as a result of GCD, we were unable to conduct a systematic investigation of this subject. However, J.W. Wilson conducted a careful study of relocation for one of the Canadian Treaty projects — Arrow Lakes (later renamed Hugh Keenleyside Dam). His study concluded that the perceived injustices of some of those forced to relocate by the Arrow Lakes project led to bitterness that lasted for decades. Thus, some lessons from that study are also relevant to the GCD case.

Wilson investigated why some of those forced to relocate to make way for Arrow Lakes felt so bitter, long after receiving the equivalent of market value of their property as compensation for what their loss. After reflecting on the human dimension of the relocation necessitated by implementation of the Arrow Lakes project, Wilson (1973: 159) offers the following observation:

> *Just as every family's life is a complex of ties, activities, and responsibilities, so displacement shatters that complex and requires it to be reconstituted. In other words, the members are required to abandon a long-evolved and shaken-down way of life, re-examine its many elements and consciously put them back together again in ways that seem to fit their new situation best. A large part of the problem frequently lies in the fact that they may not know the area into which they think they would like to move, and the range of and nature of its opportunities. In the face of this they have to wait and decide a number of inter-related questions peculiar to their own*

> *circumstances: Can Dad get a job? Can he change that job if he doesn't like it? Can we get a place where we can grow fruit, cut wood, and graze a cow? Can we afford a house? Will we have to fix it up much? What will the taxes be? What and where are the schools and colleges? Are there doctors, dentists, and hospitals within reach? Is there a supermarket? Are the people friendly and do we have any kin nearby?*

After pondering these issues, Wilson (1973: 160) concluded that the water resource development agency that asks: "How can we acquire the necessary land?" has posed the wrong question. For Wilson, the appropriate question is "How can we best enable these people, whom we are displacing for the public good, to get established again with maximum efficiency and [the] least [amount of] stress for them?"

8.8 Limits to Government Planning in a Market Economy

Issue:	Limits to government planning in a market economy
Component of Project Cycle:	Planning
Lesson:	Limits exist on the extent to which government plans can be implemented effectively in a market-driven, capitalistic economy.
Evidence:	Changes in the economics and technology of farming provide irrigators with incentives to circumvent Reclamation's acreage limitations.
Views (divergent):	

Even if there had been periodic re-evaluations of changes in farm size and technology on CBP lands, it may not have been possible for Reclamation planners to stay ahead of market forces. The original CBP planners did their work during the 1930s, a period when the government was attempting to rely on administrative regulations to control market forces. In contrast, however, the US is currently in a period of government downsizing and de-regulation. During the coming years, it may be increasingly difficult for government planners to use administrative controls to pursue social objectives in a predominately market-driven economic system such as the US.

The circumstances surrounding Reclamation's acreage limitations help illustrate the limits of planning in a market economy. During the 1930s, Secretary of the Interior Harold Ickes was aware of Reclamation's past practice of allowing farmers to hold parcels larger than maximum acreage limits despite the law (Pitzer, 1994: 269). Ickes was determined not to let that happen with CBP. However, Reclamation's efforts to maintain acreage limitations at levels as low as 80 or 160 acres (32 or 64 hectares) were unsuccessful. It is unlikely that those acreage limitations could have been maintained, regardless of how diligent Reclamation was in monitoring practices on the ground. As long as a land market existed, either directly or indirectly (in the form of land rental opportunities), the actual size of farm-operating units was be determined by technology, capital, economies of scale, and other market-related variables. It is likely that any administratively organised acreage limitation scheme would have been circumvented at some level. The root of the difficulty is that Reclamation's planners were implementing a "command and control" regulatory system in a market-driven context. Unless that regulatory system could be changed often enough to keep up with market forces, it was destined to fail.

8.9 Centralised Versus Decentralised Basin Management Institutions

Issue:	Centralised versus decentralised basin management institutions
Components of Project Cycle:	Planning and operations
Lesson:	In designing institutions for river basin management, centralisation and decentralisation each have their advantages and disadvantages.
Evidence:	Co-ordinated decision-making process by four agencies — BPA, the Corps, Reclamation, and BC Hydro — has been effective in managing for flood control and hydropower, but some stakeholders feel left out of the decision process for operations. Decentralised decision-making can mean improved responsiveness to particular constituencies, but in the case of GCD, more decentralised processes have not solved inter-agency co-ordination difficulties in the Columbia River Basin.
Views (divergent):	

The terms "centralisation" and "decentralisation" can be defined by examining extreme cases, recognising that what occurs in practice generally lies between the extremes. The polar case of centralised management is represented by a single agency with authority for basin-wide management. The extreme case for decentralised river basin management involves a large number of single-purpose organisations, such as publicly and privately owned utilities, federal and state fish and wildlife agencies, and irrigation districts, each operating as independent, self-optimising entities. While neither extreme case exists in the Columbia River Basin, the experiences here help illuminate some advantages and limitations of the two management forms.

The closest thing to a centralised, basin-wide management institution within the Columbia River Basin is the co-ordinated decision-making process used by four agencies — BPA, the Corps, Reclamation, and BC Hydro — to optimise flood control and hydropower under the Columbia River Treaty. This co-ordinated management system has been very effective at curtailing floods and yielding an efficiently run hydropower system that generates enormous quantities of electricity at a relatively low cost. Because of the institutions created to enhance co-ordination among the four agencies in real-time, co-ordination mishaps regarding flood control and power are rare.

While the reduction of co-ordination difficulties is an advantage of centralisation, this management form has some notable disadvantages in terms of the ability of entities outside the centralised body to gain access to the decision-making process. Some stakeholders we interviewed (eg, tribal members and environmental group representatives) expressed frustration because they felt — justifiably or not — that BPA held all of the authority over decisions related to the mitigation of adverse effects on anadromous fish. NPPC provides a vehicle for integrating the views of tribes and environmental groups in BPA's management decisions, but some individuals we interviewed complained that NPPC's role was strictly advisory. They felt NPPC could try to persuade BPA to make changes in operations, but that it had no power to impose its decisions on BPA.

The GCD case also illuminates some of the advantages and disadvantages of decentralisation. On the positive side, decentralised special-purpose units can be responsive to local constituencies. Thus, for example, stakeholders concerned with fisheries can find a means of expressing their views with agencies such as NMFS and USFW, and the multi-agency Technical Management Team (a group charged with managing the FCRPS with the needs of anadromous fish in mind). Supporters of irrigation can find an advocate in Reclamation.

While this ability to be responsive to particular, often localised, constituencies is a definite advantage, decentralised agencies face problems in co-ordinating with each other, and there are often imbalances of power among decentralised agencies. This is demonstrated in the Columbia River Basin, where the proliferation of agencies has inevitably resulted in the following shortcomings: duplication of effort; the inability of agencies to co-ordinate their independent efforts effectively; and instances where agencies have either missed or ignored cautions presented by others. The following are examples of instances where more effective co-ordination and long-term vision may have led to more satisfactory outcomes: severe depletion of salmon and steelhead runs, unsatisfactory handling of issues related to tribes of indigenous people whose lands and fisheries were affected by dam construction, and inefficient and costly duplication of studies and development plans.

8.10 Actions Having Significant, Irreversible Effects

Issue:	Decisions to take actions that have irreversible impacts
Components of Project Cycle:	Operations
Lesson:	Decisions that introduce significant irreversible effects should only be taken after very careful study and broad input from all affected parties.
Evidence:	Building GCD without fish passage facilities was, for all practical purposes, virtually irreversible; the decision was made without significant study and participation by all affected parties.
Views (divergent):	It is difficult to know *a priori* what will turn out to be irreversible.

GCD created a practically irreversible barrier to the migration of salmon and steelhead into the upper Columbia River Basin. However, as the historical record makes clear, the issue of irreversibility was not widely discussed at the time the decision was made. As the record also makes clear, many stakeholders have a strong interest in restoring anadromous fish to the upper Columbia River Basin. The possibilities for doing so are remote because of the substantial investment involved in creating GCD.

In a number of our interviews, environmentalists, Native Americans, and members of First Nations expressed a strong desire to bring salmon and steelhead back to the upper Columbia River Basin. At the same time, even the most ardent critics of dam construction on the Columbia River felt that, at this point, even contemplating the removal of GCD was not realistic. Examining the consequences of permanently blocking anadromous fish runs with GCD drives home an important point: a decision that is, for all practical purposes, irreversible should only be made after a very thorough study and a careful weighing of options that takes account of the views of all affected parties.

Two conversations on this lesson took place at the stakeholder meeting in Portland on 13 January 2000. First, one stakeholder disagreed with the lesson because he said knowing what will be irreversible ahead of time is like trying to “guess the unguessable”. In response, a stakeholder who agreed with the lesson indicated that at the time the decision was made to build GCD it was well known that the dam would cut off all the upstream habitat of anadromous fish that traditionally spawned upstream of the dam site. There was no guesswork involved. Second, another stakeholder who disagreed with the lesson claimed that it “wasn’t the dam that led to the loss of fish, maybe it was something else, like over-harvesting”. However, still another meeting participant, one who agreed with the lesson, pointed out that over-harvesting is reversible.

