US Army Corps
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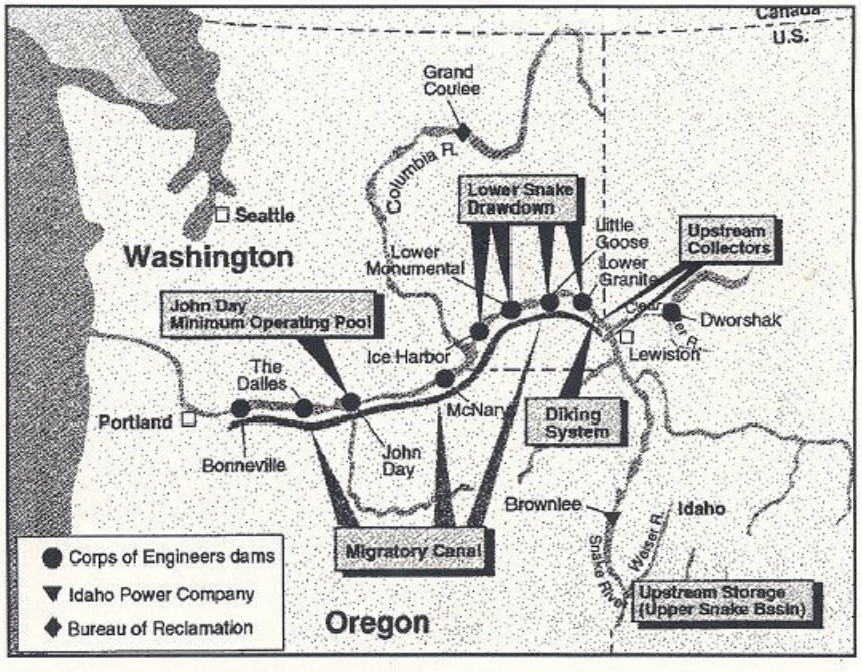
Columbia River Salmon Mitigation Analysis
System Configuration Study
Phase I

Executive Summary



Prepared in Response to
Northwest Power Planning Council
Columbia River Fish and Wildlife Program

April 1994

1. Introduction

The genesis of System Configuration Study (SCS) was in response to the Northwest Power Planning Council's (NPPC) Fish and Wildlife Program Amendments (Phase Two), issued in December 1991. The SCS is assessing various possible alternatives for improving survival of anadromous fish, both juveniles and adults, migrating through the lower Columbia and Snake River dams and reservoirs. The study is being conducted in two phases. Phase I is a reconnaissance-level assessment of alternatives, which were identified in the NPPC Strategy for Salmon. The alternatives that display the most potential for benefiting anadromous fish will be carried into Phase II, where detailed studies will be conducted and a plan of action will be identified.

Phase I provides a preliminary assessment of the costs, environmental opportunities, economic effects, and implementation schedules associated with the various alternatives under study. This draft report has been submitted to the U.S. Army Corps of Engineers (Corps) in Washington D.C., various state and Federal agencies, NPPC, and other regional interests for review and comment. A decision to continue these studies will be based on recommendations made by the Corps, as well as input received from regional interests. The more detailed Phase II studies and resulting report may be used for Congressional authorization and subsequent funding for the implementation of specific actions that have received regional and Federal support.

The purpose of this draft report is to present the preliminary results of the SCS Phase I study. This study evaluated an array of physical changes to the Columbia and Snake River system with the objective of improving survival of juvenile and adult anadromous fish migrating through the eight Federal dams and reservoirs on the lower Columbia and Snake River. These physical changes of alternatives went through a screening process in an effort to identify which actions showed promise in meeting the objective and warranted further consideration in Phase II.

The Phase I study focused on the engineering aspects (particularly design and cost estimates) of constructing the various alternatives, as well as their continued operation. Also, analysis of the impacts to fisheries (anadromous and resident), and other aquatic and terrestrial ecology resources and habitats were conducted to estimate potential positive and negative impacts of the design, construction, and operation of each alternative. Impacts to economic and cultural resources were also assessed, and potential mitigation opportunities were identified.

On April 6, 1993, the National Marine Fisheries Service (NMFS) and the Corps of Engineers (Corps) announced their plan to study the potential for conducting a biological drawdown test on the lower Snake River. The objective of such a test is to gather scientific data to help in deciding whether drawdown operation of lower Snake River reservoirs is an effective means of increasing juvenile salmon survival. Provided an appropriate test can be designed and useful information gained at acceptable cost, National Marine

Fisheries Service and the Corps consider biological testing of drawdown an essential element in evaluating the use of drawdown. Drawdown testing is an integral part of the SCS and, if carried out, will support the evaluation of drawdown in the SCS Phase II studies.

2. Oversight and Coordination.

Studies of the operation and configuration of the lower Snake River projects and the John Day Dam (on the Columbia River) are being monitored and overseen by the Columbia-Snake River Drawdown Committee. The committee is specifically charged with oversight of studies that examine the long-term drawdown of these projects during the downstream migration of juvenile salmon and steelhead. The committee was established by NPPC, as identified in its *Strategy for Salmon*, and serves in an advisory capacity to NPPC. The committee, chaired by NPPC, consists of representatives from each of the following groups and agencies: the Corps; Bonneville Power Administration (BPA); Bureau of Reclamation (BOR); the States of Idaho, Oregon, Washington, and Montana; the Columbia River Inter-Tribal Fish Commission; and the Shoshone-Bannock Tribe. The committee facilitates regional involvement in ongoing Federal processes related to drawdown, and helps prevent the duplication of efforts between Federal and NPPC-sponsored efforts.

The assessment of biological impacts and the effectiveness of alternative measures studied as part of the SCS are conducted under the full collaboration of the Technical Advisory Group (TAG). The TAG is a group of technical experts representing regional fish agencies and tribes, river operating agencies, user groups, conservation groups, and other interested parties. It was formed in the spring of 1991 to develop plans for the 1992 Lower Snake reservoir physical drawdown test. This group has continued to meet, since the completion of the March drawdown test, to address issues related to the SCS. The preparation of this document was coordinated with the TAG, who provided guidance in the development and screening of alternatives and fishway design criteria. The TAG also reviewed and commented on various drafts of this document.

