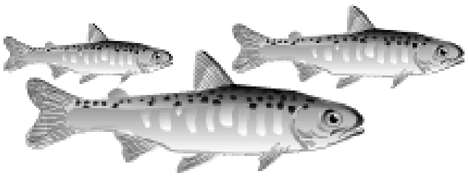
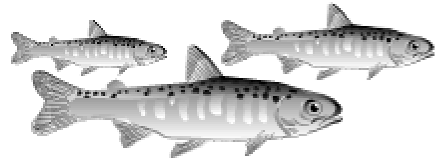


Chapter 3

Plan Formulation



3. Plan Formulation

In response to National Marine Fisheries Services' (NMFS) 1995, 1998, and 2000 Biological Opinions and the results of the *Interim Status Report* (Corps, 1996a), the U.S. Army Corps of Engineers (Corps) continued evaluating various improvements to the Lower Snake River Project. These improvements are intended to improve the effectiveness of downstream migration by juvenile salmonids and upstream passage of adults. This section describes the four alternatives that are evaluated in detail (Sections 3.1 through 3.4). These alternatives include:

- Alternative 1—Existing Conditions
- Alternative 2—Maximum Transport of Juvenile Salmon
- Alternative 3—Major System Improvements (Adaptive Migration)
- Alternative 4—Dam Breaching.

This section also addresses actions that were considered, but were not evaluated in detail in this Feasibility Report/Environmental Impact Statement (FR/EIS) because they were either outside the scope of the FR/EIS (Section 3.5) or they were eliminated from further consideration for various reasons (Section 3.6). Further details on dam breaching alternatives and major system improvements are provided in Appendix D, Natural River Drawdown Engineering, and Appendix E, Existing Systems and Major System Improvements Engineering, respectively.

The Draft FR/EIS was released in December 1999 and was based on the 1995 and 1998 Biological Opinions. NMFS' 2000 Biological Opinion, released in December 2000, extends many of the actions prescribed in the earlier opinions. However, it specifically addresses the dam breaching question by outlining a process and planning mechanism for breaching.

The RPA in NMFS' 2000 Biological Opinion establishes a schedule for determining whether to pursue breaching as a means of avoiding jeopardy. As indicated in Section 1.3.3, this process involves major reviews in 2005 and 2008 that determine if the RPA in the 2000 Biological Opinion is meeting certain performance standards. These standards are based on the stock status of listed species and the likelihood of their survival and recovery. If the 2005 and 2008 reviews indicate failure to implement the RPA of the 2000 Biological Opinion or that the prescribed actions have not been effective, authorization for dam breaching may need to be sought so that this option is available for implementation.

3.1 Alternative 1—Existing Conditions

Alternative 1—Existing Conditions consists of continuing the operation of the fish passage facilities and project operations that were in place or under development at the time that this FR/EIS was initiated.

Operations under Alternative 1—Existing Conditions would continue to meet the authorized uses of the Lower Snake River Project (see Section 1.2, Purpose and Need). Figure 3-1 summarizes the activities that would continue with the existing operations (and activities for other alternatives). These operations are described in detail in Section 2.0, Affected Projects and Programs. Existing environmental conditions are described in Section 4, Affected Environment. This alternative is the base case or "no action" alternative considered in this National Environmental Policy Act (NEPA) process.

Under Alternative 1—Existing Conditions, activities prescribed in the 1995 and 1998 Biological Opinions to improve juvenile fish passage conditions would be continued. In addition to the structural changes that would be implemented (e.g., adding end-bay deflectors) and the facilities that would be developed (e.g., additional barges for transporting juvenile fish), it is assumed that flow augmentation would continue.[1]

Project operations—including all ancillary facilities such as fish hatcheries and Habitat Management Units (HMUs) under the Lower Snake River Fish and Wildlife Compensation Plan (Comp Plan) (see Section 2.1.8, Lower Snake River Fish and Wildlife Compensation Plan), recreation facilities, power generation, navigation, and irrigation—would remain the same, unless modified through future actions. For example, the captive broodstock program of the Comp Plan could be expanded to include all listed species, which could modify some or all hatchery operations from

[1] Flow augmentation of 427,000 acre-feet from upstream sources has been assumed for certain periods of juvenile downstream migration. However, the Idaho statute that established this flow level has expired. Negotiations concerning this flow augmentation are continuing under a separate Section 7 consultation.

producing high numbers of juvenile salmon to fewer, but higher quality, juveniles that may have a higher survival rate.

Alternative 1—Existing Conditions would include a “spread-the-risk” strategy for downstream juvenile fish passage. This strategy provides operational options which ensure that “the majority of the downstream migrants from any one stock is not transported and that uncollected migrants are exposed to (the) best possible in-river conditions” (NMFS, 1998). However, this is accomplished through existing or currently planned facilities and not major system improvements. Adult and juvenile fish passage facilities would continue to operate.

Existing operations include several other planned measures that would be used to increase fish passage survival. These include:

- **New Turbine Cams**—Cams are computer software based upon the turbine performance curves that automatically control the turbine blade angle and wicket gate openings. These cams may be modified to increase the hydraulic efficiency of the turbines. The increased hydraulic efficiency of the turbines would likely reduce fish mortality. The existing condition assumes that new or modified cams would be used on all turbines at all dams to optimize turbine efficiency.
- **New Turbine Runners**—Studies are currently underway to develop turbine runners that reduce fish injury and associated mortality for those juvenile fish passing through the turbines. It is assumed that for the existing conditions, all turbines and generators would eventually require rehabilitation and, new turbine runners would be installed at that time. This would imply that new turbine runners could be installed over the next 5 to 15 years.
- **Upgrade Lower Granite Juvenile Fish Facilities**—Certain structural modifications and upgrades would be made to this facility to more effectively handle fish. Proposed activities include:
    1. Replacing the thirty-six 254-millimeter (10 inch) orifices extending from the bulkhead slots to the juvenile fish collection gallery with thirty-six 305-millimeter (12 inch) orifices. Each orifice would be equipped with an air operated knife valve, and an air back-flush system for dislodging debris. The valves would be automated and controlled with a programmable logic control computer so they could be cycled to prevent clogging.
    2. Mining the gallery to a 2.7-meter (9 foot) width so orifice flow would not strike the far wall. The gallery is currently 1.8 meters (6 feet) wide.

Figure 3-1. Lower Snake River Juvenile Salmon Migration Feasibility Study, Alternatives Matrix

	Alternative 1 —Existing Conditions	**Alternative 2** —Maximum Transport	**Alternative 3** —Major System Improvements	**Alternative 4** —Dam Breaching
Existing System Operations				
Adult Fish Passage Systems				
Fish Ladders	√	√	√	
Pumped Attraction Water Supplies	√	√	√	
Powerhouse Fish Collection Systems	√	√	√	
Juvenile Fish Bypass and Collection Systems				
STS – IHR, LMO	√	√	√	
ESBS – LGO, LGR	√	√	√	
Collection and Transportation Facilities	√	√	√	
Trash Shear Boom	√	√	√	
Minimum Operating Pool – During Fish Migration	√	√	√	
Turbine Operations – Within 1 percent Peak Efficiency	√	√	√	
Voluntary Spill				
Current Operations	√			
Minimize Operations – IHR Only		√		
Optimize Operations			√	
No Spill				√
Flow Augmentation (Dworshak)	√	√	√	√
Flow Augmentation (Upper Snake River) – 427,000 acre feet	√	√	√	√
Dissolved Gas Abatement Measures				
Spillway Gas Control Measures (Deflectors)	√	√	√	
Spillway Gas Monitoring	√	√	√	
Continue Fish Facility Operations	√	√	√	
Continue AFEP Evaluations	√	√	√	
Power				
Current Production	√		√	
Increased Production		√		
No Production				√
Navigation				
Current Operations	√	√	√	
No Operations				√
Fish Transportation				
Spread-the-Risk	√			
Optimize Transportation			√	
Maximize Transportation		√		
No Transportation				√

3. Mining an exit channel from the dam out to daylight, and installing a non-pressurized flume system to the fish collection facility.
4. Installing a dewatering system to reduce the flow from 7.08 m^3/sec (250 cfs) to 0.85 m^3/sec (30 cfs), similar to the design at Little Goose Dam, and routing the excess water to the adult fish collection facility.
5. Installing a size separator to separate smaller (primarily salmon) from larger (primarily steelhead) smolts so smaller and larger smolts can be transported in separate truck or barge compartments.
6. Upgrading raceways and distribution flume systems at the collection facility.
7. Upgrading direct barge loading facilities.