8.11 Cumulative Impact Assessment

Issue:	Cumulative impacts
Components of Project Cycle:	Planning
Lesson:	Tools for cumulative impact assessment need to be applied to avoid resource management problems.
Evidence:	Failure in the past to account for cumulative impacts of dams is at the heart of many fisheries-related controversies within the Columbia River Basin today. The lack of cumulative impact assessment for the series of major dams on the Columbia and Snake rivers constituted a failure to recognise a major fisheries management problem before it occurred.
Views (divergent):	

An interesting dimension of the experience in developing the upper Columbia River Basin is that a plan created in 1932 was, with relatively minor modifications, used as the blueprint for developing all the major hydroelectric and irrigation projects in the US portion of the main-stem Columbia River above the Snake River. Even with this blueprint in hand, the cumulative impacts of individual projects were not given much attention when the fate of GCD was decided. Certainly, the Butler Report cannot be faulted for this omission because in the 1930s the terms “environmental impact assessment” and “cumulative impact assessment” did not exist. Since the 1970s, with the maturing of environmental impact assessment as a field, the notion of cumulative impact assessment has received a great deal of attention. Indeed, US Council on Environmental Quality (1978) regulations implementing NEPA call for an assessment of cumulative impacts.

One way to characterise some of the water-related problems in the basin, from pollution to habitat destruction, is in terms of cumulative impacts. For example, the current crisis over endangered salmon and steelhead developed as a result of a number of decisions to build new dams. Many of these decisions were made one at a time, without accounting for the cumulative effects of future dams in the Corps’ basin-wide plan. Now, despite substantial investments in salmon and steelhead recovery programmes, enormous difficulties in enhancing stocks of endangered anadromous fish persist. Failure in the past to account for cumulative impacts of dams is at the heart of many fisheries-related controversies within the Columbia River Basin today.

If the theoretical literature on cumulative impact assessment is put more vigorously into practice, perhaps management failures that occurred in the Columbia River Basin can be avoided elsewhere. While practical tools for cumulative impact assessment are not highly developed, those tools will never be refined if water resources development agencies do not fully embrace the concept of cumulative impact assessment in practice.

9. Reflections on the Development Effectiveness of GCD and CBP

9.1 Criteria for Gauging Effectiveness

An assessment of development effectiveness cannot be undertaken without first delineating the criteria to be used in judging effectiveness. In the context of GCD and CBP, applicable criteria can be categorised conomic efficiency, income redistribution, regional economic development, and environmental quality. Inevitably, significant differences of opinion arise about the value of GCD and CBP because the relative weight attached to different criteria for judging effectiveness varies across individuals and groups. Finding a consensus about weighting is complicated further because weights frequently vary over time as a result of changes in cultural values, social norms, and economic conditions. In the US and many other countries, the assessment of development effectiveness requires decision-makers to devise their own weightings based on their perceptions of the weights that have been selected by different groups. No widely accepted computational procedure exists for helping decision-makers determining weights or combining weighted scores for different effectiveness criteria. Instead of using a mechanical calculation for combining weighted objectives and making choices, a political process is employed to accomplish these ends. At a conceptual level, the above-noted criteria used to characterise development effectiveness can be defined as follows.

"Economic efficiency" refers to the condition in which the difference between the present value of economic benefits of a project and the present value of economic costs are as large as possible.[169] (Economic benefits are not the same as monetary benefits except in the case where markets are reasonably competitive.) Although economists have several conceptions of economic efficiency, the maximisation of net benefits is the one commonly used in US water resources planning. A national accounting stance is adopted and benefits and costs are counted without regard to who would obtain the benefits and who would shoulder the costs. In contemporary US water resources planning practice, a federal project that does not have economic benefits greater than costs is often termed "economically infeasible".

"Regional development" refers to the objective of fostering growth in particular areas. The congressional goal of encouraging settlers to farm in arid portions of the American West in the late 19th and early 20th century is an example of a regional development objective. In the case of GCD and CBP, the vision for regional development was to have the project area populated by a large number of individual farm families living in an economically productive region that had agriculture as its economic base.

"Equity" refers to the fair distribution of a project's positive and negative effects among stakeholders. The lack of widespread agreement on what constitutes a fair outcome makes it difficult to apply this criterion. One dimension of equity concerns how the project changes the distribution of income. Growth in national income, in and of itself, does not make incomes more equitable. Often, the hope is that increases in economic efficiency will raise the absolute levels of income across groups. Although efforts have been made to integrate income distribution considerations directly into formal project appraisals, those efforts have not become standard practice. Another dimension of equity concerns the distribution of environmental benefits and costs. Project analysts do not have formal calculation procedures for gauging whether project outcomes are distributed fairly; a helpful analysis is one that makes the distribution of project gains and losses clear to decision-makers.

Finally, the criteria of "environmental quality"is a broad category that includes a project's effects on the biological and physical environment as well as effects on social conditions and cultural resources.[170] While it is possible to conceive of additional objectives of water resources development projects, such as the maintenance of national food security, the four categories of factors defined above are appropriate ones for characterising development effectiveness in the context of GCD and CBP.

Another important characteristic of these development effectiveness criteria is that attempts to optimise any single factor may lead to decreases in other factors. For example, if subsidies are used to encourage settlement of arid lands by farmers to meet a regional development objective, those subsidies may distort market prices to the point where resources are allocated in ways that do not maximise contributions to economic efficiency. Similarly, use of below-market electricity rates to attract industry to a region may mean that more than the economically optimal amounts of electricity will be used. In both these examples, there are trade-offs between attaining a regional development objective and maximising contributions to national income.

9.2 Temporal Shifts in Weights Ascribed to Different Effectiveness Criteria

The roles of economic efficiency, regional development, equity, and the environment in contemporary US water resources planning are different from those roles at the time GCD and CBP were being planned. To provide a perspective on whether or not GCD and CBP was developmentally effective, it is useful to review the way these categories of criteria came to be integrated into contemporary US water resources planning. An examination of change over time is helpful because judgments about the development effectiveness of a project can change with temporal shifts in the criteria used to define effectiveness.

In the late 1920s and early 1930s, when GCD was being planned, regional development was a dominant theme in federal water resources planning in the US. Indeed, the preoccupation with using water resources projects to foster the development of arid lands in the American West goes back to the presidential administration of Theodore Roosevelt in the early 1900s. This period witnessed the establishment of Reclamation and its efforts to assist farmers in settling the West by providing them with low-cost irrigation water.

An important outgrowth of this period in American history was the view that experts in fields such as forestry, engineering, and hydrology should play key roles in managing the use of natural resources. Consequently, agencies such as Reclamation, the US Forest Service, and others were staffed by engineers and scientists, and those technical specialists were given substantial authority in resource management.

This tradition of relying on technical and scientific experts to manage resources is displayed in the Butler and Reclamation reports of the early 1930s, in which well-trained engineers played the lead role in presenting information to decision-makers on the development of the upper Columbia River. The emphasis of those technical specialists was on the use of water resources to meet regional development objectives related to irrigated agriculture. This concern with regional development is particularly evident in the Butler report, which provides extensive detail on the way increased farming would yield a sequence of multiplier effects triggered when farmers purchased farm equipment, seeds, transportation and storage services, and so forth.

Neither the Butler Report nor the 1932 Reclamation Report was concerned with economic efficiency in the sense of maximising net economic benefits. The authors of the reports discussed economic feasibility in terms of whether or not the beneficiaries of GCD and CBP could, collectively, pay for project's monetary costs. In the view of the US Army Chief of Engineers writing in 1932, "the irrigation of land as pertains to the Columbia River area under consideration is not an economical proposition at this time and should await the future" (USACE, 1933: 4). The Chief was concerned particularly about whether Butler's assumptions about the ability of the region to absorb power from GCD in a timely fashion were unduly optimistic. Without substantial revenues from power, the sale of power at the proposed rates would not be sufficient to finance CBP. [171]

Writing in 1932, the Commissioner of Reclamation, Elwood Mead, took exception to the US Army Chief of Engineers. Mead argued as follows:

> *I should like to add my belief that no development of the land and water resources of the arid region equals this [refers to GCD and CBP] in importance and in the beneficial results which would come. It will enable the largest single water supply of the arid region to be used to give cheap power to industries, and make feasible the irrigation of the largest and finest body of unreclaimed land left in the arid region.* (USACE, 1933: 5)

The Butler and Reclamation reports each recognised that the goal of bringing irrigated agriculture to the Columbia Plateau could not be satisfied without using a portion of the hydroelectric power revenues to cover a sizeable portion of the investment costs for irrigation.

The introduction of an economic efficiency objective (ie, the condition that economic benefits exceed costs) for water resource projects developed by the Corps and Reclamation did not come about until the late 1930s and early 1940s. Consequently, this objective had little formal influence on the planning of GCD and CBP. However, concerns about what would now be termed "economic efficiency" were raised in the context of project planning. For example, the US Secretary of Agriculture and the Chief of the US Army Corps of Engineers both used economic efficiency arguments to support their opposition to the project. Both were concerned with what they perceived as the absence of sufficient demand for agricultural outputs, and the Chief of Engineers was also concerned about the lack of adequate demand for electricity. However, these critics of the economics of the project did not carry the day. Political factors— including extensive lobbying by local project supporters and Franklin Delano Roosevelt's strategy for using water projects to increase employment, as well as his desire to honor political commitments to the US Northwest — played the key roles in the decision to proceed with GCD.

Although no formal benefit-cost analysis was required, both the Butler and Reclamation reports were concerned, implicitly at least, with ensuring that the project's benefits — gauged qualitatively — outweighed the costs. Some of those benefits related to generating outputs that were marketable, whereas others related to the overall economic development of the Columbia Plateau in particular and the US Northwest in general. During the late 1930s, this implicit concern for having benefits greater than costs was formalised with the introduction of benefit-cost analysis into federal water resource development in the US. At that time, the economic efficiency objective was formally introduced into federal water resources planning: benefit-cost analysis methods were to be used to identify projects that maximised the difference between economic benefits and costs, without regard to who would obtain the benefits and who would shoulder the costs.

