

John Day Pool (Lake Umatilla)

The key resident fish species in Lake Umatilla are smallmouth bass, northern squawfish, and walleye. The model evaluated the quantity of spawning, rearing, and overwintering habitat for smallmouth bass, rearing success of northern squawfish, and the effects of entrainment on walleye. Based on the model, there would be no significant differences among the SOSs for squawfish or walleye (Figure 4-16), but walleye entrainment would be slightly higher under SOS PA and the lowest under SOS 1a.

Predicted index values for smallmouth bass vary only slightly among SOSs, and all SOSs would provide for relatively good bass production, if reservoir fluctuations remain low.

The effects of water-level changes in the spring and summer, as modeled, suggest that SOSs 9a and 9c would have slightly more adverse effects on smallmouth bass compared to the other alternatives. SOS PA would have the least adverse effects. But, similar to the other two stocks modeled, differences among the alternatives would be slight for smallmouth bass.

However, SOSs 5, 6, 9a and PA, because of their drawdown to lower reservoir levels (elevation 257 feet [78.3]) in the spring and summer, are likely to have marked adverse effects to resident stocks that are not evaluated by the models. Drawdown to this level would reduce shallow-water habitat by about 6,000 acres [2,428 ha] (see Appendix K), which is important spawning and rearing habitat for most of resident stocks. Because drawdown would occur in the spring, yellow perch spawned

eggs may be desiccated. It was not possible to model these effects, so the extent of the impact to these stocks can not be quantified. But it is likely that SOSs 5,6, 9a and PA would have similar adverse effects on resident stocks, and would be worse overall than other SOSs.

Box Canyon Reservoir

Box Canyon Reservoir is located on the Pend Oreille River below Albeni Falls Dam. The key resident fish species in this reservoir are yellow perch, pumpkinseed and largemouth bass. Spawning success of largemouth bass is thought to be affected by water level fluctuations during and after spawning and by the amount of flow passing through the reservoir during April and May. Optimum flow during May and June is between 40 and 45 kcfs (1,133 and 1,274 cms). All SOSs have flows exceeding this range during May and June. However, those SOSs with lower flows, while reducing short-term flow fluctuation, would provide the best habitat conditions for largemouth bass. Based on this flow criterion, alternatives that would supply flows closest to optimum include SOSs 1, 2, 5, and 6. All of these alternatives have similar

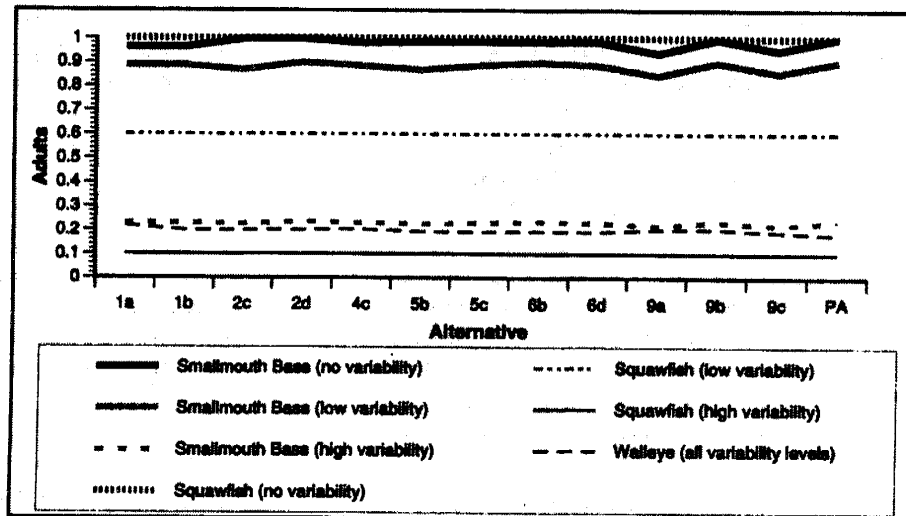


Figure 4-16. Comparison of 2-year index values for fish species at Lake Umatilla (John Day pool) assuming a range of variability in pool elevation

monthly flows, averaging 47 kcfs (1,331 cms) in May and 59 kcfs (1,671 cms) in June. SOSs 9c and 4c, which have May flows of 47 or 48 kcfs and June flows of 61 to 62 kcfs, would be slightly worse for spawning largemouth bass. SOSs PA and 9b have slightly higher flows, which may be worse for largemouth bass. It is expected that short-term flow fluctuations may be less for SOS PA than other alternatives, which should benefit largemouth bass spawning. SOS 9a would have the greatest average flows, 56 and 64 kcfs, during May and June. These flows are much higher than optimum spawning bass.

Non-modeled Resident Fish Populations

Lower Columbia fish populations that were not modeled would generally respond in a similar manner as described for John Day. The exception would be the adverse effects of drawdown that occur only in John Day Reservoir and not in McNary, The Dalles or Bonneville pools. Substantial increases in velocity under SOSs 5, 6, 9b, and PA might benefit spawning of native species, such as trout, sturgeon, and northern squawfish, present in both reservoirs and riverine habitats. The increased spill would increase dissolved gas concentrations that in turn could adversely affect resident fish in the lower Columbia under SOSs 2b, 9a, 9b, 9c, and PA, depending on duration of spill and exposure length of fish. Increased sediment effects on rearing habitat from SOSs 5 and 6 are likely to be minor in these reservoirs, except possibly in McNary during the first year of activity.

Fish in the lower Snake River pools would be expected to respond similarly to the fish in Lower Granite Reservoir. The effects on lower Snake River fish should mostly follow those shown for Lower Granite (Figure 4-15) except for SOS 6d. SOS 6d draws down Lower Granite only. Also, the cumulative effect of increased gas saturation would increase in a downstream direction, so that fish in the lower reservoirs would be subjected to higher gas levels than those of Lower Granite. This could possibly increase mortality during spring for

those alternatives with higher spill (SOSs 2d, 9, and PA). The increased sediment load associated with drawdowns of SOSs 5, 6, 9a, and 9c, especially during the first year, could also diminish the quality of rearing habitat in the reservoirs. Sediment load is likely to also adversely affect zooplankton and other fish food sources. The overall potential effects of this increased sediment load would be likely to adversely affect resident fish populations. SOS 9c might be the worst for resident fish in the lower Snake, but SOSs 5b, 6b, and 9a would also create poor conditions; the others would generally produce good conditions.

Several other projects and river reaches in the Columbia River system were not modeled, and the distinctive differences in effects among SOS alternatives could not be determined. While it is known that changes in operations affect some of these projects and reaches, information was insufficient to determine how the SOS alternatives would affect the hydroregulations, reservoir and river fluctuations, or the fish populations. Those projects where information was insufficient to determine differences among the alternatives include: the Canadian projects (Kinbasket, Arrow, Kootenay Lake, and Duncan Lake), Clark Fork River (below Cabinet Gorge Dam), Pend Oreille River (below Albeni Falls Dam), and mid-Columbia River projects (reservoirs of Wells, Rocky Beach, Rock Island, Wanapum, and Priest Rapids), the Hanford Reach below Priest Rapids Dam, the Hells Canyon Reach, and the Columbia River below Bonneville. Projects where operations appear to be fairly independent of SOS alternatives and would, therefore, likely be affected the same for any alternative include Rufus Woods Reservoir, a run-of-river project below Grand Coulee Dam, and Flathead Lake, a modified lake in the upper Columbia River that appears to have similar hydroregulation and reservoir level independent of any SOS alternative.

The fish populations in river reaches (e.g., Hanford Reach, Hells Canyon, below Bonneville) are often primarily affected by hourly and daily flow fluctuations, which

influence adult spawning, juvenile and egg stranding and food supply. These hydrological changes among alternatives could not be modeled with available information, so predictions of project effects in these areas is not possible. However, it is unlikely that drastic changes from current hourly and daily flow fluctuations would occur among any of the alternatives because daily load demand, which usually controls daily discharge changes, is not likely to change markedly among the alternatives. In other words, such short-term fluctuations in flows result from load following, and would not be attributable to selection of an SOS.

Summary

None of the SOSs is consistently good or bad for resident fish populations in all reservoirs and river reaches in the Columbia River Basin (Table 4-11) (Appendix K, Resident Fish, presents informative comparisons). In many cases, detrimental changes in water management in one area would be offset by positive changes in another area. For instance, the beneficial higher pool elevations in spring and summer at Lake Kootenai and Hungry Horse Reservoir would be offset to a degree by the transfer of flood control functions to Lake Roosevelt and the subsequent reduction in reservoir level during the spawning and incubation season.

Overall, SOS 4c would be good or neutral for resident fish populations throughout the region, and SOSs 5b and 9a would be the worst for fish production. SOSs 5c, 9c, and PA would have varied effects throughout the basin. SOSs 4c, 9a, 9b, 9c, and PA are expected to provide improvements in the probability of survival of the Kootenai white sturgeon. No other SOSs are likely to provide sufficient spawning opportunities to maintain the population. SOS 4 is the only alternative that would provide sufficient flows to support white sturgeon and benefits to resident fish regionwide.

Differences among SOS alternatives could not be determined for most unmodeled projects of the middle and upper Columbia, primarily

because of lack of sufficient hydrological and biological information.

4.2.6 Wildlife

The Columbia River creates and maintains suitable conditions for a diversity of wildlife habitat. The open water, wetlands, islands, and shore (riparian) environments support animals and plants that would not otherwise survive in the surrounding area. Many other wildlife live in the adjacent mix of sagebrush steppe, agricultural land, or conifer forest, but they use river-dependent habitats for cover or food. These species may occur in non-riverine environments, but their numbers may increase where river habitats are available.

During the SOR scoping, people expressed concern about the impacts of river operations on wildlife and associated river and open-water environments. Such species include shorebirds and waterfowl, which nest on islands and feed on plants or animals in the river or adjacent wetlands and riparian lands. They also include non-game birds, which nest or forage in riparian trees or shrub thickets. Some of the species dependent on the river system represent major resources of Washington and Oregon, such as the hundreds of thousands of ducks that winter on Lake Umatilla (John Day pool). Concerns also focused on species not entirely dependent on riverine habitat, but whose numbers reflect its quality, for example, deer and elk.

Wildlife Impact Issues

To evaluate the effects of SOS alternatives, the Wildlife Work Group identified groups of species (see box) to represent the spectrum of wildlife resources influenced by system operations. One or more species of wildlife (or plant, in one instance) were selected to represent each category for evaluation purposes at each particular reservoir or reach of the river. For example, mallards and great blue herons were often selected as indicator species representing waterfowl and colonial nesting birds.

Table 4-11. Relative overall effect of the SOSs on resident fish production in the Columbia River^{a/}

	1a	1b	2c	2d	4c	5b	5c	6b	6d	9a	9b	9c	PA
Koocanusa	--	--	--	-	++	-	-	--	--	--	-	++	-
Hungry Horse	--	--	--	--	++	--	--	--	--	--	0	++	-
Pend Oreille	-	-	-	-	++	-	--	-	-	-	-	-	-
Roosevelt	-	0	+	+	+	+	+	+	+	--	-	-	+
Dworshak	0	+	-	-	++	0	+	0	0	-	--	-	--
Brownlee	0	0	0	0	++	0	0	+	+	--	--	-	-
L. Granite	-	0	0	0	0	--	+	-	-	-	0	-	+
John Day	0	0	+	+	+	--	--	--	--	--	0	-	++
Other Snake R.	-	0	0	0	0	--	+	-	-	--	0	-	+
White Sturgeon	-	--	--	--	++	-	--	--	--	++	+	++	+
Overall	-	-	-	-	++	-	0	-	-	--	-	0	0

a/ Ranging from significantly positive (++) to significantly negative (--).

To evaluate how the various wildlife categories could be affected by changes in river operations, the work group identified important habitats and physical factors. These are aspects of the wildlife "support system" that respond to changes in the magnitude or timing of reservoir or river elevations. The work group analyzed five habitats in as much detail as available data permitted (see box), estimating acre changes at affected projects and reaches where possible. Other factors, such as human intrusion and fish productivity, were also considered in the evaluation. Chapter 3 of Appendix N, Wildlife, describes evaluation methodology in greater detail.

The abundance and quality of wetland and riparian habitat depend on water levels and timing. When dams were constructed, many acres of wetland and riparian vegetation were drowned and converted to open water. Some wetlands and riparian plants re-established along the new shoreline, but in some reaches of the Columbia River system, the new shoreline sloped much more steeply than the pre-dam

shoreline, and the area of shallow water or saturated soils required for wetland establishment was much reduced compared to pre-dam conditions. More important than modified shoreline topography, however, were changes in the timing and magnitude of water level fluctuations brought about by regulated releases from the dams.

KEY HABITATS

- Emergent Wetland
- Submergent Wetland
- Riparian Zone
- Drawdown Zone
- Islands

Although it is difficult to predict accurately, the acreage of wetland and riparian habitats changes as water levels change. Daily fluctuations in water levels resulting from power peaking operations, and longer-term fluctuations

**WILDLIFE CATEGORIES USED FOR
EVALUATING IMPACTS**

- Waterfowl
- Colonial Nesting Birds
- Shorebirds
- Non-game Birds
- Raptors
- Aquatic Furbearers
- Terrestrial Furbearers
- Big Game
- Reptiles and Amphibians
- Threatened/Endangered Species

resulting from seasonal drafts, create conditions generally inhospitable for wetland and riparian plants. Along much of the Columbia and Snake Rivers, lowering water levels for even a short time during the hot, dry summer can desiccate and kill shoreline plants, as well as small aquatic animals inhabiting the mud and shallow waters. Consequently, relatively little wetland habitat survives under current operating conditions. This is particularly true at storage projects, where water elevations fluctuate from day to day, month to month, and year to year. Emergent marsh and riparian habitat are most abundant where water level changes are dampened by backwaters, relatively reduced drafts, or active management of impoundments.

In addition to desiccation, periodic drafts from reservoirs accelerate erosion. Ledges of saturated substrates exposed as water levels recede can slough, or break up, as a result of wave action.

When water levels drop over a period of days or months, exposed sand and gravel create a barren drawdown zone. Wide drawdown zones typically ring the storage reservoirs of Lake Koochanusa (at Libby Dam), Hungry Horse, Lake Pend Oreille (Albeni Falls Dam), Lake Roosevelt (Grand Coulee Dam), and Dworshak. At Lake Roosevelt, for example, average water conditions expose approximately 23,000 acres (9,300 ha) of bare substrate. The

width of exposed drawdown zone can greatly increase susceptibility of nesting waterfowl or denning furbearers to predators such as coyotes or raptors. It can also benefit shorebirds and other species that feed along the water/land interface, but on the whole, a barren drawdown zone decreases wildlife numbers and limits wildlife productivity at the storage projects.

Islands provide ground-nesting birds with protection from coyotes and other non-flying predators. Colonial ground-nesting species found in the lower Columbia River system include ring-billed and California gulls, and Forster's and Caspian terns. Large numbers of Canada geese nest on islands in the lower portion of the system, including about 350 pairs in the Umatilla National Wildlife Refuge. In some reaches, islands provide deer with fawning sites safe from predators. If water levels drop low enough, islands reconnect to the shore and lose their water barrier. If water levels drop after wildlife have selected an island for nesting or fawning, the ensuing predation on the young can be severe.

In addition to the timing and duration of water levels, system operations affect wildlife habitat by changing river velocity. Higher-velocity flows resuspend sediments and shift larger-sized stones and cobbles, sometimes removing established vegetation and depositing a new layer of sands and fine particles. Cottonwood and willow seeds require the resulting bare mineral soils for successful germination and survival. Although flow or river velocity no longer shapes the Columbia River valley landscape, it still maintains important habitat in the unimpounded Hanford Reach. Prior to damming, high spring flows, followed by gradually declining summer flows, exposed a cobble and stone substrate habitat that is now uncommon. Occurrences of persistent sepal yellow-cress, a member of the mustard family and a candidate for Federal listing as threatened or endangered, are believed restricted in Washington to the few areas of exposed cobble habitat remaining along the shores of the Hanford Reach and one locale below Bonneville Dam. This plant also occurs in other states.

The timing of high flows can directly affect wildlife productivity. For example, high flows occurring after shorebirds and waterfowl have selected nest sites can flood nests. Loss of one year's young can dramatically reduce numbers of waterfowl and shorebirds.

Effects of Alternatives

SOS 1 and Pre-ESA and SOS 2, Current Operations

Continuation of recent or current operations would cause little change in wildlife trends throughout the Columbia River system. Both SOS 1 (pre-ESA operations) and SOS 2 (current operations) would provide similar habitat conditions throughout the system. Large seasonal drafts from the storage projects would continue to restrict wetland area to current levels (Figure 4-17).

Compared to pre-ESA operations, current operations drop Lake Umatilla by about 1 foot (0.3 m) during the critical part of the growing season (April, May, and June). This area harbors some of the largest summer populations of waterfowl in the Oregon/Washington region. Some loss of marsh habitat fringing the upper edge of areas such as Paterson Slough would be expected, but new marsh may expand into bare sediments exposed at the water's edge. When fully implemented, current operations will desiccate roughly 735 acres (224 ha) of shallow water habitat including beds of aquatic plants, as well as some pond habitat. Under current operations, some of the small ponds hydrologically linked to Lake Umatilla dry up. With full implementation of the

current operations plan, more ponds will be similarly affected. These ponds support western painted turtles and are used by mallards and other ducks for raising broods. Waterfowl populations breeding at various locales in Lake Umatilla might also lose nesting sites and experience slightly increased predation from mammals as a result of the shallower depths produced by SOS 2. These combined impacts associated with SOS 2 might slightly reduce long-term breeding duck and Canada goose numbers by from 5 to 33 percent at Lake Umatilla, compared to SOS 1 (Section 4.2.19, Appendix N, Wildlife).

Elsewhere in the system, effects of SOSs 1 and 2 on wildlife populations would be similar.

Expected Changes with Other Alternatives

The Wildlife Work Group considered the effects of other SOS alternatives on all of the projects and reaches of the Columbia River system. At some projects, all SOSs produced identical simulated water levels and flows. At others, simulated hydrological data varied so little among alternatives or from continuation of

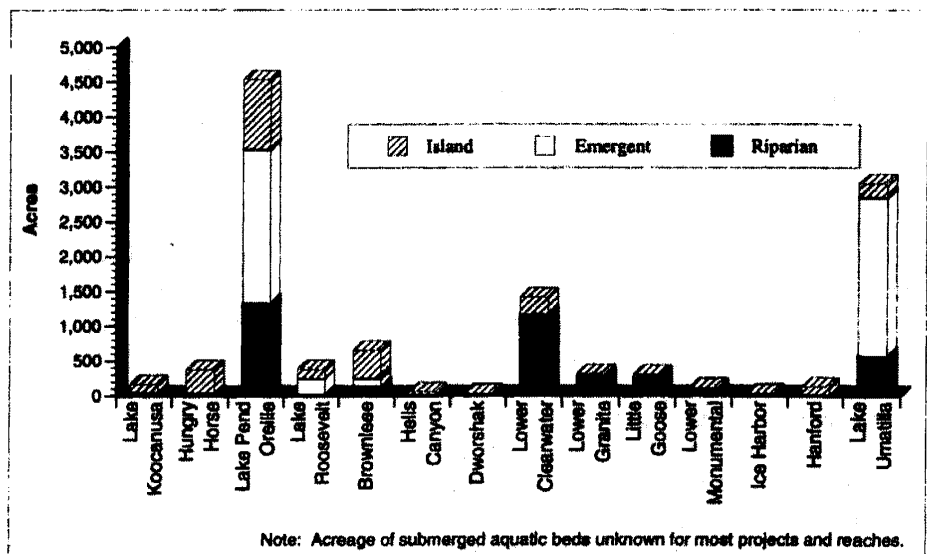


Figure 4-17. Current distribution of water-dependent habitats in principal affected areas of the Columbia River System

current operations that no differential effects on wildlife were considered likely. The work group focused primarily on projects and reaches where wildlife resources were considered sensitive to change, depending on the operational strategy selected. After detailed analyses, potential changes in wildlife resources were identified at 14 areas. Effects at these 14 geographical areas provide the basis for the evaluation presented below. Appendix N provides more detailed analyses of effects at each of the 14 areas, plus the other reaches and projects evaluated.

SOS 4, Stable Storage Project Operation

This strategy attempts to stabilize water level fluctuations at the storage projects, perhaps the single most important factor affecting wildlife resources over much of the Columbia River system. Of all alternatives, only SOSs 4c and 9b would markedly improve the abundance of water-dependent habitat (Figures 4-18 and 4-19). Areas of emergent marsh and riparian habitat would be expected to increase by more than 1,100 acres (445 ha) at Lake Pend Oreille, and by much smaller amounts at Hungry Horse (less than 50 acres [20 ha]) and Lake Kootenai (about 10 acres [4 ha]). The large projected increase in wetland area at Lake Pend Oreille derives from dropping the maximum summer pool elevation 2.5 feet (0.8 m), coupled with providing relatively stable water levels during the growing season. Wetland and riparian plants would colonize the 2.5 feet (0.8 m) (vertical drop) of exposed sediments, benefiting essentially all categories of wildlife. Of particular importance at Lake Pend Oreille are large flocks of migratory and resident waterfowl, big game, ospreys, and bald eagles, which have recently nested along the shore. Osprey and eagles would benefit primarily from increased fish productivity associated with the stable storage operation. Lake Pend Oreille is a major spring and fall stop for waterfowl migrating along the Pacific Flyway. Fall and winter surveys conducted by the Idaho Department of Fish and Game (IDFG) indicate that numbers of duck and Canada geese peak each year in November, at an estimated 24,000 ducks and

2,200 geese. Early winter counts of redhead ducks have ranged as high as 17,000, which IDFG estimates constitutes almost 98 percent of the statewide count and approximately 20 percent of the total Pacific Flyway population of this species. The degree to which wildlife populations would increase is difficult to predict, but at both Lake Pend Oreille and Lake Kootenai increases could range between 5 and 33 percent. Greater percentage increases might occur at Hungry Horse Reservoir, where recent large drafts have further reduced densities of most species dependent on aquatic or wetland habitats (Appendix N, Sections 4.3.1 through 4.3.8).

At Brownlee Reservoir, SOS 4c would raise February and March pool elevations. Higher pools would decrease the incidence of land-bridging of islands used for nesting, and benefit Canada geese and colonial nesting birds such as killdeer and American avocet.

The stable storage strategy would reduce the full pool elevation and spring drawdown at Lake Roosevelt, reducing the area of barren drawdown zone and providing opportunity for wetland expansion into the drawdown zone. Aquatic vegetation and benthic invertebrates might also increase in shallow water areas in response to lesser spring drawdowns. Additional wetland habitat and more productive shallow water habitat would benefit essentially all categories of wildlife.

Higher spring flows prior to nest initiation should reduce the incidence of nest flooding along the Hanford Reach, benefiting waterfowl, colonial nesting birds, and shorebirds. The higher late spring flows would also improve brooding and foraging habitat in sloughs and backwaters.

SOS 4c would provide the same water level regime at Lake Umatilla as occurred under SOS 1. Compared to no action, slightly more acreage of shallow water habitat, including some aquatic vegetation, would be maintained. The higher summer pool would maintain open water in the small ponds located within Irrigon

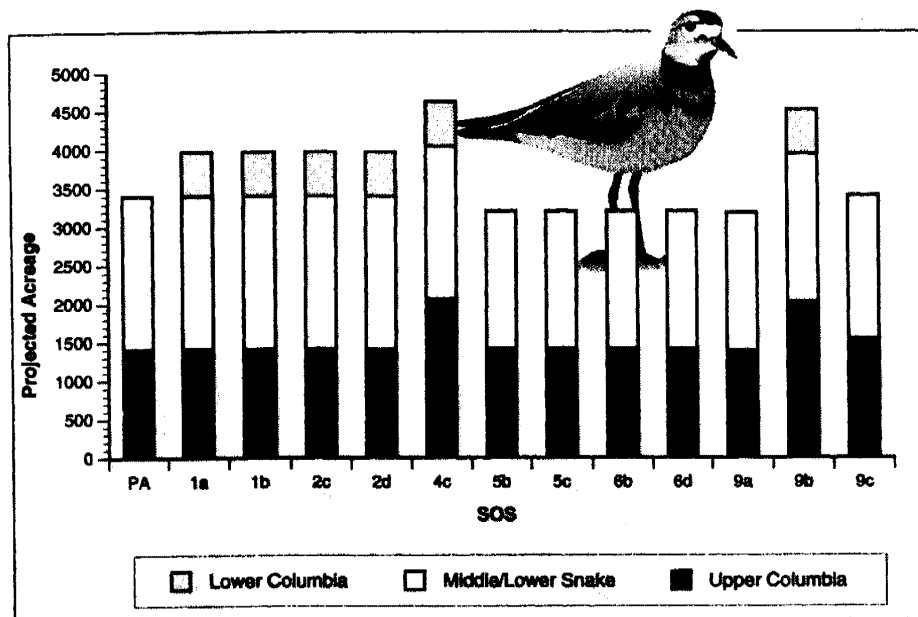


Figure 4-18. Quantity of riparian habitat under SOSs at principal affected areas of the Columbia River System

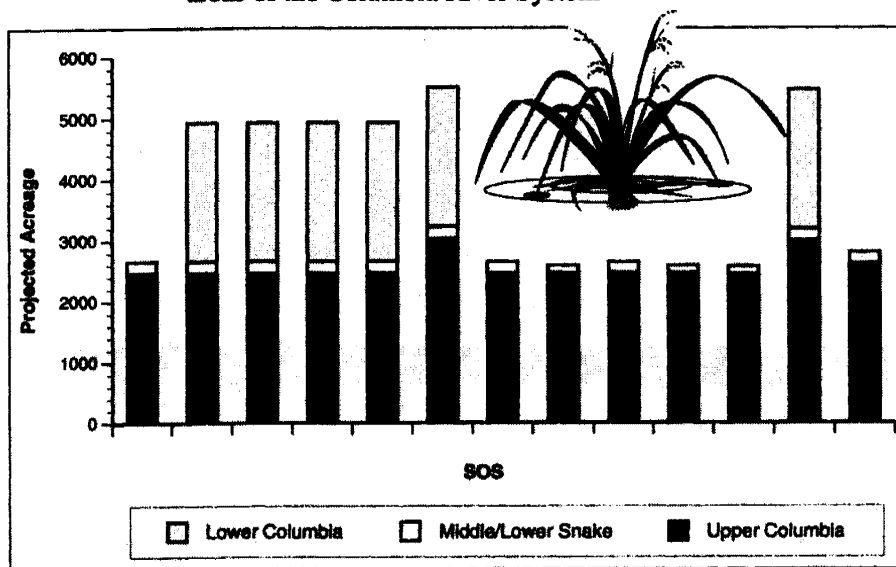


Figure 4-19. Quantity of emergent marsh habitat under SOSs at principal affected areas of the Columbia River System

Wildlife Management Area and other areas that are hydrologically linked with the Columbia River. Waterfowl productivity would, therefore, be slightly greater than under SOS 2c.

SOS 4c would have little or no effects on wildlife resources associated with Hell's Canyon

Reach, lower Clearwater Reach, or lower Snake projects.

SOS 5, Natural River, and SOS 6, Fixed Drawdown

These strategies would affect wildlife resources of the Columbia River system similarly. They would decrease wildlife habitat in the lower Columbia (primarily on Lake Umatilla) and lower to middle Snake reaches, but would not cause significant differences from current operations in the upper Columbia region (Figures 4-18 and 4-19).

These strategies would annually lower water levels in Lake Umatilla to a minimum elevation of 257 feet (78.3 m) for 4 months (May through August), compared with recent (pre-ESA) operations which maintained the water level at elevation 263.5 feet (80.3 m) during May and June, and at elevation 266.5 feet (81.2 m) during July and August. SOSs 5 and 6 would, similar to SOS 1 and 2, continue to

restore Lake Umatilla to between 266 and 267 feet (81.1 and 81.4 m) by the end of September. The summer drafts produced by these strategies would desiccate the entire 2,100 acres (850 ha) of existing extensive emergent marsh and riparian habitat including highly productive areas at Paterson Slough, McCormack Slough, Willow

Creek Wildlife Management Area (WMA), and Irrigon WMA. Another 6,000 acres (2,430 ha) of shallow water, supporting mud-dwelling animals and aquatic plants, would be de-watered. Few of these animals and plants would survive until fall, when the water level at Lake Umatilla would return to 266 to 267 feet (81.1 to 81.4 m) elevation. The return of the water level in the fall to 266 feet (81.1 m) would flood and kill any emergent plants colonizing the lower edge of the drawdown zone. Large losses of shallow-water, emergent marsh, riparian and pond habitats would substantially reduce breeding populations of ducks, Canada geese, colonial nesting gulls and terns, and western pond turtles. Reductions in wildlife might exceed 50 percent for representative species such as Canada geese, great blue heron, and yellow warbler (Table A-24 and Section 4.2.20, Appendix N, Wildlife). Loss of aquatic vegetation and shallow water benthic communities could create a serious food shortage for the hundreds of thousands of waterfowl that stopover during fall migration. The large flocks of wintering Canada geese and mallards would be relatively unaffected, as long as irrigation is not affected and irrigated croplands near the river continue to produce waste grain. Wintering diving ducks would decline as a result of decreased abundance of benthic organisms, a principal winter food. Raptors, aquatic furbearers such as river otters, and amphibians would also decline with lost habitat.

The natural river and fixed drawdown strategies would significantly degrade wildlife resources associated with the lower Snake projects; essentially all categories of wildlife, with the exception of non-game birds, would suffer from habitat loss. SOSs 5b and 6b would draw water levels down at all four

projects by approximately 100 and 35 feet (30.5 and 11 m), respectively. The drawdowns would extend from April through August, desiccating wetlands, aquatic plants, and mud-dwelling organisms, and re-connecting islands to the shore. SOSs 5b and 6b would return water levels to within 3 to 5 feet (0.9 to 1.5 m) of full pool by September, which might maintain riparian vegetation for some years. The smaller drawdown resulting from SOS 6b (about 35 feet [11 m]) might retain riparian plants for an extended time. Even an annual drawdown of 35 feet (11 m) during the growing season, however, would preclude occurrence of moist soil required for successful germination and survival of cottonwood and willow seeds. Under both options, riparian habitat would gradually convert to upland vegetation as willows and cottonwoods failed to regenerate. The width of barren drawdown zone ringing the water's edge at middle/lower Snake projects would increase substantially, compared to SOS 2c or other strategies such as SOS 4c (Figure 4-20). The greater width of drawdown zone subjects nesting ducks, geese, and shorebirds to greater predation.

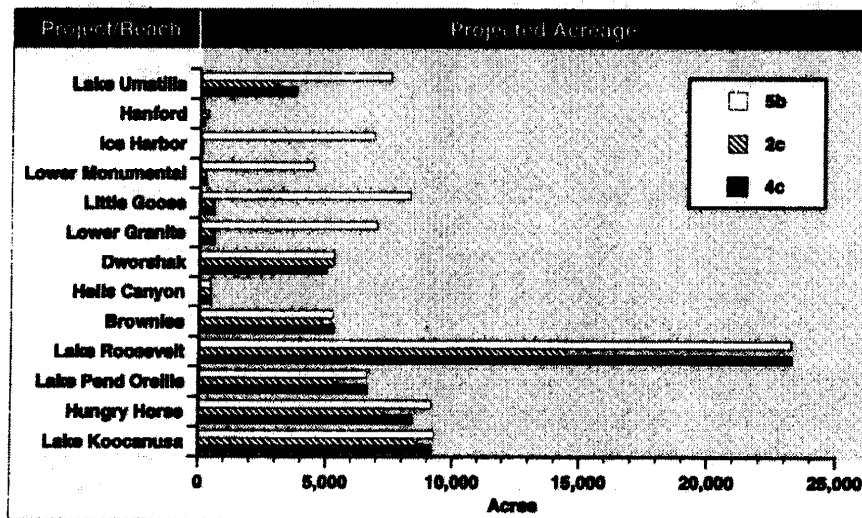


Figure 4-20. Quantity of drawdown zone projected for stable storage, natural river, and continued current operations at affected projects and reaches: SOSs 2c, 4c, 5b

Under SOSs 5b and 6b, wildlife resources in the lower and middle Snake River would suffer from the combined effects of desiccation of submerged aquatic plants and mud-dwelling fauna, land-bridging of islands, gradual loss of riparian vegetation, and increased predation associated with an extensive drawdown zone. Populations of waterfowl (Canada geese, mallards), colonial nesting birds, shorebirds, furbearers (beaver and otter) and amphibians could decline to 50 percent of current populations or even less. Over time, raptor occurrence along the lower Snake could also decline as riparian trees used for perching die without replacement. (Table A-21 and Section 4.2.17, Appendix N, Wildlife).

SOS 5c would implement a permanent 100-foot (30.5-m) drawdown at all four projects along the lower Snake River. The short-term impacts would be similar to those described above for SOS 5b; riparian habitat might disappear more quickly without a return to near full pool during non-growing season months. Over many years, however, natural-river operation associated with SOS 5c would allow riparian and some wetland habitats to reestablish. The more stable water levels resulting from natural-river operation would provide conditions suitable for colonization by emergent and riparian plants. The extent and timing of habitat establishment and rebound in wildlife would greatly depend on suitability of sediments for plant growth and topography of shoreline.

Effects of SOS 6d would be identical to SOS 6b, except restricted to Lower Granite Reservoir. Water levels at Little Goose, Lower Monumental and Ice Harbor projects would be identical to those resulting from no action (SOS 2c).

SOS 9, Settlement Discussion

Effects of SOS 9 vary widely depending on the option (Figures 4-18 and 4-19). SOS 9a, the DFOP, would eliminate wetland and riparian habitat at Lake Umatilla and at the lower Snake River projects as described for SOSs 5b and 6b.

Water levels resulting from SOSs 9a, 5b and 6b would be similar at these areas. Declines in most categories of wildlife could exceed 50 percent at Lake Umatilla, including Canada geese, ducks and colonial nesting birds. SOS 9a would also adversely affect various categories of wildlife at Lake Koocanusa, Brownlee and the Hells Canyon reach of the Snake River; colonial nesting birds, non-game birds, and aquatic furbearers would decrease in all three of these areas.

Wildlife dependent on aquatic vegetation or sensitive to human intrusion would likely increase at Lake Pend Oreille if SOS 9a were implemented. Higher winter lake levels would enhance aquatic beds and increase densities of benthic invertebrates and fish, which provide prey to waterfowl, shorebirds, aquatic furbearers and other species. Effects of SOS 9a on wildlife at other projects within the Columbia River system would be either negligible or a mix of beneficial and adverse effects.

SOS 9b, adaptive management, would create about the same amount of additional wetland and riparian habitat at Lake Pend Oreille as the stable storage strategy would (Figures 4-18 and 4-19), increasing waterfowl and other categories of wildlife by 6 to 30 percent. Lake Pend Oreille is an important stopover point for waterfowl migrating along the Pacific Flyway. Similar to stable storage, SOS 9b would lower Lake Pend Oreille during summer months, favoring expansion of marsh and riparian habitat and the wildlife these habitats support. Unlike SOS 4c (stable storage), SOS 9b would not improve conditions at Lake Koocanusa or Hungry Horse, but would maintain wildlife populations at these two projects at levels expected from SOS 2c. SOS 9b would reduce shorebird and aquatic furbearer populations at Brownlee Reservoir by 6 to 30 percent. At John Day (Lake Umatilla), SOS 9b would provide water levels similar to SOS 2c, and thus reducing shallow water and pond habitat compared to recent (pre-ESA) acreage. As described for SOS 2c, this would reduce the important waterfowl populations at Lake Umatilla by 6 to 30 percent.

SOS 9c, a balanced impacts operation, would eliminate wetland habitat at the John Day project as described above for SOSs 5, 6, and 9a. Acreage of wetland and riparian habitat in the lower Snake projects would decline, but not as much as under SOS 9a. Drawdowns at the lower Snake River projects would be implemented earlier in the year under SOS 9c and for slightly shorter duration (March through June) compared to SOS 9a. SOS 9c would operate Libby Dam and Hungry Horse Dam projects under IRCs, which would create more stable reservoir levels and would generally improve wetland habitat. Elsewhere in the system, SOS 9c would not affect wildlife resources differently than SOS 2c.