- **New Fish Barges**—Seven additional 22,700-kg (50,000-lb) capacity barges would be constructed to allow direct loading at fish collection facilities. Direct loading would reduce the amount of fish handling and associated stress. These would replace two 10,400-kg (23,000-lb) capacity barges scheduled for retirement and would provide additional capacity. The two barges being replaced are old hulls (over 50 years old) that are approaching the end of their serviceable life.
- **Adult Fish Attraction Modifications—**The adult fish attraction water at selected dams would be modified in order to ensure an adequate water supply for the fish ladders in the event of a pump failure. This may include electrical upgrades to provide a more reliable source of electrical power to the attraction water pumps, upgrading existing pumps, adding new pumps, or adding a gravity feed system for the attraction flow.
- **Modified Fish Separators—**To improve fish separation and to reduce fish stress, delay, and mortality at existing juvenile fish facilities, the existing fish separators would be modified. New separators would be installed at Little Goose and Lower Monumental, and would be included in an upgrade of the Lower Granite juvenile fish facility.
- **Cylindrical Dewatering Screens**—Cylindrical dewatering screens would be installed at Little Goose, Lower Monumental, and Ice Harbor, and included in an upgrade of the Lower Granite juvenile fish facility. These screens reduce the amount of water routed into the fish collection facilities. They are a more effective means (compared to stationary screens) for avoiding plugging of screens and for removing trash from the inflow. This screen design may be an improvement over existing stationary screen designs.
- **Spillway Flow Deflectors/Pier Extensions**—Additional spillway flow deflectors, modifications to existing spillway flow deflectors, and pier wall extensions would be added at Lower Granite, Little Goose, and Lower Monumental. These improvements are expected to further reduce dissolved gas concentrations and, thus, provide more control of TDG levels. They would be similar to the designs for the recently installed deflections at Ice Harbor. Overall, the dissolved gas abatement structures should assist in lowering concentrations.

- **Improvements to the Extended Submerged Bar Screens**—The existing ESBSs at Lower Granite and Little Goose would be modified to improve their operability and longevity.

3.2 Alternative 2—Maximum Transport of Juvenile Salmon

All of the existing or planned structural configurations and flow augmentation of 427 thousand acre feet (KAF) from the existing conditions would be included in this alternative (Figure 3-1). This alternative is the same as the Corps' Alternative 2a that is described in Appendix E, Existing Systems/Major System Improvements Engineering.

Under Alternative 2—Maximum Transport of Juvenile Salmon, project operations—including all ancillary facilities such as fish hatcheries and HMUs under the Comp Plan (see Section 2.1.8, Lower Snake River Fish and Wildlife Compensation Plan), recreation facilities, power generation, navigation, and irrigation—would remain the same, unless modified through future actions. However, this alternative assumes that the juvenile fishway systems would be operated to maximize fish transport and that voluntary spill would not be used to bypass fish through the spillways (except at Ice Harbor).

To accommodate maximum transport of juvenile salmon, measures would be used to maintain, upgrade, and significantly improve fish facilities (see Section 3.1, Alternative 1—Existing Conditions) that would focus on limiting in-river migration. For example, even though conditions for flow augmentation under the 1995, 1998, and 2000 Biological Opinions would be met, in-river migration would be minimized by limiting spill, and fish collected in facilities would be transported downstream by trucks or barges rather than bypassed below the dams. Also, there would be no need to modify spillway flow deflectors at Lower Monumental, Little Goose, or Lower Granite because voluntary spill (except at Ice Harbor) would be eliminated. As with Alternative 1—Existing Conditions, two end-bay deflectors would be added at Lower Monumental and Lower Granite (see Table 3-1). This should help to improve water quality conditions associated with elevated levels of dissolved gas.

Under Alternative 2—Maximum Transport of Juvenile Salmon, activities prescribed in the 1995 and 1998 Biological Opinions to improve juvenile fish passage conditions would be continued the same as for Alternative 1—Existing Conditions.

3.3 Alternative 3—Major System Improvements (Adaptive Migration)

Alternative 3—Major System Improvements assumes that the juvenile fishway systems would be operated under an adaptive migration strategy that balances the passage of fish between in-river and transport passage methods. This strategy addresses concerns about the risks and effectiveness associated with bypass-only and transport-only approaches. It would also allow the flexibility for implementing operational changes within a migration season, if necessary.

Alternative 3—Major System Improvements would include all of the existing or planned structural configurations from Alternative 1 and most structural configurations found under Alternative 2—Maximum Transport of Juvenile Salmon

(Figure 3-1). For example, spillway flow deflectors and pier extensions would be used to help lower TDG concentrations. In addition, Alternative 3—Major System Improvements would include major system improvements that would provide a greater ability and more options to better adjust migration approaches (i.e., either in-river or transport).

Under Alternative 3—Major System Improvements, activities prescribed in the 1995 and 1998 Biological Opinions to improve existing juvenile fish passage conditions would be continued the same as for Alternative 1—Existing Conditions. In addition, it is assumed that flow augmentation of 427 KAF would continue. Project operations—including all ancillary facilities such as fish hatcheries and HMUs under the Comp Plan (see Section 2.1.8, Lower Snake River Fish and Wildlife Compensation Plan), recreation facilities, power generation, navigation, and irrigation—would remain the same, unless modified through future actions.

Major system improvements that are focused on more effective diversion of juvenile fish away from the turbines would be implemented under Alternative 3—Major System Improvements using SBCs (Figures 3-2a and 3-2b). Ten different SBC options were developed and evaluated for Lower Granite (see Annex B to Appendix E, Existing Systems/Major System Improvements Engineering). These 10 were narrowed down to 4 possible options, based on the results of the prototype testing and results of the evaluations. A fifth SBC option was later added.

Some of the possible surface bypass options would be used in conjunction with existing ESBSs and a new behavioral guidance system (BGS). The BGS (Figure 3-2b) is a long and deep physical structure used to guide migrating juvenile fish to the SBC. Fish collected by the SBC or ESBSs would be combined and delivered to the transportation facilities, and either trucked or barged downstream. Implementation of the SBC system with transportation would involve a high volume dewatering system which results in directing juvenile fish from a large and dispersed volume of water to a smaller volume where they can be more readily collected. A variety of options under this alternative could be implemented, depending on results of ongoing or future tests of equipment, facilities, and approaches (see Appendix E, Existing Systems/Major System Improvements Engineering).

At Lower Granite and Lower Monumental, SBC systems would be installed in front of Turbine Units 5 and 6. Surface collectors could then be used to collect fish at these two dams for downstream transport. Lower Granite is a logical location for collecting fish for transport because it is the furthest upstream dam and therefore, the first dam encountered by outmigrating juvenile fish. The SBC at Lower Monumental would allow collection of 1) fish not collected at Lower Granite, 2) fish entering the Snake River from the Tucannon River, and 3) fish released from the Lyons Ferry Hatchery.

When in transport mode, the SBC at Lower Granite and Lower Monumental would collect downstream migrating fish and pass them through a dewatering section into the surface collector, delivering them to the existing juvenile fish collection channel