The overriding significance of regional development as an objective of GCD and CBP has continued, and it is reflected in contemporary assessments of the effectiveness of the project. For example, when the participants at the second stakeholder meeting held on 13 January 2000 in Portland, Oregon were asked to list their criteria for development effectiveness, many of those present focused on net monetary benefits to the region, not on formal benefit-cost calculations that employed economic (as opposed to monetary) benefits and costs, and not on issues related to equity or the environment. Similarly, as reported in Section 5.3, representatives of irrigators, PUDs, and local governments that we interviewed also adopted a regional development perspective in characterising whether or not GCD and CBP was a worthwhile endeavor. As reported by a representative of a potato-farming organisation, if one looks at the overall net gains to the region, "the greater social and economic good has come" from GCD. Indeed the consensus of the 12 individuals we interviewed representing irrigators, PUDs, and local governments in the CBP area was that the net positive impacts of GCD and CBP far outweighed the costs to Native Americans.

Such regional development arguments frequently ignore the subtleties involved in making arguments related to economic efficiency. Indeed, some of those who trumpet the economic significance of the project did not recognise either the failure to pay interest on the capital cost of irrigation or the lost power revenues associated with providing below-market price energy to pump irrigation water as signs of economic inefficiency. This is only natural: like many farmers, irrigators in the project area are struggling to eke out a living, and they have difficulty perceiving that GCD and CBP were anything but economically successful.

The other two components of development effectiveness — what we have termed equity and environmental quality — did not become major elements of US water resources planning until the late 1960s and early 1970s. This is the period that witnessed a preoccupation on the part of the US citizenry with the environmental and social impacts of water resources and other federal infrastructure projects. Critics argued that destructive projects were being built by federal agencies primarily because they only considered economic and technical factors in making their decisions. Environmental and social impacts were, the critics charged, being ignored. As a consequence of these concerns, the US Congress passed NEPA.

The fundamental goal of NEPA was to force all agencies of the federal government to integrate environmental and social concerns into their planning and decision-making. Indeed, Section 101 of the Act makes it a matter of national policy that federal agencies should "use all practical means and measures . . . to create and maintain conditions under which man (sic) and nature can exist in productive harmony and fulfil the social, economic and other requirements of present and future generations of Americans". The Act also introduced requirements for environmental impact statements, documents that were to disclose fully the environmental and social impacts of proposed federal projects and alternatives to those projects. Notably, the US Council of Environmental Quality (1978) regulations to implement NEPA required that environmental impact statements highlight any irreversible and irretrievable commitments of resources which would be involved in a proposed action should it be implemented.

Concern for the impacts of government actions on communities in the US was enlarged and expanded during the 1980s with the advent of a social movement to ensure environmental justice. This movement began in response to evidence suggesting that African-Americans, Native Americans, and other ethnic minorities were being discriminated against by being exposed to a disproportionate share of environmental hazards. Since then, the term "environmental justice" has expanded to refer to the equitable distribution of environmental costs and benefits. Undoubtedly, the effects of GCD on Native Americans and First Nations would be considered an environmental justice issue by contemporary observers.

Another notable outcome of the period from the 1960s through to the 1980s concerns the increased use of the US judicial system by citizens making claims of unjust treatment in cases centring on adverse environmental impacts. Several Supreme Court decisions in the 1960s and 1970s made it possible (for the first time) for environmental groups to bring suit in US courts in instances where adverse environmental impacts were significant but plaintiffs had not suffered direct monetary damages. In many environmental cases brought before the federal courts in this period, judges found in favour of environmental groups. Many of the environmental lawsuits were brought using laws passed in the 1970s, but a substantial number relied on statutes that had been on the books for decades. US Supreme Court justices appointed during the administrations of Ronald Reagan and George Bush have frequently ruled against environmentalists. However, their rulings have not diminished the claims of citizens with grievances about adverse environmental effects of development projects or alleged instances of environmental injustice. Indeed, the judicial system has provided an important means for those with relatively modest economic and political clout to have their claims heard. In the context of GCD, this kind of situation is illustrated by those representing the claims of US Native American tribes adversely impacted by the project.

9.3 GCD and CBP: Trade-offs Between Regional Development and Economic Efficiency

Judged solely in terms of regional development objectives (without regard to environmental and social impacts), many people would argue that GCD and CBP were developmentally effective. Indeed, this is clear from the interviews that we conducted with irrigators and users of the relatively inexpensive hydroelectric power in the US Northwest who feel that the project was a great success. They point to the contributions of low-cost electricity to the booming economy of the US Northwest, the contributions of agriculture to the regional economy and food supply, the numerous monetary benefits associated with recreation and flood control, and the way storage at GCD creates opportunities to generate additional power at downstream dams. In addition, there are additional (unanticipated) benefits resulting from thermal emissions avoided because of the use of hydropower as an energy source versus thermal (eg, coal-fired) powerplants. While difficult to quantify with certainty, these benefits may indeed be substantial.

In general, the desirability of water projects as viewed from a regional perspective may be perfectly compatible with the efficient use of resources as seen from a national point of view. Under circumstances where inputs and outputs are priced in reasonably competitive markets, if public investments yield a return equal to or above returns from alternative uses of capital, then maximising income from a regional perspective also maximises income from a national perspective.

The picture changes, however, when regional development becomes an end in itself. When regional development becomes a policy objective, governments frequently intervene (directly or indirectly) in markets for inputs to and outputs from production processes. With the exception of instances where such interventions are a response to incomplete or imperfect markets, the distorting policy interventions needed to implement a regional development objective lead to an inefficient allocation of national resources.

The attitudes of regional stakeholders toward such national interventions depend, of course, upon whether the interventions constitute a tax or a subsidy. The formation of these attitudes is somewhat complicated by the fact that many taxes and subsidies are implicit or indirect. In our interviews with local residents affected by GCD and CBP, for example, interviewees acknowledged that direct payments, such as those used to cover a large part of the cost of CBP's construction, were a subsidy. They often failed to see, however, that market interventions that indirectly enhance an industry's financial competitive position are also subsidies.

In the case of GCD and CBP, the criteria for efficient energy use have been met to some degree by the energy component of the project. Environmental and social issues aside, energy production by GCD, including its associated Third Powerplant, has contributed greatly to the development of the Pacific Northwest. Although below-market energy pricing has reduced revenues to the government from what they might have been, the project has repaid the US Treasury for the funds expended in constructing hydroelectric facilities, and that portion of the project has clearly demonstrated a positive economic benefit-cost ratio.

Supporters of agricultural development in CBP, past and present, have argued that development of irrigation facilities should also be seen as positive from a national perspective. Although the original planners acknowledged that agricultural development could not pay for itself, those planners maintained that: (i) substantial national benefits would accrue from the regional development in the form of secondary benefits; and (ii) it was legitimate to use the proceeds from power sales to finance the difference between what the farmers could repay and what it actually cost to construct irrigation works. The concept of using secondary benefits in an analysis of the projects economic efficiency was controversial in the 1930s when those benefits were touted by project supporters. In subsequent federal guidelines, most notably the US Bureau of the Budget Circular A-47, secondary benefits were ruled to be inadmissible in evaluating the economic efficiency of federal water resource development projects (Committee, 1955).

From a national perspective, claiming benefits for regional development that exceeds the benefits to direct beneficiaries runs afoul of the point that resources used to produce location-specific secondary benefits have alternative uses. When labour and capital markets are reasonably competitive, as they are in the US, the value of resources in their original use outside the area is roughly equal to the value of their use in the newly developing region. Hence, from a national point of view, what new areas gain is matched by what existing areas lose.

Project appraisal guidelines used by many government agencies now also question cross-subsidisation in which profitable investments are combined with unprofitable ones in order to produce positive benefit-cost ratios for the combined components. Such practices have been used extensively by government agencies to justify a scale of investment not justified by appraisals of economic efficiency.

Where the economic returns from regional development projects do not yield an acceptable rate of return on government investments, the difference must be made up in the form of subsidies. Economists typically distinguish between two forms of subsidies: (i) a direct subsidy, which is a payment made by government directly to an individual or organisation; and (ii) an indirect subsidy, which occurs when government policies produce distortions in what would otherwise be competitive markets (Gittinger, 1984).

When GCD and CBP are analysed separately, it is apparent that the magnitude of the direct government subsidy involved in the construction of CBP has been substantial. As noted in Section 3.1, as result of cost overruns, CBP has cost approximately three times the original projected cost. Irrigators will pay only about 15% of this cost in dollars uncorrected for inflation (see Section 5.4). The US Treasury paid the remaining construction cost. Eventually, this balance will be repaid (in dollars uncorrected for inflation) by BPA using revenues from power sales.

But direct construction subsidies to the CBP covered by power sales have not been the only drain on funds that would otherwise have remained with the US Treasury. Indirect subsidies have been provided to a variety of regional power users by contractual and regulatory arrangements that have delivered energy at below-market costs. For example, in the interests of expanding power use and creating greater competition with investor-owned utilities, residential electricity users, rural co-operatives, PUDs, and other publicly-owned utilities received preferred (ie, below-market) rates for electricity. In addition, below-market rates were provided to aluminium companies and other DSIs as an incentive for them to expand production in the US Northwest, thereby assisting with efforts to win World War II and promote regional economic development through the post-war period (Norwood, 1981: 131-136). Lastly, energy used for pumping water has been provided to the CBP at roughly the cost of production at GCD, again well below the market price.