SOS PA, Preferred Alternative

SOS PA would lower Lake Umatilla to 257 feet (78.3 m), as would SOSs 5, 6, 9a, and 9c. This magnitude of change in lake elevation would desiccate marsh and aquatic plants, benthic organisms, and eventually riparian vegetation. Ponds adjacent to the lake, mostly in the Irrigon Wildlife Management Area (WMA) and sheltered backwaters, would dry up. Habitat losses would be severe, as they would also be for the SOSs 5, 6, 9a, and 9c. Unlike the other options, however, SOS PA would maintain water levels at Lake Umatilla within 5 feet (1.5 m) of the 257-foot (78-m) elevation. After 1 to 5 years of relatively stable water levels, riparian, emergent and aquatic vegetation should re-establish along the new shoreline, and benthic organisms and aquatic plants should colonize the new areas of shallow water. The extent and timing of re-establishment is difficult to predict, depending greatly on the suitability of exposed substrates and shoreline topography.

Initially, impacts on wildlife resources at Lake Umatilla would be severe. Breeding waterfowl, primarily Canada geese and mallards, would decline by greater than 50 percent. Many important nesting islands used by geese would become land-bridged; loss of protective marsh and riparian plant cover would subject goose brooding areas to increased predation. The de-watering of McCormack Slough, Patterson

Slough, Irrigon WMA and other sites would reduce mallard and other duck reproduction. Currently, total duck brood production on the Umatilla NWR approximates 2,000 ducklings; lowering the reservoir to 257 feet (78 m) would decrease duck production 50 to 80 percent. Diving ducks would suffer greater declines because they nest in emergent marsh near open water, and require aquatic plants for brood rearing.

In 1 to 5 years following implementation of SOS PA, goose and duck production would increase as habitat re-establishes. The extent to which marsh, aquatic bed and pond habitat would rebound, which is currently unknown, would largely determine the future numbers of breeding waterfowl at Lake Umatilla.

The important wintering habitat for geese at Lake Umatilla would probably not be affected by SOS PA, assuming irrigation practices are not altered. Wintering waterfowl feed primarily on waste grains in adjacent irrigated farm lands. Wintering mallards might be significantly affected by loss of protected backwater wetlands and sheltered open water, which they use for winter cover. Diving ducks, which do not feed on agricultural lands, would likely disappear immediately following implementation of SOS PA. Numbers of wintering diving ducks would increase over 1 to 5 years following implementation, as benthic productivity increases.

The lowered lake level would land-bridge or reduce the water barrier protecting islands which currently provide sites for colonial nesting birds; the thousands of ring-billed and California gulls and other birds that currently use these islands might relocate to new islands exposed by reduced lake elevations, if and when the new islands became adequately vegetated. Island habitat currently used for nesting might be restorable if sufficiently deep-water barriers can be dredged.

Non-game birds such as downy woodpeckers, yellow warblers, and red-winged blackbirds would incur substantial losses as riparian

vegetation succumbed to droughty soils. Populations of these species would recover over time, as riparian plants re-established along the new shoreline.

Beavers and otters would be severely affected by exposure of dens and loss of riparian and backwater habitat for foraging. Recovery for beavers could require 15 to 25 years, depending on the time required for growth of willow and alder. Otters might recover more quickly if macrobenthos rebound following establishment of the new pool level.

The ponds inhabited by western painted turtles at the Irrigon WMA and Umatilla NWR would likely dry up. Some turtles would likely pioneer into newly formed ponds and/or backwaters, but the net result of SOS PA would likely be a significant reduction in western painted turtles at Lake Umatilla.

Additional information about likely changes in wildlife resources at Lake Umatilla under SOS PA is presented in Appendix N, Wildlife. Efforts to replace lost pond and backwater habitat would be hampered by the abundance of porous soils, which are not easily impounded, in the area adjacent to Lake Umatilla. Control of carp, a nuisance fish that seriously interferes with establishment of aquatic vegetation, might be more difficult under conditions created by the new topography and open water configurations. These factors and others indicate that replacement of waterfowl and other wildlife habitat at the John Day Project would be costly and not necessarily entirely successful.

Effects of SOS PA at other projects in the Columbia River system would differ relatively little from those of SOS 2. At Lake Roosevelt, the rapidity of spring and summer drawdowns would stress emergent, submerged and riparian vegetation, leading to reduced numbers of waterfowl, colonial nesting birds, non-game birds and amphibians.

Threatened or Endangered Species

The Wildlife Work Group evaluated possible effects on bald eagles and, at the Hanford Reach, on persistent sepal yellow-cress, because these species are rare and closely tied to the health of Columbia River system habitat. The bald eagle is listed by the USFWS as threatened in Washington and Oregon, and endangered in Idaho and Montana. Persistent sepal yellow-cress is a candidate species that has been proposed for listing. Possible effects on the threatened grizzly bear, endangered peregrine falcon, and endangered Macfarlanes' four o'clock were also examined on a preliminary basis at projects where occurrence of these species indicated possible impact. Comparison of SOS alternatives based on possible effects on the grizzly bear (Hungry Horse Reservoir) yielded results identical to those based on effects on the bald eagle. No SOS alternatives were considered likely to affect the peregrine falcon (Brownlee Reservoir, Hells Canyon) or Macfarlanes' four o'clock (Brownlee Reservoir) any differently. The endangered gray wolf may occur in the vicinity of projects located within the upper Columbia River system, but population changes for this species will primarily reflect factors other than Columbia River system operations.

The number of projects where listed wildlife might benefit or decline are summarized for each alternative in Figure 4-21. Potential impacts generally relate to the effects of each alternative on emergent marsh and riparian habitat. Expansion of wetlands into the narrow zone of exposed sediments produced by flow augmentation at Lake Koocanusa, for example, would provide more foraging area for eagles.

Stable storage operation would allow wetland expansion into exposed sediments at Lakes Koocanusa and Pend Oreille. SOS 4 would also reduce water level fluctuations at Hungry Horse sufficient to favor some establishment of marsh and riparian vegetation. As with flow augmentation, SOS 4 would produce relatively high flows in the lower Clearwater reach, favoring larger trees used for perching.

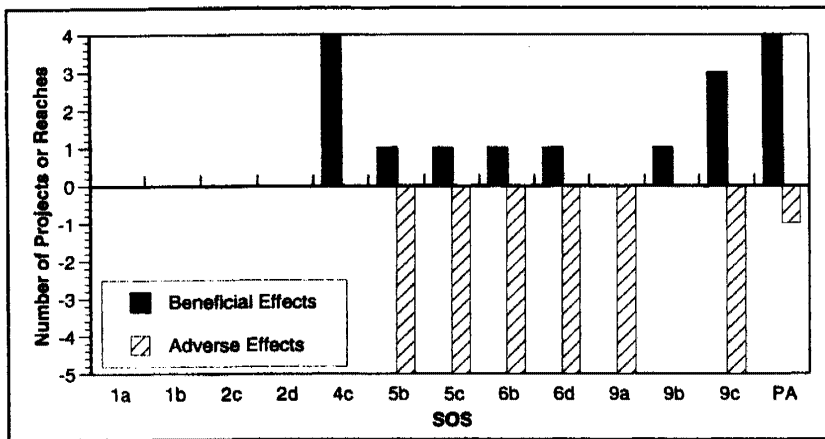


Figure 4-21. Number of projects or reaches with beneficial or adverse effects on Federally listed wildlife

SOSs 5 and 6 would maintain perching trees for eagles along the lower Clearwater reach, but would desiccate marsh and riparian habitat at the four lower Snake River projects and at John Day pool.

SOSs 9a and 9c would also prevent regeneration of riparian perch and roost trees at the four projects along the lower Snake River. In time, eagle foraging opportunities would diminish. SOS 9b would increase emergent marsh and aquatic beds at Lake Pend Oreille, with consequential increases in benthic organisms and fish; an increase in fish productivity should enhance foraging for bald eagles.

SOS PA implements the recommendations of the NMFS and USFWS Biological Opinions issued in March 1995 to avoid jeopardizing the continued existence of anadromous fish and other listed species, including plants and wildlife, in the Columbia River system. However, possible effects on bald eagles at John Day were not presented, and a biological assessment describing these has been prepared. From its own review of SOS PA, the Wildlife Work Group determined that this alternative would likely decrease bald eagle numbers in the

vicinity of Lake Umatilla as a result of a decrease in the wintering waterfowl population and lost riparian habitat.

Modification of irrigation facilities to maintain existing crop rotation patterns should mitigate impacts to wintering waterfowl. The decrease in numbers would not be substantial but probably greater than 6 percent (see Appendix N, Wildlife). In time, riparian habitat would likely re-establish along the new shoreline of Lake Umatilla, but this

process might take 20 to 40 years. SOS PA would have no immediate beneficial effects on listed wildlife.

4.2.7 Cultural Resources

This section discusses direct and indirect impacts on historic and cultural properties that are typically associated with river system operations. Certain SOSs would involve the modification of structures such as spillways, dam embankments, and fish passage facilities, potentially causing direct impacts to historic or cultural properties. These structural elements are not considered in the SOR. Instead, they are addressed in the Corps' SCS. The following summary of direct and indirect impacts is based on the complete report on cultural resource studies provided in Appendix D.

Cultural Resources Impact Issues

Changing water levels and flows can cause wave action, inundation, and exposure of reservoir drawdown zones, all of which can affect cultural resources. System operations can also cause indirect impacts to historic properties as a result of changes in the human use and aesthetics of the shore and drawdown zones.

Impacts within the reservoir pool occur most often to non-structural archeological deposits, since initial reservoir construction and filling usually removed or damaged above-ground or structural cultural resources such as historic architecture. Direct impacts to archeological deposits resulting from reservoir shoreline fluctuations occur differently in each of three reservoir zones: 1) the littoral (exposed beach), 2) wave-impact, and 3) inundation zones (Figure 4-22).

Exposed archeological deposits within the littoral zone are subject to direct impacts that are mechanical, human, and animal in origin. Because inundation removes vegetation, wind and water (runoff) erosion deflates archeological sites in this zone. Deflation is the removal of the archeological soils, leaving heavier items and artifacts in place. Water running over unvegetated slopes also causes erosional rills and gullies and moves artifacts. The movement of artifacts and site features within or away from a site decreases its scientific integrity and value

because it becomes more difficult to reconstruct the site's original features and placement of artifacts.

The littoral zone is also subject to repeated cycles of wetting and drying, which can cause organic deposits, such as bone, and some artifacts, such as ceramics, to deteriorate. In certain soils, rapid drawdown can cause mass wasting (e.g., slumping or landslides) of slopes in or above the reservoir. This occurs as water rapidly vacates the pores between soil particles, causing the soil to lose cohesion. Progressive soil slumps on beach cut-banks form erosional fronts that can slowly advance landward. Over time, this can result in the loss of large areas of bank.

Wind- and powerboat-generated wave action erodes and deflates archeological sites. It may also stimulate geomorphological changes that can destroy intact archeological deposits. These changes can include slumping, scouring, terracing, and piping (see the Glossary for definitions of these terms).

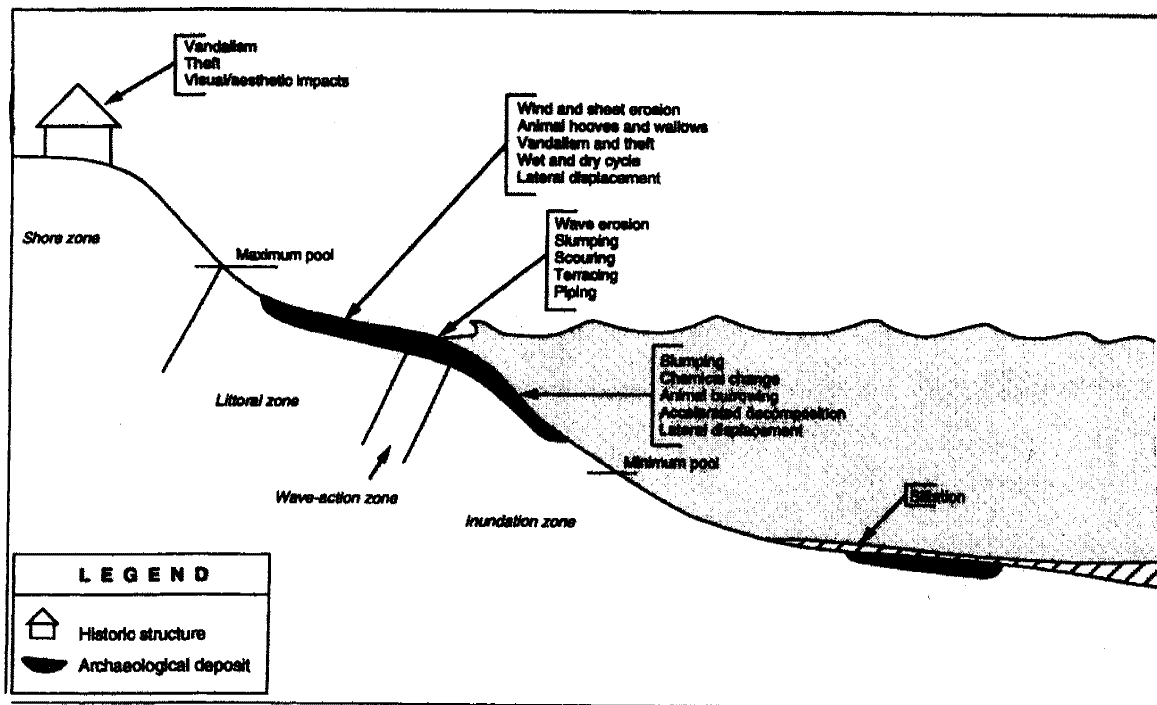


Figure 4-22. Reservoir impact zones and potential impacts on historic and cultural properties

Direct impacts on archeological deposits that occur underwater include erosion, chemical change, and accelerated decomposition (Lenihan et al., 1981). Underwater currents can cause slumping or displace materials and artifacts already brought to the surface by wind- and water-caused erosion. For example, drawdowns at Kettle Falls in Lake Roosevelt have revealed that underwater eddies have caused pothole erosion of archeological sites. Reservoir water dissolves organic materials and ceramics, and changes chemical attributes, such as pH, phosphate, and nitrogen levels of deposits. Aquatic organisms such as burrowing clams can disturb archeological deposits by moving artifacts as they burrow. An accumulation of organic acids accelerates the decomposition of organic materials and ceramics.

Indirect impacts to historic and cultural properties due to system operating strategies involve changes in the human use of the shore and littoral zones. For example, reservoir operations affect the attractiveness of the reservoir for recreation, and thereby influence the number of people visiting these zones. The devegetation and deflation of archeological sites in the littoral zone, furthermore, make them more visible to the public. When more people are present and archeological sites are more visible, there is a greater likelihood of vandalism and artifact theft. Archeological sites in the devegetated littoral zone also are susceptible to disturbance, artifact displacement, and erosion from cattle trampling and wallowing and the operation of off-road vehicles on reservoir beaches.

Land management actions not related to system operations can also affect human activities at the reservoirs, and different uses can have different effects on archeological and historic sites near system reservoirs. Decisions to develop or permit camping, summer homes, hiking trails, or off-road vehicle uses, for example, may all lead to increased impacts on historic and archeological sites from human-caused erosion, vandalism, and artifact theft. A comprehensive analysis must, therefore, consider the effects of land management actions that

affect projects in the SOR study area as well as system operations.

System operating strategies that change land uses might also change the integrity of "feeling" or association of a historic or cultural property. For example, change in nearby recreational uses might adversely affect a traditional cultural property such as a Native American ritual site, by increasing sights and sounds incompatible with ritual use. Reservoir drawdown might destroy the visual integrity of a historic site or traditional cultural property by introducing an element that is inconsistent with its historic or cultural character.

Effects of the Alternatives

All of the SOSs would cause adverse effects to cultural resources, and some of these effects would be more dramatic than others. Reservoir sites that have been covered by siltation, for example, are to some extent protected from erosion and vandalism. At the same time, the siltation may have caused chemical changes in the soils, and also reduced access to these sites for scientific study. Some sites in vulnerable locations in the reservoir drawdown zone have already been eroded or deflated beyond significance, while others contain intact deposits. Recreational use of the reservoir shoreline has led to vandalism at some sites above the operating pools, while other sites remain relatively inaccessible.

The relative effects of the SOSs on the known cultural resources can be estimated by measuring the length of time a given operation would cause shoreline erosion and exposure of these properties. The potential for a given alternative to cause geomorphological changes that would affect historic properties can also be estimated.

Shoreline Erosion, Site Exposure, and Inundation

To assess each alternative's potential to cause archeological shoreline erosion and drawdown zone exposure, the Cultural Resources Work

Group developed a site impact computer simulation model. This model simulates the movement of the reservoir shorelines over a 50-year period during which water volumes would be the same as actual water volumes between 1929 and 1978. For each alternative, it calculates the number of days in the 50-year period on which wave erosion, site exposure in a drawdown zone, and inundation would occur for each known archeological site. The simulation results are thus general rates of ongoing impact. Because reservoir elevations and patterns of shoreline movement differ significantly between alternatives, these rates of impact also differ significantly between alternatives.

The simulation is based on month-to-month changes in elevation as predicted by the ROSE hydroregulation models. To simulate shoreline wave erosion potential, it calculates the number of days in the month that the reservoir shoreline would be within the site boundary, based on the site's upper and lower elevation limits and the change in the reservoir elevation from the previous month. To simulate site exposure potential, the model calculates the number of days in the month that the reservoir shoreline would be below the site's upper boundary, also based on shoreline transgression from the previous month. To simulate inundation, the model calculates the number of days in the month that the reservoir shoreline would be above the site's upper boundary. The model then calculates overall shoreline erosion, drawdown zone exposure, and inundation scores for each alternative. The model represents these as the average number of days per year when a given effect would occur and as the average percentage of time that the effect would occur.

The simulation uses archeological site data from the known sites only. It should be kept in mind that archeological survey can never be considered complete. Archeological survey of the operating pool is relatively complete for some projects, including Libby, Albeni Falls, Chief Joseph, and the four lower Snake River projects. Data is relatively incomplete and of poor quality for Grand Coulee, though a project is currently ongoing to add to the survey

coverage. Recent surveys have greatly improved the data from Hungry Horse and Dworshak. The lower Columbia projects had little or only cursory survey before the dams were built. Subsequent surveys have filled in some of these gaps, but the data are sparse. These are run-of-river projects, however, and except for John Day, do not vary in elevation among alternatives. The simulation results, therefore, are valid only for portions of the reservoirs that have been surveyed.

The simulation study helped highlight general patterns of effect on cultural resources. For example, the average rates of shoreline erosion for some reservoirs under some alternatives are somewhat lower in general than expected. Shoreline erosion rates are moderately high or high (shoreline erosion occurring 40 to 80 percent of the time) only for Albeni Falls and Dworshak. For many reservoirs, including Libby and the lower Snake projects, the average rate of shoreline erosion is low (shoreline erosion occurring less than 20 percent of the time) for all alternatives. This does not mean, however, that reservoir operation impact on the sites is low. It only means that the impact is taking place more slowly than might have been expected.

Another result of the simulation study is that there are large differences in simulated rates of impact among reservoirs. The rates of shoreline erosion and site exposure are both high or very high at Albeni Falls, for example, and low or very low at the lower Snake River reservoirs for most alternatives. These patterns have to do with the distribution of the known sites in relation to the reservoir operating zones.

The simulation study also indicates that site exposure is particularly a problem at the storage reservoirs. Exposure rates at Albeni Falls, Hungry Horse, and Dworshak are all predicted to be high to very high (known sites exposed, on average, more than 60 percent of the time). Actual rates of impact will depend on the local topography, soil conditions, and the extent of recreational use, but the simulation indicates that rapid site deterioration may be taking place.

The simulation study predicts that SOSs 1a, 1b, and 2d would be very similar to the baseline condition (2c) in their overall rates of shoreline erosion and site exposure (Figures 4-23 and 4-24; Table 4-12). SOS 4 would increase the rate of shoreline erosion at the same time that it would slow the rate of site exposure. This indicates that the two kinds of impacts vary inversely. When reservoir shorelines are high, site exposure decreases while shoreline erosion tends to increase. This is because the known sites tend to be disproportionately located high in the reservoir pool.

SOS 5 would show the opposite pattern. Since this alternative involves deep drawdowns at the lower Snake River projects and greater pool fluctuation at the storage reservoirs, it would increase the rate of site exposure while lowering the rate of shoreline erosion. The more the shoreline moves, the less time it will spend attacking any given archeological site.

According to the simulation model, SOSs 5c and 9a would cause the greatest overall increase in the rates of shoreline erosion and site

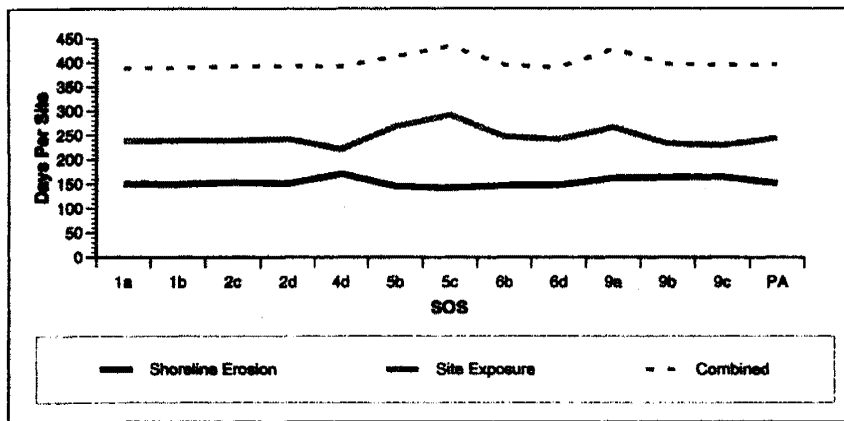


Figure 4-23. Average days per year that archaeological sites would experience shoreline erosion and site exposure

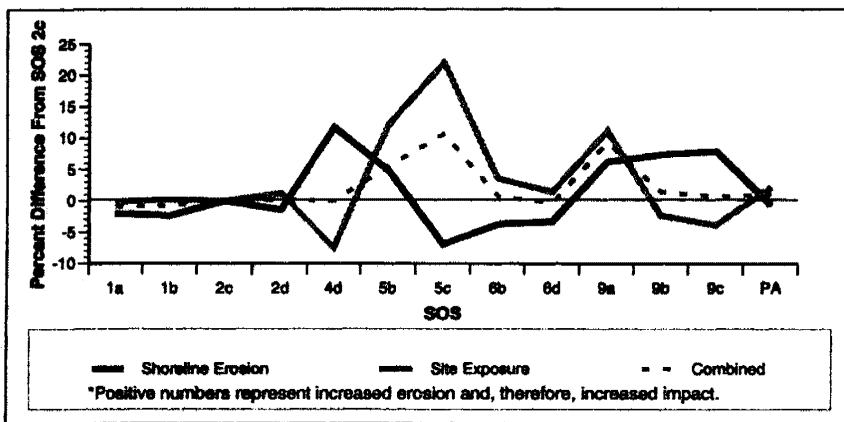


Figure 4-24. Percent difference from SOS 2c in historic property shoreline erosion and site exposure*

Table 4-12. Comparison of archaeological site shoreline erosion, site exposure, and inundation by SOS

SOS	Shoreline erosion			Site exposure			Inundation			Shoreline and exposure combined		
	Site-Days per 50-Year Model Period	Site-Days per Year	Percent Difference from SOS 2c	Site-Days per 50-Year Model Period	Average Site-Days per Year	Percent Difference from SOS 2c	Site-Days per 50-Year Model Period	Average Site-Days per Year	Percent Difference from SOS 2c	Site-Days per 50-Year Model Period	Average Site-Days per Year	Percent Difference from SOS 2c
1a	9,995,358	150	-2.0	15,892,549	238	-0.1	14,111,917	212	0.2	25,887,907	388	-0.9
1b	9,949,051	149	-2.4	15,954,048	239	0.2	14,050,418	211	-0.3	25,903,099	389	-0.8
2c	10,195,966	153	0.0	15,916,362	239	0.0	14,088,104	211	0.0	26,112,328	392	0.0
2d	10,051,816	151	-1.4	16,113,565	242	1.2	13,890,901	208	-1.4	26,165,380	393	0.2
4c	11,389,874	171	11.7	14,731,722	221	-7.4	15,272,744	229	8.4	26,121,596	392	0.0
5b	9,693,683	145	-4.9	17,846,256	268	12.1	12,157,210	182	-13.7	27,539,940	413	5.5
5c	9,489,138	142	-6.9	19,430,007	292	22.1	10,574,460	159	-24.9	28,919,144	434	10.7
6b	9,819,781	147	-3.7	16,493,818	247	3.6	13,510,648	203	-4.1	26,313,600	395	0.8
6d	9,858,071	148	-3.3	16,144,321	242	1.4	13,860,145	208	-1.6	26,002,392	390	-0.4
9a	10,825,025	162	6.2	17,706,861	266	11.2	12,297,605	185	-12.7	28,531,885	428	9.3
9b	10,948,532	164	7.4	15,528,805	233	-2.4	14,475,661	217	2.8	26,477,338	397	1.4
9c	11,006,151	165	7.9	15,300,437	230	-3.9	14,704,029	221	4.4	26,306,589	395	0.7
PA	10,121,952	152	-0.7	16,264,098	244	2.2	13,740,368	206	-2.5	26,386,049	396	1.0

exposure at the known sites combined, compared with the baseline condition. SOS 5c, however, would do so by greatly increasing rates of site exposure while slowing down the overall rate of shoreline erosion. One interesting aspect of this is that SOS 5c involves permanent drawdown at the four lower Snake River projects. The site exposure that this would cause would be mitigated by the fact that, under these conditions, the drawdown zone at these projects would eventually revegetate. This would provide some protection to archeological deposits and restore their accessibility. In other words, SOS 5c might be seen as an overall improvement in terms of impacts to cultural resources. SOS 5b, on the other hand, would involve drawing down the lower Snake River projects annually and then refilling them. SOS 9a would increase the rates of both shoreline erosion and site exposure compared to the baseline. The preferred alternative would not differ significantly from the baseline condition, according to the simulation.

Geomorphic Change

The Cultural Resources Work Group also analyzed the potential effects of reservoir operation on cultural resources by looking at the ways in which various features of system operation could accelerate erosion and change to the landforms on which cultural resources are located. This analysis took into account geomorphic processes such as land slumping that were not included directly in the simulation model. It also considered effects on the entire reservoir pool at each project. The simulation model, on the other hand, examined only impacts to the known historic properties. Since cultural resources surveys are incomplete, the geomorphic model provided a way to account for the effects on unrecorded sites. The simulation and geomorphic models are thus complementary approaches to impacts analysis.

The following discusses the potential effects of the system operational features on cultural resources through sedimentation and erosion.

Flow Augmentation—Augmenting flows increases water velocity through the reservoirs. Depending upon the rate of flow and the volume of additional water, such increases can be sufficiently large to increase erosive cutting at reservoir shorelines, particularly on peninsulas and embayments. Currents of 4 feet per second (0.3 m per second) can increase shoreline erosion by 30 percent in light soils such as those that occur on the Columbia Plateau.

Some level of flow augmentation would occur under every option except SOS 1b. SOS 1a includes the original Water Budget flow augmentation. SOSs 2, 9, and PA incorporate substantial flow augmentation in addition to the Water Budget.

New Reservoir Levels—The construction of a dam and reservoir upsets the dynamic equilibrium of the river on which the dam is built. As soon as the reservoir fills, the shoreline begins to erode and sediment collects on the reservoir sideslopes. As time passes, erosion rates decrease as the reservoir reaches a new equilibrium state. When reservoir operation changes, a new erosional cycle begins. Shoreline waves begin to cut deeper benches at new stable levels. The benches undermine steeper slopes above the benches, which lead to landsliding and slumping that, in turn, may affect cultural resources. If new reservoir levels are considerably lower, this can lead to narrower pools through which water travels faster, causing increased bank erosion.

Rapid Drawdown—Rapid drawdowns (greater than 2 feet [0.6 m] per day) can dramatically accelerate ongoing processes of soil creep, landsliding, and mass wasting. This occurs as water becomes trapped in the pores between soil particles, then exerts pressure on surrounding soil particles during drawdown, causing an unstable soil mass. This can cause slumping and sliding, affecting archeological deposits located nearby.

Rapid Pool Fluctuation—Reservoir fluctuations of more than 5 feet (1.5 m) per day (including both raising and lowering of the pool)

because the existing data may not reliably represent the full range of all cultural resources. A more detailed analysis of the effects of the SOS alternatives would require complete archeological inventories of all reservoirs; evaluations of the eligibility of their historic properties for nomination to the National Register; and information about the susceptibility of cultural sites to reservoir exposure and wave erosion effects, based on their soils, slopes and locations in the landscape.

The lead agencies have formerly initiated the National Historic Preservation Act (NHPA) Section 106 consultation process. Section 106 requires Federal agencies to evaluate the effects of their actions on historic, archeological, and cultural resources, and to provide the Advisory Council on Historic Preservation with the opportunity to comment on the proposed actions. The SOR agencies will develop an interagency agreement, based upon a statement of shared principles and commitments, that will identify specific agency roles, responsibilities, and commitments for budget allocations necessary to meet cultural resources requirements for Section 106 and 110 compliance. Based on the SOR impact analysis, the lead agencies will also develop cultural resources implementation plans for specific projects or river reaches; these plans will outline the steps to be taken to fulfill the interagency agreement, as part of the NHPA Section 110 consultation process. For some projects, treatment for mitigation will be according to an existing memorandum of agreement or programmatic agreement (see Appendix D, Chapter 6 for further discussion).

Traditional Cultural Properties

Information submitted by the tribes within the region indicates that the Columbia River system has significant, ongoing, adverse effects upon traditional cultural properties valued by Native Americans. Some of these effects involve aquatic and terrestrial resources associated with a free-flowing river system that were diminished or lost with development of the dam and reservoir system. Other adverse effects occurred through inundation of ceremonial grounds, sacred sites, important plants and life forms, fishing sites, social and political

gathering areas, unique landforms, and other features important to the traditional way of life of the Indian peoples. Some traditional cultural properties were not inundated and remain accessible, but their integrity and value has been diminished through project-related landscape changes and the management of project lands for recreation and other public purposes. For example, some vision quest sites are still accessible, but have lost their traditional context and feeling because the original riverine landscape has been significantly modified.

Based on the nature of these effects, the adverse impacts of the system on traditional cultural properties have occurred and will continue primarily as a result of the construction and continued presence of the dams and reservoirs. The variable effects of system operations on these resources are somewhat limited. In assessing the effects of the 13 SOSs on traditional cultural properties, an important distinction is that the SOSs would vary the physical characteristics of the water flowing through the system, but they would not directly change the structures of the system or the management of project lands. The SOSs therefore would primarily affect resources in the water (principally fish), or resources that would benefit from or be harmed by changes in water levels. In addition, a significant potential effect would be for changes in water levels to expose traditional cultural properties that now are normally inundated.

Given the ways in which system operations can affect traditional cultural properties, comparison of the SOSs on this basis is partially subsumed in the previous assessments for anadromous fish, resident fish, and wildlife (Sections 4.2.4, 4.2.5, and 4.2.6, respectively; see also Section 4.2.8). The traditional cultural significance of these natural resources is very high. Based on the information submitted by a few of the tribes, the SOR agencies conclude that the lower river treaty tribes in particular would view an SOS that would benefit anadromous fish as being protective of one important dimension of traditional cultural properties. For the upriver tribes in areas where anadromous fish are not present, the SOR agencies have concluded that this dimension of

traditional cultural properties would depend primarily on SOS effects on resident fish and wildlife.

Aside from the biological dimension, SOS effects that would result through exposure of cultural sites would generally be based on the depth, duration, and geographic extent of reservoir drafting. In the case of storage reservoirs, seasonal drafting under current or past operations has probably exposed and provided tribal access to some traditional cultural properties on an intermittent basis. Access to these areas is considered a positive effect by at least some of the tribes. This type of effect would continue under all 13 SOSs, with relatively minor incremental differences among the SOSs. In general, however, any benefits from increased access to inundated sites at storage reservoirs would likely be at least partially offset by less desirable conditions for resident fish.

The greatest potential for change in operations effects through exposure of and access to cultural sites applies to mainstem reservoirs at which drawdown has been considered. The CTUIR, for example, reported that nearly 1,500 known sites of particular cultural significance to the Umatilla tribes have been inundated by the eight lower Columbia and Snake River dams, and that many more such sites may exist but have not yet been identified (see Appendix D, Section 4.6). Natural river or drawdown operations for one or more of these projects would (in conjunction with appropriate land management and resource protection) restore access to numerous culturally significant sites and expand opportunities for the tribes to actively practice their culture. Based on the characteristics of the 13 SOS alternatives, The SOR agencies conclude that SOS 5c would be the most beneficial by this impact measure, as it would provide year-round access to all sites inundated by the four lower Snake River pools (approximately 660 sites in the CTUIR inventory), and to sites around the upper margin of the John Day pool (if any exist in this zone). SOS 5b would allow access to the same sites, but for only about half of the year. SOSs 6b, 9a, and 9c would expose cultural sites in the upper one-third (by elevation) of the lower

Snake River pools on a seasonal basis, and therefore would allow use of a considerably smaller and unknown number of sites. SOS 6d would have the same type of effect, but limited to the Lower Granite pool.

The CTUIR and the Spokane Tribe have specifically indicated that access to culturally significant sites and resources, and opportunities to practice their culture, are very important factors in how they view system operations and the effects of the SOSs. Other tribes have expressed or probably hold similar views with respect to the places and resources that have special significance for them.

4.2.8 Native Americans

The purpose of this section is to identify and discuss potential consequences of system operations on Native American resources and interests. In many ways, this is a non-traditional impact assessment; while some of the resources of interest to Native Americans are tangible physical or biological features, others include considerations such as spiritual and cultural attributes of the resources. The following material attempts to identify SOR-related issues of interest to Native Americans and characterize the effects of the SOS alternatives on Indian resources and concerns.

Native American Impact Issues

Coordination with the tribes to date has indicated that, in general, issues that particularly concern tribes with respect to the SOR include treaty rights, impacts on fishing, and the protection of graves and cultural resource sites. While these may be the key concerns, a wide range of other resources and issues is of interest to the Indians of the basin. Some of these interests are best described through prior tribal expressions of their views of the SOR.

Many Native Americans from the basin's tribes traditionally have centered their lives around the Columbia River and depended on its resources, such as salmon and transportation. Some quotations from the April 1993 edition of the SOR newsletter, *Streamline*, illustrate how some Native Americans view the river:

Shoshone-Bannock Tribes: The Shoshone-Bannock Tribes believe that the entire Columbia River system is culturally significant, not just individual "sites" within the system. The preservation of the free-flowing rivers and associated riparian ecosystems should be included in the cultural resources elements analyzed.

Fred Ike, Sr. and Johnson Meninick, staff, Yakama Indian Nation Cultural Program: The Yakama Nation has a vested interest in the river basin, which is our homeland. It is important that the SOR recognize Tribal sovereignty. Our interests are more than fishing rights; we are concerned about preserving a seasonal round of life that is the focus of people up and down the river. We want to preserve a traditional way of life connected to the river and the resources of the river.

Many of the tribes are extensively involved in fish and wildlife management, and the SOR agencies have received a number of comments from tribal representatives concerning these resources. Specific concerns or requests included use of the empirical life-cycle model for anadromous fish being developed by the state agencies and tribes; managing water in upstream reservoirs more for the benefit of resident fish and wildlife; and protecting existing investments in fish and wildlife mitigation. Tribal representatives have also expressed concern over exposure of cultural resource sites at the reservoirs, the overall approach to the cultural resources assessment, and the development of management plans to monitor and protect affected cultural resources. As indicated in Section 2.2.1, the tribes are concerned about a broad range of features of the natural environment. They believe that this more expansive definition of cultural resources and values should be considered throughout the SOR analysis. This issue is discussed further in Appendix D.

In addition to these issues, tribal rights and resources described in Section 2.2.3 represent significant issues for the SOR. There are several Indian reservations that abut projects

within the SOR study area and that conceivably could be directly affected by system operations. The tribes have treaty fishing rights that are of interest, both directly through possible influence on fishing sites, and indirectly through potential effects on fish resources. Generally, for example, upper Columbia-Snake River tribes (e.g., Colville, Kalispel, Kootenai, Coeur d'Alene, and Spokane Tribes) are very concerned about the status of resident fish; lower Columbia-Snake River tribes (Warm Springs, Umatilla, Yakama, and Nez Perce) have greater concern for anadromous fish. Similar circumstances may apply to off-reservation hunting and gathering rights. Finally, as representatives of the United States, the Federal agencies have obligations to uphold their Indian trust responsibilities, and deal with the tribes on a government-to-government basis.