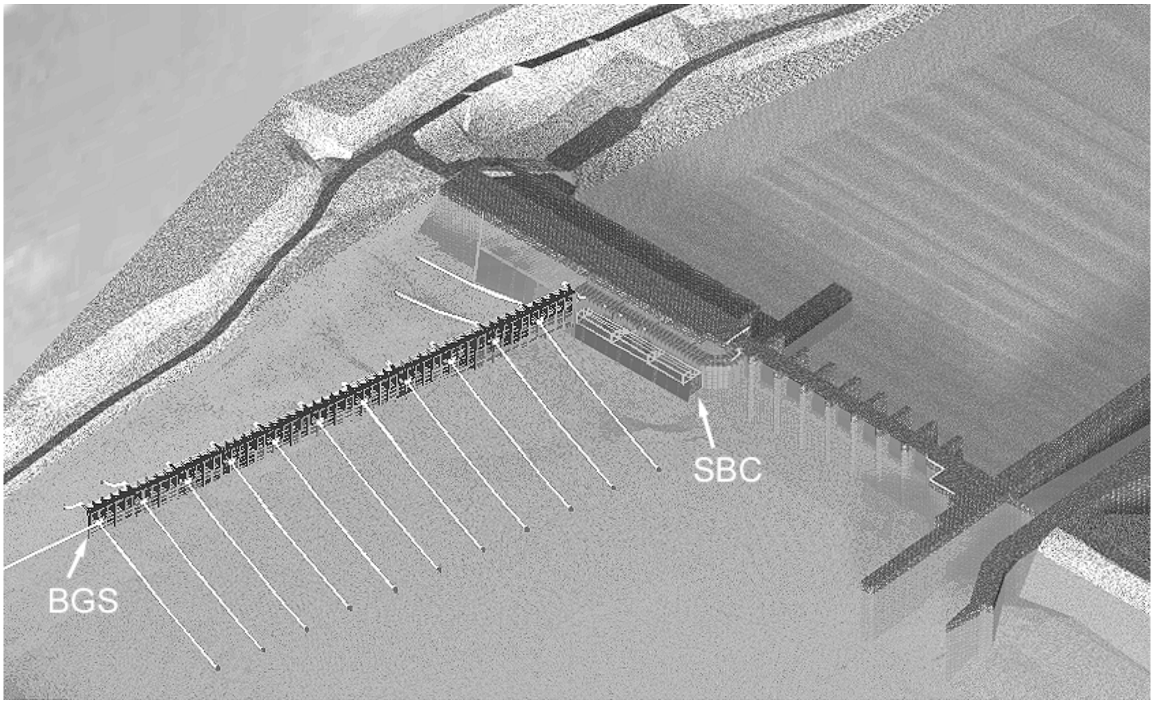


Figure 3-2a. Surface Bypass Collector Prototype System

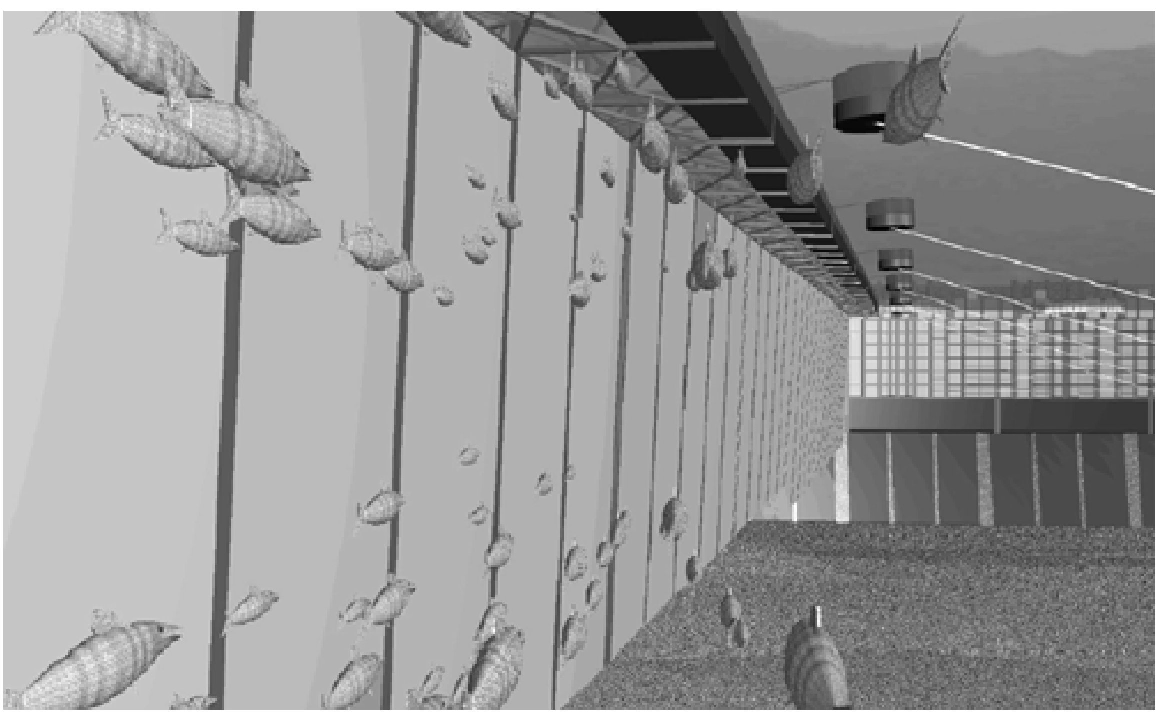


Figure 3-2b. Behavioral Guidance Structure Underwater View

within each dam. To guide fish away from Turbine Units 1 through 4, a BGS would be constructed in the forebay.

When it is desired to keep juvenile fish in the river, the surface collector would be shut off and the fish would be guided by a BGS past the SBC to removable spillway weirs (RSWs).

The RSW is a removable steel structure that is inserted in front of the existing spillbay, creating a raised overflow weir above and upstream of the existing spillway crest (see Figures 3-3a, 3-3b, and 3-3c). Figure 3-3a, which shows the Lower Granite 2001 surface bypass and RSW prototype, is presented to illustrate the RSW location relative to other dam components. No modifications, except the addition of support brackets, would be required to the existing spillway to accommodate the RSW. Because the flow over the RSW is essentially uncontrolled, the flow rate would vary depending on the forebay water elevation. Discharge would be greater when the forebay is at maximum operating pool and smaller when at the minimum operating pool.

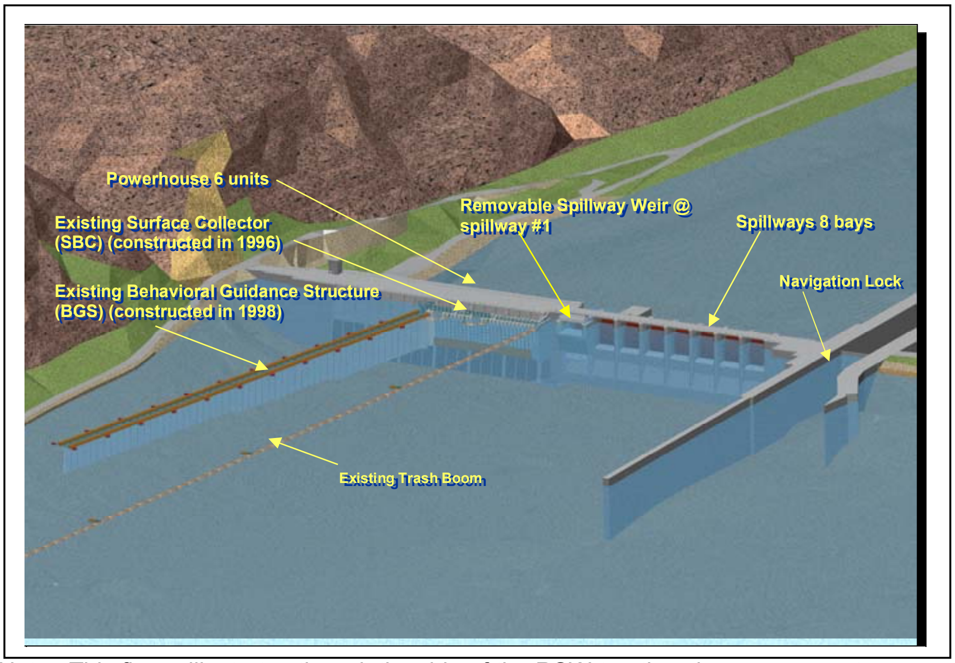
The RSW is supported vertically on hinges attached to the spillway. During high river flows, the RSW is rotated off the spillway by gradually filling flotation tanks within the RSW with water. This reduces the buoyancy of the RSW, causing it to rotate upstream. Filling continues until the RSW is lowered onto a landing pad resting on the bottom of the river (Figure 3-3d). This restores the hydraulic spill capacity. After the river flows drop to an acceptable level, the tanks are gradually filled with air, replacing the water. This causes the RSW to rotate back into position on top of the spillway.

The RSWs would provide a surface attraction flow and a less stressful method of bypassing fish than is now used for spillway passage. The best shape of the downstream portion of the RSW to provide optimum passage would have to be determined from prototype testing.

ESBS intake diversion systems would be used in conjunction with these two-unit SBC structures. At Lower Granite, the existing ESBS would be used, whereas at Lower Monumental, there would be new ESBSs to replace the existing submerged traveling screens (STSs). ESBS would be located in the turbine intakes of all six units of both powerhouses to bypass fish that pass around or under the BGS.

An SBC system termed a full-length powerhouse Occlusion Structure (see Appendix E, Existing Systems/Major System Improvements Engineering) would be installed at Little Goose. This structure would be expected to improve the performance of the ESBSs and to increase the guidance of fish away from the turbine intakes and towards the spillway. RSWs would be placed in spillbays 1 and 3 to bypass fish. Also, each turbine unit at Little Goose would have an existing ESBS in place. Fish diverted by the ESBS would be directed to the juvenile fish facilities where they would be collected for transport or returned to the river.

At Ice Harbor, a SBC system would be constructed. A BGS would extend from the interface of the powerhouse and spillway. Two RSWs would be installed, one on spillbay 1 and the other on spillbay 3. The RSWs would provide attraction flow to the spillways and would provide a method of bypassing fish over the spillway. New ESBSs would replace the existing STSs at Ice Harbor. They would be installed in the turbine intakes to offer a bypass for fish passing around or under the BGS.



Note: This figure illustrates the relationship of the RSW to other dam components.