Interventions that distort prices also create second order effects as inefficiencies become embedded in private decisions. For example, BPA has been criticised for setting prices of electricity at below-market levels for some consumers (as BPA must as a matter of federal law) because these below-market costs failed to encourage parsimonious use of electricity. Although this criticism could apply to homeowners who found it financially advantageous to minimise their investments in home insulation because electricity rates were so low, this type of criticism centres most frequently on the rates charged to aluminium companies and other DSIs. For example, Palmer (1997: 62) observes that the aluminium industry in the US Northwest uses between 20% and 33% of BPA's electricity, and it pays a lower rate then BPA's residential users. Electricity from hydropower facilities in the US Northwest has been sold at retail rates that are much below the national average. "As a result of low electricity rates, per capita consumption is 61% above the national norm" (Palmer, 1997: 62).

Indirect energy subsidies that distort water costs also discourage water-saving innovations in agriculture. During the 13 January 2000 stakeholder meeting in Portland, Oregon, divergent views were expressed on whether the subsidised price of irrigation water provided by CBP effects the decisions of farmers to install more efficient irrigation systems. But experiences from other areas, most notably California in the drought years of the mid-1980s, indicate that there is substantial room for better water management when water becomes truly scarce. When subsidies keep the cost of irrigation water low, farmers are less likely to give attention to more water-efficient agricultural practices.

Regional development has been a dominant theme in the planning and implementation of GCD and CBP. Experience in the US Northwest and CBP over the past several decades demonstrate that these regional development objectives have, to a considerable extent, been achieved. But they have come at a substantial cost to the rest of the economy, both in terms of direct construction subsidies and in revenues foregone from indirect subsidies in the form of below-market energy prices.

9.4 GCD and CBP: Trade-offs Between Regional Development, Equity, and the Environment

Trade-offs also exist between regional development and objectives related to equity and the environment. This is clearly shown by the way GCD affected indigenous peoples in the upper Columbia River Basin. In the view of many Native Americans and members of First Nations in Canada, GCD was nothing short of catastrophic. Indeed, a Native American who spoke at the stakeholder meeting held in Portland, Oregon said he viewed the GCD as the functional equivalent of an atomic bomb in terms of its effects on the Colville tribe. In his view, the losses to Native Americans — in terms of cultural impacts, historic artefacts destroyed, changes in language, rituals, diet, economics, and inter-tribal relationships — were disastrous, and compensation received by the tribes was a mere pittance in comparison to the losses they have endured.

Similarly, at the meeting of stakeholders held in Castlegar, Canada on 4 October 1999, a representative of the First Nations in Canada affected by the project emphasised that some of the principal negative effects associated with the loss of salmon in the Canadian portion of the Columbia basin had to do with the continuance of culture. He highlighted the importance of Kettle Falls and other fishing areas as places where different tribes came together to enhance mutual understanding, share language and stories, and continue rituals and other social traditions. These opportunities were lost after GCD blocked the runs of salmon to the upper Columbia River.

There is no calculation procedure that allows a balancing of these negative social impacts and cultural losses against the substantial regional development benefits that the US Northwest has enjoyed as a result of GCD and CBP. Today, US citizens rely on an open planning process tied to NEPA to help decision-makers become aware of trade-offs: how much of one objective, such as the quality of the environment, must be sacrificed when attempting to augment another, such as regional development. However, nothing equivalent to NEPA existed at the time that Franklin Delano Roosevelt and his administrators decided to proceed with construction of GCD. Moreover, even the open planning prescribed by NEPA has limitations. For example the NEPA process does not necessarily address the consequences of unequal power among stakeholders, a problem that still plagues the anadromous fish recovery and recreational jurisdiction issues associated with GCD and CBP.

Effects on Native Americans and First Nations are not the only ones that would be questioned in gauging the development effectiveness of GCD and CBP using contemporary criteria. The effects on salmon and steelhead upstream of the dam would also be called into question, primarily because the placement of GCD constituted an irreversible commitment to eliminate anadromous fish in the hundreds of miles of habitat upstream of the dam. The fish mitigation programme implemented in the late 1930s and early 1940s also had an irreversible impact: the hatchery and transplantation elements of GCFMP constituted the permanent elimination of the wild stocks of salmon and steelhead in the middle Columbia River tributaries. While it is certainly true that the number of anadromous fish able to migrate upstream of the GCD site in 1932 was a small fraction of the number of fish migrating past that location before settlers arrived, it is conceivable that restrictions on harvesting procedures could have been developed to substantially increase those numbers. Once GCD was put in place, use of regulatory means to enhance anadromous fish runs to the upper Columbia River was no longer an option.

The observations in this section about the history of decision-making criteria used by federal resources development agencies during the 20th-century in America help put the stakeholder discussion of the draft version of our report in perspective. After nearly 60 years of project operations, our 13 January 2000 meeting in Portland, Oregon demonstrated that those who have benefited from GCD and CBP have, quite naturally, become focused on maintaining the advantages they have enjoyed as a result of the project, mainly low-cost irrigation water, low-cost electricity, and benefits from flood control and recreation. At the same time, groups that were disadvantaged by the project (ie, Native Americans and First Nations) are continuing their struggles to obtain compensation for what they perceive as broken promises and grave injustices of the past. It is possible that individuals who gain or lose from future water resources projects will be just as tenacious in defending their gains or seeking compensation for their losses many years after basic project decisions have been made.

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Endnotes

[1] In some early project authorisation documents, the term “Columbia Basin Project” referred to both GCD and the Columbia basin irrigation project. Over time, people have come to refer to the irrigation portion of the project as CBP. GCD has come to mean the portion of the overall project concerned with hydropower generation, flood control, and the recreational benefits associated with Lake Roosevelt.

[2] The convention for references used in this report is as follows: (author, year) refers to a document and (name year) [no comma in between] refers to an interview or personal communication. All references, interviews, and personal communications cited are listed in the sections that follow Section 9 of the report.

[3] Unless otherwise cited, information presented in this section comes from the following three sources: USBR, 1976; USBR, 1983; USBR, undated(a).

[4] Banks Lake functions as an equalising reservoir by making it unnecessary to regulate pumping from Roosevelt Lake to match shifts in irrigation demand.

[5] 1985 was the last year Reclamation developed CBP land.

[6] At some points in the Butler Report, higher rates of settlement are projected. For example, at one point, the report indicates that “it does not appear unreasonable to expect an average rate of settlement, which would result in the development of 50,000 acres per year on average”. (USACE, 1933: 1029)

[7] Using constant dollars eliminates the effect of increased agricultural prices (inflation) on the results of the analysis.

[8] The 1992 GVP shown in Table 3 is slightly less than the actual (Table 2) because the percentage of high value crops is larger than the acreage under potatoes alone. These specialty crops were not included because they were not anticipated in the Joint Investigations conducted in 1945.

[9] The 960-acre limit represents the equivalent of 960 acres of Class 1 land. Thus, a farmer with more than 960 acres of lower class land is eligible to receive subsidised water up to the acreage that would provide the same value as 960 acres of Class 1 land would.

[1010] Several adjustments are required to make a comparison between the costs of the predicted and actual developments achieved over the period from 1949 to 1985. First, the costs given in the Reclamation Report need to be reduced to reflect the fact that the project consists of only 560 000 acres (226 628ha) instead of the originally planned 1 200 000 acres (485 600ha). Second, costs reported in 1932 dollars in the Reclamation Report and in nominal dollars in Reclamation financial statements need to be adjusted so that both are in $1998.

The figure given in the Reclamation Report for development of 560 000 acres is $105 099 000 (USBR, 1932: 114–15). Because the development of most of the 20 000 acre (8 090ha) blocks is shown as being done for the same $3.327 million, it can be assumed that the analysis was (correctly) done in constant dollars. In developing the CBP, Reclamation expended $674 million measured in nominal dollars (Patterson, 1998: 7).

[11] Central facilities consisted of the primary pumping plant, the main canal, Banks Lake, etc.

[12] Stretching out the irrigation development also helped meet objections to the project based on the substantial "over capacity" that existed in the agricultural sector at the time. These objections to the Columbia Basin project were formalised in the Secretary of Agriculture’s Report to the Board of Engineers for Rivers and Harbors. (USACE, 1933: 538-544)

[13] Testimony of Major Butler at the 1932 House of Representatives hearings on the Columbia Basin project (US Congress, 1932: 6):

Butler: Normally — and I think the irrigation people will bear me out on this — the faster you can settle your irrigation project, the better it is financially. It is just the reverse in this case. The slower you can settle it, the better it is financially. The longer you put off the irrigation part of the development, the better the project is as a financial enterprise.

Mr. Summers: That is because of the consumption of power and the liquidation of costs?

Butler: Yes, sir. It is simply due to the fact that irrigation, when considered alone, will not carry the full burden. Power must help carry the irrigation costs.

[14] Our definition of subsidy is taken from Gittinger, who defines subsidies as follows:

> *A direct subsidy (transfer payment) is a payment made by a government to a producer (such as a farmer) and is a direct transfer payment. An indirect subsidy may occur when manipulation of the market produces a price other than that which would have been reached in a perfectly competitive market. The benefit received by a producer or consumer as a result of this difference constitutes an indirect transfer payment. Indirect subsidies may be transfers from other parties in the society or from the government.* (Gittinger, 1984)

Note: Some CBP farmers object to the use of the word “subsidy” in this context.

[15] The indirect rate subsidy per kWh is $0.00175 (2.25 mills minus 0.5 mills). Assuming 950 million kWh yields a subsidy in 1932 dollars of $16.6 million. Dividing by .084, the 1932 dollar to 1998 CPI conversion factor yields $19.8 million.

[16] The indirect subsidy in 1994, measured in $1998, was $0.02845 per kWh. (26.8 mills minus 0.95 mills, converted to $1998). Assuming 950 million kWh gives $27.0 million.