Effects of Alternatives

Generally, key Native American interests—principally, access to and protection of natural and cultural resources sites—would be adversely affected by all of the SOS alternatives, with few exceptions. All the SOSs would continue the existing pattern of soil erosion, mass wasting, and exposure of cultural resources to damage, looting, and vandalism. These impacts are discussed in Section 4.2.7, Cultural Resources, and more extensively in Appendix D. Other effects (e.g., the potential for interference with fishing, hunting, and gathering rights) are considered in this section. The effects of the SOS alternatives on anadromous fish, resident fish, and wildlife are dealt with extensively in Appendices C, K, and N, respectively.

Eleven of the affected Indian tribes have so far agreed to contract with the SOR agencies to provide independent reports on the effects of the dam operations: the Confederated Tribes and Bands of the Yakama Indian Nation, the Nez Perce Tribe, the Confederated Tribes of the Umatilla Indian Reservation, the Burns Paiute Tribe, the Confederated Tribes of the Warm Springs Reservation, the Colville Confederated Tribes, the Kalispel Indian Community, the Coeur d'Alene Tribe, the Kootenai Tribe of

Idaho, and the Mid-Columbia Council. Contracts with the Shoshone-Bannock, Shoshone-Paiute, and Burns-Paiute Tribes will soon be in place to likewise ensure their continued and future participation. Additionally, the Confederated Tribes of the Umatilla Indian Reservation submitted to the SOR agencies and to the Secretaries of Defense, Energy, and the Interior, a communication "not to be considered as technical comments" but as comments to address "broadly defined tribal concerns and inadequacies related to the SOR process" (CTUIR, 1994). This communication was published in the Draft EIS. Much of the documentation submitted since by the tribes through their contracts has been included as Exhibits 1 through 9 of this Final EIS. Additional material submitted by the tribes is provided in Appendix D, Cultural Resources.

The following discussion is based on the submittals from these tribes (also represented among exhibits) and on analyses reported elsewhere in Section 4.2 that address the effects of the SOSs on resource areas of great importance to Native Americans. This discussion specifically addresses Indian trust assets as well as other resources of interest to Native Americans. The conclusions stated in the discussion of impacts do not necessarily represent the views of the affected tribes. The submittals reviewed by the SOR agencies were largely of a general nature, not specific to the SOSs.

SOS 1 and SOS 2, Pre-ESA Operations and Current Operations

Returning to operations prior to enactment of measures to benefit anadromous fish (SOS 1) would continue shoreline erosion and mass wasting with resulting negative effects on natural and cultural resources. Down-river Indian tribes would face diminished populations of salmon (Burns Paiute Tribe, 1994), which for those tribes are critical to fulfillment of their treaty fishing rights and to the basis of their cultural and spiritual existence. This alternative also would result in a decline in resident fish populations, limiting the Federal government's

ability to meet its trust responsibilities for both resident and anadromous fish. Returning to pre-ESA conditions could further diminish the way of life for those practicing traditional lifestyles. Although SOS 2 would improve salmon survival somewhat over pre-ESA operations, other adverse effects resulting from SOS 1 operations (e.g., shoreline erosion, mass wasting, decline in resident fish populations) would prevail with SOS 2.

SOS 4, Stable Storage Project Operations

The goal of this SOS, to benefit resident fish and wildlife, would also benefit Native American cultural interests at some locations. Stabilizing water level fluctuations at storage projects generally would improve conditions for resident fish and improve wetland and riparian habitat available for waterfowl, big game, and other wildlife. However, such action could negatively affect wildlife at Lake Roosevelt and on the Hanford Reach and the lower Clearwater River, where spring flow augmentation could reduce wetland vegetation available for foraging and nesting. Anadromous fish survival would be about the same as under current conditions, continuing to limit the supply available to meet Indian fishing treaty expectations and Federal government trust responsibilities. Setting new seasonal pool levels at upper Columbia storage reservoirs could increase or cause new damage by exposure to looting and erosion of traditional use sites and areas. Erosion and mass wasting of traditional use areas would continue.

SOS 5 and SOS 6, Natural River Operations and Fixed Drawdown

While benefiting Snake River anadromous fish stocks by moving them faster downstream, SOS 5 would result in increased damage to virtually every other resource of interest to Native Americans. Resident fish spawning and egg development on the lower Snake River projects would be adversely affected by either option for natural river operations, reducing the availability of this trust resource. Wildlife resources would be reduced due to desiccation of vegetation and habitat critical to their survival.

Thus, hunting and gathering opportunities would be diminished by this operating strategy. Severe drawdown would result in bank destabilization of traditional use sites. Impacts under SOS 6 would be similar to those from SOS 5, except they would be limited under Option 6d to the Lower Granite area. Effects of storage reservoir operations on resident fish and wildlife in the upriver areas would be similar to those of SOS 1.

SOS 9, Settlement Discussion Alternatives

The SOS 9 options would appear to have some benefit for anadromous fish trust assets, compared with current conditions. Impacts on wildlife habitat affecting hunting rights and on vegetation conditions affecting gathering would vary from reservoir to reservoir. Drawdowns below current minimum pool at the lower Snake projects and to minimum pool at John Day under SOSs 9a and 9c would result in some desiccation of riparian vegetation and would accelerate erosion of traditional use sites in the drawdown zones. SOS 9c incorporates IRCs or similar features for some of the storage projects, and therefore would offer improved conditions for resident fish and wildlife in some locations. SOSs 9a and 9b would variously increase storage reservoir elevation fluctuations for some projects, thereby worsening conditions for resident fish.

SOS PA, Preferred Alternative

The preferred alternative would benefit the recovery of anadromous fish stocks. Fish migration flow augmentation water would reduce wetland vegetation at Lake Roosevelt, on the Hanford Reach, and on the lower Clearwater somewhat. This would cause some reduction of favorable wildlife habitat. Drafting storage reservoirs for flow augmentation would have some adverse impacts on resident fish, although summer draft limits included in SOS PA are intended to afford some protection to resident fish.

Summary

All tribes that submitted comments on the SOS alternatives generally felt that all SOSs would continue the overall decline of resources associated with their traditional way of life. Since they view the entire Columbia River as an integrated whole, for which impacts anywhere affect the entire river and basin, they believe that all SOS alternatives would impair the cultural environment of the Native Americans who reside in and use the Columbia River Basin. All strategies would continue to diminish hunting, fishing, and gathering capabilities and to damage cultural resource sites. The eleven tribes that provided evaluations expressed the view that it would be increasingly difficult for the U.S. government to meet treaty and trust responsibilities so tied to these issues. This, in turn, would reduce Native American access to important resources and eliminate habitat for some resources (Yakama Indian Nation, 1994).

All eleven tribes expressed the concern that their sovereignty is compromised by failure of the SOR agencies to afford the tribes what they consider a meaningful role in decisionmaking over anadromous and resident fish, and by the lack of trust responsibility for their rights and resources (CTUIR, 1994; Yakama Nation, 1994). Finally, based on the tribal submittals and informal input received during various coordination activities, there appears to be general agreement among all the tribes that additional monitoring must be provided at cultural resource sites and that enforcement of existing Federal and state laws protecting cultural resources (that is, cultural resources as broadly defined by the tribes) must be improved.

4.2.9 Aesthetics

Reservoir operations, primarily drafting, can have significant aesthetic impacts on adjacent lands. These impacts result from a number of factors, including increased shoreline visibility and contrast, erosion, changes in recreational facilities, reduction in the size of embayments and seep lakes, changes in water characteristics, and production of dust and odors. A decrease in

aesthetic quality at a project can affect recreational use and have social and economic consequences for visitors and residents.

Aesthetic Impact Issues

Changes in the aesthetic qualities of reservoirs and river reaches can be attributed to changes in specific physical factors. These factors are discussed in general terms below and then are related to the SOS alternatives. Aesthetic issues and projected impacts are addressed in more detail in Appendix J, Recreation.

Shoreline Contrast

Shoreline contrast (the visual effect of exposed shorelines caused by reservoir drafting) is generally more of a concern at reservoirs, particularly storage reservoirs, than on free-flowing river reaches. In fact, some shoreline contrast along river reaches and natural lakes is often natural and appealing. The aesthetic impact of reservoir drafting depends on the amount of shoreline exposed, the color and textural contrast between shoreline and adjacent uplands, and the number of people viewing the affected shorelines. As reservoir levels decrease, the demarcation between the water and land becomes more distinct. Shoreline contrast tends to increase with the vertical and horizontal distances between full pool and the current reservoir level. Visual contrast is also higher if the exposed shoreline materials are light in color and differ markedly from, for example, the dark background created by forested uplands adjacent to the reservoir. Other visual elements of reservoir drafting include floating debris (such as logs) left on the shoreline and exposed stumps.

Erosion

Fluctuating reservoir levels can cause landslides and erosion along reservoir shores. Scarring from erosion and landslides increases visual contrast makes landscapes unattractive. Shoreline facilities that are built on surficial sediments may be subject to undercutting and even collapse with fluctuating reservoir levels.

Erosion is generally less of an aesthetic concern on free-flowing river reaches, where dynamic natural processes are expected.

Facility Impacts

Reservoir drafting can expose waterside facilities such as beaches, swimming areas, boat ramps, docks, and marinas, leaving them unusable and unsightly. Recreational facilities at the run-of-river projects typically depend on irrigation for park landscaping. Operating these reservoirs at elevations below irrigation intakes could reduce or eliminate the ability to irrigate lawns and plantings. The aesthetic quality of these facilities would be diminished by withered or dead landscaping.

Seep Lakes and Embayments

Seep lakes are water bodies separated from reservoirs by railroad and highway embankments, but hydrologically connected to the reservoirs by culverts and/or groundwater interaction. Embayments are backwater areas connected to reservoirs by open channels. These features are common at the run-of-river projects. Both are connected to the reservoirs hydrologically and, without water replenishment, their size and water quality can be reduced. Possible visual impacts include exposure of bottom material and damage to nearby wetland areas.

Water Characteristics

Changes in reservoir levels can affect the physical and visual characteristics of water in several ways. When water levels in reservoirs are lowered, the remaining water flows at a higher velocity and picks up additional sediment, which in turn leads to increased turbidity. Erosion of reservoir sediments exposed by drafting has the same effect. Increases in turbidity can decrease water clarity and change its color.

Reservoir drafting also changes water motion. As the reservoir recedes, shallow areas and the far reaches of the reservoir become



Lake Koochanusa (Mamers Haven Marina) at low and full pool

exposed and the extent of slack water is reduced. Water velocity increases at the head of the reservoir, giving these areas a more riverine character. Tributary streams entering the reservoir re-establish channels in the exposed lake bed. As a result, decreased reservoir size is accompanied by a decrease in slack water and a corresponding increase in river and stream areas with a moving or free-flowing character.

The quantity of water in a river can affect its aesthetic quality. Different viewers have different perceptions about the relationship between quantity of river flow and the aesthetic quality of the river environment. The Recreation Work Group assumed that flows similar to historic flows would be acceptable to most viewers.

Dust and Odors

Reservoir drafting exposes shorelines and lake bottoms to the effects of wind. Fine sediments dry out and are carried off by the wind, which can be a nuisance to nearby residents and recreationists. Odors can be created in areas where organic material is exposed as a result of drafting. The extent of odor impacts depends upon the amount of organic material exposed, the amount of shoreline exposed, the wind direction, and the proximity to areas frequented by people.

Effects of Alternatives

Most of the SOS alternatives would vary little from SOS 1a (historic conditions) or SOS 2c (no action) in terms of physical changes in water levels. Other alternatives would cause

Significant changes in reservoir elevations and resulting shoreline exposure would affect the aquatic environment of some projects. Most of these changes would occur during the spring or fall, generally the times of year when recreational use and highway travel are greatest. The aesthetic effects in most cases represent incremental changes to impacts that regularly occur from existing operating patterns, rather than the introduction of new types of impacts. In addition, the aesthetic impacts of any SOS occur within landscapes already actively modified by human activity (such as boating, railroads and highways, residential and recreational development, transmission lines, etc.). Such modifications are apparent in virtually all parts of the study area.

The average annual vertical shoreline exposure (the difference between the average elevation and the full-pool elevation) can be used as an overall indicator of the aesthetic impacts of SOSs on reservoirs. However, these exposure measurements are somewhat limited because these measurements are annual averages, and do not reflect seasonal variations. For example, under some of the SOSs, storage reservoirs are lowered during the winter and do not stay near full pool during the summer. In these cases, the average amount of annual shoreline exposure does not reflect the aesthetic condition during the time of year when visitation would occur. Nevertheless, these annual measurements of vertical shoreline exposure do allow comparisons among the SOSs and indicate the relative impacts they would have on aesthetic quality.

Table 4-13 indicates that compared to the other SOSs, SOS 4c would expose the least amount of shoreline at most of the storage reservoirs. The average vertical shoreline exposure would be 35 feet (10.7 m), at Hungry Horse 24 feet (7.3 m), at Dworshak 33 feet at Grand Coulee 12 feet (3.7 m), and at Falls SOS 5 feet (1.5 m). SOS 9a would expose the most shoreline at Libby (83 feet [25.3]), Hungry Horse (83 feet [25.3]), and Grand Coulee (26 feet [7.9 m]). At Albeni Falls SOS 6b would result in the most shoreline

exposure (6 feet [1.8 m]) of any of the SOSs. At Dworshak, SOS 9b would expose the most (80 feet [24.3 m]).

The average annual vertical shoreline exposure at the run-of-river projects would vary considerably by SOS. SOS 5 would expose the greatest amount of shoreline (from 46 to 112 feet [14.0 to 34.2 m]) at run-of-river projects of any of the SOSs. Some SOSs, such as SOSs 6b, 9a, and 9c, would expose from 8 to 28 vertical feet (2.4 to 8.5 m) of shoreline. The other SOSs would not expose much shoreline at the lower Snake River projects or John Day. At the John Day project, SOS PA would expose the greatest amount of shoreline, while SOSs 5c, 6b, 9a, and 9c would expose between 3 and 5 feet (0.9 to 1.5 m).

4.2.10 Recreation

The 14 projects and 5 river reaches addressed in this EIS have varying degrees of local, regional, or national recreational significance. They support recreational activities that are dependent on, or are enhanced by, nearby lakes or rivers. Some of the more popular activities, such as boating, fishing, and swimming, require developed facilities that allow access to the water. Use of the facilities depends on adequate water levels in reservoirs and adequate instream flows for river reaches.

The SOS alternatives would result in lake elevation and river flow patterns that would affect recreational facilities and influence visitation at those facilities. The recreation analysis indicated that, systemwide, there would be insignificant to moderate differences among the alternatives in terms of total visitation. However, visitation at some projects and river reaches would vary significantly among the SOSs. In addition, operations that would benefit certain projects or areas of the system, in some cases, would worsen conditions for recreation in other areas.

The following material summarizes the results of the recreation analysis. The discussion addresses the ways in which recreation could be



Lake Koochanusa (Marners Haven Marina) at low and full pool

exposed and the extent of slack water is reduced. Water velocity increases at the head of the reservoir, giving these areas a more riverine character. Tributary streams entering the reservoir re-establish channels in the exposed lake bed. As a result, decreased reservoir size is accompanied by a decrease in slack water and a corresponding increase in river and stream areas with a moving or free-flowing character.

The quantity of water in a river can affect its aesthetic quality. Different viewers have different perceptions about the relationship between quantity of river flow and the aesthetic quality of the river environment. The Recreation Work Group assumed that flows similar to historic flows would be acceptable to most viewers.

Dust and Odors

Reservoir drafting exposes shorelines and lake bottoms to the effects of wind. Fine sediments dry out and are carried off by the wind, which can be a nuisance to nearby residents and recreationists. Odors can be created in areas where organic material is exposed as a result of drafting. The extent of odor impacts depends upon the amount of organic material exposed, the amount of shoreline exposed, the wind direction, and the proximity to areas frequented by people.

Effects of Alternatives

Most of the SOS alternatives would vary little from SOS 1a (historic conditions) or SOS 2c (no action) in terms of physical changes in water levels. Other alternatives would cause

significant changes in reservoir elevations and the resulting shoreline exposure would affect the aesthetic environment of some projects. Most of these changes would occur during the spring or summer, generally the times of year when recreational use and highway travel are greatest. These aesthetic effects in most cases represent incremental changes to impacts that regularly result from existing operating patterns, rather than the introduction of new types of impacts. In addition, the aesthetic impacts of any SOS would occur within landscapes already substantively modified by human activity (such as logging, railroads and highways, residential and recreational development, transmission lines, and dams). Such modifications are apparent in virtually all parts of the study area.

The average annual vertical shoreline exposure (the difference between the average pool elevation and the full-pool elevation) can be used as an overall indicator of the aesthetic effects of SOSs on reservoirs. However, shoreline exposure measurements are somewhat skewed because these measurements are annual averages, and do not reflect seasonal variations. For example, under some of the SOSs, storage reservoir pools are lowered during the winter and kept near full pool during the summer. In these cases, the average amount of annual vertical shoreline exposure does not reflect the aesthetic condition during the time of year when most visitation would occur. Nevertheless, average annual measurements of vertical shoreline exposure do allow comparisons among the SOSs and indicate the relative impacts the SOSs would have on aesthetic quality.

Table 4-13 indicates that compared to the other SOSs, SOS 4c would expose the least amount of shoreline at most of the storage projects. The average vertical shoreline exposure at Libby would be 35 feet (10.7 m), at Hungry Horse 24 feet (7.3 m), at Dworshak 33 feet (10 m), at Grand Coulee 12 feet (3.7 m), and at Albeni Falls SOS 5 feet (1.5 m). SOS 9a would expose the most shoreline at Libby (83 feet [25.3 m]), Hungry Horse (83 feet [25.3]), and Grand Coulee (26 feet [7.9 m]). At Albeni Falls, SOS 6b would result in the most shoreline

exposure (6 feet [1.8 m]) of any of the SOSs. At Dworshak, SOS 9b would expose the most (80 feet [24.3 m]).

The average annual vertical shoreline exposure at the run-of-river projects would vary considerably by SOS. SOS 5 would expose the greatest amount of shoreline (from 46 to 112 feet [14.0 to 34.2 m]) at run-of-river projects of any of the SOSs. Some SOSs, such as SOSs 6b, 9a, and 9c, would expose from 8 to 28 vertical feet (2.4 to 8.5 m) of shoreline. The other SOSs would not expose much shoreline at the lower Snake River projects or John Day. At the John Day project, SOS PA would expose the greatest amount of shoreline, while SOSs 5c, 6b, 9a, and 9c would expose between 3 and 5 feet (0.9 to 1.5 m).

4.2.10 Recreation

The 14 projects and 5 river reaches addressed in this EIS have varying degrees of local, regional, or national recreational significance. They support recreational activities that are dependent on, or are enhanced by, nearby lakes or rivers. Some of the more popular activities, such as boating, fishing, and swimming, require developed facilities that allow access to the water. Use of the facilities depends on adequate water levels in reservoirs and adequate instream flows for river reaches.

The SOS alternatives would result in lake elevation and river flow patterns that would affect recreational facilities and influence visitation at those facilities. The recreation analysis indicated that, systemwide, there would be insignificant to moderate differences among the alternatives in terms of total visitation. However, visitation at some projects and river reaches would vary significantly among the SOSs. In addition, operations that would benefit certain projects or areas of the system, in some cases, would worsen conditions for recreation in other areas.

The following material summarizes the results of the recreation analysis. The discussion addresses the ways in which recreation could be

Table 4-13. Average annual vertical shoreline exposure (in feet)^{a/, b/}

	Representative SOS Alternatives									
	1a	2c	4c	5b	5c	6b	9a	9b	9c	PA
Storage Projects										
Libby	59	57	35	61	61	61	83	49	35	55
Hungry Horse	60	57	24	61	61	61	83	29	24	29
Albeni Falls	6	6	5	6	6	6	5	3	4	6
Grand Coulee	19	16	11	16	16	16	26	16	16	13
Dworshak	51	46	33	46	39	40	50	80	61	66
Run-of-River Projects^{c/}										
Lower Granite	3.6	3.3	0.6	55.4	112	12.4	14.1	0.8	10.1	1.2
Little Goose	1.8	2.7	0.9	55.3	112.2	13.1	15	1.2	10.3	1.1
Lower Monumental	1.3	1.7	0.4	52.1	106.7	28.4	14.3	0.5	10.4	0.5
Ice Harbor	1.3	1.7	0.4	45.7	95.7	13.7	14.3	0.5	8.4	0.5
John Day	3.6	4.6	1.1	1.9	4.9	4.3	3	0.4	5.3	8

a/ Based on the difference between the full-pool elevation and the average end-of-month reservoir elevation for a given SOS.

b/ 1 foot = 0.3048 m.

c/ Elevations would not vary among SOSs for Chief Joseph, McNary, The Dalles, and Bonneville.

affected, the physical effects on recreation facilities, potential changes in recreation visitation, and apparent tradeoffs associated with different operations. Appendix J, Recreation, contains details on methods and results for the analysis. The impact results that are presented here are based on operational effects without mitigation; visitation effects could be reduced if the potential mitigation measures discussed in Section 4.3.3 were implemented.

Recreation Impact Issues

Operation of the Columbia River system directly affects the suitability of storage reservoirs, run-of-river reservoirs, and controlled downstream river reaches for recreation uses. System operations result in

variable reservoir pool elevations and downstream flows that influence recreation by affecting:

- the usability of recreation facilities
- fish habitat and fishing success
- wildlife habitat and hunting or wildlife viewing success
- geophysical characteristics and recreational safety
- water quality parameters influencing recreation
- aesthetics

These types of effects from the SOSs are described quantitatively and qualitatively in Appendix J, Recreation, and are summarized in the following section.

Project visitors can be expected to adjust their participation in water-dependent and water-related recreation activities, either positively or negatively, in response to these physical recreation impacts. The primary measurement of the effects of an alternative on recreation in the Columbia River system is visitation. Impact assessment models were developed to estimate participation in terms of annual recreation days for key recreational activities at 14 Federal projects and two downstream river reaches under each alternative SOS. Appendix J describes the models and their results. The results are summarized below.

Physical Effects

The most important physical recreation impact is the effect of operations on water-based recreation facilities. Fixed water-based facilities, such as boat ramps, swimming beaches, and moorage facilities, have very specific ranges of elevation in which they can function. These facilities become less usable as pool elevations and flows decline (or if flows are too high), eventually reaching a point where access to the water is severely constrained or precluded. Some floating facilities, such as docks, can be relocated as pool elevations drop. Moving facilities can be difficult, however, and it is often not practical to move them because pool elevations fluctuate frequently or rapidly.

Pool levels at the run-of-river projects fluctuate on a daily and weekly basis. Daily fluctuations typically vary between 0.5 and 2 feet (0.2 and 0.6 m), and weekly fluctuations by as much as 5 feet (1.5 m). Project recreational facilities have generally been designed to function over these normal operating ranges. The use of some facilities can be impaired at the low end of normal operating ranges. Low pool levels can also increase shoaling at moorage facilities and entrance channels, and wind and wave erosion, accentuated by low pool elevations, can damage banks and the toes of boat ramps.

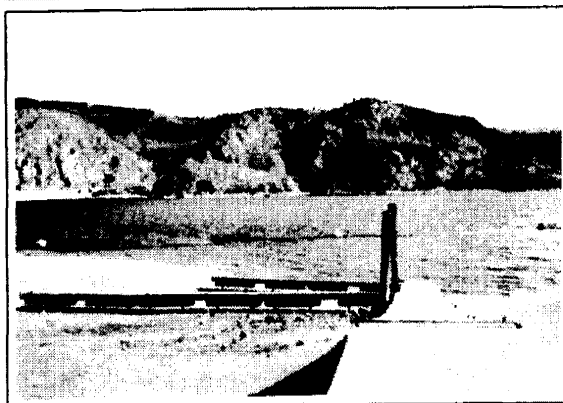
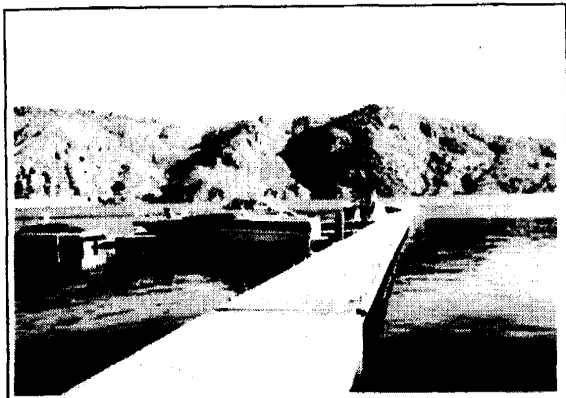
Pool elevations outside the normal range at run-of-river projects would have more acute

effects on recreational facilities. Nearly all developed facilities would become unusable at pool elevations more than a few feet below the normal range. Low pool elevations can expose rocks, tree stumps, shoals, and other objects that pose hazards to boaters, wind surfers, waterskiers, and other water users. Increased water velocity can be dangerous to swimmers and watercraft operators. Drawdown outside of normal operating ranges can also dry out intakes for irrigation systems used to maintain lawns and plantings at some recreation sites.

For recreational facilities to be used at storage reservoirs, pool elevations must be sufficiently high when there is a demand for the facilities. Developed swimming areas tend to be the most sensitive to reservoir elevations, as they typically can be used only over the top 5 to 10 feet (1.5 to 3 m) of a normal operating pool. Most storage reservoirs have one or more boat ramps designed to be used over a wide range of elevations and functional for longer periods. While boat access to the water may be physically possible at very low elevations, using such ramps becomes difficult and time-consuming.

Use of land-based facilities can also be diminished by operations, particularly at storage reservoirs. Visitors participating in land-based activities often seek recreation sites close to the water. Large drawdowns leave camping, picnicking and other land-based facilities visually and physically separated from the water, reducing the quality of recreational experiences and demand for recreation sites.

Changes in flows resulting from system operations can also affect recreation suitability in downstream river reaches. Generally, the recreational use of rivers is optimized by maintaining stable flows within a preferred range. Although the river is usable at flows greater or less than preferred, fluctuations outside of the preferred range make floating more difficult and hazardous and reduce the quality of the experience. The optimum range of flows varies by river reach and, in some cases, by recreation activity.



Dewatered boat ramp, before and after (Grand Coulee—Spring Canyon Recreation Area)

While the primary emphasis of this analysis is on pool elevations and river flows and their associated effects on recreation facilities, there are several other types of physical effects on recreation that can be significant. Water levels can reduce or improve fish and wildlife population numbers, which in turn influences opportunities for fishing, hunting, and wildlife viewing. Low pool elevations can expose rocks, tree stumps, and other objects that can pose hazards for water recreationists. Increased water velocity can increase risks to swimmers and water craft operators. System operations can influence turbidity and other water quality parameters that are noticeable to recreationists. Finally, the aesthetic impacts discussed in Section 4.2.9 also often become adverse physical effects for recreationists. Appendix J, Recreation, provides a more detailed discussion

of the various physical effects on recreation for each SOS.

Visitation

Numerous factors determine how flows and elevations influence recreational participation. One important factor is how sensitive various user groups are to water levels. A study of Hungry Horse Reservoir found that 43 percent of the recreational users surveyed had no preference as to lake level and as long as they could still participate in recreational activities after adjusting their activities to be compatible with reservoir conditions (Ben-Zvi, 1990). Many recreationists participate in more than one activity, and some no doubt switch activities or locations depending upon water levels. If reservoirs are drawn down severely, it is likely that more people would decide to participate in land-based recreational activities.

Abt Associates (1978) found that on most reservoirs in the Columbia River Basin, most recreationists are fairly insensitive to moderate reductions in water elevation as long as water facilities are still available. Ben-Zvi's research at Hungry Horse Reservoir supported that premise, as it found that the most common reason recreationists decided not to visit a reservoir was because they could not launch their boats (Ben-Zvi, 1990).

At some point, water levels and resource quality may decline to where demand for specific activities may drop to zero. Recreationists can: (1) accept the lower quality of the resource and continue to use it, (2) decide to recreate less frequently or not at all, or (3) travel to a different site (Corps, 1980). If the change in resource quality is temporary, users may change the timing of their use by scheduling a trip to a reservoir earlier or later than they would under normal circumstances. To some extent, if use drops at a given reservoir due to low water levels in May, it may shift to later months when water elevations have returned to higher levels.

In addition to water levels and resource quality, weather and other climatic conditions can have a significant influence on recreational activities and use levels (see also Section 3.3.7 and Appendix J). Even if pool elevations are conducive to certain activities, weather conditions might cause recreationists to choose not to participate in certain activities, or to choose substitute activities.

Recreationists frequently participate in several activities while at one recreation site. Campers often visit a particular lake because they are attracted by its boating and fishing opportunities. A change in operations that eliminated the use of boat ramps could result in a decrease in the other activities if recreationists avoided sites where they could not participate in their primary activity. In this case, visitation at the affected site would decrease and likely be shifted to nearby sites with usable facilities. On the other hand, the recreationists could still use the site but substitute other activities for their primary activity.

Effects of Alternatives

This section discusses the physical effects of the SOS alternatives relative to the operating ranges of recreation facilities and river recreation uses. The flow and elevation patterns that characterize the physical conditions drive the analysis of recreational visitation. The visitation levels for the different SOS alternatives are the key value measure for the recreation analysis.

Physical Effects on Facilities

The following material discusses the expected physical conditions at the projects and river reaches across the range of SOS alternatives. Effects for each SOS are presented in comparison to SOS 1a, representing the historic operating conditions with which most visitors are familiar, and the no-action conditions represented by SOS 2c. The discussion is highly generalized because there are many aspects of physical characteristics that influence recreational use. Each project or river reach has different types of facilities and/or activities, each

of which responds in different ways to physical conditions. For a given reservoir or river reach, each SOS would result in elevation or flow patterns that vary considerably both during the year and from year to year as water conditions change.

This discussion attempts to summarize the range of variability in physical conditions for each geographic component of the study, based on the elevation and flow characteristics from the hydroregulation model. The complexity of the hydrologic and facility characteristics generally limits the discussion to average conditions and key times of the year. This focus admittedly overlooks much variability in physical conditions that can be quite significant for recreation. The reader should review Appendix J and the hydroregulation results in Appendix A for more comprehensive and in-depth information on the physical characteristics for recreation at each project and river reach.

Libby—Seasonal reservoir fluctuations at Libby result in low pool elevations of between 100 and 160 feet (30.5 and 48 m) below full pool (elevation 2,459 feet [749.5 m]). Lake Koocanusa has typically been full by the end of July and remained so through the end of August. By the end of September, the pool has historically been lowered to about elevation 2,450 feet (746.8 m).

Boat ramps and moorage facilities function over a wide range of elevations. All but two of the project's 11 boat launching and mooring facilities are operable down to 15 feet (4.6 m) below full pool. Six are operable down to 35 feet (11 m) below full pool (elevation 2,424 feet [738.8 m]), and three at 50 feet (15.2 m) below full pool. Two boat ramps remain usable down to elevation 2,310 feet (704.1 m), which is 149 feet (45.4 m) below full pool. Three of the project's five developed beaches are functional only within 5 feet (1.5 m) of full pool, and the other two are functional down to slightly lower elevations.

SOSs 4c and 9c would be the best for recreation in an average water year. The pool

level would rise to within 6 feet (1.8 m) of full pool by the end of June, and stay at that level through the end of August. These alternatives would improve boating compared to SOS 2c because facilities such as floating and fixed docks would be able to operate due to the high-pool elevations.

During average water years with SOSs 1 and 2, pool elevations by the end of May would be approximately 20 feet (6.1 m) below full pool. By the end of July, the reservoir level would rise to within 10 feet (3.1 m) of full pool and remain there through the end of August. Boat ramps would continue to be usable, but the use of some swimming beaches and boating facilities (particularly on the Canadian side of the lake) would be more difficult. SOSs 5 and 6 would be similar to SOSs 1 and 2, but would refill slightly more slowly and would reach slightly higher elevations in July and August.

SOS 9a would be the worst SOS for recreation at Libby. The end-of-June pool elevation would be 64 feet (19.5 m) below full pool, and would be lowered an additional 5 feet (1.5 m) by the end of August. Although most boat ramps on the American side of the lake operate down to 80 feet (24.4 m) below full pool, most other facilities on the lake would not be usable in the summer during average water years.

SOS 9b would fill to within 23 feet (7.0 m) of full pool by the end of June, and would not get any higher than 17 feet (5.2 m) below full pool for the rest of the summer. Impacts to recreation facilities would be similar to those of SOS 9a.

SOS PA would refill to within 35 feet (10.7 m) of full pool by the end of June, and then reach an elevation approximately 23 feet (7.0 m) below full pool in July and August. Impacts to recreation facilities would be similar to those of SOS 9a.

Kootenai River—The volume and timing of releases from Libby Dam greatly influence recreation on the Kootenai River. The primary

concern with releases is the effect of flows on fishing success and the ability to float the river for fishing access. Normal minimum discharge from Libby is 4 kcfs (113.3 cms), although the flow is sometimes reduced to 3 kcfs (85 cms). Between May 1 and September 15, operators attempt to keep flows below 8 kcfs (227 cms) from early morning to after sunset to benefit anglers. The optimal flow for bank fishing is between 4 and 8 kcfs. Optimal flows for other river uses, such as boating (and fishing from boats), canoeing, and rafting, range from approximately 8 to 14 kcfs (227 to 397 cms). The optimum flow in terms of accommodating the greatest number of water-related activities is approximately 8 kcfs. Stable flows are important for all types of water-related activities, particularly fishing. In addition, stabilized short-term flows would improve habitat for fish, which would in turn lead to improved fishing experiences and increased visitation.

SOSs 1, 2, 5, and 6 would produce flows that would be fairly stable and within or close to the optimal range for recreation during the summer of average water years. SOSs 4c, 9a, and 9b would produce flows of 17 to 19.7 kcfs during June and July, which would be greater than the optimal or acceptable flow range. SOS PA would produce flows near the optimal range throughout the summer except for June when flows would be as high as 21 kcfs. SOS 9a would produce the greatest summer flows, with flows of 26.8 and 21.2 kcfs in June and July, respectively.

Hungry Horse—Annual drafts at Hungry Horse range as low as 3,336 feet (1,016 m) and affect the use of recreational facilities. Ideally, Hungry Horse reaches full pool (elevation 3,560 feet [1,085 m]) by early July and is kept near full pool through Labor Day to allow use of the project's recreational facilities. Lowering the reservoir 5 feet (1.5 m) renders some swimming beaches unusable. Only 5 of the 11 boat ramps are usable at 20 feet (6.1 m) below full pool. When the pool is drafted to elevation 3,483 feet (1,062 m), the only facility that functions is the Abbot Bay boat ramp.

With SOS 1a or 2c, Hungry Horse would be expected to fill within 2 feet (0.6 m) of full pool by July in 62 and 54 percent of the water years, respectively. There would be a 74 and 78 percent chance the reservoir would refill to an elevation of at least 3,540 feet (1,079 m) in July. Expected summer pool elevations in low water years would be below the minimum that would allow any boat ramps to function. During high water years, the pool would be full in July and August. Operations and elevations for SOSs 2d, 5, and 6 would be essentially the same as under SOS 1a or 2c. With these SOSs, 6 of the 11 boat ramps would be operable during average water years. During low water years, only 1 would be operable and during high water years, all 11 would be.

SOSs 4c, 9, and PA are the only alternatives that would result in summer pool elevations significantly different from those under SOS 1a or 2c. SOSs 4c and 9c would establish high pool elevations through the summer. The reservoir would refill to within 2 feet (0.6 m) of full by the end of June in 82 percent of the water years, and would remain near full pool through the summer with SOS 4c, and within 5 feet (1.5 m) of full 98 to 94 percent of the time in July and August with SOS 9c.

SOS 9a would be the worst alternative for recreation at Hungry Horse. During average water years the pool would come to within 10 feet (3.0 m) of full from 22 to 4 percent of the water years between June and August.

SOSs 9b and PA would refill to within 2 feet (0.6 m) of full by the end of June 20 percent and 30 percent of water years, respectively. The probability of the pool remaining within 10 feet (3.0 m) of full by the end of August would be 20 and 4 percent, respectively.

Columbia River in Canada—There are few formal water-oriented recreational facilities (two docks and three boat ramps) on the free-flowing reach of the Columbia River in Canada. Releases from the Hugh Keenleyside and Brilliant projects control flows on the upper Columbia and influence both the accessibility of

facilities and the types of activities that can occur on the river. Flows between 71 kcfs (2,200 cms) and 99.3 kcfs (2,800 cms) are considered optimal for general recreational use of the river. Optimal flows for swimming are considered to be between 78 kcfs (2,200 cms) and 99.3 kcfs (2,800 cms).