Figure 3-3a. Overview of the Lower Granite 2001 Surface Bypass and Removable Spillway Weir Prototype

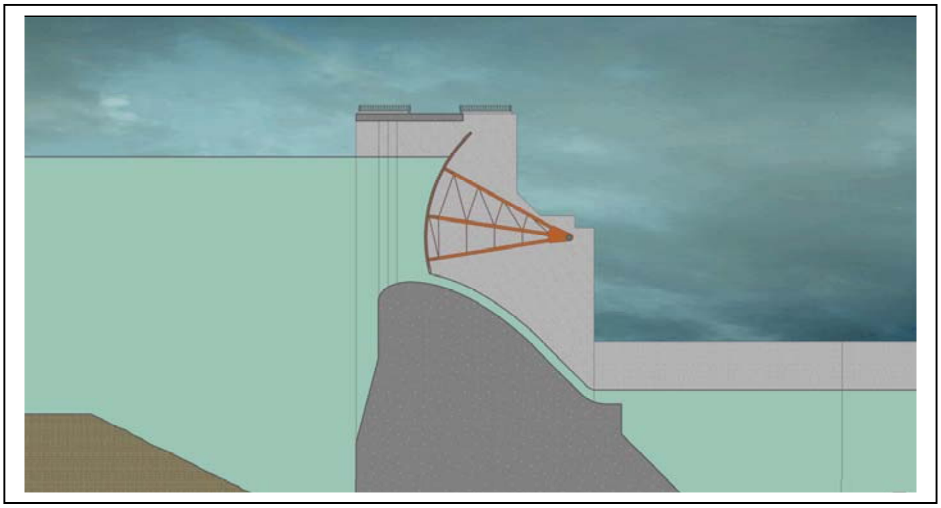


Figure 3-3b. Spillway without Removable Spillway Weir (Typical Spillway Operation) (Cross-Sectional View)

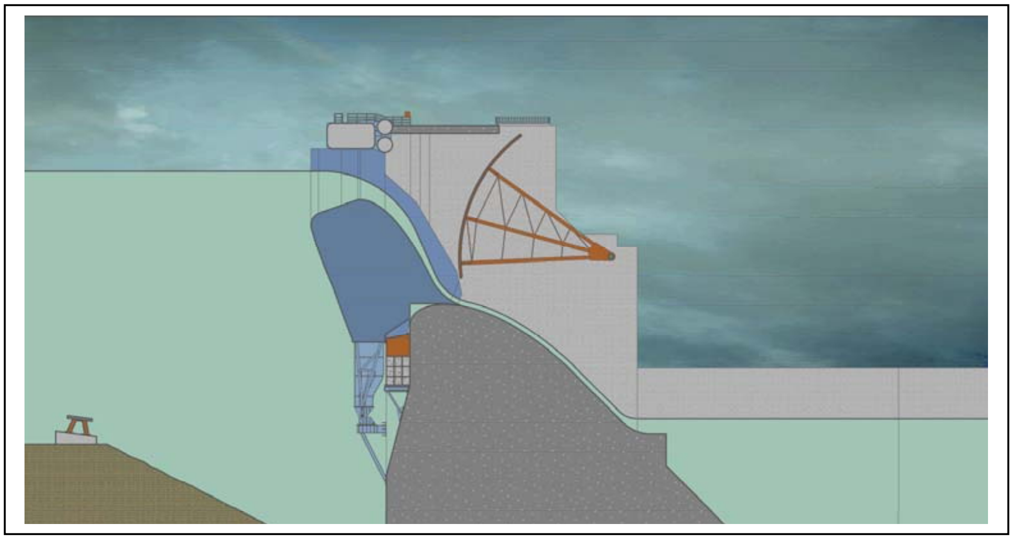


Figure 3-3c. Spillway with Removable Spillway Weir Deployed (Operating Position) (Cross-Sectional View)

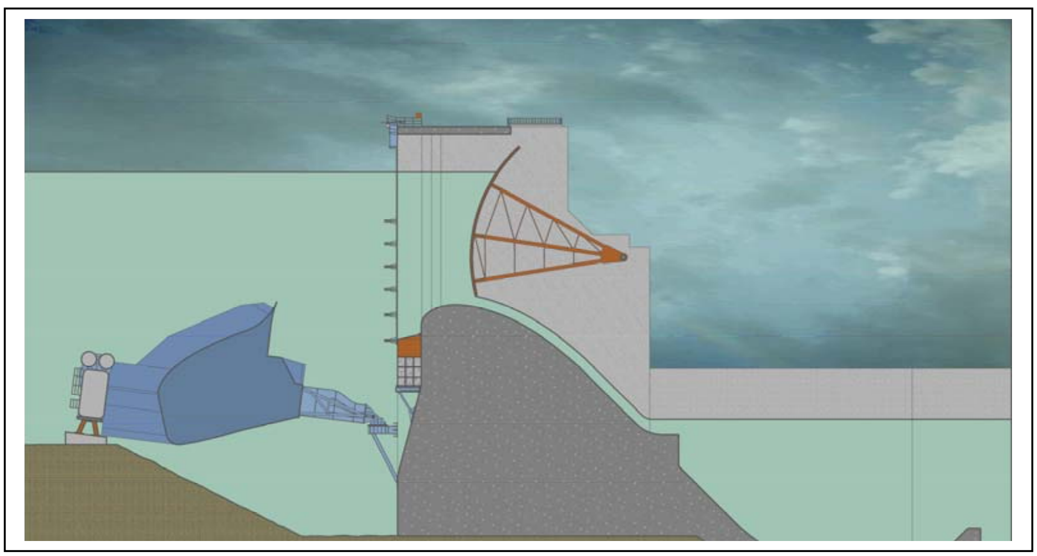


Figure 3-3d. Spillway with Removable Spillway Weir Removed (Flood Control) (Cross-Sectional View)

When operating in the bypass mode, it is anticipated that there would be a need for voluntary spill only over the RSWs at Lower Granite, Lower Monumental, and Ice Harbor. This is because the BGS proposed for these dams is expected to divert a majority of fish away from the powerhouse to the RSWs. Also, two RSWs are expected to provide adequate surface attraction to the RSWs at these dams.

When collecting and transporting fish, there would be no need for voluntary spill at Lower Granite or Lower Monumental because fish would be collected for transport. Voluntary spill over the RSWs alone is required at Little Goose and Ice Harbor in an effort to bypass fish at these dams.

Alternative 3—Major System Improvements would be implemented in two phases. The first phase would be considered "near-term actions" that involve a number of model and full scale tests of various SBC, BGS, RSW, and other structure configurations to determine their effectiveness. For example, model testing would be required to determine the ability of the occlusion structure to effectively divert fish by the spillway RSWs at Little Goose. Then the need for additional voluntary spill at Little Goose can be accessed. This would apply when the river is in bypass or transport mode. Prototype testing of other potential major improvements would also occur in this first phase. In addition, near-term actions would include implementation of existing facility improvements that require little or no additional research or evaluation.

Once the "near-term actions" have been completed and the prototype testing has demonstrated which configurations are most effective, "long-term actions" would be implemented. These actions would likely include full-scale construction and operation of major structures at each of the four dams. These "long-term actions" may not include all of the system upgrades currently included under this alternative because results from the prototype tests may alter the need for certain structures or require addition or deletion of other structures. For any significant adjustments, compliance with NEPA may also be required.

3.4 Alternative 4—Dam Breaching

The *Interim Status Report* (Corps, 1996a) considered three drawdown options: 1) seasonal, spillway crest; 2) seasonal, natural river drawdown; and 3) permanent, natural river drawdown. None of these drawdown options specifically incorporated a dam breaching scenario (see Section 1.2, Purpose and Need).

The dam breaching scenario differs from all other drawdown scenarios. Structural modifications are undertaken at the dams, allowing reservoirs to be drained, and resulting in a free-flowing river that would remain unimpounded. For example, with flows of 20,000 cubic feet per second (cfs), the total drawdown below normal maximum pool levels would be approximately 115 feet at Lower Granite, 114 feet at Little Goose, 108 feet at Lower Monumental, and 97 feet at Ice Harbor. Breaching of only one, two, or three dams was not considered in this FR/EIS because the removal of only one dam would eliminate major navigation in the lower Snake River and would curtail options for collecting and transporting juvenile fish. In addition, the 1995 Biological Opinion only addressed drawdown concepts for all lower Snake River reservoirs.

With dam breaching, the navigation locks would no longer be operational, and navigation for commercial and large recreation vessels would be curtailed. Similarly, recreation opportunities, operation and maintenance of hatcheries and HMUs, and other activities associated with the modification from a reservoir environment to an unimpounded river in the lower Snake River would entail important changes in these activities (see Sections 5.10.2, 5.12, and 5.5.2 for details on specific changes). No hydropower would be produced at the four dams under this alternative. In addition, some water quality conditions such as TDG concentrations would likely be at or near natural conditions. However, other conditions such as water temperature, would still be affected by upstream conditions or releases.