3. Problem Statement.

The NMFS has listed the Snake River sockeye salmon as endangered, and the spring/summer and fall Chinook as threatened species under the Federal Endangered Species Act (ES). These actions are the culmination, to date, of a historical decline in w8ild salmon stocks in the Columbia/Snake River system. There are many factors, some natural and some human-caused, that have contributed to the listing of these salmon stocks. This study only addresses one of these factors, the physical modification of the natural river by eight Federal run-of-river dams and reservoirs on the Columbia and Snake Rivers.

This system of dams and reservoirs has provided many benefits to the region, including power, commercial navigation, irrigation, water quality, recreation, and resident fish and wildlife. However, the projects also have lowered the velocity at which the water flows through the impounded reaches of the river system. This slower water velocity has increased the time it takes juvenile salmon to migrate from their freshwater spawning

grounds to the saltwater of the Pacific Ocean. Some believe the longer migration time may affect salmon survival by increasing their chances of being eaten by predators. It may also interfere with the natural physical changes required for them to adapt from freshwater to saltwater, thus reducing their instinct to migrate and decreasing their survival.

The population decline of adult fish returning from the ocean to their freshwater spawning grounds paralleled the development of dams, irrigation diversion, livestock grazing, mining, municipal and industrial development, and over-fishing of the salmon and steelhead runs. Before these development in the Columbia Basin, up to 16 million wild salmon and steelhead are estimated to have returned to the Columbia and Snake Rivers to spawn in streams where they were born. By 1938, when Bonneville Dam was completed, this number had fallen to 5 to 6 million, mainly as a result of over-fishing and the effects of upstream activities that blocked spawning access or degraded habitat. Today the total run is typically about 2.5 million, including known fish harvested in the ocean. About 0.5 million of these are wild fish. Four general categories are used to encompass the range of factors associated with the decline of the anadromous fishery in the Columbia River Basin. These factors are harvest, habitat, hatcheries, and hydropower.

The listings of Snake River wild spring/summer and fall Chinook, and sockeye salmon, raised the consciousness of the region to the current status of salmon and the ecosystem in which they live. In effect, the ESA listings emphasized the general decline in the overall quality or health of the natural system (due to man's development of that system) that often is first reflected in the loss of water quality, watershed quality riparian quality, and impacts on the fish and wildlife populations that rely on the natural health of the system to survive.

Several issues and uncertainties are at the forefront of decision-making that affect water resource management, and how best to optimize the hydroelectric system to meet the multiple-use demands (most with competing interests) that were the justification for the very projects now headlined as the major contributor to the salmon declines. Many of the issues and uncertainties relate to biological parameters associated with anadromous fish. These issues include: 1) Flow/survival relationship; 2) juvenile fish transport vs. in-river migration; 3) estuary and ocean uncertainties; 4) effects of mortality above the Lower Granite reservoir; 5) survival model limitations; 6) predation and others.

4. Description of Alternatives.

As stated earlier, the objective of the SCS is to define and evaluate alternatives for improving mainstem passage of juvenile and adult anadromous fish. Under this major objective, alternatives address one or both of two general sub-objectives: 1) reduce reservoir-associated mortality; and 2) reduce dam-passage mortality. Reservoir-associated mortality factors include predation and effects associated with fish travel time to the estuary (*i.e.*, incidence of disease and physiological conditioning for transition from freshwater to the salt water environment. These and other concerns

are thought to be fundamental to, or inherent in the relationships between flow, velocity, fish travel time, and juvenile survival generally supported in the region, but not well understood. Mainstem reservoir drawdowns, flow augmentation, and improvements in juvenile fish collection and transportation are the concepts considered to address this objective. Dam-related mortality includes turbine, juvenile bypass system and spillway passage-induced mortality on juvenile fish, and adult passage mortality. Various system improvements, collection and transportation operations, and mainstem drawdowns are considered.

Many of the structural and operational alternatives and/or concepts considered in Phase I were initially identified in the 1990 and 1991 Salmon Summit, and carried forward in NPPC's *Strategy for Salmon*. The alternative long-term actions considered in this study include: 1) annual drawdown of the four lower Snake River reservoirs; 2) drawdown of John Day reservoir on the lower Columbia River; 3) development of additional water storage projects on the Snake River to support flow augmentation; 4) constructing an upstream (above Lower Granite Dam) collector facility and a new conveyance system, such as a migratory canal or pipeline, past the mainstem dams; and 5) making further improvements to existing facilities to improve fish migration conditions.

a. Lower Snake River Drawdown.

The idea of drawing down reservoirs below design operational levels during the salmon migration season first surfaced at the regional Salmon Summit meetings, convened by Senator Hatfield in 1990. The idea was pursued in the NPPC's *Strategy for Salmon*. There are four dam and reservoir projects located on the Snake River. The projects are Ice Harbor, Lower Monumental, Little Goose, and Lower Granite. The projects were constructed between 1961 and 1975m and are operated as run-of-river for navigation and power generation. The maximum lift for the navigation locks and head for power generation varies from 101 to 105 feet at each project.

Water travel time (WTT) has been identified as a possible factor in juvenile fish survival. The relationship between water travel time, migration time, and fish survival is a general one, and is not considered to be a quantitative expression. Migration research that supports this general relationship applies mainly to spring and summer Chinook salmon. One method suggested for achieving a decreased water travel time involves reducing the reservoir cross-sectional area by operating the reservoirs at lower water surface elevations. The proposed operation would occur during the annual juvenile migration period. Drawdown is considered to be an effort to keep juvenile fish migrating in-river, thus replacing the need for the existing transportation program. In any event, navigation would not be possible with lowered reservoir water surface elevations on the Snake River. Collection and transport from McNary Dam would be possible. However, this was not evaluated because it was not consistent with the goal of in-river migration.