[17] These estimates were derived using water flow models that developed in part to judge the impact of the National Marine Fisheries Services 1995 Biological Opinion and Salmon Recovery Plan on energy generation. The conservative $39.3 million estimate assumes no re-shaping of the current release patterns that could result from increased water supplies. With re-shaping, annual foregone revenues could reach $51.9 million.

[16] The issue of secondary benefits has a contentious history in the reclamation field. Albert Hirshman comments on both the effort and the results:

> *Benefits include principally: (1) the "stemming benefits" or the net value added through subsequent handling, processing, and marketing to the farm output that is due to irrigation; and (2) the "induced benefits, or the profits made by enterprises supplying goods and services to the project either for family living or for purposes of agricultural production (for example, fertilizer and farm machinery.)*
>
> *To make precise calculation possible, the manual supplied percentages to be applied to the various farm outputs for stemming benefits and to the farm and family purchases for the induced benefits. The many arbitrary assumptions underlying these figures provided any would-be critic with a tempting target. But the criticisms that ensued not only ridiculed this misguided, if heroic, attempt at quantification; it went on to attack the very concept of secondary benefits and to deny their existence. (Hirshman, 1967: 175)*

At the same time that Reclamation was codifying secondary benefits, the Bureau of the Budget, in the first (1952) draft of Circular A-47, was moving toward a statement of policy that distinguished clearly between primary and secondary benefits and noted that only the former should be included in formal benefit-cost analysis. These first tentative comments were articulated more clearly in the 1955 revision. The relevant paragraphs advance the reasoning that is applied in contemporary project appraisal efforts.

> *Until standards and procedures for measuring secondary benefits are established by amendment of this circular, the benefit-cost analysis of any program or project shall be based upon primary benefits. Because all benefit estimates are to be made from a national viewpoint, secondary benefits may not be included in the benefit-cost analysis if similar benefits would accrue from alternative uses of the resources to be invested in the program or project for which the analysis is being made. Despite the importance of effects which are local or regional rather than national in character, such effects shall not be considered as part of the benefit-cost analysis; rather these effects shall be fully evaluated as part of the analysis of the relation of the project to sound local and regional economic development in accordance with criteria set forth in paragraphs 9 and 12 above* (Committee, 1955: 62-63).

Sections 9 and 12 require that the project appraisal include a "statement of the manner in which the programme or project contributes to the sound economic growth of the locality and the region". The weight that these considerations are to be given is unspecified.

In addition to limiting the role of secondary benefits, Circular A-47 also recommended shortening the project analysis period to 50 years, charging interest on construction costs, identifying the repayment sources before initiating future developments, and limiting "intangible" benefits. These suggestions provoked strong objections in Congress from states that had been, or wanted to be, the recipients of reclamation projects. Chairman Engle (California) of the House Committee on Interior and Insular Affairs after challenging Bureau of the Budget Rowland Hughes to name a single reclamation project that would pass muster under the new circular, declaring that the objective of the Circular was in essence to kill reclamation. (Committee, 1955: 2-15)

[19] Olsen (1996: 8) cites a study by the System Operation Review group of the Corp of Engineers that suggests an income/employment multiplier of about 1.7 for irrigation sector impacts.

[20] No effort has been made to tax capital gains on land or other project-related secondary benefits in order to help repay the project's construction costs.

[21] While there may have been high nitrate concentrations in some groundwater wells in the CBP area prior to being affected by irrigated agriculture, there is a clear link between irrigated agriculture and elevated nitrate levels. The USGS (1997) states: "Land use practices are the dominant influence over the distribution and concentration of nitrate in ground water". It also states that "Irrigated agriculture is consequently associated with high nitrate concentrations." (USGS, 1997)

[22] Although DDT sales in the United States were discontinued in the early 1970s, it and other organochlorine pesticides are very persistent in the environment. These pesticides, the breakdown products of which continue to exist in the environment, bind to soil particles and, when these soils erode, are carried into streams (USGS, 1998: 14).

[23] CBP farmers benefit from this incentive to different degrees. For 1998, Quincy District farmers benefited to the amount of $1.30 per acre, East District farmers received a benefit of $1.42 per acre, and South District farmers benefited in the amount of $0.98 per acre. Grand Coulee Project Hydroelectric Authority. (undated). "Incentive Payment by Year for Each Plant." These figures were derived by dividing the "Incentive Payments by Year for Each District" values for 1998 by the acreage of each irrigation district.

[24]

[25] Because they are not observed except through the functioning of reasonably perfect markets, they are also referred to as "shadow prices".

[26] Where possible, all dollar figures presented in this report are converted to their $1998 equivalents. However, a sum total of nominal revenue streams or expenditures require additional information concerning the annual input to the revenue stream that was not available to the study team. Thus, these kinds of dollar amounts are reported in nominal form.

[27] The calculation of the 2:1 benefit-cost ratio is based on the following argument. The ratio of predicted costs to actual costs measured in $1998 is 0.648. Using the amortisation assumptions mentioned above, the annual actual cost would be $114 million. Divided into an annual benefit of $235 million yields a benefit-cost ratio of 2.05:1.

[28] Interruptible power is sold at low rates to the aluminium companies on the condition that it is delivered only when streamflow is adequate.

[29] In contrast, Butler estimated the annual power output at 8 305 074 954kWh, based on the energy available 90% of the time. Under the plan devised by Butler, 785 000kW would be available 100% of the time (USACE, 1933: 743).

[30] These 14 projects are a subset of federal dams included in the Columbia River Basin System Operation Review. For additional details on the Columbia River Basin hydropower generation system, see Annex titled "System Operations — Hydropower, Flood Control, and Anadromous Fish Management Activities" and USDOE et al., 1992.

[31] The 1932 report made explicit mention of each of the following: Bonneville (referred to as the Warrendale site), the Dalles, GCD, the Kootenai River site near Libby, Montana (ie, Libby), the site at the Flathead River at Hungry Horse Creek (ie, Hungry Horse), the site of Chief Joseph Dam (called the Foster Creek project), and the site of Albeni (referred to as Albany) Falls on the Pend Oreille River. Some of the projects referred to in Butler's 1932 report — namely, Rocky Reach, Rock Island, and Priest Rapids — were subsequently developed by public utility districts. The scope of the1932 report did not include the Snake River (USACE, 1933: 1737).

[32] According to BPA (1998), the percentage of US Northwest power usage attributable to hydropower using sustained peak as an indicator of demand is 28 302MW with a total demand of 41 021MW (ie. 69% of total). Using 12-month average firm energy as an indicator of demand, hydropower supplies about 12 055aMW versus a total of 21 540 (ie, 56%). For further details on these figures, refer to the following URL: http://www.bpa.gov/Corporate/KCC/ff/98ff/ff1998x.shtml

[33] Of the 28 302 sustained peak demand for hydropower, reportedly 17 676MW (62%) came from FCRPS. Of the 12 055aMW 12-month average firm energy, 58% came from FCRPS (BPA, 1998).

[34] For a description of the legislative mandate establishing this preference order for power, see Norwood, 1981.

[35] This paragraph was provided to us via a personal communication from Anthony White of BPA (2000) TheMW referred to in the portion of this paragraph that refers to rates is typically written as "average megawatt" (or aMW): the average amount of energy, in megawatts, supplied or demanded over a specified period of time; this amount is equivalent to the energy produced by the continuous operation of 1MW of capacity over the specified period. White describes the four quartile arrangement as follows:

> *The total first quartile ranged from 500 aMW to 800 aMW and was served by surplus firm energy, non-firm energy, and service techniques of the hydro-system, which included provisional draft of federal reservoirs. If these energy sources were unavailable, the individual DSI purchased replacement energy from the open market. The other three quartiles were served with firm power. The first and second quartiles were interruptible under certain circumstances and provided a reserve for BPA to use in times of emergency. Following several first quartile interruptions, lasting from several weeks to several months, the DSIs began to feel this service arrangement was not sufficiently reliable. The first of these interruptions was February 1989 and with several off and on into the early 1990s. For that reason, and the fact that the price of BPA power was higher than other power markets, the DSIs threatened to terminate their full-requirements power sales contracts with BPA.*

[36] As part of GCD's power peaking operation, the pumps and pump-generators in the pump-generating plant are used for pumping during light load hours. This allows BPA to sell more power during high power demand periods. It also provides a load during light load hours to reduce spill. GCD's pump-generating plant provides a load swing of 600MW consumption with all units pumping to 300MW generation with the six pump-generators generating.

[37] References for this statement are the following: BPA, 1960; BPA, 1966; BPA, 1969; BPA, 1975; BPA 1979; BPA, 1985; BPA, 1993.

[38] Section 3.2.7.1 is an edited version of materials provided originally by Harza Engineering Company, Chicago, IL under contract to the WCD. For an expanded treatment of material in Section 3.2.7.1, see Annex titled "A More Detailed Examination Of Hydropower".

[39] The generating capacity assigned to the function of frequency regulation is called “regulating reserve,” and is part of the “Automatic Generation Control” function.

[40] All generating utilities within a control area operate and control their combined resources to meet the power demand (ie, load) as if they were one system. Because systems are interconnected with neighboring utilities, each control area must assure that its load matches its own internal generation plus power exports to other control areas less power imports from other control areas. (US Congress, Office of Technology Assessment, 1989)

[41]A sudden drop in system frequency occurs when a large generating unit suddenly trips out or when a heavily loaded transmission line that is importing power trips out.

[42]Black start, which is not identified as an ancillary service by FERC, is the capability of generating units to restart themselves after shutdown without taking power from the grid. Its total costs include the capital costs of the equipment used to start the unit, the cost of the operators, the cost of routine maintenance and testing of equipment, and the cost of fuel (zero with hydroelectric power) when the service is required.