For dam breaching, the primary reason for leaving portions of the project in place is that it meets the operational criteria at the lowest practical cost. However, modifications to structures would be done in such a manner that the structures could be restored to operating conditions with later modifications (Figure 3-4). With this alternative, reservoirs behind the four lower Snake River dams would be eliminated, which would result in a 140-mile near-natural river. This requires the protection of structures from near-natural river flows, and the decommissioning of equipment and structures. Secondly, construction operations would be phased so that power production, navigation, and fish migration could continue until the last possible period.

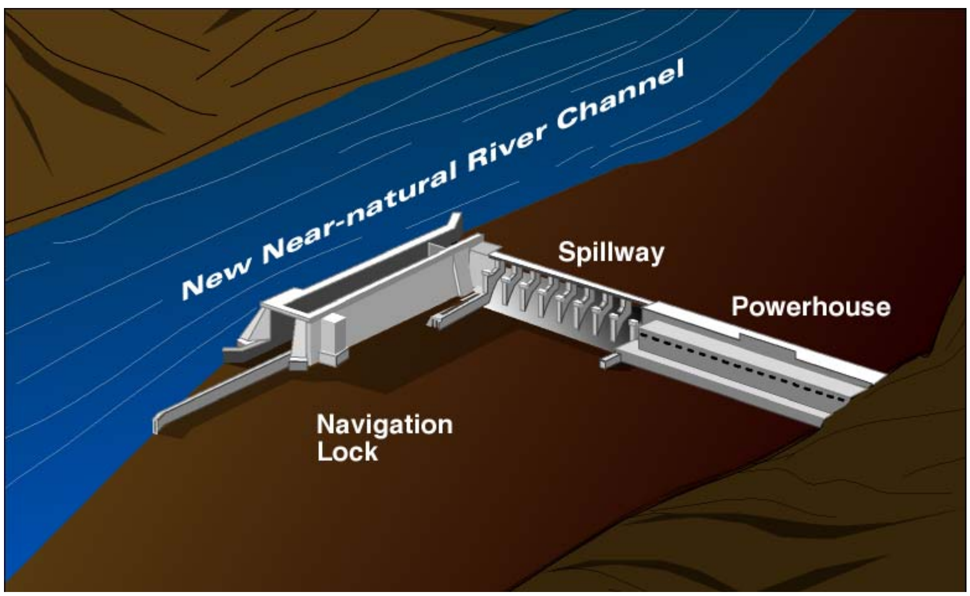


Figure 3-4. Dam Breaching

Dam breaching would involve removal of the earthen embankment section and abutment at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor. Once the embankment is removed, the river would flow around the remaining structures (powerhouses, spillways, and navigation locks). Levees would be used to "shape" the river into a channel around these structures. Long-term maintenance or preservation of these powerhouses, spillways, and navigation locks would be minimal.

The following sections describe key aspects of dam breaching.

3.4.1 Reservoir Drawdown

The powerhouses and spillways would be used to lower upstream pool elevations from full pools to near existing spillway crest elevations. Below spillway crest, the current powerhouses and existing spillways would become inoperable. Additionally, based on a drawdown rate of 2 feet per day, current facilities to pass juvenile and adult fish would be inoperable within a few days to two weeks of initiating the drawdown process. This drawdown rate of 2 feet per day is based on the need to achieve drawdown in a specified timeframe to reduce the risk of embankment failure.

Because none of the four lower Snake River dams were constructed with a low-level outlet, reservoir drawdown below spillway crest is not possible without some major structural modifications. Several options were considered to evacuate the reservoirs below spillway crest, including mining through the concrete of the spillway bays or the powerhouse, excavating through the embankment section, and modifying the navigation lock to discharge low-level flows. The selected option is to modify the six units so that water can be discharged through the units at varying reservoir levels.

It is necessary to provide a discharge capacity of 60,000 cfs. The minimum base flow for the Snake River during late fall and winter is 20,000 cfs. It is estimated that each powerhouse unit (one of six) must pass up to 15,000 cfs during various reservoir stages. Since each powerhouse bay is designed so that upstream and downstream bulkheads can be installed to stop flow, construction could proceed without the construction of independent cofferdams. Construction could proceed on some activities well in advance of the drawdown operation. However, early preparations will need to balance power generation, fish mitigation, and control of dissolved gas supersaturation.

Although discharge of water through the turbine passages would allow drawdown of the majority of the reservoir, some ponding would still exist behind the earthen embankments. After draining as much water as possible through the new outlets, a section of the embankments would be removed to allow the river to run through the channel.

Reservoir drafting would be controlled. For example, at Lower Granite, drafting would be limited to 2 feet per day, requiring 58 days to draft 115 feet below full pool. The total reservoir storage, in the four reservoirs, that would be evacuated during drawdown would be about 1.67 million acre-feet (MAF).

3.4.2 Required Modifications

A number of structural modifications to the features of each dam would be necessary for a permanent drawdown. Some embankment would be removed and replaced with a channel to allow the near-natural flow of the river. Some channelization of the river in the dam reach would be necessary to create hydraulic conditions that allow upstream fish migration. In addition, facilities for passing adult fish upstream and during construction activities, as well as during the time when the reservoir is being lowered would be needed.

Criteria, assumptions, and key considerations for upstream fish passage during construction activities and for permanent drawdown were established for the feasibility evaluation. Construction activities would be orchestrated in a manner to ensure, so far as possible, that upstream passage of adult fish would not be adversely affected. For example, it was assumed that channel velocities below 5 feet per second (ft/s) require no supplemental adult fish upstream passage facilities. Channel velocities above 5 ft/s require features in the river to produce rest areas. The higher the velocity, the more numerous and frequent the rest areas. It was also assumed that the maximum flow against which adult fish are assumed to swim upstream is 170,000 cfs. Specific options and facilities for adult fish passage during construction are described in Section 3 of Appendix D, Natural River Drawdown Engineering.

Juvenile fish would be allowed to pass downstream through the open channel that would be present after dam breaching. Collection and transport facilities for juveniles would no longer be operated following dam breaching. Construction will occur August through December, a period where downstream passage of juveniles does not occur, except for subyearling fall chinook salmon smolts that pass through October, depending upon annual flow and subsequent water temperature resulting from augmentation operations upriver (see Section 4.5.1, Anadromous Fish).

Additional criteria, assumptions, and key considerations for dam breaching included in the feasibility studies are described below:

No Catastrophic Drawdown

The evacuation of the reservoirs would be done at a maximum fixed rate of 2 feet per day. This rate is designed to minimize or avoid slope failures in the reservoirs, which could put highways and railroads out of service.

Minimal Cost

When considering various options for implementing drawdown, the lowest cost option was the primary consideration. The goal of the Feasibility Study was to identify the major activities necessary to implement a four-reservoir drawdown and to document a feasible, reasonable method to accomplish those activities.

Mitigation Measures

Numerous construction activities and post-construction mitigation measures were assumed for implementation of dam breaching and modification of existing structures in the reservoirs. Direct measures are those activities necessary to evacuate each reservoir, remove a portion of the dam structure, and establish a river channel at each dam site. An example would include maintaining conditions for upstream passage of adult fish. In addition to these activities, modifications and repairs to transportation facilities adjacent to and across the river (e.g., bridge supports would need additional protection from potential scour) would be needed. Existing access to the river for cattle watering and protection of cultural resources would need to be addressed.

Other discretionary mitigation measures were also considered because they are authorized under current and anticipated project authorization. Examples include modifications to current wildlife mitigation lands, modifications to an operating fish hatchery, and measures to provide river access and appropriate recreation facilities. These are evaluated in greater detail in the respective sections of this FR/EIS.

The process of decommissioning the project requires a number of tasks. Key modifications are discussed in detail in the following sections.

3.4.2.1 Bulkheads

To use the turbine units as low-level outlets, some modification to the intake gates would be required. Upon completion of unit modifications, discharge through the turbine passages would be initiated by raising the intake gate, or by some coordinated operation of the turbine wicket gates and draft tube bulkheads. Neither gate was designed to regulate flow, so modification or replacement would be necessary so the gates would regulate discharge. Modifications may include gate strengthening, added operators, and new rollers and seals. Such modifications would apply to all gates. Further modifications may be necessary to the draft tube bulkheads.

3.4.2.2 Turbines/Generators

Modifications to turbines and associated equipment would be necessary to allow the use of the turbine and passages to function as outlets. Modifications would need to be completed well in advance of drawdown. However, some turbine capacity must be maintained during the previous spill season in order to aid in controlling the total dissolved gas supersaturation in the river. Excessive spillway use raises total dissolved gas supersaturation to unacceptable levels. Modifications must be scheduled so that turbine use is maximized and spillway use is limited to acceptable timeframes.