During average water years flows associated with SOSs 1, 2c, 5, 6 and 9 would generally be within the optimal range for river recreation. No boat ramps, boat docks, or swim beaches would be affected.

SOSs 2d, 9b, 9c and PA, on the other hand, would exceed optimum flows during June and/or July, and would have impacts to varying degrees on recreational facilities. Swimming beaches, in particular, would be affected by the high flows and would not be usable during June and July. SOS 2d would produce the highest flows (106 to 107 kcfs [29.9 to 30.2 cms]), while SOSs 9b, 9c, and PA would result in June and July flows between approximately 101 and 109 kcfs (28.5 to 30.7 cms).

Albeni Falls—Recreational facilities at Lake Pend Oreille were designed to be operational during the summer, when the pool has traditionally been maintained at a high elevation. Most of the facilities function from full pool (elevation 2,062.5 feet [629 m]) down to approximately 11.5 feet (3.5 m) below full. This relatively narrow functional range for a storage reservoir is due to the limited draft capability at Albeni Falls and reliable historical operation near full pool during the recreation season.

All SOS alternatives, except SOSs 4c, 9a, and 9b would produce average pool elevations of 2,062.5 feet (629 m) from June through the end of August during all water years.

SOS 4c would result in average August pool elevations during all years of 2,060 feet (628 m), which would be 2 feet (0.6 m) below optimal and would affect the use of recreational facilities. During low water years, the pool

would be kept at the 2,060-foot (628-m) elevation the entire summer.

SOS 9b would keep pool levels from approximately 1 to 2 feet (0.3 to 0.6 m) below full pool during the summer which would affect some recreational facilities. SOS 9a would keep the pool 4 to 7 feet (1.2 to 2.1 m) below full pool and would result in many or most recreational facilities not being usable.

Grand Coulee—Some recreational facilities at Grand Coulee, such as boat ramps, are usable throughout much of the reservoir's annual drawdowns. Developed swimming beaches and some moorage facilities function only, or function best, within 5 feet (1.5 m) of the full pool elevation of 1,290 feet (393 m). The pool has typically been kept within 5 feet (1.5 m) of full pool during the summer. Seven of the 14 boat ramps are functional to at least an elevation of 1,240 feet (378 m). However, at that elevation, other facilities such as swimming beaches and some docks will be dry.

Under SOS 1a or SOS 2c, the chances of Grand Coulee refilling by the end of July would be approximately 95 percent. As a result, all water-based recreational facilities would be fully operational throughout the summer. Pool elevations during low and high water years would be very similar to those of average water years.

SOSs 1b, 2d, 4c, 5, and 6 would result in pool elevations that would be similar to SOSs 1a and 2c. Summer pool elevations under SOSs 9a, 9b, 9c, and PA would be lower. These four options would draft the reservoir in July and/or August to augment river flows. As a result, end-of-August pool elevations with SOS 9c and PA would be approximately 8.5 feet (0.3 m) lower than the end-of-August elevation of SOS 2c. The end of August pool elevations with SOSs 9b and 9c would be approximately 40 and 19 feet (12.2 and 5.8 m) lower.

Chief Joseph—Recreational facilities at Chief Joseph are functional from a full pool elevation of 954 feet (291 m), to elevation 950 feet

(290 m). All SOSs would maintain an average pool elevation of 953.2 feet (290 m) during all water years. As a result, no SOS would significantly change conditions for recreational facilities at Chief Joseph.

Mid-Columbia River—The five mid-Columbia PUD projects (Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids) offer an assortment of developed and dispersed recreational facilities. There are 15 facilities with boat launches and 11 facilities with boat moorage spaces. All of these projects are currently maintained at a relatively stable pool elevation, and all facilities are functional over the normal operating range for the respective project. Some Rock Island project recreational facilities near Wenatchee can be flooded during high spring lows, however.

None of the SOS alternatives would result in elevations outside the normal range, but there would be some shifting of flow patterns in some cases. For example, under SOS 4c, the peak monthly average flow would shift from May to June and would increase relative to SOS 1a or 2c. Flow patterns under these operations would likely add to existing reported problems with high flows at some recreation facilities near Wenatchee, but it is not expected that this would measurably change participation rates. SOSs 1, 2, 5, and 6 would all continue historical flow patterns on the mid-Columbia reach.

SOS 9a would have the highest flows during the summer recreation season of any of the SOSs. June flows would exceed acceptable levels (25 kcfs) approximately 50 percent of water years. July flows would be at the high end of the acceptable range over 90 percent of water years and within the desirable range approximately 10 percent of the water years. During August, flows would be in the upper end of the acceptable range, but would never fall within the desirable range.

SOSs 9b, 9c, and PA are similar and would produce acceptable to desirable flows during the entire summer. Flows would be relatively high

in June, and then would be very stable and within the desirable range for July and August.

Flow patterns projected for the mid-Columbia projects would also generally apply to the Hanford Reach downstream. While there might be some redistribution of monthly flows compared to current operations, all of the SOS alternatives would continue to meet the requirements of the Vernita Bar Agreement (which specifies flows downstream from Priest Rapids). Under those conditions, there would be no significant effect on recreation conditions or suitability in the Hanford Reach.

Brownlee—Optimum pool elevations at Brownlee for swimming beaches and all boat ramps are in the upper 5 feet (1.5 m) of the pool, ranging from approximately 2,072 to 2,077 feet (632.0 to 633.5 m). Four of Brownlee's six ramps are operable when the pool elevation falls 10 feet (3 m) below full pool.

Under SOS 1, pool elevations within 10 feet of full pool (2,067 feet [630.4 m]) would occur in 48 percent of water years during May, 100 percent in June, 82 percent in July, and 68 percent in August. In representative low (1941) and high (1976) water years, pool elevations are predicted to remain within 10 feet (3.0 m) of full during the primary recreation use season.

SOSs 2, 4c, 5, and 6 have essentially identical hydrological characteristics. Average elevations would generally be higher than SOS 1 in all prime recreational use months. In May, pool elevations would remain within 10 feet (3.0 m) of full pool (2,077 feet [633.5 m]) in 56 percent of water years. Elevations would be within 10 foot (3.0 m) of full (2,067 feet [630.4 m]) in all water years during June, July, and August.

Middle Snake River: Hells Canyon—Flows in the Hells Canyon reach are controlled by releases from Brownlee Reservoir. Recreational use of the river is largely by private and commercial floaters and jet boat operators, and the prime season is from June through August.

Flows of 10 to 15 kcfs (283 to 425 cms) are considered ideal for float boat and jetboat activity. Flows of 8 to 10 kcfs (227 to 283 cms) and 15 to 25 kcfs (425 to 708 cms; 30 kcfs [850 cms] for jet boats) are considered the acceptable low and high range of flows for river recreation. Flows of between 10 and 15 kcfs (283 and 425 cms) are considered most desirable.

Fluctuations in flow (particularly rapid fluctuations) can change the river level, which may cause navigational and safety hazards and erode beaches.

In general, SOS 1a would provide stable, relatively high flows during all types of water years, which would benefit recreation. The Brownlee operation follows essentially the same plan under SOSs 2, 4c, 5, and 6. These SOSs operation would result in a wider range of desirable flows during the prime recreation season than SOS 1a, but would average slightly less (8.5 kcfs [239.7 cms]) than desirable in August.

Dworshak—Most recreational facilities at Dworshak cannot operate over the annual fluctuation of up to 155 feet (47.2 m). Developed swimming beaches can only be used to elevation 1,595 feet (486.2 m), which is within 5 feet (1.5 m) of full pool (elevation 1,600 feet [487.7 m]). All six boat ramps are functional above elevation 1,577 feet (480.7 m) (23 feet [7 m] below full pool). The Big Eddy ramp is functional down to the minimum elevation of 1,445 feet (440.4 m). Some moorage docks can partially function down to elevation 1,505 feet (458.7 m), but an elevation of above 1,590 feet (484.6 m) is considered necessary for the docks to be fully functional. Because most visitation occurs during June, July, and August, operators have attempted to keep the pool above elevation 1,590 feet (484.6 m) through the summer.

Under SOS 1a, Dworshak would be within 2 feet of full pool by the end of July in 62 percent of the water years. In 78 percent of the years, the pool would reach an elevation of at least 1,590 feet (484.6 m) by the end of July, which would allow use of all recreational facilities

except developed swimming beaches. During low water years, pool elevations would range from about 1,567 feet (477.6 m) in June, down to 1,538 feet (468.8 m) at the end of August. As a result, the only developed facility that would be functional during the summer would be the Big Eddy ramp. During high water years, the pool elevation would be high enough to allow use of all developed facilities the entire summer.

Under SOSs 2c, 2d, and 9c, recreational facilities would be less usable than under SOS 1a. Dworshak would refill to within 2 feet of full pool by the end of July in 0 percent of water years and to the 1,590-foot (484.6-m) elevation in approximately 22 percent of the water years. During low and high water years, summer pool elevations would have essentially the same impacts on recreational facilities as SOS 1a.

SOSs 1b and 9a would have similar impacts on access to recreational facilities. Based on the hydroregulation model, these SOSs would reach full pool by the end of July in approximately 82 and 52 percent of the water years.

SOSs 4c, 5, 6 would produce the highest summer pool elevations of all of the SOSs. With these SOSs, there would be an 80 percent probability of refill to within 10 feet (3 m) of full pool during average water years.

SOSs 9b and PA would result in the lowest summer pool elevations of all the SOSs. During average water years, SOS 9b would refill to within 10 feet of full pool approximately 2 percent of the water years, and under SOS PA Dworshak would have 0 percent probability of refilling.

Clearwater River—Releases from Dworshak influence flows on the North Fork of the Clearwater River, and to a lesser extent, on the mainstem. Releases from Dworshak have been used to enhance steelhead fishing on the main system during the prime season (from November through February). Optimum mainstem flows for fishing are considered to be between 3 and 7 kcfs (85 and 198 cms).

Steelhead fishing between November and February has traditionally been the dominant recreational activity on the Clearwater River. In recent years, however, natural resource managers are reporting that steelhead fishing now accounts for slightly less than 50 percent of the total recreational use on the Clearwater. Slightly over 50 percent of the total recreational use of the river is now devoted to summer river activities such as trout fishing, innertubing, and swimming. While the importance of both steelhead and summer river recreation is acknowledged, the primary focus of the analysis of the impacts of the SOSs on recreation will be on winter steelhead fishing.

Optimum flows for steelhead fishing range between 3 kcfs and 7 kcfs (85 to 198 cms) and occur between November and February. SOSs 2c, 2d, 4c, 5, 9a, 9b, 9c, and PA would have low probabilities (from 12 to 40 percent) of providing optimum average monthly flows from November through February.

SOSs 1a, 1b, and 6 would have somewhat greater probabilities of reaching optimal flows during that period. The probabilities of optimum flow in February would range from 42 to 47 percent.

Lower Snake River—Recreational facilities at the four lower Snake River projects are designed to function within 5 feet (1.5 m) of full pool. When pools reach this level, some ramps, moorage facilities, and almost all developed swimming beaches become difficult to use due to shallow water, shoaling, and/or the distance required to travel from the normal shore to the water. Some facilities (primarily boat ramps) can function at elevations more than 5 feet (1.5 m) below full pool, but the use of most facilities is eliminated or compromised. Pool elevations can fluctuate between 0.5 and 2 feet (0.02 and 0.6 m) daily, which can make some facilities easier or more difficult to use at different times of the day.

Under SOS 1a, the projects would operate within their normal range, with an average elevation near full. Under SOSs 2, 4, 9b, and

9c, the lower Snake River pools would operate within 1 foot (0.3 m) above MOP generally from mid-April through July (SOSs 9b and 9c would operate from early April through late August). At this low end of the normal operating range, daily and weekly pool fluctuations would make use of some facilities difficult.

SOS 5b would result in a 4.5-month drawdown at the lower Snake River projects to natural river levels that would be well below the minimum required for the use of recreation facilities. Developed recreational facilities at all four projects would not be usable during the summer.

SOS 5c would operate the four projects at natural river levels all year. No existing developed recreational facilities would be usable.

SOS 6b would draw down the four lower Snake projects 33 feet (10.1 m) below full pool for 4.5 months. As with SOS 5, existing recreational facilities would not be usable during the late spring and summer (from mid-April to the end of August). SOS 6d would draw Lower Granite down 33 feet (10.1 m) below full pool for 4.5 months. The other lower Snake River projects would not be affected by SOS 6b. No existing developed recreational facilities at Lower Granite would be usable during the summer.

SOS 9a would also draw the lower Snake project down 33 feet (10.1 m) but from early April through late August. It would essentially have the same effects on recreational facilities as 6b, but for 1.5 months longer.

Lower Columbia River—The recreational facilities at the lower Columbia River projects are designed to function over a range of pool elevations varying from 5 feet (1.5 m) (McNary and The Dalles) to 8 feet (2.4 m) (John Day) below full pool. The pool elevations on the lower Columbia projects fluctuate daily and weekly. Daily pool fluctuations normally range from 0.5 to 1 foot (0.15 to 0.30 m), but can fluctuate as much as from 2 to 3 feet (0.6 to

0.9 m). Pool elevations from July through October have typically been kept higher than at other times of the year to benefit a number of resources, including recreation.

All of the SOSs would maintain the normal summer operating range at McNary, The Dalles, and Bonneville. As a result, there would be no effect on the accessibility of recreational facilities at either project as a result of pool elevation.

In addition to pool elevation, the velocity of water traveling through the projects influences recreation. Although flows vary throughout the year, optimal summer flow velocity for recreation is between 150 and 250 kcfs (4,200 and 7,050 cms). Natural flows peak in May and June, then decline rapidly over the summer. During all water years, the high spring flows associated with SOSs 9a and 9b could affect some facilities at McNary, The Dalles, and Bonneville. High flows could erode reservoir banks near some facilities, such as ramps, and would make using the facilities dangerous.

Recreational facilities at the John Day project would be more affected by some of the SOSs than any of the other lower Columbia River projects. Under SOS 1 or 4, the effects on recreational facilities at John Day would be minimal. SOSs 2, 9b, and 9c would establish an average summer pool elevation (elevation 262.5 feet [80 m]) that would be at the low end of the normal operating range.

SOSs 5, 6, 9a, and PA would have more of an influence on recreational facilities. These strategies would involve drawing the John Day pool down to minimum operating pool (elevation 257 feet [78.3 m]), resulting in significant impacts on project facilities and their use. This operation would occur from May through August under SOS 5 or 6, April through August under SOS 9a, and year-round under SOS PA. SOSs 5, 6, 9a, and PA would significantly reduce the usability of recreation facilities at Lake Umatilla during the entire peak recreation season, and all year in the case of SOS PA.

Recreation along the free-flowing Columbia River below Bonneville Dam is influenced by flow velocity and river elevation. Annual flows and river elevations vary considerably throughout the peak summer recreation season. After peaking in April and staying high through June at between 300 to 400 kcfs (8,400 to 11,200 cms), flows typically decline to 75 to 100 kcfs (2,100 to 2,800 cms) by the end of August. Optimal flows for recreation are considered to be between 150 and 250 kcfs (4,200 and 7,000 cms).

Flows with SOSs 1, 2, 4c, 5, and 6 are generally similar. June and July flows with these SOSs during average water years would be within the optimum range between 42 and 58 percent of the years (during July SOS 4c would be in the range in June 34 percent of the water years). By August when flows would decrease, the optimum flows would be achieved between 6 and 10 percent of the years.

SOS 9a would be the best SOS for recreation. Flows would be within the optimal range 70 percent of the average water years in July, and 100 percent of the years in August. SOSs 9b, 9c, and PA would be similar in terms of optimal flows in June (30 to 42 percent of the time) and July (52 to 64 percent of the time). In August SOS 9b would be in the optimal range 52 percent of the water years, and SOSs 9c and PA would be 28 and 38 percent, respectively.

Estimated Visitation Effects

Recreation Impact Assessment Models

The Impact Assessment Models (IAMs) developed by the RWG and used to estimate the quantitative impacts of the alternative SOSs on recreation visitation for the Draft EIS have been replaced in this Final EIS. As early as 1991, the RWG had concluded that the validity of the break-point curves that formed the basis for the IAMs was questioned because evidence of users' actual response to changes in lake elevations and streamflows was absent. Although the lake elevation (streamflow)/activity relationships may approximate reality, for the most part, they are

not based upon empirical user behavioral response (demand) curves. Other important limitations of the Draft EIS modeling approach were: (1) it did not correlate visitation to fishing and hunting success as it may be influenced by the effects of alternative SOSs on fish and wildlife populations; and (2) it does not address shifts in participation across substitutes in the region under the alternative SOSs.

To remedy these concerns, the RWG determined that recreation user surveys should be conducted at a number of Federal projects to enhance the predictability and credibility of the SOR recreation IAMs applied in the Draft EIS. To this end, a comprehensive study plan was developed to improve upon the Draft EIS analytical tools and to accomplish the following objectives for the Final EIS: 1) implement visitor use surveys throughout the Columbia River Basin; 2) apply a Contingent Valuation Method (CVM) to elicit the public's participation and economic valuation response to changes in lake elevations and/or streamflows; 3) estimate contingent evaluation and participation user responses to alternative hydrologic conditions; and 4) develop a simulation model that will statistically predict changes in recreation demand and social welfare values under various hydrological (pool levels and streamflow rates), substitution, resource quality, and social, demographic, and economic conditions in the basin.

A survey of Columbia River Basin recreationists was carried out in fall 1993 and designed to provide data needed for developing the revised models. The statistical estimation tasks and development of a basinwide simulation demand model were subsequently completed and the results incorporated into the Final EIS. The simulation modeling results predict changes in recreation participation for the final set of SOSs and replace the quantitative estimates that were provided in the Draft EIS. Appendix J, Chapter 3 describes the conceptual framework of the model development, while Appendix J-1 provides a detailed technical description. Chapter 4 of Appendix J presents the quantitative estimates of changes in trip-taking

behavior resulting from changes in the alternative operating alternatives (SOSs). The monetized non-market value of these changes in visitation to Federal hydro projects are presented in Appendix O (Economic and Social Impacts).

The systemwide visitation estimates in the Final EIS are greater than those used for the Draft EIS. There are several reasons for the changes, one of which is the use of the new IAMs models discussed above. The other reason is that visitation numbers for the Mid-Columbia PUD projects are being used in the Final EIS and were not used in the Draft EIS. By adding the Mid-Columbia PUD projects, 1,482,000 recreation days are added to the systemwide total for all SOSs.

Changes In Visitation

Table 4-14 displays the estimated visitation at each project or river reach for selected SOSs, based on average water conditions over the 50-year simulation period. The SOSs for which results are included in the table are representative of similar options that are not shown. Complete details are provided in Appendix J. The recreation models estimated that systemwide visitation for the No Action Alternative (SOS 2c) would average about 18,043,600 recreation days over the 50-year period of record. The model results indicated lower visitation under most other SOSs, although some alternatives generated slightly higher visitation estimates compared to SOS 2c.

The highest estimate of average visitation is 18,305,600 under SOS 1b, or 262,000 recreation days more than the corresponding figure for SOS 2c. In other words, the model estimates suggest that, over the long term, operation according to SOS 1b would maximize recreational use of the system. Visitation estimates for SOSs 1a, 2d, and 4c are also higher than the average figure for SOS 2c. They range from about 18,305,600 for SOS 1b to 18,057,300 for SOS 2d. The SOS 1b result is similar to the estimated aggregate visitation under SOS 1a, while the SOS 2d estimate is approximately 13,800 recreation days higher than the SOS 2c figure.

At the other extreme, the minimum estimated visitation level is about 15,970,600 recreation days for SOS 5c. The latter figure is 2,073,200 recreation days lower than the estimate for SOS 2c. The average-condition model results for SOSs 6b, 6d, 9c, and PA range from 16,886,400 (6b) to 17,152,800 (9c), or from 1,157,200 to 890,800 recreation days below expected visitation with SOS 2c. The visitation estimate for SOS 9a, at 15,986,000, is also lower than for SOS 2c. The SOS 9b visitation estimate is greater (17,631,000) than many SOSs, but less than SOS 2c.

Table 4-14 indicates the relative differences in projected recreation participation as a result of the SOSs, compared to the baseline (SOS 2c). These differences are displayed graphically in Figure 4-25. These relative differences represent expected departures from baseline conditions that would likely occur, all other factors being equal, if a given SOS were implemented. They reflect long-term average conditions and should not be interpreted as definitive changes from existing or recent visitation that would occur immediately upon implementation of an SOS.

Changes compared to SOS 2c range from about 1.5 percent above (SOS 1b) to 11.5 percent below (under SOS 5c) the estimated visitation for SOS 2c. In absolute terms, the difference between the maximum and minimum estimates is approximately 2,319,600 recreation days, or about 13 percent of the expected total of 18,043,600 recreation days for SOS 2c. This difference represents a rather narrow band of potential outcomes, and suggests that aggregate systemwide visitation is not highly sensitive to change with the types of operational measures included under the SOS alternatives. However, recreational suitability and visitation at individual areas within the system can be quite sensitive to operational changes, as indicated in the discussion of tradeoffs below. Some of the SOSs would have significant impacts to visitation at some projects.

The visitation estimates in Table 4-14 apply specifically to average water years. While not

Table 4-14. Estimated annual recreation days for an average water year, by project and SOS (in thousands)

Project/River Reach	SOS							
	1a	1b	2c	2d	4c	5b	5c	
Libby	604.6	603.8	607.2	605.0	619.9	602.9	602.9	
Kootenai River	34.3	34.9	35.6	35.1	34.0	35.0	35.0	
Hungry Horse	128.3	125.7	129.3	128.6	152.6	126.5	128.5	
Albeni Falls	1215.9	1216.9	1222.5	1222.5	1183.1	1217.8	1217.8	
Columbia River, Canada	40.7	41.5	41.6	37.2	40.4	41.5	41.5	
Grand Coulee	1631.0	1637.2	1670.1	1662.8	1661.5	1665.9	1665.9	
Chief Joseph	47.9	47.9	47.9	47.9	47.9	47.9	47.9	
Mid-Columbia PUD	1482.0	1482.0	1482.0	1482.0	1482.0	1482.0	1482.0	
Snake River Hells Canyon	43.5	43.5	43.5	43.5	43.5	43.5	43.5	
Dworshak	182.7	185.6	201.4	159.7	207.6	213.7	226.9	
Clearwater River	109.1	105.3	128.2	198.9	147.3	126.7	141.6	
Lower Granite	1653.9	1687.1	1662.7	1662.7	1649.8	859.3	652.3	
Little Goose	244.8	244.9	240.4	240.4	239.6	92.7	71.1	
Lower Monumental	140.0	140.1	137.6	137.6	136.7	57.6	44.1	
Ice Harbor	525.7	525.9	514.7	514.7	507.0	164.1	127.3	
McNary	2747.5	2747.5	2747.5	2747.5	2747.5	2747.5	2747.5	
John Day	2860.0	2860.0	2555.4	2555.4	2760.0	2121.0	2121.0	
The Dalles	1411.3	1411.3	1411.3	1411.3	1411.3	1411.3	1411.3	
Bonneville	3164.6	3164.6	3164.6	3164.6	3164.6	3164.6	3164.6	
System Total	18267.7	18305.6	18043.6	18057.3	18236.3	16221.5	15970.6	
Changes in Visitation Relative To:								
SOS 1a	Total	0.0	37.9	-224.2	-210.4	178.9	-1835.9	-2297.1
	Percent	0.0	0.2	-1.2	-1.2	1.0	-10.0	-12.6
SOS 2c	Total	224.2	262.1	0.0	13.8	192.7	-1822.1	-2072.9
	Percent	1.2	1.5	0.0	0.1	1.1	-10.1	-11.5
SOS PA	Total	1338.5	1376.5	1114.4	1128.1	1307.1	-707.7	-958.5
	Percent	7.9	8.1	6.6	6.7	7.7	-4.2	-5.7

1995

FINAL EIS 4-163

Columbia River SOR Final EIS

4

Table 4-14. Estimated annual recreation days for an average water year, by project and SOS (in thousands)Page 2 of 2

Project/River Reach	SOS						
	6b	6d	9a	9b	9c	PA	
Libby	602.9	602.9	546.2	596.8	618.4	601.6	
Kootenai River	35.0	35.0	14.3	28.9	33.9	25.0	
Hungry Horse	126.5	126.5	91.0	135.4	152.6	133.5	
Albeni Falls	1217.8	1217.8	1001.1	1148.0	1187.9	1243.2	
Columbia River, Canada	41.5	41.5	40.7	39.4	40.2	39.1	
Grand Coulee	1665.9	1665.9	1257.2	1482.1	1570.7	1612.8	
Chief Joseph	47.9	47.9	47.9	47.9	47.9	47.9	
Mid-Columbia PUD	1482.0	1482.0	1482.0	1482.0	1482.0	1482.0	
Snake River Hells Canyon	43.5	43.5	43.5	43.5	43.5	43.5	
Dworshak	198.9	198.9	180.4	133.2	183.1	149.6	
Clearwater River	133.9	133.9	136.2	135.3	143.3	151.3	
Lower Granite	1250.0	1250.0	1175.3	1618.3	1485.5	1673.5	
Little Goose	164.4	240.4	151.9	233.1	203.3	242.7	
Lower Monumental	96.5	137.6	89.4	133.4	119.3	138.8	
Ice Harbor	335.3	514.7	301.6	494.8	449.6	519.2	
McNary	2747.5	2747.5	2747.5	2747.5	2747.5	2747.5	
John Day	2121.0	2121.0	2103.8	2555.4	2068.3	1502.1	
The Dalles	1411.3	1411.3	1411.3	1411.3	1411.3	1411.3	
Bonneville	3164.6	3164.6	3164.6	3164.6	3164.6	3164.6	
System Total	16886.4	17182.9	15986.0	17631.0	17152.8	16929.2	
Changes in Visitation Relative To:							
SOS 1a	Total	-1381.4	-1084.9	-2281.8	-636.7	-1114.9	-1338.5
	Percent	-7.6	-5.9	-12.5	-3.5	-6.1	-7.3
SOS2c	Total	-1157.2	-860.7	-2057.6	-412.6	-890.7	-1114.4
	Percent	-6.4	-4.8	-11.4	-2.3	-4.9	-6.2
SOS PA	Total	-42.8	253.7	-943.2	701.8	223.6	0.0
	Percent	-0.3	1.5	-5.6	4.1	1.3	0.0

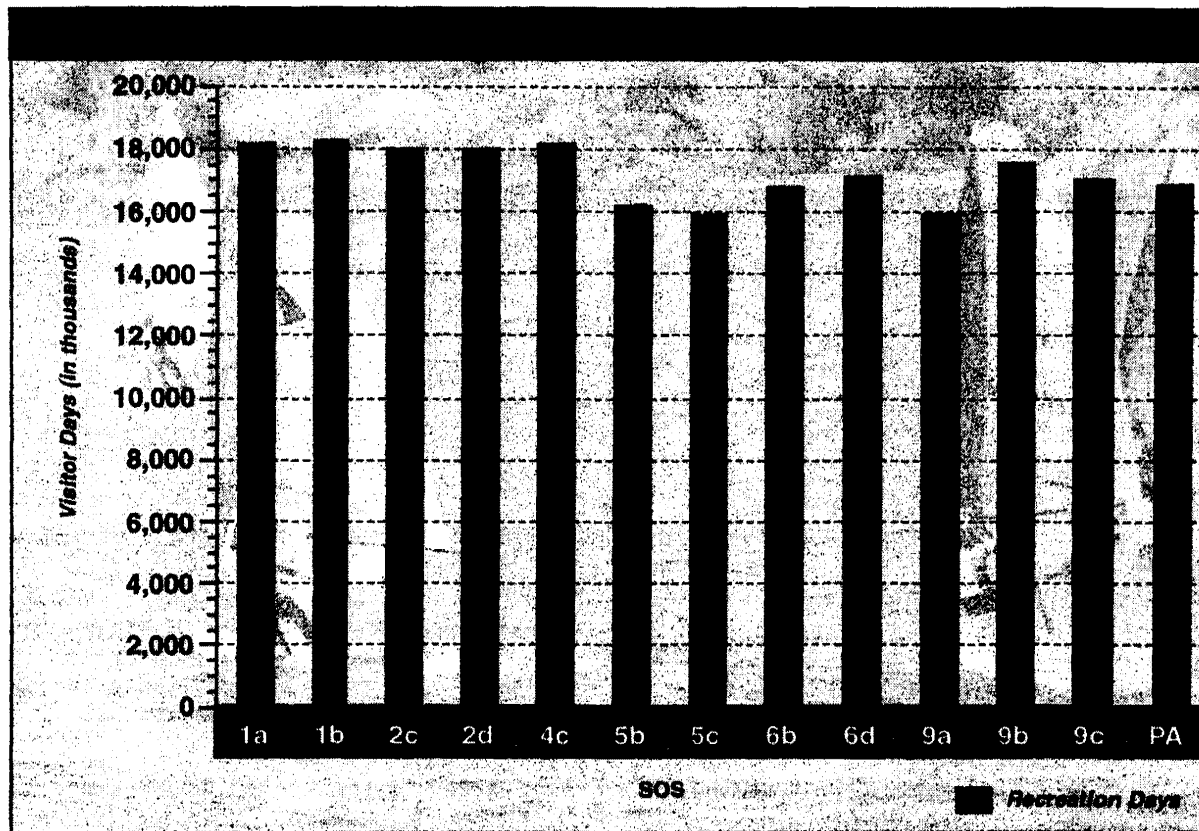


Figure 4-25. Estimated systemwide recreational use for representative SOS options (average water conditions)

shown, visitation figures for low and high water years are very similar to, or somewhat higher than, corresponding figures for average water years. Changes in visitation during low and high water years compared to average water years would generally not be great—usually between 0 and 5 percent, although in some cases it would be as much as 15 percent.

Key Tradeoffs

The systemwide visitation estimates in Table 4-14 reflect a mixture of positive and negative effects on recreation under the various SOS alternatives. The following discussion highlights some key tradeoffs in systemwide visitation and among the different portions of the system that are responsible for the results indicated in the table. For a more detailed

account of effects at individual projects, please see Appendix J.

The systemwide visitation patterns, particularly the narrow range across the SOS alternatives, are largely determined by the distribution of existing use and potential operational measures. The four lower Columbia River projects are the most heavily used portion of the system for recreation. The operation of three of these projects (Bonneville, The Dalles, and McNary) would remain the same under all SOSs, while significant operational changes would occur at John Day with SOSs 5, 6, 9a, 9c, and PA. Consequently, a large portion of the systemwide visitation total would be relatively unaffected by most SOSs. Similarly, operations would change little or not at all at Albeni Falls and the lower Snake River projects

under most SOSs. In short, changes in system operations only affect a small portion of systemwide visitation.

Several of the alternatives, particularly SOS 4c, would result in high pool elevations at storage reservoirs during the prime summer recreation season. As a result, visitation at these reservoirs would be higher than under SOS 2c.

Visitation numbers for the storage reservoirs would also be higher than the baseline condition in some other cases. For example, visitation at Dworshak would be higher under SOSs 5a and 5b compared to SOS 2c. Despite these increases at Dworshak, there would be a significant systemwide decrease in visitation because of the impacts of drawdowns on the more heavily used lower Snake River projects and John Day. Visitation during average water years at Dworshak under SOS 2c is estimated at 201,400 recreation days. By contrast, Lower Granite alone would receive 1,662,700 recreation days under SOS 2c. Under SOSs 4c and 5, the comparatively small increases in visitation at Dworshak would be more than offset by decreases at the lower Snake River projects and John Day, resulting in a net systemwide loss in recreation days. There would be similar tradeoffs between storage reservoirs and run-of-river projects under other alternatives.

Aside from systemwide patterns, there are some other tendencies in the impact results that apply more to specific projects or types of resources. For example, SOSs 5 and 6 would decrease recreation at some run-of-river projects, but would have neutral or positive effects on recreation at the storage reservoirs.

The model results also indicate there can be localized tradeoffs near the storage reservoirs. Operations that would improve recreational conditions and thus visitation at storage reservoirs could also affect visitation at downstream river reaches. At Libby, for example, holding water during the summer would maintain high pool elevations but result in low outflows into the Kootenai River. As a result, recreation at the reservoir would benefit,

but visitation along the Kootenai River would decrease due to lower flows. At Dworshak, on the other hand, holding water in the summer would help recreation on the Clearwater River. Flow releases from late fall through early spring would be particularly beneficial to steelhead anglers, the largest group of recreationists using the Clearwater.

Visitation at most storage reservoirs under SOS 4c would slightly increase or stay essentially the same as under SOS 2c. At Albeni Falls and Grand Coulee, however, estimated visitation for SOS 4c would be less than under SOS 2c. Although the pool level at Albeni Falls would be stable, which would likely benefit resident fish and wildlife, it would be from approximately 1 to 2.5 feet (0.3 to 0.8 m) below full pool in July and August. This level would be too low for many of the fixed-access recreational facilities on Lake Pend Oreille. The negative effects for recreation in this case reflect only the effects of pool elevation on recreation facilities and access to water. The Recreation Work Group and local users consulted for the analysis believe that SOS 4c would benefit kokanee and other resident fish sufficiently to increase fishing success and demand. The resulting increase in fishing use, which is not reflected in the model results, could offset the negative use effects based on the elevation change.

Although there is not a great deal of difference among the SOSs in terms of impacts on systemwide recreation, Table 4-14 indicates there would be significant impacts on recreation at specific projects. Changes in visitation at projects that receive the most use would affect the greatest number of recreationists and have the greatest impacts systemwide. A sizeable change at projects such as the lower Snake River projects, John Day, or Grand Coulee would affect many more people than an equivalent change at a project that receives fewer visitors, such as Hungry Horse. Nevertheless, considerations such as the local economic significance of a recreation resource must be factored into any evaluation and comparison of the effects of the SOSs on recreation.

4.2.11 Flood Control

Flood control is one of the authorized purposes of six of the 14 Federal projects in the SOR study area. Construction and operation of these and related projects in Canada have dramatically reduced the damage caused by floods on the Columbia River system. Assessing changes to the current level of local and systemwide flood protection is an important aspect of the SOR, and each alternative was evaluated to determine how it would affect the amount of property damage that currently occurs each year. Compared to SOS 2c, implementing most of the other SOS alternatives would not change average annual property losses. Changes from SOS 2c conditions ranged from a \$27,000 increase in losses under SOS 9b to an increase of \$459,000 under SOS 9c. Complete details of the analysis are reported in Appendix E, Flood Control and Appendix O, Economic and Social Impacts.

Flood Control Impact Issues

Flood damage has historically occurred in many areas of the Columbia River system, but some of these areas are no longer subject to flooding because they are protected by various flood control measures. The Tri-Cities area for example has a high degree of flood protection from levees; because the SOSs evaluated in the Final EIS would produce only minor changes in the maximum level of flow and stage, the Tri-Cities area was not included in the specific analysis of flood control impacts. The flood control analysis addressed expected flood damages in the following regions and locations (termed damage centers):

- Upper Columbia region—includes the following damage centers and control points: Libby Dam to Kootenay Lake (Bonners Ferry, Idaho gage); Columbia Falls to Flathead Lake (Columbia Falls, Montana gage); Flathead Lake shoreline (Somers, Montana gage); Kerr Dam to Thompson Falls (Polson, Montana gage); Pend Oreille

Lake shoreline (Newport, Washington gage;, and Albeni Falls to Cusick (gage near Hope, Idaho)

- Clearwater River region—includes Clearwater River reach between Dworshak Dam and the city of Lewiston (Spalding, Idaho gage)
- Lower Columbia region—includes the area between Bonneville Dam and Columbia RM 40 (The Dalles, Oregon gage).

Since the 1970s, when the Columbia River Treaty storage projects were completed and the Columbia River Treaty Flood Control Plan was instituted, overall system flooding has been largely brought under control. Major levee systems have also been instrumental in reducing local flooding. This relative security from flooding is naturally important to those who live and work in areas that would be subject to more frequent or severe flooding if the projects were operated with less regard to flood control.

Section 3.2.1 explained that the objective of the Columbia River system flood control operation is to capture enough runoff in the primary flood control season—May through July—to keep downstream flows from reaching dangerously high levels. To do this effectively, the water level in the reservoirs must be low enough at the beginning of the flood control season—which occurs at the end of April—to provide ample storage space for the flood season runoff.