[43] Chief Joseph Dam regulates the discharge from GCD and is thus called a “re-regulating” dam.

[44] GCD is at the hub of an extensive high voltage transmission network, as well as being situated in close electrical proximity to large industrial loads. As a result, generators at GCD are used to regulate system voltage. Voltage regulation is accomplished by adjusting the reactive power output of the generators.

[45]In addition, the GCD availability factor compares favourably with the North American Electric Reliability Council average of 89.9%.

[46] Reservoirs that inundate forests that have not been cleared can be a significant source of greenhouse gases, but we found no evidence for this in the case of GCD.

[47] Details of the computational procedures used to arrive at the numerical amounts presented in this sub-section are described in the Annex titled “Atmospheric Pollutants Avoided”.
[48] As detailed in Section 4, the “Columbia River Treaty Projects” refer to the following upstream dams: Duncan, Keenleyside, and Mica in British Columbia, Canada, and Libby Dam in Montana.

[49] The total storage capacity of the 14 flood control reservoirs in the system is 39.7 MAF, which only represents 41% of the average annual runoff of the river at the Dalles. Thus, complete control of flooding in the basin is impossible with reservoirs alone (USACE, 1991: 6).

[50] This includes both dams and levees.

[51] The navigation component of the project is negligible compared to other project purposes, as the Grand Coulee Dam does not serve any direct navigational purposes in the Columbia River transportation system.

[52] In fact, under the Columbia River Treaty Flood Control Operating Plan (USACE, 1972), storage at the Grand Coulee Dam and Arrow Dam are regulated as if they were one reservoir.

[53] Flood control works are, in fact, not designed to eliminate any possibility of flooding, which would be impossible. Rather, they are designed to prevent most floods up to and including the design flood (eg, 50-year flood, 100-year flood), which has an associated, non-zero risk of occurrence.

[54] Agencies that manage these facilities include the Washington State Department of Fish and Wildlife, Washington State Parks and Recreation Commission, and USFWS.

[55] Olsen used a variety of data collection and analysis methods in his investigation including: minimum standard recreation value estimates developed by the federal government, estimates of recreational activity, and estimates from recent studies conducted on recreational activity for similar types of recreational activity.

[56] For example, in 1996 and 1997, particularly large drawdowns were required, bringing the lake level down to approximately 1 230ft (374.9m) and 1 210ft (368.8m) (NPS, 1998: 171).

[57] The initial draft of this sub-section was contributed by Marilyn Watkins, Watkins Historical Research, Seattle, Washington.

[58] A more complete treatment of the material in this section is provided in the Annex titled "Grand Coulee Fish Maintenance Programme".

[59] A race consists of a subset of a species, such as fall chinook. A stock consists of members of a species and race that spawn in a particular reach of a river. For example, one refers to the Methow River fall chinook as a stock.

[60] Salmonids include the salmon species and steelhead trout.

[61] Steelhead can live to spawn for several cycles, but repeat spawning of upper river fish is rare.

[62] The bell-shaped curve refers to a graph of the number of fish verses the time they enter the freshwater environment. This historical distribution has been modified in recent history. The run timings of the stocks have been shifted due to artificial propagation and environmental factors, and the peak summer stocks were overfished, thereby depressing the summer runs.

[63] The estimate by CRITFC (1995) includes only salmon and steelhead that spawned upstream of Bonneville Dam.

[64] Discrepancies were found throughout the literature regarding the start date of this facility. Estimates ranged from 1876 through 1888.

[65] For example, the Rock Island Dam counts for coho from 1933 to 1938 are 182, 69, 10, 0, 58, 78, respectively.

[66] The Fish Maintenance Programme was originally called the Fish Salvage Programme.

[67] The Board's plan did not intend for the Winthrop and Entiat substations to be fully functioning hatcheries. The Board assumed the salmonids released from these facilities would spawn naturally in the tributaries, and therefore fish ladders and adult holding ponds would be unnecessary. Entiat and Winthrop were meant to operate as satellite facilities for the main hatchery at Leavenworth. Because of the poor returns at the Leavenworth Hatchery, this plan proved infeasible and fish ladders and adult holding facilities were necessary at Entiat and Winthrop in order to increase egg collections. Both facilities were upgraded from substations to fully functioning hatcheries.

[68] The Division of Fish Culture was established in 1887 by the US Fish Commission for the scientific propagation of fresh water food fish. Control of the Division moved to the Bureau of Fisheries in 1903, and to USFWS in 1940. It was re-designated the Division of Game-Fish and Hatcheries in 1945. Currently, it is known as the Division of Fish Hatcheries under USFWS.

[69] The primary purpose of a satellite facility is to provide early and extended salmonid rearing in the specific region the fish are to be released. The salmonids are raised at a main hatchery facility and transferred to a satellite facility at a suitable early age. By strategically placing satellite facilities in

regions identified for enhancement, acclimation that approximates existing conditions will facilitate their eventual release to the stream system (eg, by making it less stressful on the fish). In addition to acclimation and release, satellite facilities may also be used for adult holding prior to spawning.

[70] Hatchery progeny that return to a tributary other than the one in which they were reared and released are considered strays. Straying can result in re-populating areas where no hatchery fish are released.

[71] Dams decrease sediment in the river, adversely affecting spawning habitat.

[72] A genome can be broadly defined as the genetic material of an organism (ie, a set of chromosomes). In this case, we are referring to the fact that some of the genetic material that makes these salmonids distinct from other salmonids may have been preserved.

[73] The Board did not differentiate between summer and fall chinook in the 1930s. These stocks were intermixed in GCFMP and the stocks are not genetically distinguishable today.

[74] For example, certain FCRPS dams must augment flow such that 80% of juveniles passing around the turbines and through the spillways survive.

[75] A spillcap is the volume of water that can be spilled in a given period of time.

[76] This is a device used to strip nitrogen from water as it descends.

[77] This amount was established via a spending cap Memorandum of Agreement among federal agencies from 1996 to 2002.

[78]Of these 30 species, 17 are native and 13 are introduced.

[79] Entrainment is passage through the turbines or a spillway.

[80] The kokanee salmon found in Lake Roosevelt are thought to have evolved as a result of project construction. When the dam blocked spawning route, the fish began a landlocked lifecycle. By the late 1960s, Lake Roosevelt had a rather large self-sustaining kokanee population that supported a destination fishery. Construction of the Third Powerhouse in 1974 severely reduced the number of kokanee in the reservoir by decreasing spawning success and increasing entrainment through the dam in the spring. Increased reservoir drawdowns also contributed to declines by destroying or eliminating shoreline-spawning habitat (DOE et al. (Appendix K), 1995: 2-26).

[81] For further details on how these figures were derived, see Section 3.5.

[82] Impacts of the project on downstream commercial and sport fishing activities are much more difficult to dis-aggregate because many factors (eg, other dams, agricultural practices, logging practices, temperature, etc.) affect salmonid populations and these effects are typically basin-wide, as opposed to project-specific.

[83] The initial draft of this section of the report was written by Nicole Carter, Ph. D., of the Stanford University Civil and Environmental Engineering Department (Environmental Planning and Management Group) while she was a doctoral candidate.

[84] The article primarily discussed land owned by "white people," so it is unclear if the 2 075 parcels that were mentioned included parcels on Native American reservations (WDW, 1939a: 7).

[85] One *Wenatchee Daily World* article stated that 4 000 or 5 000 people were displaced by Lake Roosevelt (Stoffel, 1940: 14). Another *Wenatchee Daily World* article stated that the Reclamation

engineers estimated that 1 000 families moved (WDW, 1939c: 13), which would make the displaced population approximately 5 000, assuming five people per family. The number of indigenous people displaced in the US is discussed in Section 3.7.

[86] The number of towns reported to have been moved ranged from 10 to 16 (Columbian, 1938: WDW, 1939d: 7; Stoffel, 1940: 14; WDW, 1941: 17; Downs, 1993: 94). Other towns that were mentioned as being moved include the following: Cedonia, Evans, Fruitland, Hunters, Miles, Plumb, and Rice.

[87] According to Luttrell and Bruce (1994: 5.4), by 1900, 75% of the Columbia Valley was under orchard production.

[88] We spoke with three Reclamation staff members — John Dooley, Craig Sprankle, and Joe Simonds, none of whom was able to provide information regarding notification (Dooley 1999; Sprankle 1999c; Simonds 1999). There was also no information in any documents we reviewed regarding whether or not Reclamation followed a notification procedure.

[89] This interpretation of when notification took place is supported by a November 11 1936 letter from Jim James, a Colville tribal chief (Luttrell and Bruce, 1994: 10.2).

[90] Project expenditures discussed in this section of the report were assumed to be spent in 1935 when converted to $1998.

[91] According to an article in the *Wenatchee Daily World* (1939a: 7), Reclamation reported that it had acquired over 90% of the land belonging to non-Native Americans, and had spent $1.84 million buying it. Therefore, the $2 to $2.5 million range covers the remaining 10% of the property needed to be purchased from non-Indians and purchases from Native Americans.

[92] Since the formation of Lake Roosevelt, Reclamation and NPS have imposed numerous restrictions on riparian land use, specifically use between the 1 310ft (399m) “take line” and the height of the reservoir (Lebret 1999).

[93] Reclamation purchased one successful irrigation district for $65 000 and retired the district's outstanding bonds, which totaled more than $57 000 (Bruce and Luttrell, 1994: 5.7). Reclamation filed a condemnation lawsuit against the Washington Water Power Company for its land at Kettle Falls and other lawsuits for similar power sites on the Spokane and Kettle rivers. Reclamation also purchased a cement plant, various mining operations, and logging and sawmill operations (USBR, 1976: V-2).