The operating turbine and generator serve to dissipate the energy of a high head and allow the passage of a significant volume of water. In order to make the turbines operate at lower heads than the current operating head, numerous modifications must be made. A detailed report on the Turbine Passage Modification Plan is provided in Appendix D, Natural River Drawdown Engineering. In summary, these modifications are as follows:

- **Addition of Performance Instrumentation**—Additional instrumentation is necessary to monitor conditions of the turbine during out-of-the-ordinary operations. The instrumentation identifies developing conditions that may lead to a failure of the system and may prevent the necessary discharge of water. Early warning provided by instrumentation allows operators to react and implement contingency plans.
- **Emergency Closure Devices—**Existing emergency closure devices should be in operating condition. The use of these gates is only in the event that conditions develop that could cause failure of the water outlet process and the purpose is to isolate that turbine passage. Currently, the intake gates at each project are either raised (with the hydraulic operators disconnected) or removed for improved fish passage purposes. During a reservoir drawdown, the fish screens would be removed. The intake gates should be connected to the hydraulic operators and stored in the normal position, ready for emergency use.
- **Cooling Water System—**Additional cooling water for turbines and generators would be required to supplement the existing gravity-fed system as the head drops.
- **Trash Rack Modifications—**Investigation is necessary to assure that the trashrack structures are adequate for debris loads over the range of head pressures to which they will be subject. Some strengthening has been assumed

to be necessary for drawdown conditions. A significant effort will be required to keep the trash racks clear of debris during drawdown.

- **Draft Tube Bulkheads**—When more than one dam is drawn down at once, the tailwater of the upstream project will drop significantly. This drop in tailwater will cause serious cavitation problems for the turbines. Approaches for addressing these problems are provided in Appendix D, Natural River Drawdown Engineering. Each dam only has one set of draft tube bulkheads, so additional bulkheads for the remaining five units would need to be purchased.
- **Turbine Blade Removal**—Up to three turbines at each project would require removal of the turbine blades to operate as bladeless runners. This would allow maximum discharge of water through the turbine passages at low heads. Removal is expected to be done several months in advance of drawdown by cutting the blades and removing them through the intake slot or out through the draft tube.
- **Operation**—Operation below the speed no load (SNL) condition is possible, but would require direct manual operation. It is not recommended without more critical evaluation. The increased risks and uncertainties of operating below SNL make this a potentially more dangerous operation.
- **Contingency Plans**—If equipment fails to operate as expected during the reservoir evacuation, contingency plans must be in place in order to continue the drawdown process and complete the embankment breach. Typical contingent operations might be operating turbine units manually at or below SNL status, breaching the embankment cofferdams at higher heads, and/or using a modified intake gate for regulated flow through the turbine passages.

3.4.2.3 Channel Preparation

Some operations related to channel excavation could be completed in advance of embankment excavation. The processing and stockpiling of riprap could also be done in advance. While some riprap could be salvaged for the embankment shells, additional riprap would be needed for protection against higher velocity and wider range of river flows. Riprap protection would be necessary adjacent to the navigation locks, adjacent to the spillway structures, and for the new levees.

3.4.2.4 Embankment Removal

Embankment removal would be expected to require a three-stage operation. The reservoir would be drawn down to spillway crest, while concurrent excavation of the upper embankment would be performed. Further drawdown would be done using the modified powerhouse units. Concurrent excavation of the embankment would continue at an accelerated rate. It may be that the powerhouse outlet configuration results in some reservoir impoundment when at its lowest level. Depending on the reservoir elevation, a controlled breach of the embankment may be necessary to provide final drawdown.

3.4.2.5 River Channelization

River channelization is expected to be relatively minimal. Final channel shaping would be done by dragline from the shore. Channelization would be necessary in the reservoir to capture the river, and divert it around the powerhouse and spillway structures. Channelization in the form of new levee structures would extend upstream some distance. Without these measures, areas may pond water, threatening water quality and creating fish migration difficulties.

3.4.2.6 Changes to Other Facilities

Numerous modifications would be necessary to ancillary structures (see Appendix D, Natural River Drawdown Engineering, for details). These modifications would include:

- Bridge pier protection
- Railroad and highway embankment protection
- Protection of drainage culverts and pipe outfalls along each reservoir
- Railroad and roadway damage repair
- Modifications to water supply, adult fish ladder, and operations at the Lyons Ferry fish hatchery
- Modifications to HMUs
- Reservoir revegetation
- Modifications to cattle watering facilities
- Modifications for recreation access
- Cultural resources protection
- Once breaching begins, the dams would no longer produce power. Provisions to modify station service power feeds would be necessary to draw power from other sources. Independent power systems may be necessary if other sources are unavailable (see Section 5.9, Electric Power)
- The relocation of roads, railroads, visitor facilities, and other facilities would be required to construct the new channels and bypass structures and to accommodate drawdown
- Flow augmentation would continue under the 2000 Biological Opinion levels and the Comp Plan would be re-evaluated.

3.4.3 Lower Snake River Compensation Plan

The Comp Plan (see Section 2.1.8, Lower Snake River Fish and Wildlife Compensation Plan) was authorized to mitigate for fish and wildlife losses caused by the construction and operation of the four lower Snake River dams. Breaching of the dams would result in cessation of operations and return of the river to near-natural or unimpounded conditions in this reach. Therefore, the conditions that resulted in the need for the Comp Plan and its mitigation requirements would no longer exist. The Comp Plan would be re-evaluated.

Specific measures such as operation of existing fish hatcheries, wildlife habitat management units, and access are likely to be discontinued or modified, likely over a transition period that would allow post-breaching conditions to stabilize. For example, operation and maintenance of HMUs and fish hatcheries may be discontinued whereas the operations of some remaining hatcheries would be modified to captive broodstock facilities that would be used to rebuild fish runs. The Lyons Ferry Hatchery may need to be maintained because the fall chinook salmon in this hatchery are included in the Snake River fall chinook evolutionarily significant unit

(ESU). It is also likely that any new measures needed to mitigate the effects of breaching on fish and wildlife would be considered.

3.5 Implementation Schedule and Costs

3.5.1 Alternatives 1 and 2

Table 3-1 includes costs for any new construction, implementing the anadromous fish evaluation program, lock and dam operations and routine maintenance, major rehabilitation of turbines, fish hatchery operation and maintenance, and BOR annual requirements for each alternative. The table also includes schedules for new construction, the anadromous fish evaluation program, and major turbine rehabilitation. These alternatives have actions that would likely take between 5 and 40 years to implement. Alternatives 1 and 2 have a 5-year-long construction schedule. All four alternatives are similar in the amount of time for research and development.

3.5.2 Alternative 3—Major System Improvements (Adaptive Migration)

Some of the proposed systems under Alternative 3, such as the RSW, SBC, and BGS, present more challenging technical issues than the other non-breach alternatives. Accordingly, Alternative 3 has a 10-year-long construction schedule. This schedule includes most of the near-term costs included under the first two alternatives, which require little or no additional study or research and could be implemented within 5 years after the ROD and this FR/EIS provide NEPA compliance for implementation. The long-term actions generally require additional evaluation, prototype development, and testing; therefore, they take more time to put into place. Near-term and long-term improvements included under Alternative 3—Major System Improvements (Adaptive Migration) are summarized below:

Near-term Improvements

- Complete installation of spillway flow deflector at Lower Monumental and Little Goose
- Upgrade auxiliary fish ladder water supply systems at Ice Harbor, Lower Monumental, Little Goose, and Lower Granite
- Modify extended submerged bar screens at Little Goose and Lower Granite
- Use additional barges for transport with upgraded mooring facilities at Lower Granite.

Long-term Improvements

- Install new juvenile facility at Lower Granite
- Install new cylindrical dewatering screens at all dams
- Replace submerged traveling screens (STSs) with ESBSs at Ice Harbor and Lower Monumental
- Install new wet separators at Lower Monumental and Little Goose
- Install turbine improvements (as powerhouses are rehabilitated)
- Install RSWs with or without BGS at all four dams

Table 3-1. Implementation Costs and Schedules

Alternative	New Construction Costs ($ million)	Construction Schedule (Duration– Years)	AFEP Annual Costs ($ million)	AFEP Schedule (Duration – Years)	Major Rehabilitation of Turbines ($ million)	Major Rehabilitation of Turbines Schedule (Duration – Years)	Lock and Dam Routine O&M and Minor Repair Annual Costs ($million)	Fish Hatcheries O&M and Minor Repair Annual Costs ($ million)	BOR Annual Costs ($ million)
1 Existing Conditions	89.3	5	5.3	27	193.6	41	36.5	14.5	2.4
2 Maximum Transport of Juvenile Salmon	67.9	5	3.6	27	193.6	41	36.5	14.5	2.4
3 Major System Improvements	389.6	10	9.5	27	193.6	41	37.2	14.5	2.4
4. Dam Breaching[1,2/]	911.1	9	2.5	27	na	na	4.9	14.5	2.3

Notes: AFEP = Anadromous Fish Evaluation Program
O & M = Operation and Maintenance
MW-hr = Megawatts per hour
BOR = Bureau of Reclamation

The duration of these costs varies by cost category and alternative. Therefore, all costs are amortized over a 100-year period for comparability.