The six Federal projects that include flood control as an authorized purpose are: Libby, Hungry Horse, Albeni Falls, Grand Coulee, Dworshak, and John Day. The first five are major storage projects that are typically operated for flood control; John Day has allocated flood control storage but is operated in a manner similar to run-of-river projects. Just over half of the system's total flood storage of 39.7 MAF (49 billion m³) is provided by storage dams in Canada, including Mica, Keenleyside, and

Duncan; operation of the Canadian storage projects is the single biggest factor affecting system flood control. None of the SOS alternatives would alter Canadian project operations.

Flood control on the Columbia River system is designed to handle both local and system flooding. Local flood control operations focus on areas immediately surrounding and downstream of the storage reservoirs. The objective of system flood control operations is to reduce peak flows on the lower Columbia. Controlling flooding on the lower Columbia requires the coordinated operation of Hungry Horse, Libby, Grand Coulee, and Dworshak in the United States and Mica, Keenleyside, and Duncan in Canada.

The Flood Control Work Group studied two means by which the SOS alternatives might affect local or system flood control. First, the level of each flood control reservoir at the beginning of the flood season affects its flood storage capacity. If the reservoir level is too high at the beginning of the flood season, the reservoir would not be able to absorb all its inflow, and the excess water would add to high downstream flows. On the other hand, reservoirs that begin the flood season at lower levels would have greater than normal flood storage capacity. The second type of effect stems from how outflow from the reservoir is managed. Alternatives that involve large releases from storage projects in certain seasons could contribute to flows that could be too high for the downstream flood control structures. The Flood Control Work Group determined that only the first type of effect (storage capacity limited by high reservoir levels at the beginning of the flood season) had the potential for any discernible impact on flooding. None of the SOSs called for seasonal storage releases that were high enough to increase downstream flooding.

Flood control operations are currently based on the use of runoff forecasts, outflow estimates, and reservoir rule curves. Each year, runoff forecasts are made beginning in January,

predicting the amount of runoff anticipated from approximately April through August. Outflow estimates indicate the expected amount of outflow during the reservoir refill period. The flood control rule curves define reservoir flood control operations that strike the appropriate balance between inflow, outflow, and reservoir storage space.

Use of the flood control rule curves is intended to ensure that downstream flows and water elevations do not exceed a certain critical point. For the SOR analysis, the Flood Control Work Group selected several stream gage locations (referred to as control points) to indicate how each alternative would perform its flood control function. At each control point, a given flow or water level (called stage) defines the point above which damage begins to occur in the associated river reach (Table 4-15).

Project operators develop frequency curves indicating the probability that a peak flow or river stage will occur. The coordinates of any point on the frequency curve indicate, on average, how rare that particular peak flow is, or the probability that it will be exceeded in any year. SOR strategies that raise the frequency curve at one or more storage projects indicate increased flooding and increased damages to property.

Effects of Alternatives

None of the SOS alternatives would have a dramatic impact on flood control, partly because none would affect operations at the Canadian storage projects. The storage provided at Mica, Keenleyside, and Duncan is the single biggest factor in system flood control. Some of the strategies, however, would be somewhat less protective than others. SOSs 9c and SOS 4c would have the greatest effects on flood damage, because they would base some storage reservoir operations on integrated rule curves (IRCs) rather than flood control rule curves. In these cases, the affected reservoir's capacity for storing upstream runoff in the spring would be reduced in order to maintain higher reservoir elevations to benefit resident fish.

Table 4-15. Columbia River system flood control points and flow or stage above which damage begins to occur

Region/River Reach	Gage Location	Stage (water level) ^{a/,b/}	Flow ^{a/,c/}
Upper Columbia Region			
Kootenai River, Libby Dam to Kootenay Lake	Bonnors Ferry, ID	1,766.5 feet	
Columbia River, Arrow Lakes and Brilliant Dam to U.S. border	Birchbank, BC		225 kcfs
Flathead River, Columbia Falls to Flathead Lake	Columbia Falls, MT		52 kcfs
Flathead Lake shoreline	Somers, MT	2,893.1 feet	
Flathead River, Kerr Dam to Thompson Falls	Polson, MT		28 kcfs
Lake Pend Oreille shoreline (Albeni Falls Dam)	near Hope, ID	2,062.5 feet	
Pend Oreille River, Albeni Falls Dam to Columbia River	Newport, WA		85 kcfs
Clearwater Region			
Clearwater River, Dworshak Dam to Lower Granite Dam	Spalding, ID		112 kcfs
Lower Columbia Region			
Columbia River, Bonneville Dam to RM 40	The Dalles, OR		450 kcfs

a/ At each location, the point at which damage begins to occur is defined either by stage or by flow.

b/ 1 foot = 0.3048 m.

c/ 1 cfs = 28 cms.

The results of the flood control analysis are summarized below. The initial discussion addresses total annual flood damages, in dollars, by SOS for all areas of the Columbia River system. This discussion is followed by a brief summary of the results for the upper Columbia, Clearwater, and lower Columbia portions of the study area.

Total System Damages

Table 4-16 shows the projected average annual flood damages by SOS and location for each alternative after it is implemented. Total estimated flood damages for the entire system under the No Action Alternative (SOS 2c) are about \$3.3 million annually. For the worst-case alternative (SOS 9c), the damages would

Table 4-16. Average annual flood damages^{a/}

SOS	Damages by Region (thousands of dollars)			
	Upper Columbia	Clearwater	Lower Columbia	Total Damages
1a	\$3,274.7	\$10.3	\$0	\$3,285.0
1b	3,274.7	10.3	0	3,285.0
2c	3,274.7	10.3	0	3,285.0
2d	3,274.7	10.3	0	3,285.0
4c	3,718.8	10.3	0	3,729.1
5b	3,274.7	10.3	0	3,285.0
5c	3,274.7	10.3	0	3,285.0
6b	3,274.7	10.3	0	3,285.0
6d	3,274.7	10.3	0	3,285.0
9a	3,532.2	10.3	0	3,542.5
9b	3,302.1	10.3	0	3,312.4
9c	3,733.5	10.3	0	3,743.8
PA	3,497.5	10.3	0	3,507.8

a/ Results are average annual damages, in 1992 dollars, assuming 100 years of operation under each alternative. Because damages are expected to be the same over the entire period of the analysis, the average annual damages would be the same using a 3.0 percent or a 7.75 percent discount rate.

increase by nearly \$0.5 million to over \$3.7 million. Stable storage operations would also have relatively high flood damages, with SOS 4c showing an increase of over \$0.4 million. SOSs 9a, 9b, and PA show smaller variance from baseline (SOS 2c) conditions, while SOSs 1, 2d, 5, and 6 would have the same level of flood damage costs as SOS 2c. Figure 4-26 displays the total annual flood damages for each option compared to SOS 2c, based on the results presented in Table 4-16.

These variances in damages might be overstated. The models used to estimate flows, stages, and subsequent flood damages are based on monthly averages. In some cases, modeling monthly averages might not adequately capture the true expected effects. At several dams (including Hungry Horse, Dworshak, Libby, Kerr, and Albeni Falls), there is considerably more flexibility in the daily management of releases than is represented by the model. Because of this additional flexibility, flood damages might be less than indicated by the model.

Upper Columbia Region

Of the three regions in the study area, the upper Columbia region is the only one for which there is measurable variation in estimated flood damages from different SOSs.

Within the upper Columbia region, the Columbia Falls damage center would experience the greatest absolute amount of flood damage under any alternative (see Appendix E for details). Damage estimates for Columbia Falls under SOSs 4c and 9c range from 21 to 73 percent higher than the estimate for SOS 2c. Residential and commercial properties adjacent to Kalispell account for approximately 60 percent of the damages. Agricultural damages would occur both upstream and downstream of Kalispell.

Flood damages for the Flathead Lake, Kerr Dam to Thompson Falls, and Lake Pend Oreille damage centers are included in the upper Columbia estimate shown in Table 4-16. As noted above, the stage and flow forecasts for

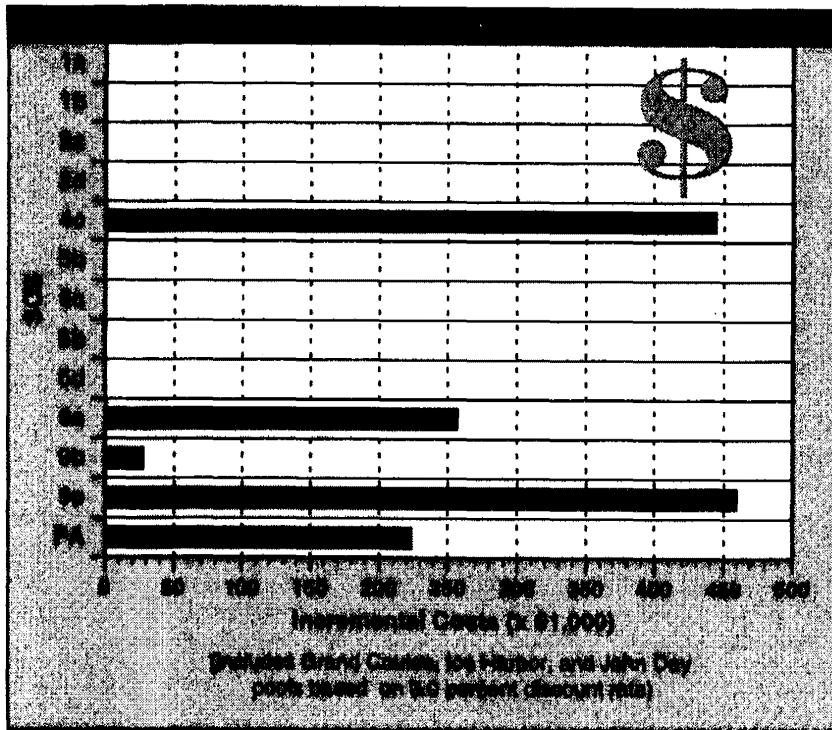


Figure 4-26. Flood control costs relative to SOS 2c

Flathead and Pend Oreille Lakes are thought to be higher than would actually occur. Daily real-time regulation would tend to reduce flows and stages below those predicted by the model.

Erosion losses of waterfront land and dock damage represent the majority of potential flood damages along Flathead Lake. In all the other areas, damages would mostly be to agricultural lands.

The Albeni Falls to Cusick reach of the Pend Oreille River would account for about 30 percent of all upper Columbia region damages under most SOSs, and the estimates for this damage center vary little among the alternatives. Damage estimates for Lake Pend Oreille are also very similar in most cases, but they are noticeably higher under SOS 4c and SOS 9c. The Kootenai River reach below Libby Dam generally accounts for the lowest damage total among the upper Columbia damage centers.

Clearwater River Region

The levees near Lewiston completely protect the highly developed industrial, commercial, and residential property in that area. No SOS would result in a discharge that exceeds the safe carrying capacity of the levees. All flood damages estimated for this region would occur upstream of Lewiston.

That upstream reach is essentially undeveloped. There are approximately 240 single-family residences, mostly at either end of the flood plain, with agricultural and undeveloped land in between. A system of roads, railroads, and bridges is also found in the area. All of the SOS alternatives analyzed for the

Final EIS would produce the same level of annualized flood damages in this area, estimated at \$10,300.

Lower Columbia Region

Levees provide property protection in the developed areas along the lower Columbia. While the frequency curves for The Dalles show high flows under some of the alternatives, a flood of sufficient magnitude to overtop the levees is unlikely. The area is prone to nuisance flooding at flows above 200 kcfs (5,600 cms), but little economic damage is expected until flows approach 450 kcfs (12,600 cms). This nuisance flooding is caused by high Columbia River flows coupled with high tides. In this situation, interior runoff (runoff behind the levees) is not able to drain into the Columbia.

A comparison of levee heights within the area to the elevation of a flood expected to occur only once in 500 years indicates that the levee height would exceed the water level by a minimum of 3 feet (0.9 m) under all SOSs.

Consequently, the SOR Economic Analysis Group attributed no flood damages to the lower Columbia region for all SOSs (see Appendix O). While there would be no direct impacts on flooding in this area, these actions might conflict with the original design criteria of the levees. Even though projected peak flows would be within maximum levee height, structural stress on the levees could occur. Repeated stress over time could weaken the levees and make them unable to hold back future flood waters.

4.2.12 Navigation

Water transportation is a key element in Columbia River Basin economic growth. Continuing improvements to the Columbia-Snake River navigation infrastructure have yielded economic benefits to cities and communities along the shoreline, and to the surrounding region. Manufacturers and commodity and agricultural producers have come to rely on the inexpensive, reliable, and easily accessible water transportation system that has developed. Other navigation uses of the river include Dworshak Reservoir log transport, which depends on specific reservoir elevations, plus recreational boat traffic and other uses such as small ferry operations.

Operations that involve deep drawdowns of the Snake River projects or that simulate natural river conditions are those most likely to restrict river navigation and result in significant economic consequences. Flow enhancement measures that increase river velocity could also have some negative effect on barge movements, water recreation traffic, and other navigation uses. Some of the SOS alternatives would result in minor net cost savings for navigation. The following material is summarized from detailed information presented in Appendix H, Navigation and Appendix O, Economic and Social Impacts.

Navigation Impact Issues

Commercial users and those who maintain and operate the waterway have been the focus of SOR public involvement and agency

coordination relating to navigation. While there are numerous other groups who benefit from maintaining a safe waterway, commercial navigation is a Congressionally authorized use of the waterway. The continued operation of the waterway is a necessity for 6 barge companies and 54 port facilities, and is important to the shippers who have chosen the waterway as a cost-effective way to transport commodities to buyers. Effects on large commercial navigation interests along the river are similar to the effects on other users, such as recreationists. The juvenile fish transportation program (see Section 3.3.3) is also a significant navigation use of the waterway.

Shallow-Draft Navigation

Most of the potential impacts to navigation would occur on the shallow-draft navigation channel, particularly on the lower Snake River upstream to Lewiston. Operating strategies that involve drawdown of one or more lower Snake River projects (SOSs 5, 6, 9a, and 9c) would prevent access to the locks at Ice Harbor, Lower Monumental, Little Goose, and/or Lower Granite Dams, making them unusable at certain times of the year. Drawdown actions would occur mostly during the spring or spring and summer, and could overlap with a period of relatively high navigation activity, for both commercial shipments and the barging of juvenile salmon and steelhead (see Section 4.2.4 for discussion of effects on fish transportation).

Normal seasonal flows of grain and other commodities would be altered if barge service were interrupted. Shippers would have to reschedule shipments, store commodities, and/or use trucks or railways to avoid major disruptions in the delivery of products to final destinations. In addition, existing activities at affected lower Snake River ports could shift to other ports in response to the interruption of service and changes in commodity movements.

A secondary, relatively minor, shallow-draft navigation issue applies to any operation that would significantly increase river velocities in the inland waterway. Increased stream velocity

attendant with flow enhancement measures could impair navigability at certain locations along the river where physical constraints now exist. Physical difficulties in navigating constricted areas could entail delays or require changes in locking procedures.

The effects of increased stream velocity would be most pronounced at the Ice Harbor Cut, downstream from Ice Harbor Dam, and just below Lower Monumental Dam. In these areas, high flows (generally above 150 kcfs [4,200 cms] at Lower Monumental and above 100 kcfs [2,800 cms] at Ice Harbor) require that barging operations be modified. Current operations place several barges together for transit. In areas with increased stream velocities, however, tows would have to be broken up into smaller groups, resulting in more trips, increased transit time and operating costs, and possibly less-safe operating conditions. The potential costs of this effect are expected to be minor, however, and were not estimated.

Deep-Draft Navigation

During the screening phase of the SOR, concern arose over potential impacts on deep-draft commercial navigation on the lower Columbia River that might be associated with Snake River drawdowns. This issue related to whether refill of the Snake River projects during late summer and fall, at the low point of the Snake and Columbia Rivers' natural hydrograph, would be sufficient to affect river stages in the deep-draft channel from Portland-Vancouver to the Columbia River mouth.

Dworshak Logging Operations

One authorized use of the Dworshak pool consists of rafting logs across the pool to a transfer area near the dam. Logs are cut from the North Fork of the Clearwater River drainage, dumped from trucks into the Dworshak pool, and then towed in rafts to a loading area where the logs are transferred onto trucks. Staging areas have been developed for several pool elevations so that timber operations

can continue during periods of normal drawdown. During periods of significant drawdown, the pool becomes unusable for log rafting.

Other Commercial Uses

There are currently two ferry operations on Lake Roosevelt (one at Keller and the other at Gifford) that provide key travel routes across the 150-mile-long (250-km-long) reservoir. They are the only crossing points between Grand Coulee Dam and Kettle Falls, near the northern end of the reservoir. The navigation analysis addressed the issue of whether service on these ferries would potentially be affected by severe drawdowns.

Effects of Alternatives

Shallow-Draft Navigation

The SOR Navigation Work Group determined the physical impacts to navigation that would result from the SOS alternatives. Using these results as inputs, the Economic Analysis Group then analyzed economic impacts to shallow-draft commercial navigation with a system transportation model developed to simulate transportation responses under different operating scenarios, and to measure transportation costs under each scenario. The model determines the least-cost transportation mode and calculates transportation costs, including storage and handling costs.

It considers rerouting commodities and using alternative transport modes, such as trucking grain to river elevators located on McNary pool, and/or shipping directly by rail to export elevators on the lower Columbia River or Puget Sound. The model thereby determines the minimum cost combination for handling and transporting commodities given the duration and magnitude of river impairments. In some cases, for grain shipments from Montana, North Dakota, and a few counties in Idaho, the shift away from barge transportation would be permanent. However, shipments of most

commodities would return to their normal patterns when pools are operated within their normal ranges.

Shallow-draft navigation would be affected most by SOSs 5b, 5c, 6b, 9a, and 9c. SOS 6d involves drawdown and navigation closure at Lower Granite only. These actions would interrupt navigation on the lower Snake River for variable periods including year-round (SOS 5c), 7 months beginning in February (SOS 5b) and ending in September, 4.5 months between April and August/September (SOSs 6b, 6d, and 9a) and 2.5 months between April and June (SOS 9c).

Total annual gross costs for commodity shipments on the Columbia-Snake River system under SOSs 1, 2, 4, 9b, and PA are estimated at approximately \$414.4 million. Under SOSs 5b, 5c, 6b, 6d, 9a, and 9c, total annual shipping costs would increase. The smallest increase would be under SOS 6d, for which shallow-draft costs are estimated to increase by \$2.1 million on an annualized basis (discounted at 3.0 percent). SOSs 9c, 9a, 6b, and 5b would increase annual shallow-draft costs by \$7.4 to \$13.6 million. The largest projected increase in shipping costs is \$37.5 million for SOS 5c.

The transportation-related costs associated with other potential drawdown impacts have been treated as implementation costs and have not been included in the annual operating costs. These include possible impacts to waterfront structures, impacts due to increased stream velocities, and impacts on alternative transportation systems, such as roads and railroads.

Deep-Draft Navigation

The Navigation Work Group assessed the potential influence of Snake River drawdown actions (SOSs 5b, 5c, 6b, 9a, and 9c) on river stages within the authorized lower Columbia River deep-draft navigation channel. They used tidal data and discharge data from the hydroregulation model to identify potential

effects on river stages for each drawdown option relative to current operations. The work group compared the percentage of time that river stages would be within a specific interval during August, September, and October, the months of concern due to low natural flows. River stages relate to the length of the refill period after drawdown.

The analysis showed that the effects of refill operations on river stage at key locations (Vancouver, Kalama, and Wauna) during these critical months would not be extreme under average water conditions. However, multi-dam drawdowns produced noticeable effects in stage at Portland and Vancouver in September. Differences in stage intervals between the drawdown/refill scenarios and the base condition would be such that the physical impact on deep-draft vessel operations would be negligible. Waterborne commerce on the deep-draft channel would not be significantly affected by any of the drawdown plans.

Dworshak Logging Operations

The impacts on Dworshak logging operations are minor and somewhat variable among SOSs. Many of the alternatives would result in actual cost savings (a benefit), or only slight increases in cost, to the operators at Dworshak. For example, SOS 4c would reduce Dworshak logging operation costs by \$228,000 per year (at a 3.0 percent discount rate) compared to SOS 2c. SOSs 1, 5, 6, 9a, and 9c would also result in cost savings (benefits) relative to SOS 2c. The only alternatives that would produce a negative impact for Dworshak timber interests are SOSs 2d, PA, and 9b, which would increase annual log transport costs by about \$93,000, \$120,000, and \$173,000, respectively. All alternatives that provide a stable high elevation at Dworshak, or delayed the drafting of the lake for flow augmentation or refill of the lower Snake River dams, were beneficial to this authorized use of the project. In many cases, these alternatives result in increased costs for other forms of transportation.

Lake Roosevelt Ferries

The Keller ferry is able to use an alternate docking and loading facility when Lake Roosevelt is drafted to low elevations. Therefore, the analysis indicated that none of the SOSs would impair the operation of the Keller ferry.

The Gifford ferry becomes inoperable when the Lake Roosevelt elevation drops by more than 72 feet (22 m), or to below elevation 1,218 feet (375 m). The analysis indicated that compared to SOS 2c, SOSs 9b and 9c would result in a slight increase in impacts to the Gifford ferry. During these service interruptions, regular users of the Gifford ferry would have to use alternative travel routes, go to alternative destinations, or cross Lake Roosevelt less frequently. The most likely alternative route would be to travel via State Route 20 to the north of Gifford and Inchelium, which would add approximately 45 miles (72 km) to the trip. The economic costs of the interruption of ferry service have not been estimated, but are not expected to be large.

Total Navigation Costs

The total navigation costs entered into the analysis of direct economic impacts include the shallow-draft navigation costs and the Dworshak log transport costs. The former component accounts for virtually all of the total navigation costs. Compared to SOS 2c and using a 3.0 percent discount rate, total navigation costs for the other SOS alternatives would range from \$0.1 million lower (SOS 1a or 1b) to \$37.4 million higher (SOS 5c; see Figure 4-27). Total navigation costs for SOSs 1a, 1b, and 4c would be slightly lower than for SOS 2c, because of improved log transport conditions for Dworshak. SOSs 9b and PA would have slightly higher total

navigation costs than SOS 2c, because of somewhat worse log transport conditions. The remaining SOSs include mainstem drawdown provisions and would have significantly higher total navigation costs.

4.2.13 Power

The 14 Federal projects under review in this EIS account for 57 percent of the Pacific Northwest's total electric capability, and 97 percent of the Federal system's hydroelectric capability. In project scoping, the importance of hydropower and its indispensability to the regional economy were common themes. With the exceptions of SOSs 1a and 1b, adopting any of the system operating strategies other than the No Action Alternative (SOS 2c) would reduce hydropower production and increase the cost of the power system to Northwest ratepayers. SOS 9a would have the greatest impact, increasing total net system power generation costs by an annual average of \$236 million assuming a 3 percent discount rate. Average annual

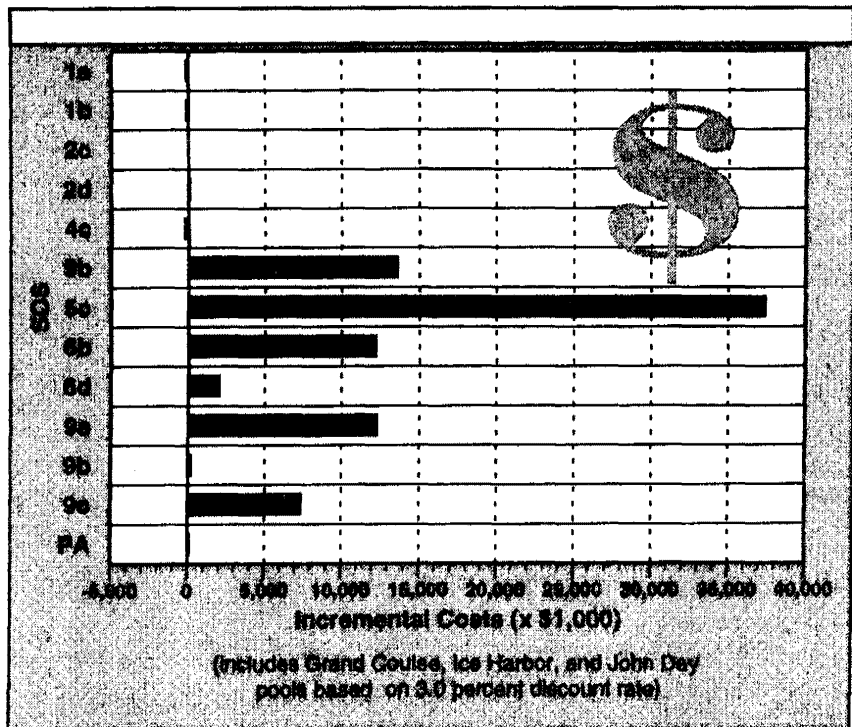


Figure 4-27. Net navigation costs

hydropower generation under SOS 9a would decrease by 6.6 percent. (Appendix I, Power, and Appendix O, Economic and Social Impacts, provide a complete report on this analysis.)

Power Impact Issues

The hydropower system currently provides many products and services, including firm and nonfirm energy, capacity (both peak and sustained), daily load-following capability, system reliability, and other attributes that contribute to the efficiency of the regional power system. Northwest residents are interested in keeping the system reliable and economical. In conducting its study for the Draft EIS, the Power Work Group assumed that BPA would cover any deficits that would result from changing system operations, so that an adequate supply of power would always be available to meet demand. For the Final EIS, the Power Work Group assumed that, at a minimum, regional utilities would strive to maintain a probability of failing to meet load equivalent to 1 day in 20 years. This is because utilities currently are relying to an unprecedented extent on spot market purchases to meet indigenous demand. The cost of supplying that power under most of the alternatives analyzed is higher than under the No Action Alternative. The economic impact of limiting power production in order to promote other river uses concerns some people; others want continued low-cost, reliable power.

Sections 3.1.3 and 3.3.6 included a description of how storage projects and run-of-the-river projects operate, how the system's firm and nonfirm energy sales are made, and how the system's generating capacity is affected by how the reservoirs are managed. Changing system hydropower operations affects the capability of the regional power system to meet its objectives in a variety of ways. The first is in its ability to generate energy, and the costs of generating that energy. The second is in its ability to provide capacity, and the associated costs. Changes in the regional power system's ability to provide both energy and capacity, and the costs of

providing these products, are at the core of the power system impact analysis.

Energy

One of the hydrosystem factors that varies among the SOSs is the relative proportion of firm and nonfirm energy produced. Firm energy is energy that could be produced in the critical period (the worst historical water conditions—see Glossary); it is very dependable because there is usually enough water to produce that much energy (currently about 12,700 average megawatts [aMW]), year in and year out. Nonfirm energy is produced when water conditions are better than critical. Nonfirm energy (currently about 4,000 aMW) is less useful for meeting Pacific Northwest loads because the amount that can be generated varies from year to year. Because of its usefulness and dependability, firm energy can be sold at higher prices than nonfirm energy. Alternatives that produce relatively less firm energy and more nonfirm energy make it more costly to provide a dependable supply of power to the consumer.

In terms of firm energy production, some of the SOSs would severely restrict the system's flexibility because they restrict the use of the storage reservoirs. In such cases, the hydrosystem has little ability to retain water in storage for later release in times of power need. It would have to generate power when the water is coming down the river, usually in response to a requirement from some other use, such as providing water flows for anadromous fish. This would severely restrict the ability of the system to generate firm energy when most needed, and instead produces more of the less-valuable nonfirm energy. In extreme cases, when flow would exceed the capacity of the turbines, water would be spilled over the dam and produce no energy at all.

Capacity

The same water management strategies that restrict firm energy production also tend to restrict capacity, particularly sustained capacity. Any restriction on the ability to draft and store

water, and the rates at which this takes place, affects the system's sustained capacity.

Thus, reservoir drawdowns and changes in flow patterns would result in lost power generation, either through forced shutdowns of powerhouses, spilling water that exceeds the capacity of the turbines, or shifting power generation from a time when it is needed to a time when it is not particularly needed. Such changes in hydroelectric generation would represent an economic cost to the region, and could translate into increased power rates. These changes could also result in an economic cost to the Pacific Southwest, because lost nonfirm power normally exported to the Southwest would require replacement with higher cost energy.

Costs of System Changes

For each SOS, the Power Work Group calculated how much it would cost to operate the entire Pacific Northwest power system if that alternative were applied under conditions identical to the 50 water years spanning September 1928 through August 1978. This calculated cost consists of capital costs for new resources plus operating costs for all resources (including any energy purchases from outside the region), less revenues from sales out of the region. The Power Work Group summed the results for each alternative under all water conditions and calculated the average annual expected cost, producing estimates that indicate the relative cost of satisfying energy demand under each alternative across the range of hydrologic conditions.

Changes in the cost of providing sustained capacity (energy for 10 hours a day, 5 days a week) and instantaneous capacity (1-hour peak loads) were also evaluated. The sum of changes in the cost of the system's ability to provide capacity and energy gives the impact on the power system as a result of each SOS.

Resource Acquisition Philosophy

The efficiency of the power system has been a product of traditional "firm planning" methods

in which resource needs were guaranteed by the acquisition of firm resources within the control of the region's utilities. For the Draft EIS, the work group used two resource acquisition philosophies to analyze the cost of each SOS. In the combustion turbine (CT) case, a resource with characteristics similar to a combustion turbine would be acquired to meet load in months when there is a deficit; that is, when the expected demand for energy exceeds the supply. In the purchases case, no resources would be acquired because it was assumed that energy would be available for purchase to cover any deficits. All deficits would be covered by purchasing energy on the short-term spot market.

At present, competition is forcing utilities to lower prices at the expense of reliability. Few, if any, Northwest utilities can afford to maintain the level of reliability suggested by the strictest interpretation of firm planning. Utilities are relying on the lower-cost spot market for purchases to meet indigenous loads to an unprecedented extent. This will continue until 1) reliability will decline to a point where the utilities decide acquisition of firm resources in the Pacific Northwest is needed, or 2) resource acquisitions will become competitive with the purchase market. How far utilities are willing to allow reliability levels to drop is unclear. No clear enforceable standards exist, and methods for assessing system reliability are in their infancy in the Northwest.

Additionally, costs of combustion turbines have fallen dramatically since the publication of the Draft EIS. This is due to three factors: historically low natural gas prices, decreases in hardware costs, and increases in CT operating efficiency.

In light of these developments, a new resource acquisition philosophy was adopted for the Final EIS. This philosophy was based on the assumption that, at a minimum, regional utilities would strive to maintain a probability of failing to meet load equivalent of 1 day in 20 years. This level of reliability is common to all alternatives including the No Action Alternative.

Therefore, the resource acquisition philosophy applied to the analysis in the Final EIS purports that it would be impossible to site, license, and construct CTs by 1995, the earliest SOS implementation date. Consequently, the analysis for that operating year was based on the assumption that all power needs would be met by spot market purchases. For the analysis of later operating years, an attempt was made to optimize the choice of CTs versus purchases after sufficient CTs were constructed to meet the reliability standard of 1 day equivalent energy outage in 20 years.

Effects of Alternatives

The work group compared the alternatives in terms of their effects on energy and capacity, and the cost of satisfying the region's total power demands. The potential implication for retail power rates is briefly explored as well. Projected generation, cost, and rate impacts are summarized below, based on the more detailed information reported in Appendices I and O.

Generation

Table 4-17 indicates that only the alternatives representing past actions (SOS 1) would produce more energy, on average, than the No Action Alternative (SOS 2c). All the other alternatives would produce between 0.1 and 6.6 percent less energy than the No Action Alternative. SOSs 5b, 5c, and 9a would cause the most substantial loss in total average annual generation. In the case of SOS 5b or 5c, turbines would be taken out of service or head would be severely reduced. SOS 9a couples large amounts of spill with drawdown of the lower Snake plants. The decreases in generation under these three alternatives would range from 828 aMW under SOS 5b to 1,095 aMW under the worst alternative, SOS 9a. For SOS PA, most of the 307-MW reduction in average annual generation is due to large amounts of spill for anadromous fish.

Energy and Capacity Costs

For the Draft EIS, total system costs, including replacement for both energy and

capacity, were estimated following both the purchases and CT replacement strategies. This approach was in line with the resource acquisition philosophy presented in the Draft EIS. However, due to the change in resource acquisition philosophy for the Final EIS, the analysis of combined energy and capacity costs has been changed accordingly.

Therefore, average annual net system cost for each SOS was based on each SOS's combined management of spot market purchases and CTs designed to ensure maintenance of the reliability standard of 1 day equivalent energy outage in 20 years. The combined energy and capacity costs were calculated for loads and resources that existed in the 1995 to 1996 operating year (OY 1996) and for the loads and resources that existed in the 2003 to 2004 operating year (OY 2004). Results for intermediate years were determined by interpolation. Results for years past 2004 were assumed to stay constant.

Additionally, several SOSs have different implementation years. For example, SOS 2c has an implementation date of 1995 while SOS 5b would be implemented in 2010, furthest into the future compared to SOS 2c. In light of the different implementation dates, average annual net system costs were assessed using two discount rates: a 3 percent or "real" interest rate and a 7.75 percent rate, the Federal discount rate for fiscal year 1995. This approach was taken to better capture changes in cost relationships among SOSs. SOSs with a longer lead-time would experience a more significant reduction in cost structure under a higher discount rate. All of the alternatives other than the past (SOS 1) operating strategies would increase the cost of operating the regional power system. Therefore, flexibility of the system would be enhanced under SOS 1 and reduced under all other alternatives. Large energy deficits would occur in a number of months, requiring CTs or out-of-region purchases to make up the difference.

Table 4-18 indicates that increases in the cost of operating the system could be substantial.

Table 4-17. Average annual hydropower generation by SOS, compared to SOS 2c

SOS	Total Generation (aMW)	Change from SOS 2c	
		(aMW)	(percent)
1a	16,909	138	0.8
1b	17,080	309	1.8
2c	16,771	0	0.0
2d	16,737	-34	-0.2
4c	16,752	-19	-0.1
5b	15,943	-828	-4.9
5c	15,826	-945	-5.6
6b	16,494	-277	-1.7
6d	16,682	-89	-0.5
9a	15,676	-1,095	-6.6
9b	16,130	-641	-3.8
9c	16,042	-729	-4.4
PA	16,464	-307	-1.8

Annual net system cost increases range up to \$236 million or 25 percent under SOS 9a, assuming a 3 percent discount rate, and up to \$207 million or 22 percent under SOS 9b assuming a 7.75 percent discount rate. As shown, incorporating the effects of implementation timing and discounting future costs at different rates has some effect on the economics of the various SOSs. Using the 7.75 percent discount rate, some of the SOSs that have longer lead-times (SOSs 5b, 9a, and 9c) showed substantially lower cost increases than when their costs were discounted at 3 percent. The reasons for the large increases in operating costs include the following:

- Under stable storage project operations, such as SOS 4, water stored in reservoirs would not be as available for power generation. In certain months of lower-runoff years, particularly in August and September, additional energy from CTs or purchase of spot-market energy would be needed to make up for energy deficits.
- Under SOS 5, drawdown of the lower Snake reservoirs to natural river levels would eliminate hydroelectric generation at these projects because they would need to be drafted below the minimum level necessary for turbine operation.
- SOS 5 or 6 would incur a substantial capital cost before the reservoirs could be safely drawn down. These additional costs, annualized over the planning period, were included in the analysis as part of the cost of operating the power system.
- Under SOS 9, drawdowns and/or large amounts of spill would result in reduced hydropower generation. Sizable amounts of replacement energy, CTs, or spot-market purchases would be necessary to augment energy deficits.
- Under SOS PA, fall/winter water storage and spring/summer flow releases would both increase, reducing system operating efficiency.

Table 4-18. Annual net system replacement power cost by SOS, compared to SOS 2c (\$1,000,000)^{a/}

SOS	3 Percent Discount Rate		7.75 Percent Discount Rate	
	\$ Change from SOS 2c	% Change from SOS 2c	\$ Change from SOS 2c	% Change from SOS 2c
1a	-38	-4	-36	-4
1b	-72	-8	-66	-7
2c	0	0	0	0
2d	24	3	24	3
4c	85	9	81	8
5b	85	9	44	5
5c	167	17	132	14
6b	35	4	23	2
6d	17	2	14	1
9a	236	25	153	16
9b	213	22	207	22
9c	138	14	90	9
PA	126	13	108	11

a/ Results are annual averages, in 1993 dollars, of system generation and capacity costs for the 100 years following implementation of each alternative, but do not include implementation costs.