[94] The town of Marcus was given a later deadline. Those who had not purchased structures at auction were required to move from the reservoir area by 1 January 1939 (WDW, 1939d: 7).

[95] Residents of the town of Daisy purchased a new town site and moved a few hundred feet up the hill to the new highway. Kettle Falls moved to the unincorporated town of Meyers Falls, which changed names to Kettle Falls.

[96] Kettle Falls, which was the second largest of the inundated towns, had 414 people in the 1930 census (USBR, 1976: V-3).

[97] Senator Homer T. Bone proposed a bill that the government duplicate at Marcus what it had done when it moved the entire town of American Falls, Idaho in preparation for the American Falls Dam (Colville Examiner, 1937). The bill was not passed.

[98] The 40 to 80 acre (16ha to 32ha) farm size was dictated by farm size limitations set by the federal government during the early days of the project.

[99] The first US environmental movement is associated with the administration of Theodore Roosevelt in the beginning of the 20th century.

[100] This section and the Annex titled “Native Americans” were contributed by Marilyn Watkins of Watkins Historical Research, Seattle, WA.

[101] For elder accounts on subjects discussed in this section, see the Annex titled “Native Americans”.

[102] Tribal elders interviewed for this study always referred to their to grandparents' houses as their grandmothers' (Arnold 1999; Flett 1999; Sam, 1999; Ackerman, 1988).

[103] The degree of reliance on salmon varied among tribes, depending on their access to major fisheries and hunting grounds. For the Spokanes, some of the tribes of the Colville Confederation, and tribes near The Dalles, salmon probably accounted for about 40% to 50% of the diet. For a tribe such as the Nez Perce with better access to buffalo hunting, or the Coeur d'Alene with more resident fish and good deer hunting, the figure would have been lower (Hunn, 1990: 140, 148; Walker, 1998:621; White, 1995: 18; Spier, 1938:12; Ray, 1954: 57).

[104] According to one Spokane Council member, "The [Spokane] Tribe was never contacted, consulted, or informed about what would take place. We were told: this is a done deal; you have no recourse" (Seyler 1999a).

[105] After examining evidence submitted by both the Colville Tribe and the US government, the Indian Claims Commission concluded in 1978 that agents of Reclamation and the Corps were fully informed in the 1930s of the effects that blocking fish runs above GCD would have on members of the Colville Tribe, but that US "agents eventually concluded, however, that the Indians had no legal rights to fish other than those held in common with white men, and no redress was made”. The Commission ruled that the US had assumed a moral obligation to preserve the Colville Tribes' access to anadromous fish when it required them to move to the reservation (ICC 181-C, 1978: 540, 542, 587 [quotation]). The US Senate report on the 1994 Colville-Grand Coulee Dam Settlement Act cited the same high level government correspondence indicating an initial intention to compensate the tribes that was abandoned by the late 1930s (US Senate, 1994).

[106] In addition to the depleted runs, fishing on the Okanogan River was made more difficult by the opposition of some local officials. In the 1920s, some Colville members were arrested and fined for fishing there (Upchurch, 1924b; Tillso, 1925).

[107] The original GCFMP plan also called for a hatchery to be built on the Okanogan River, but no suitable location was found in the US. A few salmon were counted at the base of GCD in the early 1940s, but none were reported in 1947. In 1946, 102 nesting locations were recorded on the main-stem Columbia River between the Chelan River and GCD (Fish & Hanavan, 1948: 27, 47).

[108] The Colville tribal estimate may be high, but seems reasonable, given the 235 allotments and 3 towns affected. Keller had about 250 residents, according to one report in 1938 (WDW, 1938). Spokane elders estimated that 100 or fewer people were displaced on their reserve, but they also estimated that 20 or fewer allotments were flooded, rather than the 46 that BIA and Reclamation recorded, so that estimate is probably low (Brisboys et al. 1999). The BIA and Reclamation only kept records on numbers of acres and allotments, not people affected.

[109] In its 1976 EIS, Reclamation listed typical residential rates from four area electrical companies. Rates from the three that served parts of the Colville reserve ranged from $7.40 to $10.72 per month for 500kWh, while the rate for the one serving exclusively non-reservation customers was $5.75 (USBR, 1976: 375).

[110] In the early 20th century, reservation land was divided into individual allotments and much of the remaining land opened to general settlement. Thus, non-Indians on the Colville and other reservations own a considerable amount of land within exterior reservation boundaries privately.

[111] White residents of the Columbia Plateau also recalled several Columbia River ferries and frequent hunting and gathering trips by Indians of the Colville Reservation to the Plateau prior to construction of GCD (GCD Bicentennial Association, 1976).

[112] The Indian Claims Commission Act of 13 August 1946 (60 Stat. 1049) allowed tribes to file claims against the US for violations of "fair and honorable dealings". Suits had to be filed by 13 August 1951.

[113] The ICC calculated this figure by assuming that the 2 677 members of the claimant tribes in 1940 (80% of the total Colville tribe's population of 3 346) each required one pound of salmon per day for subsistence purposes; that salmon was then worth $0.20 per pound ($2.30 in $1998), for a total subsistence value of $195 425 (2 272 000 in $1998); and that $3,257,083 ($37 870 000 in $1998), if invested, would produce this annual income. The meaning of this award is an issue in the Colville tribe's 1999 intervention in *United States v. Oregon*.

[114] The Shoshone-Bannock tribe of the Fort Hall Reservation in Idaho has fishing rights on the Snake River and is also included under *United States v. Oregon*, but that tribe has somewhat different recognised rights than the four middle Columbia River Indian treaty tribes discussed here.

[115] Chief Sophie Pierre, an admininistrator of the Ktunaxa/Kinbasket Tribal Council, and William Green, Director, Canadian Columbia River Inter-Tribal Fisheries Commission, wrote the initial draft of Section 3.8.

[116] The only exceptions to Lake Roosevelt water being used on the CBP are in Blocks 2 and 3, near Pasco, which are irrigated directly from the Columbia River, and natural inflow into the Project area, such as in Crab Creek (Pitzer, 1994: 282; Montgomery Water Group, 1997).

[117] All run-of-the-river projects in the FCRPS provide hydraulic head for power generation, and in some cases, navigation. These projects pass water through the dam at roughly the same rate as it enters. Reservoir levels behind projects like Chief Joseph Dam can only fluctuate a few feet (USDOE et al., 1992: 9).

[118] The initial draft of Section 3.9.1.2 was prepared by Tim Newton of Powerex, a subsidiary of BC Hydro. Gordan MacNaab commented on an earlier version of this section.

[119] Comments made by Gordan MacNabb at the Canadian Linkages Workshop held for the World Commission on Dams (Grand Coulee Dam and Columbia Basin Project Case Study), 4 October 1999, Castlegar, British Columbia.

[120] For details, see Departments of External Affairs and Northern Affairs and National Resources, 1964: 101.

[121] Josh Smienk chaired the Columbia River Treaty Committee, and reports prepared for the Committee are as follows: Nakusp and District Round Table and Economic Development Board, 1994; Dobell, 1994; Gravelle, 1994; Hambruch, 1994; Townsend, 1994; Regional District of East Kootenay, 1994; Bogs, 1994.

[122] The World Commission on Dams, Grand Coulee Dam and Columbia Basin Project Case Study, Canadian Linkages Workshop, was held on 4 October 1999 in Castlegar, British Columbia. Eighteen people attended the meeting including representatives of First Nations, Ministry of Environment, Canadian Columbia River Inter-tribal Fish Commission, Columbia Basin Trust, Columbia Power

Corporation, and BC Hydro. Approximately 50 individuals and organisations received invitations to attend the workshop. See Annex titled "Consultative Meetings and Minutes" for a list of attendees.

[123] The low estimate is compiled from data in a presentation developed by the Departments of External Affairs and Northern Affairs and National Resources (1994: 44, 69, and 75). Highlights of the presentation were prepared for the WCD consultant team by Gordon MacNabb, who assisted Canadian negotiators to the Columbia River Treaty (MacNabb 1999b). The high estimate was provided by Josh Smienk, based on his review of reports prepared by citizens in 1994 for the Columbia River Treaty Committee. The difference in opinion appears to be concentrated at the Keenleyside and Libby projects since Smienk and MacNaab both agree that 110 000 acres was inundated by Mica and Duncan. It may be possible that the difference of opinion turns on whether the natural surface area of the Arrow Lake is considered part of the "flooded area," but this has not been verified.

[124] The following figures give a sense of possible reservoir fluctuations. The maximum drawdown at Libby Dam is 172ft (52m). In addition, the maximum drawdown at Keenleyside is 66.1ft (20m), and that at Duncan is 97.8ft (30m). (MacNabb 1999a)

[125] According to Gordon MacNabb (1999a), the "Columbia Board's reports say that the maximum drawdown at Mica is 155ft (47m) . . ."

[126] This paragraph is adapted from personal communication with Josh Smienk, based on his review of reports prepared by citizens in 1994 for the Columbia River Treaty Committee.

[127] A difference of opinion is reported by Gordon MacNabb, who reports: "I knew the Lands and Forest Minister of the time very well and he was fully aware that Mica reservoir was just that, a reservoir. In fact, it was the key reservoir in the Canadian scheme and would always be drawn down each year, although usually not to its maximum drawdown level. The minister…was not the type to lie, so I can only assume that the residents heard what they wanted to hear and would naturally be disappointed with the reality of all reservoirs — they get drawn down". (MacNabb 1999a)

[128] Observations in this paragraph concerning public meetings are from personal correspondence with Josh Smienk, Director of the Columbia Basin Trust (Smienk 1999b).