Twenty-two different alternatives have been identified as potential drawdown conditions on the lower Snake River. The alternatives are defined by the drawdown level, as well as by the features at each dam that would need to be modified or newly constructed to achieve the drawdown level. To limit the number of drawdown alternatives for which design and cost information would be required, conceptual designs were screened based on engineering feasibility, biological effectiveness, and acceptability. The review of biological effectiveness was accomplished by the TAG. Twelve alternatives were found to be unacceptable and were eliminated. Alternatives that proposed spillway-only operations were found to be not feasible due to the adverse impact on adult fish passage, associated high dissolved gas levels, and problems associated with passing juvenile fish over the spillways. Variable pool alternatives that require turbine operation below existing spillway crest elevations were eliminated due to unacceptable impacts to turbines, and unacceptable operational impacts to fish bypass system components. Ten alternatives, however, were further evaluated. These 10 alternatives are outlined in the following section. Table ES-1 shows a list of the 22 alternatives initially considered, and identifies those considered further.

Table ES-1
Initial Screening of Drawdown Alternatives

No.	Description	Drawdown Level (Feet)	Further Study in Phase I
	Variable Pool--No Powerhouse Operation	(Note 1)	Eliminated
1	Existing Spillway Only	28 to 57	Eliminated
2	Modified Spillway Only	38 to 67	Eliminated
3	New Low-Level Spillway Only	52 to 76	Eliminated
4	Auxiliary Regulation Outlet (ARO) Only	>76	
4A	Natural River Option	Near Freeflow	Added
	Variable Pool With Existing Powerhouse		
5	Existing Powerhouse with Existing Spillway	28 to 57	yes
6	Existing Powerhouse with Modified Existing Spillway	38 to 67	Eliminated
7	Existing Powerhouse with New Low-Level Spillway	52 to 76	Eliminated
8	Existing Powerhouse with ARO	>76	Eliminated
	Variable Pool With Modified Powerhouse		
9	Modified Powerhouse with Existing Spillway	28 to 57	yes
10	Modified Powerhouse with Modified Existing Spillway	38 to 67	Eliminated
11	Modified Powerhouse with New Low-Level Spillway	52 to 76	Eliminated
12	Modified Powerhouse with ARO	>76	Eliminated
	Constant Pool with Existing Powerhouse		
13	Existing Powerhouse with Existing Spillway	33	yes
13A	Existing Powerhouse with Existing Spillway--Lower Granite Only	33	yes
14	Existing Powerhouse with Modified Existing Spillway	43	yes
15	Existing Powerhouse with New Low-Level Spillway	52	yes
16	Existing Powerhouse with ARO	52	Eliminated
	Constant Pool with Modified Powerhouse		
17	Modified Powerhouse with Existing Spillway	33	yes
18	Modified Powerhouse with Modified Existing Spillway	43	yes
19	Modified Powerhouse with New Low-Level Spillway	52	yes
20	Modified Powerhouse with ARO	52	Eliminated

Note 1. A 57-foot drawdown represents an upstream pool at a level equal to the existing spillway crest at Lower Granite Dam.

b. John Day Operation at Minimum Operating Pool (MOP).

The drawdown of the John Day Project reservoir, to elevation 257 (MOP level) is addressed in NPPC's *Strategy for Salmon*. This operation would be in effect each year, from May 1 to August 31. Lowering the pool level at the John Day project is being considered as a means of improving the downstream migration of juvenile fish. Normal operating pool level during this period varies, but is about elevation 265. Since the Salmon Summit, an operation at "minimum irrigation pool" (defined as the lowest level the pool can be operated without impacting irrigation pumping stations) has been employed. This level is elevation 262.5 or higher, as required.

The objective of the drawdown is to increase river velocities so that the travel time currently required for smolts to transit the river system to the ocean is reduced. Travel time has been identified as a possible factor in smolt survival, and it is generally believed that a reduction in travel time will increase smolt survival.

c. Additional Snake River Basin Storage.

Potential development of new upstream storage projects in the Snake River basin is addressed in NPPC's *Strategy for Salmon*. This additional storage would be used for flow improvements during anadromous fish migration periods. The study utilized existing information on previously proposed storage sites. The objective of flow augmentation is to increase water velocity in an effort to decrease fish travel time, theoretically reducing reservoir-related mortality.

The analysis includes information on site location, storage, possible flows, types of structures, preliminary design and costs, and estimated implementation schedules. In addition, the estimated biological benefits to juvenile fish passage are also included.

The BOR facilitated an interagency committee whose purpose was to inventory and screen potential storage sites for upstream storage. The committee is made up of representatives from BOR, the Corps, BPA, and the various involved states. The final report, dated January 1994, from the BOR was submitted to NPPC in February 1994.

d. Upstream Collection and Conveyance.

Upstream collection and conveyance of downstream migrating salmon and steelhead is addressed in NPPC's *Strategy for Salmon.* Several options for collecting and transporting downstream migrants were examined, including alternative collection and diversion sites and transportation methods. By collecting juvenile fish at the upper end of Lower Granite reservoir and transporting them to below Bonneville Dam, both reservoir and dam passage-related mortality can be significantly reduced or eliminated.

The collection facilities would divert juveniles from the river into holding facilities for barge or net pen transport, or for bypass to a migratory canal or pipe transportation system that would carry the fish below Bonneville Dam. The collection concepts identified include constructing a new collection facility upstream of Lower Granite Dam (near Lewiston, Idaho, and Clarkston, Washington) for juveniles, and the diversion point for a bypass channel/pipe. The proposal developed by the Idaho National Engineering Laboratory (INEL) for the floating pipeline was also evaluated.

e. System Improvements.

This element of the study defines and evaluates potential improvements to existing systems (both adult and juvenile) that may enhance fish survival, by reducing dam-related mortality or barge transport-related mortality. Potential improvements were limited to those measures not currently scheduled for implementation. They include the following: 1) improvements to juvenile fish passage facilities which are aimed at improving Fish Guidance Efficiency (the efficiency at which juvenile fish are guided away from turbines) or reducing stress involved in the existing collection/bypass systems; 2) improvements to the Juvenile Fish Transportation Program to reduce stress and potential mortality associated with barge transport, improve direct loading capabilities so that juvenile fish do not have to wait in holding ponds, and expand transportation to John Day on the lower Columbia River; 3) modification to adult fish passage facilities to improve operations and reduce delays in passage; 4) modifications to fish hatcheries have also been added in an effort to improve the quality of hatchery-reared salmon and potentially decrease the negative impacts on wild juvenile salmonids; and 5) improvements to spillway/stilling basins were included to decrease the problems associated with spill-related dissolved gases.