1/ Detailed implementation costs are presented for Alternative 4—Dam Breaching in Appendix D, Natural River Drawdown Engineering, Annex X, Table 1. The new construction cost total presented in this table ($911.1 million) is higher than the construction and acquisition cost total presented in Appendix D, Natural River Drawdown Engineering, Annex X, Table 1 ($858.9 million) because it includes fish and wildlife mitigation and cultural resources mitigation costs of $52.2 million. These costs are included in the operation and maintenance cost category in Appendix D, Natural River Drawdown Engineering, Annex X, Table 1.

2/ The actions associated with the non-breach alternatives can be implemented more quickly than Alternative 4—Dam Breaching, even with the recognition that the long-term improvements associated with Alternative 3—Major System Improvements could take up to 10 years to fully implement. This is due, in part, to the fact that these actions do not require Congressional authorization. Potential issues surrounding implementation duration are discussed further in Section 6.4.32.

Source: Appendix E, Existing Systems and Major System Improvement Engineering, Tables ES-1 and ES-2.
Appendix D, Natural River Drawdown Engineering, Annex X, Table 1.

- Install two-unit powerhouse surface bypass with or without dewatering system at Lower Monumental and Lower Granite
- Build full-length powerhouse occlusion structure at Little Goose.

It is important to note that while the implementation time for the construction schedule under Alternative 3 is 10 years, which is 1 year longer than the construction schedule for Alternative 4—Dam Breaching, actions associated with dam breaching are actually expected to take longer than 10 years to fully implement. Alternative 4—Dam Breaching would involve Congressional authorization and, potentially, other processes that would draw out the completion date. Potential issues surrounding implementation duration are discussed further in Section 6.4.32.

3.5.3 Alternative 4—Dam Breaching

Assuming that funds and resources are available when required, it is estimated that, from the date authority is granted and funds are appropriated, it would take about 9 years to fully implement Alternative 4—Dam Breaching. In addition, if more study or research identifies any unforeseen technical problems, additional time may be required to obtain acceptable solutions.

Dam breaching activities would take at least 4 full years to complete after an estimated 5-year period necessary for preparation of a detailed design report and assessment of contracts.

Removal of all four lower Snake River dams can be sequenced in several ways. The proposed method selected (see Appendix D, Natural River Drawdown Engineering) is to sequence the work so that Lower Granite and Little Goose Dams are breached during the fifth year of the construction period. Lower Monumental and Ice Harbor Dams would be breached during the sixth year of the construction period. Several other variations are possible; however, this method provides a realistic phasing of design and construction activities.

A feasibility-level cost estimate was developed for Alternative 4—Dam Breaching (see Appendix D, Natural River Drawdown Engineering). The estimate includes costs for construction, real estate, cultural resources, engineering and design, construction management, and project management. Construction costs were prepared using the Micro Computer-Aided Cost Engineering System (MCACES) software. The estimate is based on a work breakdown structure (WBS) that was developed to seven levels, as follows: project, feature, subfeature, element, bid item, assemblies, and detail.

The major assumptions used in preparing the estimate are as follows:

- Drawdown of the reservoirs and breaching of the dams will occur at a rate of two dams per year.
- Fish passage around the projects will be maintained during construction. The Lyons Ferry Fish Hatchery will remain operating as near to current capacity as possible.
- The rock sources identified will have enough material available.

- In-water work will be allowed to occur during normal fish window closures. Some in-water work must occur outside the normal fish window closures.

Other assumptions are documented in the detailed estimate found in Appendix D, Natural River Drawdown Engineering.

The total cost of this drawdown implementation action is $911.1 million. This cost includes required monitoring activities, operation and maintenance costs, and other related costs.

Previous estimates of cost have ranged from a high of approximately $5 billion to a low of approximately $600 million. The high cost features of earlier concepts have been eliminated and replaced with features more appropriate considering the available construction methods. The previous low estimates were revised as more details were developed for stabilization, modification, or mitigation measures.

3.5.4 Average Annual Cost Comparison

This section presents a summary of the total and average annual implementation costs for all four alternatives. Construction, interest during construction, Anadromous Fish Evaluation Program, and operation, maintenance, repair, replacement, and rehabilitation (O, M, R, R & R) costs are displayed in average annual equivalent terms, taking into account the 100-year period of analysis and adjusted to base year 2005 in Table 3-2. Average annual costs were calculated using three discount rates: the Corps' rate of 6.875 percent, the BPA rate of 4.75 percent, and 0.0 percent, at the request of the five Tribes represented by the Columbia River Inter Tribal Fisheries Commission (CRITFC).

Average annual costs vary widely depending upon which discount rate is used, but the ranking of the alternatives remains constant. Alternative 2—Maximum Transport of Juvenile Salmon, is the lowest cost alternative with a lower cost than the base case. Alternative 1—Existing Conditions, and Alternative 3—Major System Improvements, are the next lowest cost alternatives, while Alternative 4—Dam Breaching, is the highest cost alternative, under all discount rates.

3.6 Other Potential Actions Outside the Scope of the FR/EIS

The purpose of this FR/EIS is to evaluate measures that may increase the survival of juvenile anadromous fish as they migrate past the four lower Snake River dams. Numerous other studies by the Corps, other Federal agencies, states, and tribes are also being conducted in the Snake River System and elsewhere in the Columbia River Basin to address salmonid species that are either at risk or listed under ESA. This FR/EIS addresses, in detail, alternatives that could be implemented at the four lower Snake River dams; it does not directly address all other actions being considered in the Columbia River System (which are being addressed in other forums—see Section 1.4.5) to conserve and restore ESA-listed salmon runs. However, it does consider these other actions as part of the cumulative impacts analysis, discussed in resource subsections throughout Section 5, and in Section 5.16, Cumulative Effects.

Table 3-2. Summary of Implementation Costs (1998 dollars) ($1,000s)

Discount Rate /Alternative	Construction and Acquisition Cost ($)[1/]	Interest During Construction Cost ($)[2/]	Total Investment Cost ($)	Average Annual Investment Cost ($)	Average Annual AFEP Cost ($)[3/]	Average Annual O,M,R,R&R Cost ($)[4/]	Average Annual Implementation Cost ($)
6.875 Percent							
Alternative 1	89,260	8,730	97,990	6,750	5,670	3,110	15,530
Alternative 2	67,900	6,790	74,690	5,140	3,820	3,110	12,070
Alternative 3	308,120	42,970	351,090	24,170	10,220	4,020	38,410
Alternative 4	759,100	50,440	809,540	55,730	2,650	5,940	64,320
4.75 Percent							
Alternative 1	89,240	5,970	95,210	4,570	4,500	2,880	11,950
Alternative 2	67,900	4,640	72,540	3,480	3,030	2,880	9,390
Alternative 3	330,630	30,610	361,240	17,330	8,100	3,720	29,150
Alternative 4	800,220	35,690	835,910	40,090	2,100	5,250	47,440
0.0 Percent							
Alternative 1	89,260	0	89,260	890	1,370	2,480	4,740
Alternative 2	67,900	0	67,900	680	920	2,480	4,080
Alternative 3	389,650	0	389,650	3,900	2,470	3,300	9,670
Alternative 4	911,120	0	911,120	9,110	640	3,340	13,090

1/ Construction costs include those for fish-improvement projects and/or to breach the dams. Construction costs associated with Alternative 4—Dam Breaching include mitigation costs, such as wildlife mitigation and cultural resources protection.

2/ Interest during construction reflects compound interest, at the applicable borrowing rate, on construction costs incurred during the period of installation.

3/ Anadromous fish evaluation program.

4/ O, M, R, R&R costs include those associated with the new fish improvement projects (e.g., purchase of water from BOR and the O&M costs associated with the screen bypass system proposed under Alternative 3, Major System Improvements).

Source: U.S. Army Corps of Engineers (Walla Walla District, Portland District), BPA and BST Associates

Measures are also being considered at McNary, John Day, The Dalles, and Bonneville Dams to improve the effectiveness of juvenile salmon migration. These measures include additional transportation, flow deflectors, collection facilities, and spill modifications. All of these measures are in the feasibility testing phase, are under study, or have been proposed. Therefore, they are not addressed in detail in this FR/EIS. They are, however, addressed in discussions of cumulative effects in resource subsections throughout Section 5, and in Section 5.16, Cumulative Effects. The actions at these lower Columbia River dams will or have been specifically addressed in detail in other NEPA documents.