[129] The initial draft of this subsection was prepared by Josh Smienk, Director of the Columbia Basin Trust.

[130] CBFWCP began operations in the 1995 by jump-starting projects underway from previous compensation programmes and activities.

[131] CBT's mandate does not involve "compensation". That set of activities still remains the responsibility of the Province of British Columbia.

[132] Both Washington and Oregon had laws in place to restrict in-river harvest during the late 1800s and early 1900s (NRC et al., 1995: 217).

[133] The Pacific Salmon Treaty of 1985 between the US and Canada was aimed at, among other things, setting limits on marine fishing. However, there have been difficulties reaching common agreement (NRC et al., 1995: 232).

[134] For example, after World War II, commercial fisheries in Oregon and Washington circumvented in-river fishing limits by fishing in the ocean.

[135] For example, during the early days of hatchery management non-indigenous broodstock was introduced without consideration of local populations (NRC et al., 1995: 261). Now, most hatcheries no

longer continue this practice. Hatchery practices, such as interstock transfers, may also inject maladaptive or inappropriate genes into breeding populations.

[136] The problem of fish diseases associated with hatcheries is widely acknowledged. Key factors affecting disease in hatcheries are as follows: (i) the high-density conditions within which fish are raised; (ii) the high stress conditions of a hatchery environment; and (iii) lack of social conditioning.

[137] For example, some scientists contend that hatchery fish have contributed to increased mortality of wild fish for two reasons: (i) hatchery-raised fish are often bigger than their wild counterparts (and thus more able to forage for food); and (ii) hatchery-raised fish are not socially conditioned to the social hierarchy of wild fish.

[138] Additionally, in cases where fish are collected and barged, the fish need to be able to withstand the stress of transfer.

[139] One adverse impact of high temperatures is that they weaken adult fish to the point that they are unable to traverse fish ladders.

[140] Scientists have determined that grizzlies that inhabited the Northern Cascade mountain ranges, parts of Idaho, and south-eastern Oregon depended almost entirely upon salmon (Olsen, 1998).

[141] See Section 4.1 for further discussion of this topic.

[142] This section is a lightly edited version of a section of the Annex titled “Attempts at Comprehensive Planning for the Columbia River Basin.” by Paul Pitzer.

[143] William Dietrich argues that many others, including the Washington State Department of Fisheries, had warned the Corps that the dams they had planned (particularly those on the Snake River) would destroy salmon and steelhead migrations in many parts of the Columbia River Basin (Dietrich, 1995: 338-339).

[144] This class of benefits include increase in local increase in land value, regional increase in land value, and increase in the value of railroad and power franchises.

[145] For example, the Spokane tribe operates a marina that had not produced a profit by 1999, and the tribe plans to open a resort at the confluence of the Spokane and Columbia rivers. The Colville tribe operates two off-reservation marinas, a campground, and a houseboat concession. By far, the most recreational income for both tribes comes from their casinos, which benefit from the tourist draw of GCD (Seyler 1999b; Knapton 1999).

[146] Interview granted under the condition of confidentiality.

[147] Quote used under the condition of confidentiality.

[148] This figure represents a total of dollars spent on the project without adjusting for inflation or the time value of money. For example, if total project expenditures were $50 million a year for ten years, the cost in nominal dollars would be $500 million.

[149] Other categories of project cost allocations include recreation, fish, and wildlife enhancement, and cultural resource activities. Combined, these categories are allocated less than 2% of the total project cost.

[150] The main power costs associated with CBP involve pumping irrigation water from Lake Roosevelt to Banks Lake (primary) and relift pumping in the project command area (secondary). This power is

charged to irrigation districts at the cost of generation at Grand Coulee rather than at a retail rate charged by BPA or local utilities. On-farm power is obtained by individual irrigators from local utilities and not included in consideration of primary and secondary pumping-related power costs (Patterson, 1999).

[151] All dollar figures that appear in "Section 5.4.2 — Repayment" are in nominal dollars.

[152] In 1993, costs per kWh at GCD were 4.59 mills. The only costs lower were that of Chief Joseph Dam at 3.37, John Day Dam at 2.62, McNary Dam at 2.84, and The Dalles Dam at 2.41 (BPA, 1993).

[153] This section relies heavily on the Annex titled "Shift from Low Dam to High Dam at Grand Coulee". The annex contains extensive citations to the literature describing the early history of GCD.

[154] The Corps report noted that because of the commercial significance of salmon, the United States Bureau of Fisheries would probably require "one or more fish ways to be built in connection with any dam up to about 75 feet [23 m] in height which may be constructed in the Columbia below mouth of the Snake . . ." (USACE, 1933: 1539). Three pages of general discussion regarding the commercial significance of fisheries are provided in pages 1474 to 1476 (USACE, 1933).

[155] See, for example, USBR, 1932.

[156] Unless otherwise noted, sources of facts in Section 6.3 are contained in the Annex titled "Native Americans".

[157] See, for example, USBR, 1945a; USBR, 1945b; USBR, 1945d; USBR, 1945e.

[158] This description of the Treaty's provisions was provided in personal communication from John Hyde (2000).

[159] Unless agreed otherwise, optimum hydropower would be calculated using the power produced in both countries. Canada sold its entitlement to downstream power benefits (for the 30 years after the completion of each Canadian Treaty dam) to a consortium of US Northwest utilities in 1964 in return for $254.4 million US dollars. This sum, along with the flood control payment, was used to fund construction of the Canadian Treaty dams.

[160] The US would only be required to consider optimum hydropower generation in calculating the Canadian Entitlement. The US would not be required to actually operate the projects in accordance with plans for optimum power. Canada must operate Canadian Treaty storage in accordance with plans for optimum power.

[161] An analysis of the decision to build the Third Powerplant is given in the Annex titled "The Decision to Build the Third Powerplant".

[162] The reasons for participating in the SOR process were different for each participating agency. For example, the Corps' main objective in conducting the SOR was a continuation of its ongoing Columbia River and Tributaries studies. These studies are basin-wide water resource development plans that included not only Corps projects but also all major projects in the Columbia River Basin (Jaren 1999). BPA's main interests in participating in the project concerned the upcoming deadlines related to the Pacific Northwest Co-ordination Agreement and the Canadian Entitlement Allocation Agreement (Hyde 1999).

[163] For example, the agencies held six roundtable discussions in the fall of 1991 to solicit feedback on the project. They also invited members of the public to join work groups assigned to develop technical appendices; issued numerous publications describing various aspects of the Columbia River system; published and mailed 20 editions of a periodic newsletter; held nine public meetings in the fall of 1994

to facilitate review of the draft EIS; and set up a toll-free telephone number. Additionally, considerable effort was put into involving affected tribes, particularly over the last three years of the process (Jaren 1999). For example, federal operating agencies provided funding to tribal members so they could attend out of town meetings, and meetings were held between the tribes and the federal operating agencies so that the needs of the tribes could be better understood by the agencies (Jaren 1999).

[164] The SOR appendices are as follows: river operation simulation (A), Air Quality (B), Anadromous Fish and Juvenile Fish Transportation (C), Cultural Resources (D), Flood Control (E), Irrigation/Municipal and Industrial Water Supply (F), Land Use and Development (G), Navigation (H), Power (I), Recreation (J), Resident Fish (K), Soils, Geology, and Groundwater (L), Water Quality (M), Wildlife (N), Economic and Social Impacts (O), Canadian Entitlement Allocation Agreements (P), Columbia River Regional Forum (Q), Pacific Northwest Co-ordination Agreement (R), Fish and Wildlife Co-ordination Act Report (S), and Comments and Responses (T) (DOE et al (Main Report), 1995).

[165] This section is based largely on interviews with James V. Cole, former Project Manager, Columbia Basin Project, Bureau of Reclamation (Cole 1999a; Cole 1999b).

[166] These details on the problems faced in obtaining funds for the Second Bacon Siphon and Tunnel are from Simonds (1998).

[167] Interestingly, because of the lack of periodic project re-evaluations, repayment requirements for farmers have not changed to reflect variations in crop values. Because of increases in the gross value of agricultural output per acre in response to a changing mix of crops (see Section 3.1), the subsidy to farmers is larger today that it was when Reclamation's contracts with irrigators were originally signed. The only time there was a systematic re-evaluation of repayment requirements was in the context of the crisis over drainage that occurred in the late 1950s and early 1960s.

[168] Hollings ideas on the subject are detailed in Holling, 1978.

[169] The concept of "present value" is commonly used to account for the fact that a unit of money this year it is different from a unit of money in subsequent years. For example, one dollar today invested at 6% interest rate will yield $1.06 the following year. In this case, the present value of $1.06 one year from now is $1.

[170] This broad conceptualisation is consistent with the interpretation of "the environment" in NEPA.

[171] The Chief of Engineers relied on the Board of Engineers for Rivers and Harbors, which challenged (as "unduly optimistic") Butler's view that "the growth in power demand will be such that the entire prime output would be absorbed in the period of 15 years after 1940 and that this output would amount to only about 30 percent of the total increase in demand . . ." The Board was concerned that if "the period required to build up the load for [the power output from GCD were to be] as much as 25 years or more, as has been estimated by the present division engineer, the capital charges would probably be so increased that the profits from the sale of power at the proposed rates would be insufficient to finance the irrigation project by the method set forth in by the district engineer [refers to Butler] or by that proposed by the Bureau of Reclamation [refers to 1932 Reclamation report] . . ." (USACE, 1933: 12). Elsewhere, the Chief added, "the policy of bringing more land under cultivation at present by large expenditures of general funds and in competition with other lands already under cultivation is questioned by agricultural authorities of the general government" (USACE, 1933:4).
[172] Interviewee spoke under conditions of confidentiality.