5. Evaluation of Alternatives.

This section presents a summary of preliminary estimates of anticipated physical, environmental, and economic effects associated with the implementation of the previously described alternatives. This information is used as the basis for comparison of the alternatives. The information presented in this section has been extracted from technical reports prepared for each of the alternatives. These technical reports are separate appendices to the SCS Phase I Main Report.

a. Lower Snake River Drawdown.

All drawdown alternatives will require substantial modifications to each of the four lower Snake River dams except for alternative 13A, which requires modifications to Lower Granite Dam only. Project cost estimates for the four reservoir drawdown alternatives, at October 1992 price levels (excluding allowance for inflation and interest during construction), range between $0.9 billion to $3.2 billion. Adjusting these prices for inflation to the midpoint of construction yields fully-funded estimates ranging from $1.3 billion to $4.9 billion. The project cost estimate for alternative 13A (Lower Granite only) is $70 million ($90 million fully funded). These costs include costs for engineering, design and construction contract supervision.

For the four reservoir drawdown alternatives, implementation timeframes are long, ranging from 14 to 17 years from the date project authorization is enacted and construction funds are appropriated to construction completion. For the Lower Granite only alterantive, implementation is estimated to take 4 years.

Economic effects of the four reservoir dawdown alternatives are substantial. The net annual economic costs of the drawdown alternatives range from $140 million (alternative 13A) to $950 million (alternative 4A - Natural River Option). These economic costs include the cost of construction, interest during construction, and direct economic impacts to other system users. Economic impacts to other users include adverse reaction impacts, flood damage reduction changes, farm income losses, negative impacts to municipal and industrial water supply, increase in transportation costs, and increase in hydropower costs. These costs do not include consideration of potential mitigation opportunities for recreation, cultural resources, fish and wildlife, and indirect economic impacts on regional and local economies.

There are many negative environmental impacts that would result from the implementation of all reservoir drawdown alternatives. Some of the impacts to resident fish and wildlife could potentially be mitigated by year-round drawdowns. However, using modeling results and currently limited biological information and judgment, only the natural river option shows a consistent potential benefit for anadromous fish, with the exception of fall Chinook.

Two mathematical models (PAM and CRiSP) were used to attempt to quantify the potential relative benefits of reservoir drawdown alternatives for juvenile salmon. The models were run with a range of assumptions about the survival benefits of reduced juvenile travel time. Both were run with sets of optimistic and pessimistic reservoir mortality and dam passage parameters as a sensitivity analysis.

Again, the only drawdown alternative to show significant improvement above the base case was the Natural River Option. For drawdown options from MOP to near spillway crest, the only alternative to show possible marginal benefits for all stocks was the Lower Granite only option, but with the inclusion of transport at Lower Granite and other downstream projects. The CRiSP model showed only a 1- to 5-percent potential benefit in juvenile survival for this alternative, but these results could change with dam passage parameters adjusted to reflect worsened conditions for collection and bypass hydraulics during drawdown operation conditions. More specifically, survival could be substantially lower for spring chinook, with these adverse hydraulic changes associated with drawdown, as compared to existing passage conditions. Although this alternative includes drawdown, it is more closely associated with the upstream collection and conveyance alternatives. The other four-reservoir drawdown alternatives, which were near spillway crest, showed negative impacts to all juvenile stock investigated. Other qualitative evaluations, and a sensitivity analysis, verified these results.

While there are many uncertainties regarding the model parameters and results that could be tested and further refined, it is highly unlikely that these refinements would produce substantial additional benefits for drawdowns below minimum operating pool to spillway crest. The PAM model utilizes a strong positive relationship between flow and survival, and ascribes relatively low benefits to transportation. These are the two main areas where changes could drive higher benefits for drawdown alternatives. It is very unlikely that any further studies would modify these relationships to an extent that would result in higher potential benefits for minimum operating pool to spillway crest reservoir drawdowns. Tests of drawdown could only affirm the flow/travel time/survival relationship used in the PAM model, but this would not increase the potential benefit that PAM modeling would show for drawdown. Potential detrimental effects not accounted for by the models, including construction, drafting, refill, adult fish passage, and other areas of impact all could adjust both model results (PAM and CRiSP) substantially downward. The base case (for both PAM and CRiSP) used for comparison consists of the current Columbia River System operation, which includes flow augmentation, operation at MOP at certain projects, and juvenile fish transportation. This base case did not incorporate the potential benefits of ongoing improvements to existing fish passage facilities, including new juvenile fish bypass systems at Ice Harbor and The Dalles Dams, and extended-length screening devices at Lower Granite, Little Goose, and McNary Dams, *etc.* Adjusting dam passage parameters to reflect these improvements would result in higher survival for the base case, and a reduced potential improvement for reservoir drawdown alternative.

The relationship used with the existing mathematical models assumes that increasing flows and velocities directly reduces juvenile fish travel time, thereby theoretically reducing their reservoir-related mortality and increasing survival. This increase in reservoir survival for the near spillway crest alternatives is not enough to overcome other factors reducing survival through the lower Snake River (*i.e.*, increased mortality from turbines, and spill and bypass operations). It is important to note that these alternatives do no include any use of fish transportation. Therefore, all juvenile fish must pass through the lower Snake River dams. In addition, the fish are then subjected to reservoir and dam mortality through the four dams and reservoirs on the lower Columbia River. Unless actions are taken on the lower Columbia River to significantly reduce reservoir and/or dam-related mortality, the near spillway crest drawdowns on the lower Snake River do not appear to be an effective action to improve system-wide migration conditions for juvenile salmon. The natural river option eliminates the effects of the four lower Snake River dams, which is enough to potentially offset the mortality through the lower Columbia River.

b. John Day Operation at Minimum Operating Pool.

Operation of John Day project at MOP (elevation 257) from 1 May through 31 August has been evaluated for its benefits and impacts to the existing project, anadromous fish, the environment, and other uses of the reservoir. An option to operate at MOP year-round to potentially provide partial mitigation of impacts was also evaluated.