Rate Impacts

Fortunately for the region's ratepayers, the wholesale and retail costs of purchasing electricity would not be expected to change as a result of the replacement power costs associated with changing system operations. In previous years, salmon-related power system costs have been incorporated within wholesale electric rate increases adopted by BPA. Recently, however, BPA announced proposed power rates that would go into effect October 1, 1996 and that represent a reduction in average costs from the current rates that were set in 1993. The new rates would be available as 2-year or 5-year flat options, with no provisions for escalation or interim rate adjustments. This rate proposal reflects BPA's commitment to remain competitive. Therefore, based on its recently announced intentions concerning wholesale rates, BPA would be expected to reduce other costs to

offset any increases in generation cost resulting from adoption of an SOS.

Nevertheless, during the preparation of the Draft EIS the Economic Analysis Group selectively analyzed the changes in wholesale rates that would result from increased system costs, and then took into account the fact that higher rates would induce some customers to reduce their demand. For illustration purposes, this analysis was repeated for the Final EIS. It showed that the highest cost alternative (SOS 9a) would be expected to reduce estimated demand by about 1 percent. This reduced demand would in turn reduce the cost of satisfying total demand. Including these demand effects, the net power replacement costs estimated for the SOS alternatives (at a discount rate of 3 percent) would correspond to net average regional rate changes ranging from about -1 percent to 4 percent under historical cost-recovery conditions.

The reduced system power costs for SOSs 1a and 1b would normally allow small rate reductions, while the potential 4-percent rate increase applies to SOS 9a. An average rate increase of 2 percent was estimated for SOS PA. Again, these estimates reflect how regional retail rates might change if power impact costs were recovered through rates, which appears unlikely.

4.2.14 Irrigation

The waters of the Columbia River system irrigate more than 7.3 million acres (2.95 million ha) of land in the Columbia River Basin, including British Columbia. This irrigation water makes possible the production of crops ranging from relatively low-valued hay and irrigated pasture to very specialized fruit and vegetable crops that provide a high return per acre. Maintaining this important sector of the Northwest economy is a vital issue to many people.

Of the 14 Federal projects under review in this EIS, three—Grand Coulee, Ice Harbor, and John Day—support irrigation that could be affected by the SOS alternatives. Other projects either do not supply significant irrigation withdrawals or would not experience changing water levels that would affect irrigation. Several of the alternatives would have a very minor effect on irrigators at Grand Coulee in most years, slightly decreasing or increasing pumping costs. One alternative—SOS 9a—could have a much more serious impact during certain months of critical water years, when irrigation deliveries may not be fully met.

Four strategies—SOS 5, SOS 6, SOS 9, and SOS PA—would affect irrigation pumping cost to differing degrees at Ice Harbor, John Day or both. This is because of drawdowns at Ice Harbor and John Day during pumping season for SOSs 5, 6, 9a, and 9c, as well as year-round drawdown of John Day under SOS PA.

Irrigation Impact Issues

During public scoping for the SOR, the Federal agencies received many comments on

the use of water for agricultural production. These ranged from numerous comments expressing strong support for existing levels of irrigation use to suggestions by a few that water used for irrigated agriculture in the Pacific Northwest should be reduced, or given a lower priority than other uses. Other comments expressed interest in keeping the price of water resources fair for all users.

Because of the importance of agricultural irrigation to the economy of the Columbia River Basin, the SOR irrigation analysis focused on determining the cost of maintaining the status quo with regard to water deliveries. The analysis was conducted within the context of additional cost to irrigators, although it is possible that the increased cost could be borne by taxpayers through Congressional approval of mitigation for irrigation impacts. In this case, increased pumping costs represent both the best proxy for irrigation impacts and the potential mitigation costs. Thus, most of the analysis is based on assumptions that cropping patterns would remain the same as current conditions and that none of the land would go out of production due to any of the alternative operating strategies. An exception to this general rule is SOS 9a; it could cause some acreage near Grand Coulee to lose irrigation water in critical water years. The SOR agencies concluded that attempting to predict indirect irrigation impacts at the other affected projects, such as changes in cropping patterns or acreage in production, would be highly speculative and inappropriate.

With the exception of SOS 9a, none of the alternatives would affect the amount of water available to irrigators. However, the alternatives that would change the water level of Grand Coulee, Ice Harbor, and/or John Day pools during the irrigation season would affect irrigators by changing the cost of maintaining their water deliveries. Irrigation water in the Columbia River Basin is pumped up out of the reservoirs and into distribution systems located on the surrounding plateaus. At all three pools, irrigators would have to pay higher annual operating costs under any alternatives that lower the pool during the irrigation season. More

electrical energy would be needed to raise water from the lower elevation and maintain pressure over a greater distance. At Grand Coulee, some alternatives would raise the water level during the irrigation season, which would lower the pumping cost paid by irrigators. At the Ice Harbor and John Day pools, some users would have to modify intakes and pumps so that the intake would reach the lower water level and the pump capacity would be adequate to raise water from a lower elevation.

SOS 9a would reduce the delivery of water to irrigators at Grand Coulee in critical water years only. This would occur, not because there would not be enough water, but because the unusually low lake level would reduce the efficiency of the pumps to where they could not keep up with the demand for water.

Effects of Alternatives

The effects of the SOS alternatives on irrigation pumping costs are summarized below, based on the corresponding results provided in Appendix F. Most alternatives would either increase or decrease costs at Grand Coulee only slightly, compared to the No Action Alternative (SOS 2c), from an annual savings of \$18,400 to an added annual cost of \$34,900.

SOSs 5, 6, 9a, 9c, and PA would have significant effects on irrigators in non-critical water years. Those effects would fall on irrigators at the John Day and Ice Harbor pools. Proposed reservoir drawdowns would result in increased pumping costs and electric power costs due to greater lift requirement, as well as increased capital and maintenance costs associated with pumping plant modification.

Because the SOS options have different implementation dates, pumping costs were discounted to 1995, year 1 of the analysis. Two discount rates were used, 3.0 percent or the "real" interest rate, and 7.75 percent or the Federal discount rate. In performing this analysis, this approach was taken to better capture changes in pumping cost relationships among SOSs resulting primarily from capital

costs associated with plan modification. SOSs with capital costs and longer lead-time would experience a more significant change in pumping cost structure under a higher discount rate.

Grand Coulee

At Grand Coulee, an extensive system of irrigation pumping plants, canals, and laterals; storage reservoirs; and drainage facilities has been constructed to serve nearly 600,000 irrigated acres (243,000 ha). Water is delivered by a pumping plant located on the south side of Lake Roosevelt and immediately upstream of Grand Coulee Dam. The pumping plant lifts water approximately 300 feet (91 m) from Lake Roosevelt to Banks Lake, an offstream reservoir with an active storage capacity of 715 KAF (882 million m³). Several irrigation districts use the water in Banks Lake to supply local irrigators.

Operations that would lower the level of Lake Roosevelt would increase pumping costs because additional electrical energy would be needed to run the pumps and raise the water more than the current average lift of 300 feet (91 m). Individual irrigators would have to cover the higher pumping costs by paying higher rates to their irrigation districts.

The annual irrigation pumping requirement at Grand Coulee is 959,254 megawatt-hours and the repayment cost to pump the water is \$911,300 under SOS 2c (Table 4-19). The other operating strategies would have a relatively minor effect on irrigation pumping costs at Grand Coulee; SOS 9a would have the greatest negative impact. With an annual pumping cost of \$946,200, SOS 9a would increase costs just \$34,900 (3.8 percent) over SOS 2c in non-critical water years. Some alternatives would reduce costs slightly compared to SOS 2c; the greatest savings would be afforded by SOS 4c, saving \$18,400 annually.

SOS 9a would have an additional cost in critical water years. During spring and summer, SOS 9a would draft Lake Roosevelt to unprecedented levels. Because the efficiency of the pumping units decreases as the level of Lake

Table 4-19. Change in annual irrigation pumping costs at Grand Coulee

SOS	Pump Modification Required	Implementation Date	Change in Annual Pumping Cost Compared to No Action Alternative	
			3%	7.75%
1a	no	1995	9,000	9,000
1b	no	1995	8,900	8,900
2c	no	1995	0	0
2d	no	1995	-3,300	-3,300
4c	no	1995	-18,400	-18,400
5b	no	2010	0	0
5c	no	2000	0	0
6b	no	2005	0	0
6d	no	2000	0	0
9a	no	2005	34,900	34,900
9b	no	1995	5,400	5,400
9c	no	2005	6,000	6,000
PA	no	1998	-2,800	-2,800

Roosevelt goes down, pumping from Lake Roosevelt to Banks Lake would not be able to keep up with peak demand. Consequently, deliveries from Banks Lake could not be fully met, and some acres would not receive their full allotment of irrigation water in some months of critical water years. Additionally, during critical water periods, pumping units would be operating for extended periods of time resulting in increased operations and maintenance costs. However, this cost was not evaluated for alternative SOS 9a.

Assessment of pumping costs under the two discount rates did not differ because it was assumed that no capital outlays for pumping plant modifications would be necessary under any alternative including SOS 9a. Consequently, pumping costs are strictly a function of annual

megawatt hours of pumping needed to meet annual irrigation demand under each alternative.

Ice Harbor

Since the construction of Ice Harbor Dam in the early 1960s, private interests have developed irrigated lands adjacent to the reservoir in Franklin County (north side) and Walla Walla County (south side), both in Washington. The irrigated lands were privately developed and funded, and include both small farms and large corporate operations. The Corps has identified 13 pumpers irrigating 36,389 acres (14,726 ha) from the Ice Harbor pool. Reservoir level fluctuations at Ice Harbor are currently kept to a narrow range between elevations 437 and 440 feet (133 and 134 m).

SOS alternatives that would lower the Ice Harbor pool during the irrigation season would cause an increase in annual pumping costs because irrigators would have to pay for pumping plant modifications and the increased energy costs associated with the additional pumping lift. Using the estimated increased pumping cost as the measure of the impact was a change from the farm income methodology used in the Draft EIS analysis.

SOS 5b/c and SOS 6a/b would draw down Ice Harbor to 343 feet (104 m) and 407 feet (124 m), respectively, during all or part of the irrigation season. SOS 9a would operate 33 feet (10 m) below full pool between April 1 and August 31, while SOS 9c would operate 35 to 45 feet (10.6 to 13.6 m) below full pool between April 1 and June 15 to meet Lower Granite flow targets. Capital costs for pump modifications would be required under all five options. These alternatives would also require irrigators to spend more on annual pump operation, including increased power costs due to greater lift requirements.

If SOS 5, 6, 9a or 9c is implemented, compared to the No Action Alternative (SOS 2c), annual irrigation pumping cost to irrigators drawing from the Ice Harbor pool would increase by \$1.4 million (SOS 6b) to \$3.2 million (SOS 5c), using a 3 percent or "real" discount rate (Table 4-20).

John Day

Like the Ice Harbor pool, the John Day pool is surrounded by private irrigation developments, ranging from small farms to large corporate concerns. The Corps has identified 24 pumpers irrigating 139,500 acres (46,463 ha) from this pool. Prior to 1992, the operating pool normally fluctuated between 265 feet (80.7 m) and 268 feet (81.6 m) during the irrigation season. John Day has generally been operated between elevations 262.5 feet (80.0 m) and 265 feet (80.7 m) from May through August during the past 2 years, as in SOS 2c. SOS alternatives that would lower the John Day pool during the irrigation season would increase irrigators'

pumping costs by increasing their costs for pump modifications and operations.

All options for SOS 5 or 6 would draw John Day down to elevation 257 feet (78.3 m) from May through August. SOS 9a or 9c would draw down John Day to elevation 257 feet (78.3 m) from April through August while SOS PA would draw it down year round. Pump modifications would be required under all seven options (SOSs 5b, 5c, 6b, 6d, 9a, 9c, and PA) and operating costs would increase due to the increase in pumping head.

If SOS 5, 6, 9a, 9c or PA is implemented, compared to the No Action Alternative (SOS 2c), annual irrigation pumping cost to irrigators drawing from John Day would increase by \$0.95 million (SOS 9a) to \$1.54 million (SOS PA), using a 3 percent or "real" discount rate (see Table 4-21).

Summary

The combined irrigation cost changes for all three affected areas, relative to SOS 2c, are shown in Figure 4-28 and Table 4-22. Overall, the SOS with the greatest impact on irrigators would be SOS 5c, which would increase irrigators' pumping costs by nearly \$4.5 million annually (using a 3.0 percent discount rate). In this case, all of the impact would fall on irrigators at the Ice Harbor and John Day pools, with Ice Harbor accounting for 70 percent of the total change and John Day 30 percent. Comparing the pumping cost results for SOSs 9a and 9c with those for SOS 6b indicates that the duration of these drawdown operations (2 months versus 4.5 months) would have little influence on the level of impact.

4.2.15 Municipal and Industrial Water Supply

Municipal, industrial, and other miscellaneous water supply diversions from the Columbia River system amount to only about 2 percent of the total withdrawals in the region. Issues related to municipal and industrial water use on the Columbia River system focus on the

Table 4-20. Change in annual irrigation pumping costs at Ice Harbor

SOS	Pump Modification Required	Implementation Date	Change in Annual Pumping Cost Compared to SOS 2c	
			@ 3% (\$000)	@ 7.75% (\$000)
1a	no	1995	0	0
1b	no	1995	0	0
2c	no	1995	0	0
2d	no	1995	0	0
4c	no	1995	0	0
5b	yes	2010	2,305.4	1,443.8
5c	yes	2000	3,164.7	3,072.9
6b	yes	2005	1,377.4	1,080.9
6d	no	2000	0	0
9a	yes	2005	1,378.1	1,081.3
9b	no	1995	0	0
9c	yes	2005	1,427.6	1,126.2
PA	no	1998	0	0

Table 4-21. Change in annual irrigation pumping costs at John Day

SOS	Pump Modification Required	Implementation Date	Change in Annual Pumping Cost Compared to SOS 2c	
			@ 3% (\$000)	@ 7.75% (\$000)
1a	no	1995	0	0
1b	no	1995	0	0
2c	no	1995	0	0
2d	no	1995	0	0
4c	no	1995	0	0
5b	yes	2010	1,013.8	650.7
5c	yes	2000	1,375.0	1,373.0
6b	yes	2005	1,181.1	945.2
6d	yes	2000	1,375.0	1,373.0
9a	yes	2005	945.9	748.4
9b	no	1995	0	0
9c	yes	2005	1,213.2	966.1
PA	yes	1998	1,540.2	1,663.7

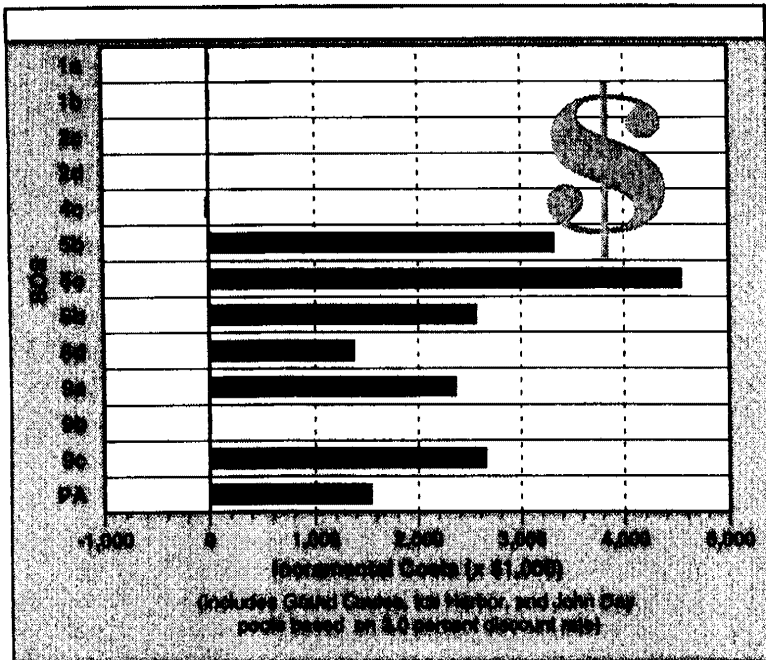


Figure 4-28. Combined incremental irrigation costs relative to SOS 2c.

recipients of the water supply. These water users include two groups: those who pump directly from the river system (some of whom would be affected by any of the SOS alternatives), and those who do not pump directly from the system, but whose water supply would be affected in other ways by one or more of the alternatives.

Several municipal, industrial, and miscellaneous water users pump water directly from the system pools but would not be affected by any of the SOS alternatives. These include, for example, the cities of Kennewick, Richland, and Pasco that withdraw water from the McNary pool. McNary pool elevations would not be changed measurably by any of the alternatives, so the means

and cost of water supply withdrawal would not be affected.

Other water users pump water directly from system pools that would be affected by one or more of the SOS alternatives. The alternatives that include drawdowns of Lower Granite, Lower Monumental, Little Goose, Ice Harbor, and/or John Day Reservoirs would affect these water users in two ways. First, some users would have to modify intakes and pumps so that the intake would reach the lower water level and the pump would be capable of raising water from a lower elevation. Second, all users would pay higher annual operation and maintenance costs, including higher energy costs. More electricity would be needed to raise water from the lower elevation and maintain pressure over a greater distance. These are essentially the same types of impacts that would affect irrigation pumping plants, as discussed in Section 4.2.14.

The Irrigation/Municipal and Industrial (M&I) Water Supply Work Group inventoried

assurance of an adequate water supply now and in the future; the cost of modifying and operating equipment to provide that water supply to users; and the quality of the water diverted by these users. Because withdrawals for municipal, industrial, and other miscellaneous uses constitute such a small fraction of total system water, all alternatives provide an adequate water supply. SOSs 5, 6, 9a, 9c and PA, however, would require additional expenditures on the part of water users to modify pumps, pay higher annual operating expenses, or make other adjustments to accommodate lower pool levels. The following information on these water supply impacts is based on the study results documented in Appendix F, Irrigation/Municipal and Industrial Water Supply.

Water Supply Impact Issues

Municipal, industrial, and other miscellaneous water use of the Columbia River system constitutes a small component of water use that is nonetheless vitally important to

Table 4-22. Combined increase in costs to irrigators at Grand Coulee, Ice Harbor, and John Day pools (\$000)^{a/}

SOS	3 percent discount rate				7.75 percent discount rate			
	Grand Coulee ^{b/}	Ice Harbor	John Day	Total	Grand Coulee	Ice Harbor	John Day	Total
1a	9.0	0	0	9.0	9.0	0	0	9.0
1b	8.9	0	0	8.9	8.9	0	0	8.9
2c	0	0	0	0	0	0	0	0
2d	-3.3	0	0	-3.3	-3.3	0	0	-3.3
4c	-18.4	0	0	-18.4	-18.4	0	0	-18.4
5b	0	2,305.4	1,013.8	3,319.2	0	1,443.8	650.7	2,094.5
5c	0	3,164.7	1,375.0	4,539.7	0	3,072.9	1,373.0	4,445.9
6b	0	1,377.4	1,181.0	2,558.5	0	1,080.9	945.2	2,026.1
6d	0	0	1,375.0	1,375.0	0	0	1,373.0	1,373.0
9a	34.9	1,378.1	945.9	2,358.9	34.9	1,081.3	748.4	1864.6
9b	5.4	0	0	5.4	5.4	0	0	5.4
9c	6.0	1,427.6	1,213.2	2,646.8	6.0	1,126.2	966.1	2,098.3
PA	-2.8	0	1,540.2	1,537.4	-2.8	0	1,663.7	1,660.9

Source: Appendix F, Chapter 5, Tables 2, 3, and 4.

a/ All values are annual averages, in 1992 dollars, for the 100 years following implementation of each alternative.

b/ Negative numbers denote a savings to irrigators.

nonagricultural water withdrawals that might be affected by SOS alternatives. The number of potentially affected pumps includes nine on the Lower Granite pool, two on Lower Monumental, two on Little Goose, three on Ice Harbor, and seven on John Day. The users of these potentially affected pumps are a sand and gravel company, Whitman County Parks, a Clarkston golf course, the Corps of Engineers (wildlife areas), Washington State Parks, Idaho State Parks, fish hatcheries at Umatilla and Irrigon, the City of Boardman water supply, the City of Umatilla sewage treatment outlet, individual groundwater wells, dredging at Umatilla River mouth, and an aluminum company.

Additionally, municipal and industrial water users and several small tract irrigators could be slightly affected by changes in operations at Grand Coulee. Any costs associated with these changes would be very minor, and the effects were not included in this analysis.

Changes in water quality associated with system operations could have an indirect impact on M&I water supplies. This primarily relates to possible increases in turbidity caused by changes in sediment transport patterns. The alternatives involving lower Snake River drawdowns, particularly SOS 5, would erode large volumes of sediment from the lower Snake River and could transport much of the fine sediment downstream. Significant increases in turbidity could require additional water supply treatment costs. The potential for this impact would be greatest at McNary pool. Please see Sections 4.2.1, Earth Resources, and 4.2.2, Water Quality, for additional discussion of sedimentation and turbidity.

Users that are not pumping water directly from the system but could be affected by some of the SOS alternatives include a variety of municipal, industrial, and miscellaneous groundwater uses located near the John Day

pool. SOSs 5, 6, 9a, 9c, and PA requiring drawdown of the John Day pool to elevation 257 feet (78.3 m), might necessitate the following responses to maintain these existing uses:

- Modifying groundwater wells affected by a lower groundwater table (additional discussion of groundwater effects can be found in Section 4.2.1),
- Extending the pipeline for the City of Umatilla's sewage treatment outfall,
- Dredging the Umatilla River to prevent blockage by sedimentation, and
- Covering a gas pipeline that would be exposed by the drawdown.

In addition to water withdrawals for municipal and industrial supplies, uses of the river system for wastewater discharge could be affected by some of the SOS alternatives. The SOR agencies have to date identified one such case, in which the Potlatch Corporation effluent discharge facility at Lewiston would need to be modified to accommodate drawdown of Lower Granite Reservoir (as in SOS 5, 6, or 9a).

Effects of Alternatives

Under SOSs 1, 2, and 4, there would be sufficient water in the system to satisfy current and expected future demands for water supply. Existing pumps and other facilities would continue to operate as they do currently, requiring routine maintenance and periodic replacement as components reach the end of their useful lives.

The reservoir drawdowns associated with SOSs 5, 6, 9a, 9c, and PA would increase average annual M&I pumping costs. Because the SOS options have different implementation dates, pumping costs were discounted to 1995, year 1 of the analysis. Two discount rates were used, 3 percent or the "real" interest rate, and 7.75 percent or the Federal discount rate. This approach was taken to better capture changes in

pumping cost relationships among SOSs. SOSs with a longer lead-time would experience a more significant change in pumping cost structure under a higher discount rate.

Average annual pumping costs would increase from \$3.3 million (SOS 5b) to \$4.5 million (SOS 5c) under a 3 percent discount rate, and \$2.1 million (SOS 5b) to \$4.6 million (SOS PA) under a 7.75 percent discount rate (Table 4-23). These costs include the amortized value of modifying pumping plants and other facilities as well as increased annual operating and maintenance costs. The costs associated with lowering the John Day pool account for over 80 percent of the total costs for each option. Figure 4-29 shows the incremental impacts, by SOS, on M&I water users.

4.2.16 Economics

Management of the Columbia River system has the potential to affect virtually every resident of the Pacific Northwest, and many people outside the area, both directly and indirectly. Commercial and sport fishing interests, irrigators, producers who ship cargo on the river, people who use the river for recreation, and recipients of the river's vast hydroelectric resources are among those who are directly affected by the way the system is managed. Others are indirectly affected, such as when an increase in shipping costs increases the cost to consumers who buy the shipped goods.

While all of these elements are affected by Columbia River system operations, satisfying the region's demand for power and the loss of recreation benefits dominate discussion of economic impacts for most of the SOS alternatives. Where alternatives reduce the amount of hydropower generation, the lost power must be replaced by other, more costly resources. Changes in the cost of operating the total Northwest power system account for more than half of the net change in measurable economic costs associated with SOSs 2d, 4c, 5c, 9a, 9b, 9c, and PA. Loss of recreation benefits make up a significant share of the increased cost

Table 4-23. Increased annual pumping cost—M&I Pumpers^{1/2/3/}

SOS	Pump Modification Required	Implementation Date	Annual Equivalent Value	
			@ 3% \$000	@ 7.75% \$000
1a	no	1995	0	0
1b	no	1995	0	0
2c	no	1995	0	0
2d	no	1995	0	0
4c	no	1995	0	0
5b	yes	2010	3,256.9	2,111.0
5c	yes	2000	4,520.1	4,483.8
6b	yes	2005	3,617.3	2,921.6
6d	yes	2000	4,126.2	4,100.5
9a	yes	2005	3,616.0	2,920.6
9b	no	1995	0	0
9c	yes	2005	3,662.5	2,957.8
PA	yes	1998	4,273.4	4,670.3

1/ See Appendix F, Exhibit A for derivation of increased pumping costs.

2/ Impacts on Grand Coulee M&I pumpers considered insignificant.

3/ Annual cost includes amortization of pump modification cost, plus increased operation, maintenance, and pumping power cost.

of SOSs 5, 6, 9, and PA. Reductions in anadromous fish benefits and increases in shallow-draft transportation costs are also large for some alternatives.

Only SOS 1 would have lower economic costs than the No Action Alternative, SOS 2c. Valued at a 3.0 percent discount rate, total annual system costs would be \$42.5 million lower than SOS 2c under SOS 1a, and \$79.9 million lower under SOS 1b. All other SOS alternatives would be more expensive. The net increase in costs compared to SOS 2c ranges from \$28.9 million annually under SOS 2d to \$399.5 million annually under SOS 9a. This summary of the economic analysis is based on

the methods and results reported in detail in Appendix O, Economic and Social Impacts.

Economic Impact Issues

The SOR Economic Analysis Group determined the economic impact of various operating strategies for eight elements: anadromous fish, irrigation, M&I water use, flood control, navigation and other water transportation, power, recreation, and construction activity associated with implementing each alternative. Not all of the values attributable to the Columbia River system are fully or accurately reflected in the economic

analysis reported here, however. Some reasons for this are:

- 1) There are limitations in the techniques available to apply certain economic theories, so that some values, such as the value people place on saving an endangered salmon species, are not counted in the analysis.
- 2) There were limitations of time and money associated with preparing the analysis. Simplifying assumptions were used to keep the analysis from becoming too detailed, and these simplifying assumptions obscure some of the changes that would take place. For example, even though more sophisticated methods are available for estimating the value of each recreation activity at each site, the analysis assumes a uniform average value for each type of recreation activity across the entire Columbia River system.
- 3) There are limitations to some of the models used in the analysis, and to the ways in

which the models were applied. For example, the flood damages analysis used results from a streamflow regulation model that predicts flooding based on average monthly flows. This tends to predict higher flows and stages than would actually occur. A model that made predictions based on average daily flows would provide a more accurate picture of expected flood damages because it would incorporate more finely tuned responses on the part of reservoir managers.

Despite these limitations, the SOR agencies believe that the analysis is sufficiently complete to be used in identifying the primary economic effects of the alternatives and differentiating among them.

The following descriptions indicate how the SOR agencies measured direct economic impacts in each area of interest, and how these results were applied to estimate indirect or regional economic impacts.

Anadromous Fish

The analysis of direct economic impacts to Pacific Northwest anadromous fisheries included four components: 1) the commercial ocean and in-river fisheries, 2) the commercial Indian fishery, 3) the ocean and lower Columbia River sport fisheries, and 4) the mid-Columbia and Snake River sport fisheries.

The direct economic impact of alternative system operations on commercial fishers is the change in net income. The change in income is a function of changes in the number of fish harvested, the expenditures to catch these fish, and the price received for the fish. The indirect impacts stem from the changes in expenditures for a

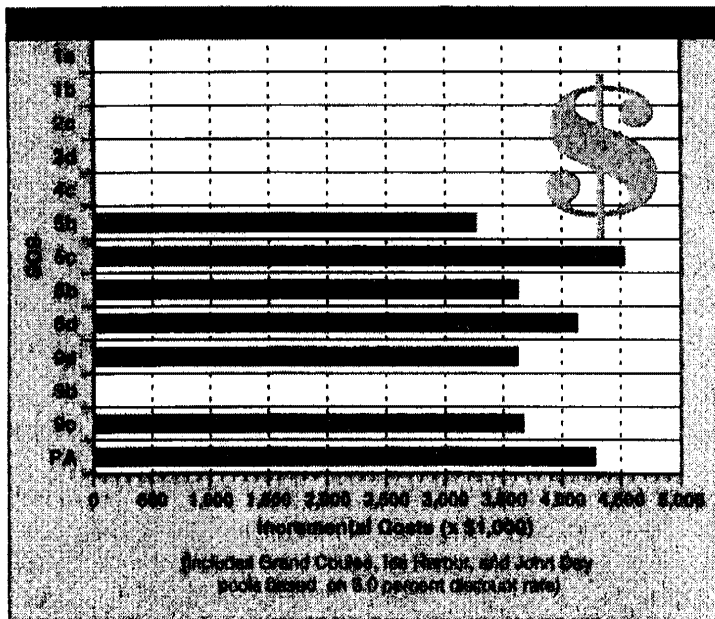


Figure 4-29. Combined incremental municipal and industrial water supply costs relative to SOS 2c

fishing operation and the change in net income retained by commercial operators.

The direct impacts of alternative system operations on recreational anglers are the change in angler days, the change in consumer surplus realized by anglers, and changes in expenditures made by anglers. The indirect impacts stem from the changes in expenditures.

Irrigation and Municipal and Industrial Water Use

Direct economic impacts to irrigators and M&I water users include two components: 1) pump or other facility modification costs, and 2) energy and other operating costs. Modifications to pumps and other facilities paid for by private owners would have a direct impact on the net income of the operation for which the facilities are required. In the case of irrigated agriculture, producers could withhold or delay investment in other farm activities in order to meet the modification expenses, or could borrow money. In either case, net farm incomes and farm household disposable income would decrease.

The indirect economic impacts associated with the annualized costs of the pump or facility modifications would depend in large part on whether these costs were paid by the public sector or by the facility owners. If the costs were paid by the public sector in the form of regional electric ratepayers, then the modification costs would likely be translated into higher electricity rates with a subsequent decline in individual household discretionary incomes in the region. If the costs were paid by the public simply as taxpayers, then any associated secondary impacts would be an increase in regional income.

Flood Control

Assessment of impacts on flood control is based on expected flood damages that would result from each SOS. Direct economic impacts are a function of the value of property at risk of

flooding and the predicted frequency and stage of flooding.

Navigation

Alternative Columbia River system operations could affect transportation of commodities, primarily by forcing shifts from barges to other transportation modes. Direct economic impacts of such shifts would include increased transportation costs, additional storage and handling costs, and incremental increases in capacity investments required to enable commodities diverted from the Columbia River system to reach their final destination. The added transportation costs are the direct impacts which drive the indirect impact analysis.

Some alternatives also affect other enterprises such as log transport on Dworshak Reservoir and small ferry systems. Direct economic impacts include changes in operating costs and revenues.

Power

The direct impacts of the SOS alternatives on the regional power system are measured as the cost of producing power to meet system demand, a concept that accounts for the change in resource mix required to meet anticipated regional loads. It includes the consumer-demand response to higher energy costs. Systems analysis and decision models were used to evaluate the direct power impacts of the SOSs.

Generally, the models evaluated the effects of the strategies on power supply, incremental energy costs, and consumer demand. The ability of the regional power system to supply both capacity and energy would be affected by the SOS. This would, in turn, modify the least-cost resource mix necessary to meet regional electricity demands. Changes to the resource mix resulting from a decrease in system hydropower generation would cause average wholesale power rates to increase. As power rates adjust upward, regional consumers would use less electricity. This would lead to continued rounds of adjustments to the resource

mix, electricity prices, and consumer demand until a supply-demand balance is achieved.

Potential wholesale rate changes are measured for the region's major power consumers, including public and private utilities and BPA's direct service customers (DSIs).

Recreation

Recreation activities affected by system operations include boating, waterskiing, windsurfing, sport fishing, swimming, hunting, wildlife viewing, camping, and picnicking. Potential direct economic impacts include changes in visitor use, and the consumer surplus associated with this use. Indirect impacts would stem from changes in expenditures made by visitors.

Construction Activities

Some of the SOS alternatives depend on future construction activities to modify projects and/or mitigate for the effects of the operations on the direct river users. Construction activities might include modification of irrigation pumping stations, additions to on-farm grain storage, improvements to boat ramps and moorages, dam modifications, and the development of new power stations. Expenditures for these construction activities would generate positive short-term indirect impacts in the regional economy. These effects are different from direct SOS economic impacts in that they could be expected to last only through the duration of the construction activity, perhaps a few months to a few years. The indirect effects associated with the SOS alternatives would continue along with the direct impacts, in many cases reflecting permanent changes in regional economic activity.

Indirect Economic Effects

Through their influence on river uses, river operations affect the demand for local goods and services and thereby the output levels in many related industries. Changes in operations would likely affect industry input requirements and the

distribution of regional output to local and export markets. Labor requirements could change, increasing or decreasing the availability of regional jobs. Personal income could rise or fall depending on the job impacts. The regional trade balance could shift as the availability of local commodities is affected by changes in production levels.

The most common indicators of these changes in regional economic activity, or indirect economic effects, are adjustments in regional employment and earnings. These are the measures from regional input-output models which best describe the change in the economic well-being for the local population. Employment is measured as the total number of jobs and includes both full-time and part-time workers. Earnings, or income, is measured as wage and salary income paid to employees plus income earned by business owners and sole-proprietorships. These indirect or regional economic impacts of the SOS alternatives were estimated using IMPLAN regional, state and sub-regional models.

Effects of Alternatives

Direct Economic Effects

Table 4-24 indicates, at a 3 percent discount rate for those elements that were analyzed, the difference in average annual costs and benefits associated with each SOS alternative compared to SOS 2c. Table 4-25 shows the same information calculated at a 7.75 percent discount rate.

Some elements are commonly defined as benefits, such as recreation and the commercial and recreational value of anadromous fish. For elements defined as benefits, the best alternatives are those with the highest positive dollar values (increases in benefits) or lowest negative values (reductions in benefits).

Other elements are commonly defined as costs, such as the cost of operating M&I water systems, the cost of transporting goods on the river, the cost of operating the power system,

Table 4-24. Direct economic impacts by alternative compared to SOS 2c, at 3.0 percent discount rate (\$1,000)^{a/}

SOS Alternative	Elements Defined as Benefits		Elements Defined as Costs							Total Annual System Cost
	Recreation Benefit	Anadromous Fish Comm/Rec Benefit ^{b/}	Irrigation Cost	M&I Water Cost	Shallow Draft Transportation Cost	Dworshak Reservoir Log Trucking Cost	Net System Generation Cost ^{c/}	Flood Damages Cost	Implementation Cost ^{d/}	
1a	4,691	(330)	9	0	0	(112)	(38,000)	0	0	(42,464)
1b	7,941	(180)	9	0	0	(120)	(72,000)	0	0	(79,872)
2c	0	0	0	0	0	0	0	0	0	0
2d	(5,015)	160	(3)	0	0	93	24,000	0	0	28,945
4c	4,171	160	(18)	0	0	(228)	85,000	444	0	80,867
5b	(66,280)	(6,370)	3,319	3,257	13,631	(51)	85,000	0	88,560	266,367
5c	(89,792)	(8,660)	4,540	4,520	37,534	(171)	167,000	0	24,600	336,475
6b	(49,057)	(11,120)	2,558	3,617	12,314	(120)	35,000	0	31,565	145,112
6d	(39,812)	(5,500)	1,375	4,126	2,146	(141)	17,000	0	7,760	77,577
9a	(96,871)	(16,710)	2,359	3,616	12,314	(42)	236,000	257	31,434	399,520
9b	(35,418)	(3,350)	5	0	0	173	213,000	27	0	251,974
9c	(37,925)	(11,490)	2,647	3,662	7,359	(5)	138,000	459	31,666	233,203
PA	(26,441)	50	1,537	4,273	(26)	120	126,000	223	5,922	164,440

a/ All costs and benefits are annual averages, in 1992 dollars, for the 100 years following implementation of each alternative.

b/ Value based on "high" values for fish and "optimistic" values for SOSs 6b, 6d, 9a, and 9c. Optimistic values reflect a 25% increase in FGE with drawdown.

c/ Net system generation cost reflects some reduction in consumer demand in response to higher electricity prices.

d/ Implementation costs are for dam modifications associated with SOSs 5, 6, 9a, 9c, and PA.