3.7 Alternative Actions Eliminated from Further Consideration

A wide variety of actions and options were identified, examined, and discussed in Phases I and II of the Corps System Configuration Study (see Section 1.1, Feasibility Study Process) (Corps, 1994). In the *Interim Status Report* (Corps, 1996a), these actions or options are specifically addressed. Many of these were eliminated for a number of reasons, such as: 1) significant biological and uncertainty concerns, 2) benefits of the action were less than other proposed actions, 3) potentially adverse effects to both adult and juvenile fish, 4) unacceptable impacts to turbines or other fish bypass components, and 5) potentially detrimental impacts to other resources, such as cultural.

Alternative actions that were not eliminated during the System Configuration Study received further preliminary detailed evaluation and analysis for this Feasibility Study (see Appendix J, Plan Formulation). As part of this evaluation process, the four alternatives (Sections 3.1 to 3.4) were selected for full evaluation while the others were eliminated for one or more of the following reasons: 1) not meeting the purpose and need of this FR/EIS; 2) the probability of success of implementation of the action was considered low or unlikely, or 3) the action would be addressed in other forums or through other NEPA analyses. The following provides general descriptions of the actions eliminated from detailed analysis. As specifically noted, the descriptions generally coincide with those alternatives evaluated in Appendix E, Existing Systems/Major System Improvements Engineering) and Section 6 of this FR/EIS.

- **In-river Migration Option with Voluntary Spill under Existing Conditions (this option was evaluated by the Corps as Option A-1a—see Appendix E, Existing Systems/Major System Improvements Engineering)**

  This option assumes that the existing or currently planned juvenile fishway systems would be operated to maximize in-river fish passage and that voluntary spill would be used to bypass fish through the spillways. Since juvenile fish would remain in the river, and voluntary spill would be used to attract the fish to the spillway, additional structures to implement dissolved gas abatement would be needed (see Appendix E, Existing Systems/Major System Improvements Engineering for details).

  This option does not follow an adaptive migration strategy because no fish would be transported. Therefore, it would not meet the objectives of the NMFS 1995, 1998, or 2000 Biological Opinions. In addition, in-river migration only would result in a lower direct survival of juveniles through the lower Snake River and the entire migratory corridor than a combination of in-river and transportation measures. Based on this, it was eliminated from further consideration.

- **Maximized Transport at the Four Lower Snake River Facilities Without Voluntary Spill (with major SBC development at all four lower Snake River dams; this action was not specifically evaluated by PATH, but is the Corps' Option A-2b—see Appendix E, Existing Systems/Major System Improvements Engineering)**

  Under this alternative, the number of fish collected—Existing Systems/Major System Improvements Engineering and delivered to the existing or upgraded transportation facilities located at each project would be maximized. Full length powerhouse SBCs would be provided at Lower Granite, Little Goose, and Lower Monumental. These would be used in conjunction with ESBSs located in the turbine intakes. Fish collected by both bypass structures would be combined and delivered to the transportation facilities, and either trucked or barged downstream.

The upper two dams (Lower Granite and Little Goose) currently have ESBSs installed in the turbine intakes. These would continue to be used. However, the intakes at Lower Monumental are currently outfitted with STSs. These would be removed and replaced with ESBSs to increase the screen diversion efficiency, and further reduce the number of fish passing through the turbines.

At Ice Harbor, the turbine intakes are also currently outfitted with STSs. As at Lower Monumental, these would be removed and replaced with ESBSs to increase the diversion efficiency of the screening system. However, no SBCs would be installed at Ice Harbor.

If the combination of the SBC and the ESBS systems function as anticipated at Lower Granite (the major system improvements alternative), there should be very few migrating fish left in the river at the lower three dams (see Section 3.3, Alternative 3—Major System Improvements). In addition, few fish enter the Snake River between Lower Monumental and Ice Harbor. Therefore, construction of SBCs at all dams would not appear to be justified, and this option was eliminated from further consideration. In addition, the intent of this option is to maximize transport, which does not incorporate an adaptive migration strategy. Therefore, it does not meet the objectives of the 1995, 1998, and 2000 NMFS Biological Opinions.

- **Maximized Transport at the Four Lower Snake River Facilities with Voluntary Spill at Ice Harbor (this is similar to the Corps' Option A-2c—see Appendix E, Existing Systems/Major System Improvements Engineering)**

  This option assumes that the juvenile fishway systems would be operated to maximize fish transportation and that voluntary spill would be needed only at Ice Harbor to aid in bypassing fish over the spillways.

  The juvenile fish passage strategies for this option are the same as under the previous option. However, there are significant differences in designs and project operations between the two. Also, the costs for this option are considerably lower than for the previous one. The primary difference is that an SBC would only be developed at Lower Granite. Only ESBSs would be used at the other three dams. This option does not incorporate an adaptive migration strategy and does not meet the objectives of the 1995, 1998, and 2000 NMFS Biological Opinions. Therefore, it was eliminated from further consideration.

- **In-river Migration Option (no transportation, no drawdown, SBCs at all dams, and flow augmentation under the 1995 Biological Opinion) Plus an Additional 1.0 MAF Flow Augmentation (this action was evaluated by the Corps as Alternative A-6a)**

  With this action, spill would be maximized to the extent possible to bypass additional fish over the spillways. There would be no transportation of juvenile fish and in-river migration would be maximized. Augmentation flows would be increased by an additional 1.0 MAF. Therefore, the total augmentation flow would be 1,427 MAF.

Juvenile fish would be passed directly downstream to the tailrace. To maximize diversion away from the turbines, ESBS intake diversion systems would be used in conjunction with the SBCs at all four dams to divert fish which might pass under the SBC and into the turbine intakes. Lower Granite and Little Goose already have ESBS systems, and these would continue to be used in conjunction with the new SBCs. The STS systems at Lower Monumental and Ice Harbor would be removed and replaced with new ESBS systems.

The Corps has an interest in flow augmentation from upstream sources and how it would affect operations and juvenile fish passage in the lower Snake River. As a result, the Corps asked BOR for assistance in developing further information on flow augmentation, particularly regarding the feasibility and potential impacts of providing the 1.0 MAF additional flow augmentation. The current findings of BOR's studies are presented in the *Snake River Flow Augmentation Impact Analysis* (BOR, 1999). The report concludes additional flow augmentation would involve high costs and multiple implementation issues. Section 7 consultation with the BOR and Idaho Power on the flow issue is continuing under a separate review process.

Additionally, PATH did a preliminary screening analysis of this alternative, designated as Alternative A-6, which found with "most realistic" assumptions that it performed at only 80 to 100 percent of the survival and recovery criteria that PATH Alternative A-2 did. Therefore, it was unlikely this alternative would perform any better than alternatives considered fully and was not included for detailed assessment.

- **In-river Migration with No Flow Augmentation (This is the same as Corps Option 6b—see Appendix E, Existing Systems/Major System Improvements Engineering)**

  This alternative was eliminated from detailed analysis because it was not recommended in the 1995 and 1998 Biological Opinions and no flow augmentation would occur. In addition, adaptive migration would not be an objective of this option and, therefore, flexibility for implementing passage options would be limited.

  PATH performed a preliminary screening analysis alternative (designated as Alternative A-6') with very similar characteristics to this alternative, but with the inclusion of SBCs at all Snake River dams to bypass fish. Even with the addition of SBCs, which should enhance dam passage survival relative to current bypass systems, the PATH preliminary analysis found that this alternative performed worse than PATH Alternative A-2 relative to the NMFS survival and recovery criteria. Therefore, considering its poor performance and NMFS' lack of recommendation in its 1995 and 1998 Biological Opinions to study this alternative, this alternative was not carried forward to full alternative analysis.

- **In-river Migration (major system improvements and flow augmentation under the 1995 Biological Opinion; this is similar to the Corps' Option A-6d—see Appendix E, Existing Systems/Major System Improvements Engineering)**

  This option assumes that juvenile fishway systems would be operated to maximize in-river fish passage. This option is similar to the previous option, except it assumes 427 KAF from upstream storage and not 1,427 KAF. It also includes different SBC components to pass fish (see Appendix E, Existing Systems/Major System Improvements Engineering).

  This option also assumes that there would be no voluntary spill except at Little Goose. Adaptive migration would not be an objective of this option and, therefore, flexibility for implementing passage options would be limited.

- **Dam Removal (for PATH analysis, this action is equivalent to A-3)**

  Dam removal would include the same actions as described for dam breaching, but would also include removal of all structures (e.g., spillways, powerhouses, navigation locks) at each facility. In addition, long-term maintenance of site structures or preservation of equipment would be eliminated. This alternative was not considered in detail because dam breaching would achieve the same results at a lower cost. In addition, the option of reestablishing the function of the dams in the future would be eliminated. Dam removal as an alternative would result in no increase in fish survival or recovery compared to the dam breaching without removal. Therefore, this alternative was eliminated from further consideration.

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