In general, project facilities have been designed for operation at this level. However, it is noted that the purpose for evacuating the pool to this level was to provide storage space to assist in controlling flooding of the Portland/Vancouver area. Because it was designed for flood control, the original project design did not envision regular or sustained operation at the MOP level. Implementation of the proposed operation would appear to require some minor modifications to existing adult fish ladders at John Day and to adult fish ladder entrances at McNary Dam to meet existing criteria. Modifications to juvenile passage facilities and/or turbines have not been included in the costs at this time because the effects are unknown.

Impacts to irrigation facilities, groundwater wells, and recreation sights have been identified. Reservoir users, particularly agricultural irrigation pump station operations would be adversely impacted by the proposed operation. Modifications to restore pumping capability are anticipated to be necessary at 23 of 24 pump station on the reservoir. Most appear to be relatively straightforward measures to extend intakes, however several large stations would require the addition of new low-head pumping facilities. An estimated 10 percent of the over 2000 groundwater wells (including municipal water supplies) could be adversely impacted and require modification. The existing Umatilla and Irrigon Fish Hatcheries' water supply would not appear to require supplementation for the 4-month drawdown operation. Under year-round operation, new sources of water or other measures, such as water recycling and reuse, may be required. From preliminary field studies, it appears that 5 recreation sites on the pool would require modifications to extend boat ramps, swimming beaches and dock facilities. Several marinas could require dredging and, at two sites, maintaining channel depths would require costly rock removal. Evaluation of alternative mitigation opportunities have not been accomplished.

Resident fish and wildlife habitat will be adversely impacted by the proposed operation. The annual 4-month operation at MOP and annual fluctuation will affect an estimated 8,000 acres of shallow water habitat and 2,000 acres of marsh-riparian zones throughout the reservoir. The existing shallow water habitat is also believed to be important to rearing juvenile anadromous fish. The Umatilla National Wildlife Refuge and two state-managed wildlife areas contain the majority of the habitat area. Year-round drawdown is estimated to provide replacement habitat area for about 25 percent of the losses after a recovery period. No other opportunities to mitigate resident fish impacts have been identified. In addition, the

drawdown could have an impact on migrating Umatilla River adult salmon due to blockages at the mouth of that river. Periodic dredging may be required.

Significant cultural resources exist on the project, and will be impacted by the proposed operation. No reliable estimate of mitigation costs can be projected at this time. A monitoring program would need to be implemented with the drawdown, and mitigation actions taken as needed.

Operating John Day at MOP reduces the water travel time (WTT). In the pool itself, the relative change in WTT is reduced about 12 to 15 percent. From the Lower Granite pool on the Snake River or from Wells pool on the mid-Columbia River to below Bonneville Dam, the change in WTT due to John Day at MOP is estimated to decrease from 2 to 5 percent. Based on these estimates, under average flow conditions in May, an approximate 15-day travel time would be reduced by 0.5 days. Under average August conditions, an approximate 56-day WTT from Granite to below Bonneville would be reduced by about 1.7 days. From Wells pool in August, an approximate 30-day WTT would be reduced by about 1.5 days.

Fish survival was estimated from the point of origin to below Bonneville Dam, using both models (CRiSP and PAM). Results from CRiSP modeling showed relative changes in survival (from the base case) for operation of the pool at MOP of -4 to +3 percent. These results would be considered to be essentially no change from the base condition due to the variability (stochasticity) of the model. Results from PAM modeling show a relative increase in survival for mid-Columbia spring Chinook of 7 percent, and no significant change for Snake River stocks.

Potential effects of the operation on survival of Snake River stocks is minimal due to the models reflection of beneficial effects for the current juvenile transport program. A vast majority of juveniles from the Snake River are being transported from upper river sites, and would not be affected by actions in the lower Columbia River. However, it should be noted that model runs without transportation, and John Day pool at MOP, showed significantly lower survival than the base case with transportation for the Snake River stocks.

Other potential effects on migrating juveniles due to operation of John Day pool at MOP have been identified and include: changes in fish guidance and/or orifice passage efficiencies, turbine passage survival, shallow water habitat (rearing areas), and predation. These were not included in the modeling due to high levels of uncertainty, or inability to model. It is possible that these changes could have adverse effects on juvenile fish which might offset benefits derived from the reduced travel time. Studies can be conducted to improve understanding of the possible extent of some of these effects in an attempt to reduce uncertainties.

The project costs for both a 4-month and a 12-month drawdown are $65 million and $99 million, respectively. These costs are October 1992 price level and do not include inflation. The major project cost items include the mitigation of impacts to adult fish passage facilities, habitat, recreation

sites, irrigation pump stations, and other water supplies. Economic impacts for the proposed operation are substantially derived from lost hydropower generation. For a 4-month drawdown, this loss is estimated to be about $3.8 million. For the year-round option, the estimate is $12.3 million. For this reconnaissance-level study, it has been assumed that recreation sites impacts (estimated at $6 million annually) would be restored and, therefore economic impacts on recreation would be virtually eliminated. Total average annual costs are $11 and $24, respectively, for the 4-month and 2-month drawdowns. These costs include amortized project and interest during construction costs, annual operation, maintenance, and replacement (OM&R) costs, and annual economic costs.

c. Additional Snake River Basin Storage.

Successive years of consultation with NMFS concerning system operation under the ESA have continued to result in increasing requirements for flow augmentation. These requirements are driven by the NMFS opinion that incremental flow increases are needed and effective as salmon recovery techniques. The need to provide these flows has signi8ficant impacts on Dworshak reservoir storage, and is leading to increased demand on upper Snake River storage.

The development of additional Snake River basin storage examined the possibility of providing additional upstream storage for flow and temperature improvement during anadromous fish migration periods. The study utilized existing information on previously proposed storage sites, such as the Galloway and Teton sites on the Weiser and Snake Rivers, respectively. Information on site location, storage, possible flows, type of structures, preliminary design and costs, and estimated implementation schedules were prepared. In addition, benefits to juvenile fish passage were evaluated.

The BOR facilitated an interagency committee effort to inventory and screen potential storage sites for further development. The committee was made up of representatives from BOR, the Corps, and BPA; as well as from the States of Washington, Oregon, and Idaho. The sites were evaluated by the Corps and BOR, depending on prior agency involvement at the specific sites. The final evaluations were completed in 1993, and the final report was submitted to NPPC, by letter dated 11 February 1994.