Table 4-25. Direct economic impacts by alternative compared to SOS 2c, at 7.75 percent discount rate (\$1,000)^{a/}

SOS Alternative	Elements Defined as Benefits		Elements Defined as Costs							Total Annual System Cost
	Recreation Benefit	Anadromous Fish Comm/Rec Benefit ^{b/}	Irrigation Cost	M&I Water Cost	Shallow Draft Transportation Cost	Dworshak Reservoir Log Trucking Cost	Net System Generation Cost ^{c/}	Flood Damages Cost	Implementation Cost ^{d/}	
1a	4,691	(330)	9	0	0	(112)	(36,000)	0	0	(40,464)
1b	7,941	(200)	9	0	0	(120)	(66,000)	0	0	(73,852)
2c	0	0	0	0	0	0	0	0	0	0
2d	(5,015)	170	(3)	0	0	93	24,000	0	0	28,935
4c	4,171	110	(18)	0	0	(228)	81,000	444	0	76,917
5b	(34,728)	(3,430)	2,094	2,111	6,966	(27)	44,000	0	154,462	247,764
5c	(72,284)	(7,030)	4,446	4,484	30,173	(138)	132,000	0	44,891	295,170
6b	(31,835)	(6,920)	2,026	2,922	7,945	(78)	23,000	0	56,793	131,363
6d	(32,049)	(4,760)	1,373	4,100	1,688	(114)	14,000	0	12,592	70,449
9a	(62,863)	(10,220)	1,865	2,921	7,945	(27)	153,000	257	56,611	295,655
9b	(35,418)	(2,990)	5	0	0	173	207,000	27	0	245,613
9c	(24,611)	(7,140)	2,098	2,958	4,730	(4)	90,000	459	56,915	188,907
PA	(23,211)	40	1,661	4,670	(169)	105	108,000	223	9,196	146,857

a/ All costs and benefits are annual averages, in 1992 dollars, for the 100 years following implementation of each alternative.

b/ Value based on "high" values for fish and "optimistic" values for SOSs 6b, 6d, 9a, and 9c. Optimistic values reflect a 25% increase in FGE with drawdown.

c/ Reflects some reduction in consumer demand in response to higher electricity prices.

d/ Implementation costs are for dam modifications associated with SOSs 5, 6, 9a, 9c, and PA.

and damages resulting from flooding. For elements defined as costs, the best alternatives are those with the highest negative values (reductions in costs) or lowest positive values (increases in costs).

Table 4-24 indicates that, compared to SOS 2c, the net annual system cost at a 3 percent discount rate ranges from a \$79.9 million lower cost associated with SOS 1b to a \$399.5 million higher cost under SOS 9a. Table 4-25 indicates a similar range when calculated at a 7.75 percent discount rate: from a \$73.9 million lower cost under SOS 1b to a \$295.7 million higher cost under SOS 9a. The Table 4-24 results are displayed graphically in Figure 4-30.

The cost of operating the power system is generally the largest element of any change. Even small percentage changes in the cost of generating electricity overwhelm many changes in the other elements.

For example, at a 3.0 percent discount rate, implementing SOS PA would increase average annual system generation costs by \$126.0 million compared to SOS 2c. The next largest economic impact would be on the benefits associated with recreation, which would be reduced by \$26.4 million annually. On the plus side, the economic benefit to commercial and sport fisheries associated with anadromous fish would equal only \$50,000 annually. In terms of aggregate measured economic impact, the power system cost clearly predominates.

System generation costs are not as dominant under SOS 5, where they account for 31 to 50 percent of the estimated net costs, or under SOS 6, where they account for 21 to 24 percent of the estimated net costs.

There are several factors that account for the difference:

- SOS 6 has a relatively small impact on system generation costs compared to the other alternatives.
- SOSs 5, 6, and 9 would substantially reduce recreation benefits and the commercial and recreational values of anadromous fish compared to most of the other alternatives. This is especially true of SOSs 5c and 9a for recreation and SOS 9a for anadromous fish. Drawing down the pools at several reservoirs would reduce sport fishing and other recreational uses.
- SOSs 5 and 6, particularly SOS 5c, would substantially increase transportation costs. Reservoir drawdowns would prevent use of the locks, requiring the use of more expensive transport modes.

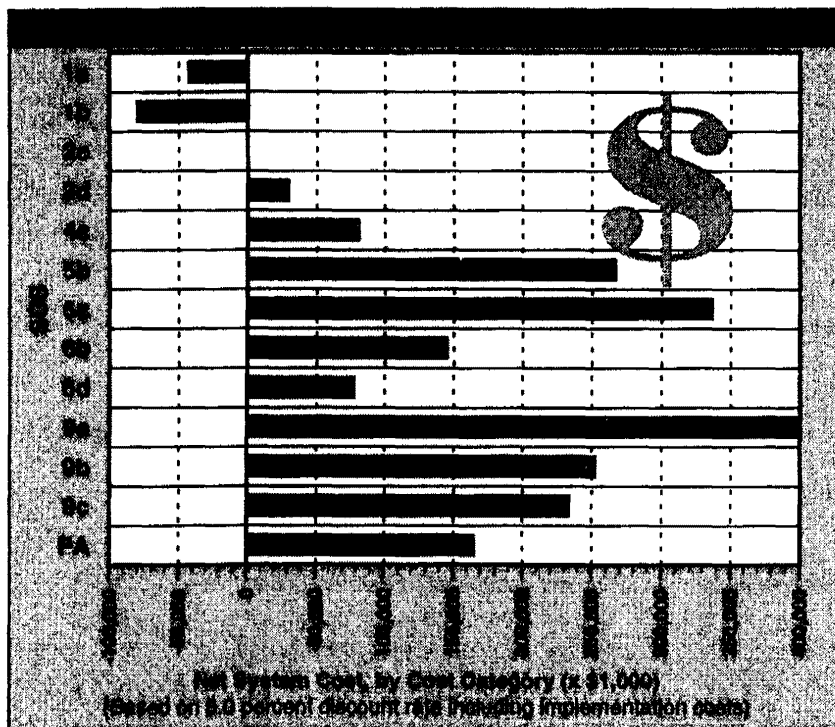


Figure 4-30. Aggregate net system operation costs relative to SOS 2c

- SOSs 5 and 6 would adversely affect irrigators and M&I water users. Drawing down the pools at Ice Harbor and John Day would cause irrigators and M&I water users to invest in new pumping equipment or to make other facility changes that would increase their costs.

SOSs 9a and 5c would increase net system costs by the greatest amount (\$399.5 million and \$336.5 million, respectively) relative to SOS 2c. Most of that effect would be accounted for by the increase in system generation costs, although losses in recreational benefits and the sport and commercial value of anadromous fish would also be substantial.

Indirect Economic Effects

Sections 4.11 and 5.5 of Appendix O, Economic and Social Impacts, provide a detailed assessment of projected indirect economic effects at the regional, state, and subregional levels. Given the scale of the region and the complexity of this multi-level analysis, the following discussion summarizes indirect economic impacts at the regional level for all resource categories. The reader is referred to Appendix O for information pertaining to specific resource types or individual states or subregions within the Pacific Northwest.

Regional economic impacts related to all resource activities likely to be affected by implementation of the SOSs were evaluated for the Pacific Northwest region using a set of IMPLAN regional analysis models. This analysis was conducted for all 13 of the SOSs, covering the entire range of the different operations reflected in the SOS alternatives. These impacts provide an indication of the net effect of the adjustments in river operations on regional employment and income.

Employment—The total employment impacts for the Pacific Northwest that are likely to result from the alternative river operations were estimated by modeling the employment influences of the direct economic effects reported previously in Section 4.2.16. Expected

changes in regional employment range from a net increase of over 2,000 jobs annually under SOS 1b to a loss of approximately 9,450 jobs annually under SOS 9a (see Table 4-26). SOS PA would result in a decrease in regional employment estimated at about 4,000 jobs. Only 2 of the 12 alternatives evaluated (SOSs 1a and 1b) would result in a net increase in regional employment. Virtually all of the job impacts would occur as a result of the power generation and cost aspects of the SOS alternatives. Under each of the SOS alternatives, Washington accounts for over one-half of the regional job impacts, ranging from a net increase of nearly 1,500 jobs with SOS 1b to a loss of nearly 6,600 jobs for SOS 9a. Employment impacts in Oregon ranged from a net increase of nearly 800 jobs under SOS 1b to a loss of over 3,300 jobs under SOS 9a. Net job impacts in Idaho and Montana are about one-half and one-fifth the levels measured for Oregon, respectively. Once again, the net effect of the SOS alternatives on state-level employment was dominated by the impact of the operations strategies on the regional power system.

Income—The effects of the SOS alternatives on Pacific Northwest regional income include the direct economic changes along with the indirect and induced changes that result from the interdependencies which exist throughout the regional economy. Expected changes in regional income range from a net increase of over \$56 million annually under SOS 1b to a loss of over \$260 million annually under SOS 9a. As with the employment impacts, all alternatives other than SOSs 1a and 1b would result in decreases in regional income. The model analysis indicated that SOS PA would decrease regional income by about \$113 million per year. The distribution of changes in regional income among the states is consistent with the distribution of the employment impacts, with Washington accounting for the largest share of the income impacts.

4.2.17 Social Impacts

Currently, uncertainty is the most significant social impact occurring throughout the Pacific

Table 4-26. Summary of regional employment impacts, compared to SOS 2c.

SOS	Andromous			Power	Recreation	Power Purchases	Total
	Fish	Irrigation	Navigation				
1a	-5	0	2	1,505	60	-526	1,036
1b	-6	0	2	3,016	63	-1,055	2,021
2d	0	0	-2	-886	0	310	-578
2c	0	0	0	0	0	0	0
4c	1	0	5	-3,443	42	1,204	-2,191
5b	-114	-434	158	-5,265	-281	1,841	-4,095
5c	-246	-437	94	-9,271	-318	2,693	-7,486
6b	-388	-347	-132	-1,854	-191	648	-2,264
6d	-144	-261	-26	-769	-153	269	-1,083
9a	-557	-335	-133	-12,509	-290	4,373	-9,451
9b	-82	0	-4	-8,519	-36	2,978	5,662
9c	-394	-356	-17	-7,317	-152	2,558	-5,678
PA	-6	-259	-2	-5,419	-237	1,895	-4,029

Northwest. Because the current operation of the Columbia River is subject to change and the future operation is unknown, individuals and economic entities are experiencing stress because they are unable to make decisions for their short- or long-term futures. It was pointed out during public meetings held in May 1994 on the *System Configuration Study and Lower Snake River Biological Drawdown Test Draft Environmental Impact Statement* at Lewiston, Idaho that economic investments are being withheld, which is affecting economic growth which in turn creates stress for individuals, families, and business interests. The stress of uncertainty will continue until decisions for the future operation of the Columbia River are made.

Overall changes in employment and income would be relatively minor from regional and sub-regional perspectives (see Appendix O, Section 5.6). SOSs 5b, 5c, 9a, 9b, 9c, and PA would have the largest impacts on regional employment and income. SOS 9a would have the largest impact, with regional job losses of 9,450 and a decrease in income of \$260 million. These changes are less than 0.25 percent of total regional employment and income.

The largest relative changes in employment and income would occur in mid-Columbia and lower Snake subregions. The largest net change in employment and income in the mid-Columbia subregion would occur with SOS PA, a loss of 1,040 jobs and a decrease in income of \$28 million (less than a 1 percent decrease in total subregional employment and income). The largest net change in employment and income in the lower Snake subregion would occur with SOS 5c, a loss of 3,800 jobs and a decrease in income of \$79 million (about 5 percent of total subregional employment and income).

Employment and income in the Mid-Columbia subregion focus communities of the Tri-Cities in Washington and the Umatilla/Morrow Counties area in Oregon would generally be positively affected by increases in grain transportation costs and negatively affected by increased pumping costs for irrigation and M&I water supplies, increased power costs, lower levels of anadromous fish harvest, and reduced levels of reservoir recreation activity. The communities are likely to experience relatively short-term positive increases in regional employment and income during the construction periods for project modifications and pump modifications of

irrigation and M&I water supplies. The construction activities associated with pump and project modifications would likely cause the greatest social impact to the Mid-Columbia focus communities. While providing an increase in employment, there would potentially be transitional impacts on local infrastructure and services resulting from the short-term influx of construction workers and their families.

The focus communities of Lewiston, Orofino, and the Nez Perce Reservation in Idaho and Clarkston, Washington, in the lower Snake subregion would experience negative employment and income changes associated with declining levels of anadromous fish harvest, increased grain transportation costs, increased power costs, declining levels of reservoir recreation activity. Decreases in navigation employment and income associated with the drawdown alternatives would occur in Lewiston/Clarkston. Orofino and the Nez Perce Reservation would be primarily affected by loss of employment associated with declines in recreation activity and anadromous fish harvests. All of the communities would be affected by increasing power costs. Lewiston and Clarkston would likely experience short-term increases in employment and income from the construction activities associated with pump and project modifications. Dam modification construction in this subregion would cause the greatest social impact in the Lewiston/Clarkston area. While providing an increase in construction-related employment, there would potentially be transitional impacts on local infrastructure and services resulting from the short-term influx of construction workers and their families.

The Upper Columbia subregion would be most affected by net changes in employment and income associated with SOS 9a, a loss of nearly 700 jobs and a decrease of \$18 million in regional income (approximately 0.5 percent of regional employment and income). These changes would be associated primarily with reductions in anadromous fish harvests, increased power costs, and lower levels of reservoir recreation activity. The region would experience positive changes to employment and

income due to declining costs for grain transportation. The focus communities of Grand Coulee/Coulee Dam and the Colville and Spokane Reservation in Washington would be primarily affected by reduced levels of recreation activity at Lake Roosevelt.

The focus communities of Astoria and Portland in the West Coast and Portland subregions, respectively, would be primarily affected by increasing regional power costs, although the impacts are not expected to be significant. Additional employment and income effects associated with declining anadromous fish harvests would also occur. In both subregions the expected impacts would be greatest with SOS 9a. Employment and income losses in the Portland subregion under this scenario would include 1,500 jobs and \$52 million (0.25 percent of regional employment and income). In the West Coast subregion employment losses under SOS 9a would reach nearly 1,025 jobs with associated income losses of \$26 million (approximately 0.75 percent of regional employment and income). In May 1994, the Pacific Coast area was declared an Economic Disaster Area because of the decline in the fishery. Employment and income impacts to the focus community of Astoria, Oregon, would be negative which would add to the decline.

The Northeast subregion would be most affected by the net changes in employment and income associated with SOS 9a, an annual loss of 1,125 jobs and an decline in income of \$28 million (0.5 percent of total subregion employment and income). Positive job and income effects would be associated with decreased costs for grain transportation while negative impacts would result from increased regional power costs. Minor declines would also be associated with some decrease in reservoir recreation. The focus communities of Libby, Flathead Lake, and the Flathead Reservation in Montana and Bonners Ferry and the Kootenai Reservation in Idaho would be primarily affected by increased regional power costs. The Montana communities would also be minimally affected by changing levels of recreation activities at Hungry Horse Reservoir.

While overall impacts are generally minor (with the exception of the potential impacts of dam modification construction), the individuals who lose jobs would be the most adversely affected group. Losing a job and having to look for another is very stressful to the individual and the family. Some individuals might have to leave their current location to obtain employment, which could mean an unwanted change in lifestyle.

4.3 SUMMARY COMPARISON OF SOS ALTERNATIVES

Section 4.3 is the "heart of the EIS" (as termed by CEQ [40 CFR 1502.14]) with respect to the SOS decision. It compares the environmental impacts of the SOS alternatives, defining the issues and providing a clear basis for choice among the options.

The text of Section 4.3 is based on Table 4-27, which is a master table comparing the key attributes of the SOS alternatives. The table presents selected value measures for each resource or subject area by alternative. The following discussion highlights key observations and conclusions from the table and the supporting analysis. Chapter 8 describes how the agencies have approached overall comparison and evaluation of the SOS alternatives and identification of a preferred alternative.

4.3.1 Summary of Effects by SOS

SOS 1—Pre-ESA Operation

Returning to river operations before they were modified by the 1990 Salmon Summit and the ESA to benefit anadromous fish would differ little from current operations except for power and recreation. SOS 1b would save \$72 million annually, compared to today, in system power generating costs. SOS 1a would save \$38 million. Both SOS 1 options could help to maintain or reduce today's wholesale power rates. Likewise, recreation would realize the greatest benefits under this operating strategy since recreation facilities were designed and built around traditional project operations. SOS 1b

would provide more recreation benefits than any other alternative, an increase in average annual benefits of \$7.9 million over today.

The effects of SOS 1 on anadromous fish would be much like existing conditions, although the study found this alternative had lower rates of successful juvenile passage and adults returning to spawn than most of the other alternatives. The analysis showed water temperature problems in the lower Snake River would occur in the summer, with temperatures exceeding the 63°F (17°C) value measure up to 79 days per year. The operations around the reservoirs that occur today, such as normal drafting for power generation, would continue with the same effects on resident fish, wildlife, erosion, aesthetics, cultural resources, and Indian trust assets. Navigation, irrigation, and M&I water supply uses would experience normal favorable conditions.

SOS 2—Current Operations

As might be expected, introducing flow improvements to benefit migrating anadromous fish diminishes the effectiveness of the system for traditional river uses. Both SOS 2 options would be more expensive than SOS 1 for power generation. This is because flow augmentation in the spring and summer requires storing water in the winter, a time when it would ordinarily be used to generate electricity. For anadromous fish, juvenile survival rates were studied for fish traveling in-river to the ocean and for fish transported under the Corps' Juvenile Fish Transportation Program. In the study, transportation emerged as the most important factor for juvenile fish survival over the next 5 to 10 years. Under SOS 2, the survival rates for juvenile passage and adult returns generally fell in the middle range of all the alternatives.

More frequent lowering of water levels in the storage projects than under SOS 1 would decrease the chance of refill, which would worsen conditions for resident fish and could reduce recreational use somewhat (1 percent less than SOS 1a). Because SOS 2d calls for additional water releases at Libby Dam to

Table 4-27. Environmental comparison of SOS alternatives—1

Resource/ Subject Area	SOS 1 Pre-ESA Operation	SOS 2 Current Operations	SOS 4 Stable Storage Project Operation
Earth	<ul style="list-style-type: none"> Continued moderate-to-severe erosion and mass wasting on storage project shorelines. Minor erosion and mass wasting on run-of-river project shorelines. Sediment accumulation in all reservoirs at historical rates; redistribution in storage reservoirs. Seasonal groundwater fluctuations near storage reservoirs; no known significant effects on wells. 	<ul style="list-style-type: none"> Continued moderate-to-severe erosion and mass wasting at storage reservoirs but at less than historical rates. Minor erosion and mass wasting at run-of-river projects, similar to historical conditions. Sedimentation patterns similar for historical patterns Groundwater fluctuations less than historical conditions with no net effects on water supply. 	<ul style="list-style-type: none"> Major decrease in erosion, mass wasting, and sedimentation at Libby and Hungry Horse. Slight decrease in erosion and mass wasting at Albeni Falls, Grand Coulee, and Dworshak. Groundwater fluctuations within historical limits except at Libby and Hungry Horse, where groundwater fluctuations would decrease moderately. Slight decrease in fluctuations near Albeni Falls, Grand Coulee, and Dworshak.
Water	<ul style="list-style-type: none"> 83 to 93 days per year with temperature exceeding 63°F at The Dalles, 66 to 79 days at Lower Granite, and 63 to 75 days at Priest Rapids. Up to 83 days per year exceeding 110 percent total dissolved gas (TDG) standard at Ice Harbor, 100 days at The Dalles. Sediment conditions similar to SOS 2. 	<ul style="list-style-type: none"> 83 to 94 days per year with temperature exceeding 63°F at The Dalles, 67 to 84 days at Lower Granite, and 67 to 77 days at Priest Rapids. Up to 61 days exceeding TDG standard at Ice Harbor (22 days less than SOS 1), 101 days at The Dalles. No exceedance of 25 mg/l silt level, no significant sediment transport. 	<ul style="list-style-type: none"> 83 to 90 days per year with temperature exceeding 63°F at The Dalles, 74 to 80 days at Lower Granite, and 64 to 70 days at Priest Rapids. Up to 61 days exceeding TDG standard at Ice Harbor (same as SOS 2), 92 days at The Dalles. Sediment conditions similar to SOS 2.

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4-27. Environmental comparison of SOS alternatives—1

SOS 5 Natural River Operation	SOS 6 Fixed Drawdown	SOS 9 Settlement Discussion Alternatives	SOS PA Preferred Alternative
<ul style="list-style-type: none"> • Minor increase in erosion, mass wasting, sedimentation, and groundwater fluctuation at Dworshak. Same as SOS 2c for other storage reservoirs. • Major increase in erosion, mass wasting, and water table lowering at the four lower Snake reservoirs (decreasing to background after 5 to 15 years for SOS 5c); also damage to embankments and shoreline structures. • Major increase in sedimentation at McNary. • Slight increase in erosion and mass wasting at John Day, with slight lowering of spring-summer water table. 	<ul style="list-style-type: none"> • Same as SOS 5 for storage projects. • Large increase in erosion, mass wasting, and sedimentation on the four lower Snake projects (SOS 6b) or Lower Granite only (SOS 6d), although only about 1/3 as much as SOS 5b. • Moderate decrease in water table during drawdown along the lower Snake reservoirs. • Moderate increase in sedimentation at McNary. Same as SOS 5b for John Day. Same as SOS 2 for other run-of-river projects. 	<ul style="list-style-type: none"> • Moderate decrease in erosion, mass wasting, and sedimentation at Libby and Hungry Horse (all options). • Moderate increase in erosion, mass wasting, and sedimentation at Dworshak (9a and 9b) and Brownlee (all SOSs). • Slight decrease in erosion, mass wasting, and sedimentation at Grand Coulee. • Major increase in mass wasting, erosion, sedimentation, and groundwater fluctuations on the four lower Snake River Projects (SOSs 9a and 9c). • Effects at John Day same as SOS 5 (SOSs 9a and 9c) or as under current operation (SOS 9b). 	<ul style="list-style-type: none"> • Moderate decrease in erosion, mass wasting, sedimentation, and groundwater fluctuations at Libby and Hungry Horse. Moderate increase in these effects at Dworshak. At John Day, temporary increase in erosion and mass wasting, and permanent lowering of water table near the reservoir. • All other projects would continue to experience conditions within historical ranges.
<ul style="list-style-type: none"> • 83 to 94 days per year with temperature exceeding 63°F at The Dalles, 58 to 76 days at Lower Granite, and 58 to 85 days at Priest Rapids. • Up to 2 days exceeding TDG standard at Ice Harbor (59 less than SOS 2), 83 days at The Dalles. • Maximum silt concentrations, exceeding 25 mg/l up to 36 percent of the time in the first year, 25 percent of time long-term. • Lead and DDT in sediments transported downstream to McNary, large increase in exceedance levels. • Prolonged reservoir bank erosion for SOS 5c would continually load lower Snake with sediments. 	<ul style="list-style-type: none"> • 83 to 93 days per year with temperature exceeding 63°F at The Dalles, 61 to 81 days at Lower Granite, and 67 to 72 days at Priest Rapids. • Up to 65 days exceeding TDG standard at Ice Harbor (4 more than SOS 2), 102 days at The Dalles. • Major sediment transport, but 1/4 to 2/3 of SOS 5b. Maximum concentrations exceed 25 mg/l 24 percent of time in first year, 5 percent long-term. • Lead and DDT in sediments transported elsewhere in lower Snake pools. 	<ul style="list-style-type: none"> • The worst SOS for water temperature. Consistently high number of exceedance days in the lower and mid-Columbia and Snake rivers. 87 to 95 days per year with temperature exceeding 63°F at The Dalles, 79 to 86 days at Lower Granite, and 71 to 80 days at Priest Rapids. • Overall worst SOS for gas supersaturation. Days exceeding 110 percent standard at Ice Harbor would be 91 more than No Action Alternative. At The Dalles there would be 82 more days. • SOS 9a and SOS 9c sediment transport would be similar to SOS 6b. SOS 9b would be similar to SOS 2. 	<ul style="list-style-type: none"> • Overall, SOS PA water temperatures are not significantly different from SOS 2. 87 to 92 days per year with temperature exceeding 63°F at The Dalles, 69 to 78 days at Lower Granite, and 67 to 77 days at Priest Rapids. • High exceedance of 110 percent gas saturation standard at The Dalles, up to 77 days more than SOS 2c, but about average in mid-Columbia and lower Snake. • Sediment transport similar to SOS 2.

1 KAF = 1.234 million cubic meters

1 MAF = 1.234 billion cubic meters

Table 4-27. Environmental comparison of SOS alternatives—2

Resource/ Subject Area	SOS 1	SOS 2	SOS 4
Air	<ul style="list-style-type: none"> • Dust emissions at Lower Granite (SOS 1a), Libby, and John Day could result in PM₁₀ concentrations greater than AAQS for fastest-mile winds at locations immediately adjacent to the emission source. • Lowest criteria and total air pollutant emissions from thermal power plants generating replacement electricity for the year 2004. 	<ul style="list-style-type: none"> • Dust emissions at Libby could result in PM₁₀ concentrations greater than AAQS for fastest-mile winds at locations immediately adjacent to the emission source. • Low dust emissions would result in small concentrations for all wind speeds at Lower Granite and John Day. • Lowest total air pollutant emissions from thermal power plants generating replacement electricity for the year 2004. 	<ul style="list-style-type: none"> • Dust emissions at Libby could result in PM₁₀ concentrations greater than AAQS for fastest-mile winds at locations immediately adjacent to the emission source. • Low emissions will result in small concentrations for all wind speeds at Lower Granite.
Anadromous Fish	<ul style="list-style-type: none"> • Relatively moderate passage survival and adult escapement for most salmon and steelhead, differences from existing conditions would be slight. 	<ul style="list-style-type: none"> • Similar juvenile in-river passage survival and adult escapement for most stocks, which represent existing conditions without transportation. Passage survival and adult escapement in the middle range of alternatives. • With transport, one of higher juvenile passage survivals (SOS 2d) for most transport hypotheses. 	<ul style="list-style-type: none"> • Nearly the same as existing conditions for juvenile in-river passage survival with transport, and adult production for most stocks.

1 kcs = 28 cms

1 ft = 0.3048 meter

Table 4-27. Environmental comparison of SOS alternatives—2

SOS 5	SOS 6	SOS 9	SOS PA
<ul style="list-style-type: none"> • Highest dust emission rates for the lower Snake reservoirs. • Dust emissions at Lower Granite and John Day could result in PM₁₀ concentrations greater than AAQS for maximum 1-hour wind speeds at locations immediately adjacent to the emission source. • Dust emissions at Libby could result in PM₁₀ concentrations greater than AAQS for fastest-mile winds at locations immediately adjacent to the emission source. • Contaminated sediments could result in airborne concentrations greater than ASILs for locations adjacent to source of sediments in drawdown reservoirs. • Highest criteria and total air pollutant emissions from thermal power plants generating replacement electricity for the year 2004. 	<ul style="list-style-type: none"> • Dust emissions at Lower Granite and John Day could result in PM₁₀ concentrations greater than AAQS for maximum 1-hour wind speeds at locations immediately adjacent to the emission source. • Dust emissions at Libby could result in PM₁₀ concentrations greater than AAQS for fastest-mile winds at locations immediately adjacent to the emission source. 	<ul style="list-style-type: none"> • Dust emissions at Lower Granite and John Day could result in PM₁₀ concentrations greater than AAQS for maximum 1-hour wind speed at locations immediately adjacent to the emission source for SOS 9a and 9c. • Dust emissions at Libby would result in PM₁₀ concentrations greater than AAQS for fastest-mile winds at locations immediately adjacent to the emission source. • Highest criteria and total air pollutant emissions from thermal power plants generating replacement electricity for the year 1996. 	<ul style="list-style-type: none"> • Low dust emissions would result in small concentrations for all wind speeds at Lower Granite and John Day. • Lowest criteria air pollutant emissions from thermal power plants generating replacement electricity for the year 2004.
<ul style="list-style-type: none"> • Highest modeled in-river passage survival for Snake River stocks. • With transport, depending on passage and transport model used, survival of Snake River spring and summer chinook—low to high; steelhead—medium; fall chinook—low. • Other salmon and steelhead stocks similar to existing conditions. • Based on one or two transport migrant models, adult production was considerably lower than existing conditions for all Snake River stocks except summer chinook, which was the highest of any alternative. • Drawdown first year would cause significant adverse effects to Snake River stocks, primarily rearing fall chinook, from high suspended sediment load and reduced food supply. Adverse effects would be reduced (5b) or eliminated (5c) in later years. 	<p>SOS 6b:</p> <ul style="list-style-type: none"> • Some of the higher or lower in-river passage survivals for Snake River stocks; other stocks' in-river survival similar to existing. • With transport, depending on hypotheses, usually one of lowest Snake River spring chinook passage survivals. Usually low passage survival for other Snake River stocks even with optimistic assumptions. Passage survival of Snake River spring and summer chinook is slightly higher without transport for one of the transport hypotheses. • Possible adverse effects on adult passage success on the Snake River, particularly for spring and summer chinook, from new untested adult passage facilities. 	<ul style="list-style-type: none"> • Some of the highest in-river survivals of the lower river Deschutes spring chinook, while similar to other SOS alternatives for Rock Creek steelhead survival. • Slightly higher in-river survival, particularly 9a, for the mid-Columbia stocks. Survival improved with transport (SOS 9b and 9c), but with slightly lower overall survival than most other alternatives for most transport models. • SOSs 9a and 9c similar to 6b for in-river effects, having in-river survival higher and lower than most SOSs depending on dam passage assumptions for Snake River stocks, except fall chinook under 9c, which was the lowest of any alternative. • SOS 9c had higher overall Snake River survival with transport, for most transport hypotheses, under optimistic dam passage conditions resulting in relatively high survival, while pessimistic passage assumptions resulted in low survival for all transport hypotheses. 	<ul style="list-style-type: none"> • Snake River in-river survival in the middle range of alternatives, similar to SOS 2. Transport resulted in significant improvement in survival, except one transport hypothesis which had survival similar to in-river. Among the highest alternatives for Snake River stocks for overall survival based on most transport hypotheses. • In-river survival of mid-Columbia and lower Columbia stocks similar to most other alternatives, in the mid-to-upper range for most stocks. Since transport does not occur for Wenatchee steelhead or Methow spring chinook with this alternative overall survival would be slightly less than alternatives with transport based on assumed transport survival. However, with transport, Methow summer and Hanford fall chinook have overall survival in the high range of all SOS alternative.

1 KAF = 1.234 million cubic meters

1 MAF = 1.234 billion cubic meters

Table 4-27. Environmental comparison of SOS alternatives—3

Resource/ Subject Area	SOS 1	SOS 2	SOS 4
---------------------------	-------	-------	-------

Anadromous
Fish
continued

**Resident
Fish**

- Variable conditions among reservoirs and species; some key populations declining.
- Production in run-of-river projects limited somewhat by pool fluctuations.
- Production in storage projects significantly limited by annual drafting, and by failure to refill in low-runoff years.

- Similar to SOS 1.
- Poorer conditions for Dworshak kokanee, bull trout, and smallmouth bass.
- Improved conditions for Kooacanusa kokanee.

- Best SOS overall for resident fish except Kootenai River sturgeon; conditions generally the same as or better than SOSs 1, 2, 5, 6 or PA.
- Improved conditions primarily at Lake Pend Oreille, Kooacanusa, Hungry Horse, and Dworshak.
- Moderately improved conditions for Kootenai River sturgeon through enhanced flow during spawning.

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4-27. Environmental comparison of SOS alternatives—3

SOS 5	SOS 6	SOS 9	SOS PA
<ul style="list-style-type: none"> • Possible adverse effects to other anadromous stocks including lamprey and American shad from reduced rearing habitat quality and quantity and from stranding, but overall population effects very small. • Benefits highly speculative due to experimental nature of 	<p>SOS 6d:</p> <ul style="list-style-type: none"> • Snake River spring and summer chinook and steelhead in-river passage survival higher or lower and fall similar to most other SOSs, depending on dam passage assumptions. • Snake River stock survival generally is much higher with transport than without for two of three transport hypotheses. For the third transport model, survival is only slightly lower than in-river survival for spring and summer chinook. <p>General:</p> <ul style="list-style-type: none"> • American shad passage possibly impeded, particularly with SOS 6b. • Increased suspended sediment and reduced rearing habitat could adversely affect rearing fall chinook, American shad and lamprey, particularly for 6b. • Benefits speculative due to experimental nature of actions, particularly for 6b. 	<ul style="list-style-type: none"> • SOS 9b has slightly higher in-river survival of Snake River spring and summer chinook, and lower survival for fall chinook and Dworshak steelhead than existing conditions. Inclusion of transport resulted in overall survival of Snake stocks being slightly lower than existing conditions except for fall chinook which is much lower. Overall survival generally improved with transport, except for one of three transport models, where values were slightly less than in-river survival (spring and summer chinook). • Adult production of Snake stocks was typically very low based on transport models, except for 9b which was moderately low relative to existing conditions. The two mid-Columbia stocks were also lower than most, particularly 9a, which has no transport. • General effects on American shad, lamprey, rearing fall chinook habitat from drawdown of 9a and 9c similar to 6b. • Benefits of 9a and 9c are speculative due to the experimental nature of these actions. 	<ul style="list-style-type: none"> • Adult production for all six stocks evaluated was in the upper range of all SOS alternatives, based on transport model survival hypotheses used.
<ul style="list-style-type: none"> • Generally poor in most areas; some reservoirs having improved conditions, particularly for SOS 5c. • Significantly worse conditions at lower Snake River Projects (5b only), and at John Day (SOSs 5b and 5c). • Improved conditions at Roosevelt and Dworshak (SOSs 5b and 5c) and the lower Snake River projects (SOS 5c). 	<ul style="list-style-type: none"> • Conditions generally the same as SOS 5, but not as severe. • Under SOSs 6b and 6d, conditions worse at Lower Granite and John Day. 	<ul style="list-style-type: none"> • SOS 9 contains some of the worst and best resident fish conditions of all SOSs, with all providing, at a minimum, acceptable flows for Kootenai River sturgeon • SOS 9a has some of the worst resident fish conditions in most areas, but best conditions for Kootenai River sturgeon, particularly poor resident fish conditions, occur in Kooconusa, Hungry Horse, Roosevelt, and John Day. • SOS 9b is generally good in many areas including Hungry Horse, Pend Oreille, Lower Granite, and John Day, but very poor for Brownlee and Dworshak. • SOS 9c has resident fish conditions both high and low; high quality conditions occurring in Kooconusa and Hungry Horse and very good conditions for Kootenai sturgeon; poor conditions occur in Brownlee and lower Snake River region. 	<ul style="list-style-type: none"> • Overall conditions are better than many other alternatives for resident fish under SOS PA. • Resident fish conditions are slightly better in Lake Roosevelt, Lower Granite, and other lower Snake projects; substantial improvements for Kootenai River sturgeon and John Day. • Conditions somewhat worse in some areas, primarily Dworshak.

1 KAF = 1.234 million cubic meters

1 MAF = 1.234 billion cubic meters

Table 4-27. Environmental comparison of SOS alternatives—4

Resource/ Subject Area	SOS 1	SOS 2	SOS 4
Wildlife	<ul style="list-style-type: none"> • Wildlife resources largely unchanged from current conditions. Downward trends might continue. 	<ul style="list-style-type: none"> • Long-term downward trend of wildlife resources. • Productivity of nesting waterfowl at John Day slightly reduced as a result of lowered water levels compared to historical levels. 	<ul style="list-style-type: none"> • Greatest systemwide wildlife benefits provided. • More than 1,100 acres of shoreline at Lake Pend Oreille suitable for reestablishment of marsh and riparian habitat exposed. • Wildlife populations moderately increase over existing conditions at Libby and Hungry Horse. • SOS 4c would reduce spring drawdown at Grand Coulee and increase wetland habitat for most categories of wildlife. • Higher February and March pools at Brownlee would decrease landbridging of islands used for nesting by Canada geese and colonial nesting birds.
Cultural Resources	<ul style="list-style-type: none"> • Ongoing shoreline erosion and exposure of archaeological sites, largely at the same rate as current conditions. Some additional erosion and bank sloughing due to hydro-power operations under SOS 1b may occur. 	<ul style="list-style-type: none"> • Ongoing shoreline erosion and exposure of archaeological sites largely at the same rate as current conditions. Increase in bank sloughing due to flow augmentation may affect archaeological sites under SOS 2d. 	<ul style="list-style-type: none"> • Very high rates of shoreline erosion at archaeological sites in storage reservoirs, particularly Albeni Falls. Concomitant decrease in exposure of archaeological sites to vandalism and erosion due to higher pools at these reservoirs.
Native Americans	<ul style="list-style-type: none"> • Continued shoreline erosion and mass wasting of lands used for hunting and gathering. • Reduced salmon populations jeopardize treaty fish rights. • Limited ability of Federal government to meet trust responsibilities because of diminished resident and anadromous fish populations. • Diminished traditional Indian way of life dependent on salmon and seasonal round. 	<ul style="list-style-type: none"> • Similar to SOS 1 except for improved salmon survival. 	<ul style="list-style-type: none"> • Improved conditions for resident fish and wildlife trust assets at most storage projects. • Possible negative impacts on wildlife at Grand Coulee, Hanford Reach, and lower Clearwater River. • Conditions for salmon same as SOS 2, continuing decline of populations and further jeopardizing treaty rights. • Continued erosion and mass wasting of traditional-use areas.