Initially, over 400 potential storage sites were inventoried. These sites included on-stream, off-stream, and enlarging existing storage projects. Based on an initial screening, the number of potential sites was trimmed to 11. The criteria used for this screening include: 1) Wild and Scenic Rivers designation; 2) State or National Park areas; 3) commercial forest lands; and 4) sites impacting anadromous fish habitat. Water availability studies were conducted on the remaining sites. Based on those results, the number of sites were further screened to three, which included: 1) Galloway on the Weiser River; 2) Rosevear Gulch near Bliss, Idaho (off-stream site); and 3) Jacobsen Gulch near Ontario, Oregon (off-stream site). To facilitate further analysis, the Rosevear and Jacobsen Gulch sites were combined. Consequently, further studies were limited to two scenarios,

including: 1) Galloway; and 2) a combination of the Galloway and Rosevear Gulch sites. Of these sites, Galloway has approximately 751,000 acre-feet of available storage. The total for all three sites is approximately 1,500,000 acre-feet.

System operation studies were conducted using the Hydrologic System Seasonal Regulation (HYSSR) computer model. Operation studies were run both with and without the new storage for flow targets at Lower Granite Dam of 85,000 cfs and 1120,000 cfs, and evaluated over two durations (2 and 4½ months), both starting on 16 April, which is the start of the juvenile fish migration period.

The estimated project costs for the Galloway, Rosevear Gulch, and Jacobsen Gulch sites are $193 million, $1.1 billion, and $390 million, respectively (uninflated at October 1992 price levels). It was found that by shifting flow augmentation operation requirements from Dworshak reservoir to the new storage sites, the Dworshak project would be able to operate at a higher head for hydropower. The change resulted in a significant reduction in system power generation costs, ranging from $26 to $65 million per year. The average annual costs, including this system power benefits, range from -$5 to -42 million per year for Galloway to $149 to $165 million per year for all three combined. The negative cost implies that there is a net economic benefit to the development of the storage site, based on the system power benefit. It should be pointed out that these estimates are reconnaissance-level only.

It has been found that benefits attributable to upstream storage for increasing anadromous fish survival appear to be negligible. These findings can be expected based on the method and level of detail used in the evaluation. The analysis was based on an appraisal level of detail which, by its very nature, cannot be responsive to what is considered to be the more critical parameters and considerations involved in the entire flow survival issue.

The biological uncertainty inherent in the flow survival relationships used in modeling efforts, as well as other areas of biological uncertainty surrounding the adult and juvenile life cycle, make it extremely difficult to draw definitive conclusions with respect to the biological efficacy of upstream storage for flow augmentation. Additionally, successive years of consultation with NMFS concerning system operation under ESA have continued to result in increasing requirements for flow augmentation. These requirements are driven by the NMFS assessment that incremental flow increases are needed and effective as salmon recovery techniques. The need to provided these flows is stressing the use of Dworshak reservoir storage, and leading to increased demand on upper Snake River storage. Therefore, further consideration of a means to reduce the impact of the water demands on the Columbia River system, and particularly existing Idaho storage, may be prudent.

d. Upstream Collection and Conveyance.

The estimated benefits associated with the collector with barge transportation appear to provide significant improvements in terms of juvenile salmon survival. This survival estimate seems to be consistent with the analysis prepared by the NMFS Recovery Team (October 1993). The other biological effects (resident fish and wildlife impacts) do not appear to be significant with this alternative.

The migratory canal and pipeline proposals have significant biological concerns and uncertainties. The proposed migratory canal and floating pipeline conveyance options have received various critical reviews by such regional groups as the TAG. The TAG and the U.S. Fish and Wildlife Service, in its Planning Aid Report, expressed a considerable amount of concern with reliance on such untested artificial conveyance system designs. Primary concerns that are common to all of the currently proposed options are both biological and ecological. They include the following:

- Bioengineering capability to artificially replicate natural ecological processes and biological conditions that are functionally interacting to the degree exhibited naturally (*i.e.*, resting ponds/areas, temperature, feeding requirements; and flow regulation).
- The mechanical complexity of each proposed apparatus, and their synchronized operation, would require constant maintenance.
- Each alternative would require either some mechanical means of lifting the fish into the channel or a pumping system to move the fish.
- Exclusive increased concentration of salmon smolts through a closed system would act to separate smolts from their natural food sources and the diversity in their food items.
- Increased concentration of salmon smolts would be highly vulnerable to inescapable stress-related factors (*i.e.*, disease outbreaks and manifestations; predator invasion, including predation by larger steelhead smolts; increased inter- and intraspecies competition; and mechanical failure or accidents that would act as catastrophic events and potentially be detrimental to small population genetic fitness).

Using the CRiSP model, it was estimated that an upstream collector used in conjunction with barge transportation could potentially increase juvenile survival benefits, relative to the base case, up to 30 percent for spring and summer Chinook and 58 percent for fall Chinook. This estimate assumes that the collector could be designed to guide and collect approximately 95 percent of

the juvenile fish with a direct mortality of 2 percent or less. This assumption is not considered to be unrealistic since Wells Dam is able to achieve an estimated 90-percent guidance using their surface-oriented system.

The estimated project cost associated with the construction of the collector facility with barge transportation is $260 to $360 million (at October 1992 price level and not including inflation). It was assumed that the existing barges would be used. The estimated time required for implementation is 6 to 8 years, following authorization and the appropriation of design and construction funds.

e. System Improvements.

A number of improvements to existing facilities to improve fish migration conditions were identified and evaluated for the lower Columbia and Snake River mainstem dams. The evaluation related to the effects on anadromous fish were primarily based upon qualitative discussion, with some limited survival modeling. This was due in some cases to the lack of specific data. In other cases, it was because the improvement was project-specific and not applicable to system-wide based survival modeling.

Some of the improvements were considered to be more related to operational or maintenance type of improvements that would be locally beneficial. Therefore, it was determined that each action would be examined for its value as a long-term or near-term action. Improvements considered to be near-term measures had relatively small cost and may not provide a significant system-wide benefit. However, they do not require extensive or costly research or testing to verify their potential benefits. In other words, they can be implemented quickly without significant further evaluation. In any case, these improvements, either independently or in groups, are not considered to be actions that can be e4qually compared to other SCS alternatives (*i.e.*, drawdowns, upstream collectors, *etc.*). These small items are more suited to implementation prior to identification and implementation of long-term actions. Improvements that were considered to be effective long-term actions included:

- Surface-oriented collector systems similar to the system at Wells Dam on the Columbia River. This system would collect juvenile fish near the surface of the reservoir. It was assumed that this system would be used in conjunction with the existing turbine collection system.
- Extended turbine screens at Ice Harbor and Lower Monumental on the lower Snake River, and John Day on the lower Columbia River, to improve FGE.
- Additional fish ladders at Little Goose and Lower Granite Dams, since these projects currently are the only projects on the lower Snake or Columbia to only have one ladder.
- Water temperature control for fish ladders on the Snake River.
- Barge transportation of juvenile fish from John Day Dam to below Bonneville Dam.
- Turbine improvements to reduce turbine-related mortality.

- Short-haul barging below the dams to reduce predation associated with fixed release sites from existing bypass facilities (where high concentrations of predators are believed to exist).

The estimated project cost associated with these improvements range from $50 to $290 million, based on October 1992 price levels and without inflation. The estimated implementation timeframe is 4 to 10 years, which includes design and construction.

Some improvements that were evaluated and determined to be near-term actions include: 1) additional barges to improve direct loading capability; 2) improvements to juvenile collection system at Lower Granite Dam (*i.e.*, new flume and separator); 3) modifications to existing barge fish release mechanisms to reduce the associated stress and possible mortality of the current system; 4) modification of fish ladder exits at McNary Dam; and 5) modification to adult collection entrances and attraction water systems.

6. Comparison of Alternatives.

The range of potential actions are compared against each other. Phase I evaluation only looked at individual alternatives. There are no comparisons of combinations of alternatives. Combinations will be evaluated in Phase II. The criteria for evaluating, comparing, and screening the alternatives analyzed in the SCS Phase I includes:

- **Technical Feasibility.** The feasibility of implementing or constructing an alternative plan, from a technical or engineering perspective. If an alternative cannot be implemented, for whatever reason, it was discarded.

- **Biological Effectiveness.** Both qualitative and quantitative procedures were used in an effort to estimated salmon survival benefits for the various alternatives. The quantitative estimates were based on CRiSP model estimates of survival percentages for juvenile fish in their migration to a point below Bonneville Dam. Due to the project-specific nature of the system improvements (and additional time limitations), CRiSP modeling was not done and the biological effectiveness was limited to a qualitative analysis. For some alternatives, there may be a conflict between making improvements to juvenile and adult migration.

- **Other Significant Environmental Effects.** Environmental effects, other than those to anadromous fish, focus primarily on resident fish, other aquatic organisms, and terrestrial ecology; but also include cultural resources, water and air quality, and other effects.

- **Cost Effectiveness.** Cost effectiveness is an evaluation tool, calculated in terms of relative costs needed to achieve a change in salmon survival, in this case juvenile survival to below Bonneville Dam. The analysis looked at each species or stock separately. The cost-effectiveness approach avoids the issues of assigning monetary values to endangered species by comparing alternatives, in an attempt to identify the least-cost way to increase survival. This approach does not determine how much improvement of the environmental objective is economically justified but, rather, it provides information regarding the cost of action for various levels of salmon survival improvement. The cost-effectiveness analysis, in general terms, identifies some alternatives that are definitely cost effective, and some that are definitely not cost effective.

- **Regional Acceptability.** Regional acceptability for each of these alternatives will be assessed based on comments received to the draft report. The primary entity for determining regional acceptability is NPPC; but State and local entities, interest groups, industry, and the general public input are also important.

7. Preliminary Conclusions.

Due to the level of regional interest, biological uncertainty, and the critical nature of the problem, no recommendations are identified in the draft Phase I report. It is very important that NPPC, agencies, Tribes, other interest groups, and the public have the opportunity to comment on the tentative Phase I findings prior to developing final recommendations. The public input will help shape recommendations, which will be included in the final Phase I report, and reflected in the Phase II Plan of Study.

The function of the Phase I study was to screen out alternatives that showed little or no potential to improve salmon migration conditions or are not cost effective, and identify alternatives that showed some promise in this regard. Due to the regional controversy and uncertainty over the flow survival relationship, juvenile fish transportation program, estuary uncertainties, salmon survival simulation model limitations, and other areas, it is important that both in-river migration and transportation alternatives be further evaluated in Phase II.

These preliminary conclusions are drawn with full recognition that a high degree of uncertainty concerning the salmon lifecycle biology exists, and there is controversy surrounding the relative merits of transport compared to in-river migration. Knowledge of biological parameters in the estuary portion of the juvenile migration is severely lacking, and could be of significance in evaluating various recovery alternatives. Efforts are underway to identify potential tests and research to reduce these levels of uncertainty. Whatever course of action is pursued further, it should be done in an adoptive management approach,

with the flexibility to be modified, should results from current or future efforts yield information that would lead to conclusions different from those resulting from the Phase I study.

a. Lower Snake River Drawdown.

Only the Natural River drawdown option warrants further analysis in Phase II. This determination is based on the fact that this option was the only four-reservoir drawdown alternative to identify any anadromous fish benefits. Based on CRiSP model results, the natural river option was the only four-reservoir drawdown alternative to show a consistent potential benefit for anadromous fish, although the benefits were limited to spring and summer Chinook, and no potential benefits were identified for fall chinook or steelhead. The other four-reservoir drawdown alternatives, which are considered to be near spillway crest, showed negative impacts to all juvenile stocks investigated. Other qualitative evaluations also supported this determination. The models were run with a range of assumptions as a sensitivity analysis, which verified the results. The only near spillway crest drawdown alternative to show possible marginal benefits for all stocks was the Lower Granite only option, but with transport. Although this alternative includes drawdown, it is more similar to the upstream collection and conveyance alternative, in terms of its function.

The relationship used with the existing mathematical models assumes that increasing flows and velocities directly reduces juvenile fish travel time, thereby reducing their reservoir-related mortality and increasing survival. This increase in reservoir survival for the near spillway crest alternatives is not enough to overcome other factors reducing survival through the lower Snake (*i.e.*, increased mortality from turbines, spill, and bypass operations). Since these alternatives do not include any transport, all juveniles must migrate through the Snake River dams. In addition, the fish are then subjected to reservoir and dam mortality through the four dams and reservoirs on the lower Columbia River. Unless actions are taken on the lower Columbia River to significantly reduce reservoir and/or dam-related mortality, the near spillway crest drawdowns on the lower Snake River do not appear to be an effective action to improve system-wide migration conditions for juvenile salmon. The natural river option eliminates the effects of the four lower Snake dams, which is enough to potentially offset the increased mortality through the lower Columbia River.

b. John Day Operation at MOP.

The Corps has initiated, and is continuing, Advanced Planning and Design (AP&D) concurrent with the Phase I SCS study in response to regional (NPPC) and legislative direction. The scope of work includes studies to further evaluate and quantify environmental and user impacts, address mitigation alternatives, develop mitigation plans, and design mitigation measures for the impacted users in anticipation of a decision to implement. The scope also includes biological studies intended to address some of the uncertainties with regard to the biological effects of the proposal and, with completion of a smolt monitoring facility at the project, to obtain baseline flow/survival data prior to potential

implementation. The projected date to complete a draft decision document and EIS is 1996. With a positive decision to implement, MOP operation could begin in 1999.

The results of the Phase I study provides little information to reduce uncertainties surrounding the biological effectiveness of the proposed operation. This uncertainty results from general flow/survival issues, as well as the relatively small physical change in pool levels and water travel time that would be achieved by the operation. Uncertainties aside, the operation of John Day at MOP may not provide a sufficient benefit to justify the costs and impacts that have been preliminarily identified. There appear to be two courses of action that may be pursued beyond Phase I for this alternative: 1) continue the AP&D process now underway; or 2) discontinue study of John Day operation at MOP as an alternative.

c. Additional Snake River Basin Storage.

The development of additional water storage sites within the Snake River Basin warrants further evaluation in SCS Phase II. This conclusion is based on the potential of these sites as effective and economical means of augmenting streamflows in the lower Snake River. Although additional augmentation storage showed no measurable quantifiable biological benefit in terms of improved salmon survival (as determined using CRiSP), the Phase I analysis may not indicate the true potential of this alternative. The Phase I quantitative evaluation was based on monthly hydroregulation models (HYSSR), rigid flow targets, and lengthy augmentation release periods, which together could understate the benefits to fish migration.

The biological uncertainty inherent in the flow survival relationships used in modeling efforts, as well as other areas of biological uncertainty surrounding the adult and juvenile life cycle, make it extremely difficult to draw definitive conclusions with respect to the biological efficacy of upstream storage for flow augmentation. Additionally, successive years of consultation with NMFS concerning system operation under ESA have continued to result in increasing requirements for flow augmentation. These requirements are driven by the NMFS assessment that incremental flow increases are needed and effective as salmon recovery techniques. The need to provide these flows is stressing the use of Dworshak reservoir storage, and leading to increased demand on upper Snake River storage. Therefore, further consideration of a means to reduce the impact of the water demands on the Columbia River System, particularly existing storage in Idaho, may be prudent.

d. Upstream Collector and Conveyance.

The option of an upstream collector and barge transportation warrants further study in Phase II based on potential anadromous fish survival benefits, cost effectiveness, and NMFS Recovery Team draft findings. The estimated biological benefits associated with the collector, coupled with barge transportation, appear to be the highest of all the alternatives being evaluated. This survival estimate is generally consistent with the analysis prepared by

the NMFS Recovery Team (October 1993). The other biological effects (resident fish and wildlife impacts) do not appear to be significant with this alternative. Further study could be pursued in Phase II, provided regional review and comment indicates support for more detailed evaluation. The migratory canal and pipeline proposals should be eliminated from further consideration due to biological concerns and uncertainties.

The option of Lower Granite Drawdown with barge transportation was compared to other upstream collector and barge transport options. It would appear that, based on cost effectiveness, further study of this option is not justified. The upstream collector options had much higher juvenile salmon survival rates and lower implementation costs.

e. System Improvements.

A number of lower Snake River improvements to existing facilities to improve fish migration conditions were determined to warrant further study, based upon qualitative evaluation of the potential benefits to anadromous fish. Some of these improvements were determined to be long-term actions, which required substantial study, research, and testing in Phase II. Others were considered to be near-term and should be studied and developed in a much quicker timeframe in a process independent from SCS. The long-term improvements that should be carried into Phase II include: 1) surface-oriented collector systems; 2) extended turbine screens at Ice Harbor and Lower Monumental; 3) additional fish ladders at Little Goose and Lower Granite Dams; 4) water temperature control for fish ladders; and 5) stilling basin improvements to reduce dissolved gas levels resulting from spill. Some of the more significant near-term measures include: 1) additional barges; 2) modification to barge fish release mechanisms; and 3) improvements to Lower Granite Dam juvenile collection and bypass facilities (*i.e.*, new flume and separator).

On the lower Columbia River, qualitative considerations and the preliminary quantitative analysis suggests that there is sufficient justification to continue study of these measures. The process for moving forward can vary depending on the measure. The FGE improvements at Bonneville first powerhouse warrants further consideration, but only in conjunction with other bypass improvements. In general a separate process for the lower Columbia projects would appear to be the most effective method to move forward beyond the SCS Phase I. This is a preliminary conclusion, subject to regional input, which would allow proceeding in a more timely manner with studies and implementation of feasible measures to improve the passage survival for mid and lower Columbia River stocks. This course of action recognizes the long-term nature of implementation of major modifications on the Snake River. It also recognizes that measures implemented for Columbia stocks would similarly benefit in-river migrating Snake River stocks.

Main Report

Appendix A - Lower Snake Reservoir Drawdown Technical Report

Appendix B - John Day Reservoir Minimum Operating Pool Technical Report

Appendix C - Additional Snake River Basin Storage Technical Report

Appendix D - Upstream Collection and Conveyance, Snake and Columbia Rivers, Technical Report

Appendix E - Improvements to the Existing Systems Technical Report

Appendix F - System Improvements Technical Report, Lower Columbia River

Appendix G - Biological Plan--Lower Snake River Drawdown Technical Report

Decision Document - Lower Granite Dam Juvenile Fish Facilities