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4-27. Environmental comparison of SOS alternatives—4

SOS 5	SOS 6	SOS 9	SOS PA
<ul style="list-style-type: none"> • Greatest loss of wildlife resources at Lower Snake and John Day projects of all SOSs. • Desiccation of submerged aquatic vegetation and mud-dwelling animals, and increased reconnection of submerged islands to the shore. • Greatest decline in waterfowl, shorebirds, aquatic furbearers, and all other categories of wildlife are expected. • Lowering of John Day reservoir would totally dry up existing marsh and riparian habitat, eliminating breeding activity of existing waterfowl and colonial nesting bird populations and significantly reducing reptile and other categories of wildlife. • SOS 5c would restore natural river flows to the four lower Snake projects and allow for long-term restoration of wetland and riparian habitat desiccated at time of initial drawdown. 	<ul style="list-style-type: none"> • SOS 6b same as SOS 5b. SOS 6d same as SOS 6b except adverse effects at lower Snake projects would be limited to Lower Granite. 	<ul style="list-style-type: none"> • SOS 9a would desiccate wetland, riparian, backwater and pond habitats at John Day with large reductions in waterfowl, colonial nesting birds, non-game birds, aquatic furbearers, reptiles and other wildlife; decreased numbers of colonial nesting birds and other wildlife at Libby, Hungry Horse and Brownlee; increased wetland and wildlife at Albeni Falls. • SOS 9b would provide benefits to wildlife similar to SOS 4, but no improvement for wildlife at Libby or Hungry Horse. • SOS 9c would desiccate habitat at John Day similar to SOS 9a; increased wetland at Libby and Hungry Horse; loss of emergent wetland at lower Snake projects 	<ul style="list-style-type: none"> • Would desiccate wetland, riparian, backwater and pond habitats at John Day, similar to SOS 5b, with large reductions in waterfowl, colonial nesting birds, non-game birds, aquatic furbearers, reptiles and other wildlife; relatively stable water levels at John Day would provide opportunity for restoring some if not all lost habitat, over long term; reduction in numbers of waterfowl, colonial nesting birds, nongame birds and amphibians at Grand Coulee; possible adverse effects on shorebirds and cobble habitat at Hanford Reach, but benefits waterfowl and colonial nesting birds.
<ul style="list-style-type: none"> • Dramatic increase in the amount of time that archaeological sites are exposed in a drawdown zone at the lower Snake River projects because of drawdowns to natural river level. Less shoreline erosion would take place at these projects. Permanent drawdowns under SOS 5c, however, would restore access to more than 200 archaeological sites and would lead to protective revegetation. 	<ul style="list-style-type: none"> • Exposure of archaeological sites in the drawdown zone would increase at the lower Snake projects, but not as dramatically as with SOS 5. Only Lower Granite would be affected under SOS 6d. There would be a corresponding small improvement in rate of shoreline erosion impact at these reservoirs. 	<ul style="list-style-type: none"> • Damage to archaeological sites due to both shoreline erosion and exposure of archaeological sites in the drawdown zones would increase. There would be increased bank sloughing due to flow augmentation under SOSs 9a and 9b. Site exposure would increase at the lower Snake projects under SOSs 9a and 9c, at Libby, Grand Coulee, and Hungry Horse under SOS 9a, and at Dworshak under SOS 9b due to drawdowns. 	<ul style="list-style-type: none"> • Ongoing shoreline erosion and exposure of archaeological sites would change little overall from current conditions. Exposure of archaeological sites in the drawdown zone would increase at Dworshak and John Day. The amount of time shoreline waves could affect John Day sites would decrease.
<ul style="list-style-type: none"> • Improved survival of anadromous fish, benefiting treaty right. • Damage to most other Indian resource interests: resident fish, wildlife, destabilization of traditional-use areas, at least in the short term. • Overall benefit to cultural and traditional-use sites with long-term recovery under SOS 5c. 	<ul style="list-style-type: none"> • Similar to SOS 5 except effects limited to Lower Granite under SOS 6d. 	<ul style="list-style-type: none"> • Positive effects on anadromous fish trust assets compared to SOS 2. • Varied impacts on wildlife and vegetation from reservoir to reservoir. • Desiccation of riparian vegetation and erosion of traditional-use sites in lower Snake River and John Day drawdown zones under SOS 9a or 9c. 	<ul style="list-style-type: none"> • Improved migration conditions for anadromous fish, benefiting recovery and treaty rights. • Reduced wetland vegetation and wildlife habitat at Grand Coulee, Hanford Reach, and lower Clearwater River. • Some adverse impacts on resident fish trust assets at storage reservoirs.

1 KAF = 1.234 million cubic meters

1 MAF = 1.234 billion cubic meters

Table 4-27. Environmental comparison of SOS alternatives—5

Resource/ Subject Area	SOS 1	SOS 2	SOS 4
Aesthetics	<ul style="list-style-type: none"> Minimal shoreline exposure at run-of-river projects. Late winter, early spring drawdowns expose significant amounts of shoreline at storage projects. 	<ul style="list-style-type: none"> Minimal shoreline exposure at run-of-river projects. Late winter, early spring drawdowns expose significant amounts of shoreline at storage projects; slight decrease compared to SOS 1. 	<ul style="list-style-type: none"> Minimum shoreline exposure at run-of-river projects. Best SOS for aesthetic quality of storage projects.
Recreation	<ul style="list-style-type: none"> Total systemwide visitation: SOS 1a—18,267,700, SOS 1b—18,305,600. McNary, Bonneville, and John Day estimated to each receive between 2.7 and 3.2 million recreation days. The Dalles, Lower Granite, Grand Coulee, and Lake Pend Oreille estimated to each receive between 1.2 and 1.6 million recreation days. Ice Harbor, Libby, Hungry Horse, Little Goose, Lower Monumental, Dworshak, and Clearwater River estimated to receive between 109,000 and 525,000 recreation days. The Snake River, Hells Canyon, the Canadian Columbia River, Chief Joseph, and the Kootenai River expected to receive between 34,000 and 48,000 recreation days. Systemwide visitation up to 262,000 recreation days or 1.5 percent (SOS 1b) more than SOS 2c. Annual benefit increase of \$4.7 million (SOS 1a) to \$7.9 million (SOS 1b) compared to SOS 2c, using a 3 percent discount rate. 	<ul style="list-style-type: none"> Total systemwide visitation: SOS 2c—18,043,600, SOS 2d—18,057,300. McNary, Bonneville, and John Day estimated to each receive between 2.6 and 3.2 million recreation days. The Dalles, Lower Granite, Grand Coulee, and Lake Pend Oreille estimated to each receive between 1.2 and 1.7 million recreation days. Ice Harbor, Libby, Hungry Horse, Dworshak, Clearwater River, Little Goose, and Lower Monumental estimated to receive between 129,000 and 607,000 recreation days. Kootenai River, Columbia River in Canada, Chief Joseph, Snake River, and Hells Canyon expected to receive between 35,000 and 48,000 recreation days. Systemwide visitation up to 225,000 recreation days (1.2 percent) less than under typical historic conditions (SOS 1a). Annual average benefit reduction of \$5.0 million (SOS 2d) compared to SOS 2c, using a 3 percent discount rate. 	<ul style="list-style-type: none"> Total systemwide visitation: SOS 4c—18,236,300. Generally, slight increase in visitation at storage reservoirs, except Lake Pend Oreille and Clearwater River. Slight decrease in visitation at Little Goose. Systemwide visitation up to 193,000 recreation days or 1.0 percent more than SOS 2c. Annual benefits increase by \$4.2 million compared to SOS 2c, using a 3 percent discount rate.

1 kcf = 28 cms

1 ft = 0.3048 meter

Table 4-27. Environmental comparison of SOS alternatives—5

SOS 5	SOS 6	SOS 9	SOS PA
<ul style="list-style-type: none"> • Significant amount of exposed shoreline at lower Snake and John Day projects for 4-1/2 months (SOS 5b) or permanent natural river operation (SOS 5c). SOS 5b worst for aesthetic quality at Snake and Columbia run-of-river projects. Possible long-term aesthetic recovery on lower Snake under SOS 5c. • No or minor aesthetic impacts to other run-of-river projects. • No incremental aesthetic impacts to storage projects. 	<ul style="list-style-type: none"> • Significant amount of exposed shoreline at lower Snake River projects under SOS 6b (less than SOS 5), or only at Lower Granite under SOS 6d. • Similar to SOS 5 for other run-of-river (including John Day) and storage projects. 	<ul style="list-style-type: none"> • Significant shoreline exposure at lower Snake River projects and John Day under SOSs 9a and 9c, similar to SOS 6. • Minimal shoreline exposure at run-of-river projects under SOS 9b. • SOS9a would have greatest shoreline exposure among all SOSs for Libby, Hungry Horse, and Grand Coulee. • Greatest shoreline exposure at Dworshak under SOS 9b; exposure at other storage projects under SOS 9b same as or less than SOS 2c. • For SOS 9c, shoreline exposure at storage reservoirs same as SOS 4c, except for large increase at Dworshak. 	<ul style="list-style-type: none"> • Permanent significant shoreline exposure at John Day. • Minimal shoreline exposure at other run-of-river projects. • Shoreline exposure at Libby, Albeni Falls, and Grand Coulee comparable to SOS 2c. • Significant increase in shoreline exposure at Dworshak, comparable to SOS 9c. • Significant decrease in shoreline exposure at Hungry Horse, similar to SOSs 4c, 9b, and 9c.
<ul style="list-style-type: none"> • Total systemwide visitation: SOS 5b—16,221,500, SOS 5c—15,970,600. • Significant decrease in visitation at lower Snake projects and John Day. • Systemwide visitation as much as 2,073,000 recreation days or 11.5 percent (SOS 5c) less than SOS 2c. • Annual benefits decrease by as much as \$89.8 million (SOS 5c) compared to SOS 2c, using a 3 percent discount rate. 	<ul style="list-style-type: none"> • Total systemwide visitation: SOS 6b—16,886,400, SOS 6d—17,182,900. • Significant decrease in visitation at lower Snake projects and John Day. • Systemwide visitation up to 1,157,000 recreation days or 6.4 percent (SOS 6b) less than SOS 2c. • Annual benefits decrease by as much as \$49.1 million (SOS 6b) compared to SOS 2c, using a 3 percent discount rate. 	<ul style="list-style-type: none"> • Total systemwide visitation: SOS 9a—15,986,400, SOS 9b—17,631,000, SOS 9c—17,152,800. • SOS 9a and 9c similar to SOS 6b, with significant decrease in visitation at lower Snake projects and John Day. • SOS 9b similar to SOS 2c for run-of-river projects, but with decrease in visitation at storage projects, except for Hungry Horse. • Systemwide visitation up to 2,057,600 days or 11.4 percent (SOS 9a) less than SOS 2c. • Annual benefits decrease by \$37.9 million (SOS 9c) to \$96.9 million (SOS 9a), using a 3 percent discount rate. 	<ul style="list-style-type: none"> • Total systemwide visitation: 16,929,200. • Significant increase in visitation at Clearwater River, slight increase at Lake Pend Oreille, Lower Granite, and Hungry Horse. • Significant decrease in visitation at Kootenai River, Dworshak, John Day; slight to moderate decrease at Libby and Grand Coulee. • Systemwide visitation: 1,114,000 days or 6.2 percent less than SOS 2c. • Annual benefits decrease by \$26.4 million, using a 3 percent discount rate.

1 KAF = 1.234 million cubic meters

1 MAF = 1.234 billion cubic meters

Table 4-27. Environmental comparison of SOS alternatives—6

Resource/ Subject Area	SOS 1	SOS 2	SOS 4
Flood Control	<ul style="list-style-type: none"> • Flooding risk in lower Columbia reach unchanged from current conditions. • Upper Columbia region accounts for virtually all flood damages. • Expected average annual flood damages under SOS 1a or 1b the same as with SOS 2c. 	<ul style="list-style-type: none"> • Flooding risk in lower Columbia reach unchanged from current conditions. • Upper Columbia region accounts for virtually all flood damages. • Expected average annual flood damages under SOS 2d the same as with SOS 2c. 	<ul style="list-style-type: none"> • Upper Columbia region accounts for virtually all flood damages. • With many reservoirs kept full later in the season, an increase in flood risk would occur in most upper Columbia and Clearwater reaches. • Higher flood risks at Columbia Falls compared to SOS 2c. • Flooding in lower Columbia reach unchanged from current conditions. • Average annual flood damages \$0.4 million more than SOS 2c and among highest of all SOSs, using a 3 percent discount rate.
Navigation	<ul style="list-style-type: none"> • Normal conditions for deep-draft navigation on Columbia River and shallow-draft navigation on Columbia-Snake Inland Waterway. • Annual shallow-draft navigation costs average the same as under SOS 2c. • Improved conditions for Dworshak log transport; annual transport costs average \$0.1 million less than under SOS 2c, using a 3 percent discount rate. • Total net annual navigation costs about \$0.1 million less than SOS 2c, using a 3 percent discount rate. • Normal conditions for Lake Roosevelt ferry operations 	<ul style="list-style-type: none"> • Normal conditions for deep-draft and shallow-draft navigation for SOS 2c. • Annual shallow-draft navigation costs average the same under SOSs 2c and 2d. • Shorter operating season for Dworshak log transport; annual transport costs average \$0.1 million more (SOS 2d) than under SOS 2c, using a 3 percent discount rate. 	<ul style="list-style-type: none"> • Normal conditions for deep-draft and shallow-draft navigation. • Annual shallow-draft navigation costs average the same as under SOS 2c. • Improved operating conditions for Dworshak log transport under SOS 4c; annual transport costs average \$0.2 million less than SOS 2c. • Total net annual navigation costs about \$0.2 million less than SOS 2c, using a 3 percent discount rate. • Normal conditions for Lake Roosevelt ferry operations.

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4-27. Environmental comparison of SOS alternatives—6

SOS 5	SOS 6	SOS 9	SOS PA
<ul style="list-style-type: none"> • Flood risk in all areas similar to SOS 2c; upper Columbia region accounts for virtually all flood damages. • Expected average annual flood damages the same as with SOS 2c. 	<ul style="list-style-type: none"> • Flood risk in all areas similar to SOS 2c; upper Columbia region accounts for virtually all flood damages. • Expected average annual flood damages the same as with SOS 2c. 	<ul style="list-style-type: none"> • Flood risk in lower Columbia and Clearwater areas unchanged from current conditions. • Upper Columbia regions account for virtually all flood damages. • Average annual flood damages range from just over \$27,000 more than SOS 2c (SOS 9b) to nearly \$0.5 million more than SOS 2c (SOS 9c), using a 3 percent discount rate. 	<ul style="list-style-type: none"> • Flood risk in lower Columbia and Clearwater areas unchanged from current conditions. • Upper Columbia regions account for virtually all flood damages. • Average annual flood damages \$0.2 million more than SOS 2c, using a 3 percent discount rate.
<ul style="list-style-type: none"> • No shallow-draft navigation on lower Snake for about 6 months (SOS 5b) or permanently (SOS 5c). • Annual shallow-draft navigation costs average \$13.6 million (SOS 5b) to \$37.5 million (SOS 5c) more than under SOS 2c. • Improved Dworshak log transport conditions; annual transport costs average up to \$0.2 million less than for SOS 2c. • No impacts to deep-draft navigation or Lake Roosevelt ferries. • Total net annual navigation costs \$13.6 million (SOS 5b) to \$37.4 million (SOS 5c) more than SOS 2c, using 3 percent discount rate. 	<ul style="list-style-type: none"> • No shallow-draft navigation on lower Snake for 6 months (SOS 6b), or on Lower Granite only for 6 months (SOS 6d). • Annual shallow-draft navigation costs \$2.1 million (SOS 6d) to \$12.3 million (SOS 6b) more than under SOS 2c. • Dworshak annual log transport costs average \$0.1 million less than SOS 2c. • No impacts to deep-draft navigation or Lake Roosevelt ferries. • Total net annual navigation costs \$2.0 million (SOS 6d) to \$12.2 million (SOS 6b) more than SOS 2c. 	<ul style="list-style-type: none"> • No shallow-draft navigation on lower Snake for 6 months (SOS 9a) or 3 months (SOS 9c); probable delays at locks under SOS 9b. • Annual shallow-draft navigation costs range from the same as SOS 2c (SOS 9b) to \$12.3 million more than SOS 2c (SOS 9a). • Slightly improved conditions for Dworshak log transport under SOS 9a, 9c; worse conditions for SOS 9b. • Compared to SOS 2c, annual log transport costs about the same for SOS 9a, 9c, \$0.2 million more for SOS 9b. • No impacts to deep-draft navigation. • Slight impacts to Gifford ferry under SOS 9b, 9c. • Total net annual navigation costs \$0.2 million (SOS 9b), \$7.4 million (SOS 9b) or \$12.3 million (SOS 9a) more than SOS 2c, using a 3 percent discount rate. 	<ul style="list-style-type: none"> • Normal conditions for deep-draft and shallow-draft navigation. • Annual shallow-draft navigation costs nearly the same as SOS 2c. • Shorter operating season for Dworshak log transport, annual costs average \$0.1 million more than under SOS 2c. • No impacts to deep-draft navigation or Lake Roosevelt ferries. • Total net annual navigation costs \$0.1 million more than SOS 2c.

1 KAF = 1.234 million cubic meters

1 MAF = 1.234 billion cubic meters

Table 4-27. Environmental comparison of SOS alternatives—7

Resource/ Subject Area	SOS 1	SOS 2	SOS 4
Power	<ul style="list-style-type: none"> • SOS 1b is the least expensive alternative for satisfying regional energy needs. • Energy production would be at its highest and load-shaping capability would be maximized. • Annual system generation costs (at 3 percent discount rate) \$72 million (SOS 1b) to \$38 million (SOS 1a) less than SOS 2c. • Wholesale rates comparable to today's level. 	<ul style="list-style-type: none"> • Flow augmentation in the spring and summer slightly reduces system efficiency compared to SOS 1b. • Annual system generation cost (at 3 percent discount rate) \$24 million higher under SOS 2d compared to SOS 2c. • Wholesale rates at today's level. 	<ul style="list-style-type: none"> • Stable storage project operation would slightly reduce average annual generation compared to SOS 2c and enlarge the mismatch between flows and generation needs. • Annual system generation costs \$85 million (at 3 percent discount rate) more than SOS 2c. • Wholesale rates comparable to today's level.
Irrigation	<ul style="list-style-type: none"> • All irrigation needs served; irrigators incur routine expenses to operate and maintain pumps. • Minor increase in annual pumping costs at Grand Coulee, compared to SOS 2c (\$9,000). 	<ul style="list-style-type: none"> • All irrigation needs served; irrigators incur routine expenses to operate and maintain pumps. • Under SOS 2d, irrigators would experience minor savings in annual pumping costs at Grand Coulee, compared to SOS 2c (\$3,300). 	<ul style="list-style-type: none"> • All irrigation needs served; irrigators incur routine expenses to operate and maintain pumps. • Minor savings in annual pumping costs at Grand Coulee (\$18,400).

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4-27. Environmental comparison of SOS alternatives—7

SOS 5	SOS 6	SOS 9	SOS PA
<ul style="list-style-type: none"> • Natural river operation would eliminate the system's load-shaping capability and reduce average annual energy by taking turbines out of service. • Annual system generation costs (at 3 percent discount rate) for SOS 5b and SOS 5c about \$85 million and \$167 million, respectively, more than SOS 2c. • Wholesale rates comparable to today's level. 	<ul style="list-style-type: none"> • Generation effects similar to SOS 5, particularly under SOS 6b. • Annual system generation costs (at 3 percent discount rate) for SOS 6d and SOS 6b about \$17 million and \$35 million, respectively, more than SOS 2c. • Wholesale rates comparable to today's level. 	<ul style="list-style-type: none"> • Drawdown (with SOS 9a or 9c) and large amounts of spill would reduce average annual hydropower generation compared to SOS 2c). • Annual system generation costs (at 3 percent discount rate), \$138 million (SOS 9c), \$236 million (SOS 9a), and \$213 million (SOS 9b) more than SOS 2c. • Wholesale rates comparable to today's level. 	<ul style="list-style-type: none"> • Increased water storage in fall and winter and increased spill during spring and summer would mismatch flow and generation needs. Average annual hydropower generation would fall compared to SOS 2c. • Annual system generation costs (at 3 percent discount rate) about \$126 million more than SOS 2c. • Wholesale rates comparable to today's level.
<ul style="list-style-type: none"> • Drawdowns at Ice Harbor and John Day require irrigators to modify pumps and increase operating expenses. • Annual irrigation pumping costs at Ice Harbor increase by \$2.3 million (SOS 5b) or \$3.2 million (SOS 5c) compared to SOS 2c using a 3 percent discount rate. • Annual irrigation pumping costs at John Day increase by \$1.0 million (SOS 5b) or \$1.4 million (SOS 5c) compared to SOS 2c, using a 3 percent discount rate. 	<ul style="list-style-type: none"> • Drawdown at Ice Harbor (SOS 6b) and John Day (SOS 6b and 6d) would require irrigators to modify pumps and increase operating expenses. • Annual irrigation pumping costs at Ice Harbor increase by \$1.4 million (SOS 6b) compared to SOS 2c, using a 3 percent discount rate. • Annual irrigation pumping costs at John Day increase by \$1.2 million (SOS 6b) and \$1.4 million (SOS 6d) compared to SOS 2c, using a 3 percent discount rate. 	<ul style="list-style-type: none"> • Irrigators incur a minor increase in pumping costs at Grand Coulee, ranging from \$5,400 (SOS 9b) to \$34,900 (SOS 9a), using a 3 percent discount rate. • Under SOS 9b, all Ice Harbor and John Day irrigators' needs are served; irrigators incur routine expenses to operate and maintain pumps. • Under SOSs 9a and 9c, drawdowns at Ice Harbor and John Day require irrigators to modify pumps and increase operating expenses. • Annual irrigation pumping costs at Ice Harbor increase by \$1.4 million (SOSs 9a and 9c) compared to SOS 2c, using a 3 percent discount rate. • Annual irrigation pumping costs at John Day increase by \$0.9 million (SOS 9a) or \$1.2 million (SOS 9c) compared to SOS 2c, using a 3 percent discount rate. 	<ul style="list-style-type: none"> • Minor savings in pumping costs at Grand Coulee (\$2,800). • No change in pumping costs or conditions at Ice Harbor, compared to SOS 2c. • Year-round drawdown at John Day would result in a \$1.5 million increase in irrigation pumping costs compared to SOS 2c, using a 3 percent discount rate.
1 KAF = 1.234 million cubic meters		1 MAF = 1.234 billion cubic meters	

Table 4-27. Environmental comparison of SOS alternatives—8

Resource/ Subject Area	SOS 1	SOS 2	SOS 4
Municipal and Industrial Water Supply	<ul style="list-style-type: none"> • Pumps and other facilities continue to operate, requiring routine maintenance. 	<ul style="list-style-type: none"> • Pumps and other facilities continue to operate, requiring routine maintenance. 	<ul style="list-style-type: none"> • Pumps and other facilities continue to operate, requiring routine maintenance.
Economics	<ul style="list-style-type: none"> • Most efficient SOS, from national economic development (NED) perspective. • Balance of total annual system costs from all measurable resources \$42.5 million (SOS 1a) to \$79.9 million (SOS 1b) less than SOS 2c, using a 3 percent discount rate. • Regional employment 2,000 jobs more than under SOS 2c, regional income \$56 million higher annually. 	<ul style="list-style-type: none"> • Baseline system costs and benefits for recreation, flood damages, irrigation, M&I water supply, navigation, power generation, and commercial and recreational use of anadromous fish. • Total annual system cost from all measurable resources \$28.9 million more under SOS 2d than with SOS 2c, using a 3 percent discount rate. • Regional employment and income at baseline levels. 	<ul style="list-style-type: none"> • Increased costs primarily for flood control and power, with increased benefits for recreation. • Total annual system cost of all measurable resources is \$80.9 million higher than SOS 2c, using a 3 percent discount rate. • Regional employment about 2,200 jobs less than SOS 2c; annual regional income \$61 million less.
Social	<ul style="list-style-type: none"> • Recent historical patterns of social stresses related to influences of river operations on employment and income. • Possible decrease in social impacts relative to SOS 2c from increased employment and income, with largest potential change in Puget Sound subregion. 	<ul style="list-style-type: none"> • Baseline levels of social stresses related to influences of river operations on employment and income. • Key social impact is uncertainty of economic future for river user communities. 	<ul style="list-style-type: none"> • Increased social stresses relative to SOS 2c from reduced employment and regional income. • Social impacts generally distributed across region through power system effects.

1 kcfs = 28 cms

1 ft = 0.3048 meter

Table 4-27. Environmental comparison of SOS alternatives—8

SOS 5	SOS 6	SOS 9	SOS PA
<ul style="list-style-type: none"> • Drawdowns of lower Snake and John Day pools require water users to modify pumps and/or make other changes to facilities. • Average annual costs increased by \$3.3 million (SOS 5b) or \$4.5 million (SOS 5c) compared to SOS 2c, using a 3 percent discount rate. 	<ul style="list-style-type: none"> • Drawdowns of lower Snake and John Day pools require water users to modify pumps and/or make other changes to facilities. • Average annual costs increased by \$3.6 million (SOS 6b) or \$4.1 million (SOS 6d) compared to SOS 2c, using a 3 percent discount rate. 	<ul style="list-style-type: none"> • Pumps and other facilities continue to operate, requiring routine maintenance under 9b. • Drawdowns of lower Snake and John Day pools under SOS 9a or 9c require water users to modify pumps and/or make other changes to facilities. • Average annual costs increase by \$3.6 million (SOS 9a) or \$3.7 million (SOS 9c) compared to SOS 2c, using a 3 percent discount rate. 	<ul style="list-style-type: none"> • Drawdown of John Day pool requires water users to modify pumps and/or make other changes to facilities. • Average annual costs increase by \$4.3 million (SOS PA) compared to SOS 2c, using a 3 percent discount rate.
<ul style="list-style-type: none"> • Increased costs or reduced benefits for almost all elements, particularly recreation, anadromous fish, irrigation, M&I water supply, navigation, and power. • Average annual implementation cost \$88.6 million (SOS 5b) to \$24.6 million (SOS 5c) more than under SOS 2c, using 3 percent discount rate. • Total annual system cost from all measurable resources, including implementation cost, from \$266.3 million (SOS 5b) to \$336.5 million (SOS 5c) higher than SOS 2c, using 3 percent discount rate. • Regional employment up to about 7,500 jobs less than under SOS 2c, regional income \$199 million less per year. 	<ul style="list-style-type: none"> • Increased costs or reduced benefits for almost all elements, particularly recreation, anadromous fish, navigation, and power. • Average annual implementation cost \$7.8 million (SOS 6d) to \$31.6 million (SOS 6b) more than under SOS 2c, using 3 percent discount rate. • Total annual system cost from all measurable resources, including implementation cost, from \$77.6 million (SOS 6d) to \$145.1 million (SOS 6b) higher than SOS 2c, using a 3 percent discount rate. • Regional employment up to 2,300 jobs less than SOS 2c; annual regional income up to \$59 million less. 	<ul style="list-style-type: none"> • Increased costs or reduced benefits primarily for recreation (SOS 9a/b/c), anadromous fish (SOS 9a/b) and power (SOS 9a/b/c). • Average annual implementation cost (at 3 percent discount rate) \$31.4 million (SOS 9a) or \$31.7 million (SOS 9c) more than under SOS 2c. • Total annual system cost from all measurable resources, including implementation cost, from \$233.2 million (SOS 9c) to \$399.5 million (SOS 9a) higher than SOS 2c, using a 3 percent discount rate. • Regional employment up to 9,450 jobs less than SOS 2c, annual regional income up to \$260 million less. 	<ul style="list-style-type: none"> • Increased costs or reduced benefits primarily for recreation, M&I water supply, and power. • Average annual implementation cost (at 3 percent discount rate) \$5.9 million more than under SOS 2c. • Total annual system cost from all measurable resources, including implementation cost, \$164.4 million higher than SOS 2c, using a 3 percent discount rate. • Regional employment about 4,000 jobs less than SOS 2c, annual regional income \$113 million less.
<ul style="list-style-type: none"> • Increased social stresses relative to SOS 2c from reduced employment and regional income. • Social impacts concentrated in lower Snake and Columbia River subregions. 	<ul style="list-style-type: none"> • Increased social stresses relative to SOS 2c from reduced employment and regional income. • Social impacts concentrated in lower Snake and Columbia River subregions, particularly the Lewiston-Clarkston area under SOS 6d. 	<ul style="list-style-type: none"> • Increased social stresses relative to SOS 2c from reduced employment and regional income. • Social impacts concentrated in lower Snake and Columbia River subregions, especially under SOS 9a or 9c. 	<ul style="list-style-type: none"> • Increased social stresses relative to SOS 2c from reduced employment and regional income. • Social impacts concentrated in lower Columbia River subregion.

1 KAF = 1.234 million cubic meters

1 MAF = 1.234 billion cubic meters

benefit Kootenai River white sturgeon, this option would improve conditions for this ESA-listed species.

Water temperature conditions under SOS 2 parallel those for SOS 1, although exceedances of the dissolved gas standard would be somewhat less. Conditions for erosion, air quality, cultural resources, flood control, navigation, irrigation, and M&I water supply would be very similar to those under SOS 1a. Indian treaty rights and trust assets would benefit from improved salmon survival.

SOS 4—Stable Storage Project Operation

The purpose of keeping upstream storage reservoirs as full as possible for as long as possible is to benefit resident fish, wildlife, and recreation. And, in fact, SOS 4c is the only strategy that would significantly improve projected conditions for wildlife. Significant increases in wildlife habitat at Lake Pend Oreille could be expected, with habitat increases also occurring at Lake Kocanusa (Libby), Hungry Horse and Grand Coulee.

This is the best strategy for resident fish. Improved conditions would occur primarily at Lake Pend Oreille, Libby, Hungry Horse, and Dworshak. Conditions for Kootenai River white sturgeon would also improve moderately.

Despite its intention to enhance recreation, SOS 4c would increase systemwide visitation by 1 percent. This minor increase is due to greater benefits to upstream storage projects (Libby, Hungry Horse, and Dworshak), while more people currently visit downstream sites, several of which would be adversely affected by SOS 4. Annual recreation benefits were predicted to increase up to \$4.2 million as a result of this strategy.

Survival rates for juvenile passage and adult returns would be about the same under SOS 4 as they are today for most stocks. Average annual power generation would decrease under SOS 4c, increasing the costs of operating the hydro system by \$85 million per year.

The operations required at storage reservoirs would increase the chance of flooding in the Flathead River drainage and elsewhere in the upper Columbia reaches. Average annual flood damage could increase by \$0.4 million.

Stable storage elevations also provide the best strategy for air quality and for maintaining the visual attractiveness of the reservoirs.

SOS 5—Natural River Operation

Making in-river fish migration more closely resemble conditions before the dams were built is the only strategy that has the potential for providing in-river survival rates for Snake River salmon equal to or greater than current rates achieved through fish transportation programs. The exception is fall chinook, which must be transported to maintain its already low numbers. Study models showed barging fall chinook provides greater survival rates for this stock than for any other in the basin. Overall, SOS 5 achieved the highest modeled in-river passage survival for Snake River stocks. However, barging of juvenile fall chinook from the Snake River would not be possible with this operation.

Survival rates for non-ESA salmon stocks and steelhead would be similar to those of today, except for Hanford Reach fall chinook and Methow River summer chinook, whose survival rates would decline without transportation. Survival rates for returning adults follow the same trends.

While none of the strategies would uniformly improve water quality, SOS 5 would provide the best long-term results. In the first 5 to 10 years of this operation, large amounts of sediment would be moved from the drawn-down lower Snake River reservoirs, creating a problem for fish, especially rearing fall chinook. The sediments would eventually dissipate, however, and SOS 5 would provide flows from upstream projects to keep water temperatures cooler than other alternatives. The lack of spill in SOS 5 would also keep dissolved gas saturation at more reasonable levels.

Building the river bypass structures called for in SOS 5 would cost as much as \$4.1 billion and take as long as 17 years. Annualized over the period of analysis, implementation costs would be \$88.6 million per year under SOS 5b and \$24.6 million per year under SOS 5c.

While benefiting anadromous fish, this strategy could have severe consequences for most other river uses. Seasonal lower Snake River drawdowns (SOS 5b) would cause significant adverse impacts on resident fish in these reservoirs, although resident fish conditions would improve with the permanent natural river operation of SOS 5c. SOS 5b and SOS 6 (discussed below) would create lake-like conditions for resident fish for 8 to 10 months and river-like conditions for the rest of the year. In general, this abrupt switch in habitat would disrupt their habitat, spawning, and food supply.

Both SOS 5 and SOS 6 would initially destroy much wildlife habitat in the lower Columbia (Lake Umatilla) and lower Snake reaches. More than half the wildlife—waterfowl, shorebirds, aquatic furbearers, and others—near Lake Umatilla and in the lower Snake reaches could be lost because much emergent marsh and riparian habitat would dry up. Under SOS 5c however, permanently restoring natural river flows to the four lower Snake projects would allow for some long-term restoration of riparian and wetland habitat. The rebound in habitat and wildlife would depend on the suitability of sediments for plant growth and topography of the shoreline.

SOS 5 would eliminate power generation at several projects. Annual power system costs would increase by \$85 million under SOS 5b or \$167 million under SOS 5c.

Lower water levels at Ice Harbor and/or John Day pools during the irrigation season under this strategy would increase annual operating costs for irrigators, by as much as \$4.5 million annually under SOS 5c. The drawdowns of the lower Snake and John Day pools under SOS 5 and SOS 6 would also require municipal and industrial water users to

modify their pumps and facilities, at an annual cost of about \$4.5 million under SOS 5c or \$3.3 million under SOS 5b.

Erosion would increase dramatically at the four lower Snake River dams as large areas of shoreline are exposed each year after initial drawdown, although the rate of erosion would decrease to background levels after the initial years under SOS 5c. Cultural resource sites at these projects would suffer major damage; 96 percent of these sites would be affected. However, SOS 5c would restore access to more than 200 sites.

SOS 5b would interrupt navigation during the spring and summer, while SOS 5c would permanently eliminate shallow-draft navigation on the lower Snake River. Activities at lower Snake River ports would shift to other locations on a seasonal or year-round basis. Annual shallow-draft transportation costs would increase by \$13.6 (SOS 5b) or \$37.5 million (SOS 5c) over SOS 2c.

SOS 5c (with permanent natural river drawdown) presents the worst scenario for recreation, an 11.5 percent drop in recreational visitors systemwide. This would translate into a loss of \$89.8 million in recreation-related benefits. Recreational visits at the lower Snake projects could drop by up to 75 percent. John Day's visitor levels could drop over 20 percent if the project is drawn down as proposed in SOS. 5

SOS 6—Fixed Drawdown

This strategy calls for less severe drawdown of lower Snake River projects than SOS 5—33 feet (10 m) compared to 100 feet (30.5 m)—but the effects would be similar.

The anadromous fish analysis used optimistic and pessimistic scenarios for fish survival during such drawdowns. Under SOS 6, the models usually yielded generally low juvenile survival rates, even with optimistic assumptions. Some of the in-river passage results for SOS 6 were

comparatively high. SOS 6b also might have adverse effects on adult passage success.

Except at Lower Granite, the fish ladders at the four lower Snake River dams would not function at the proposed levels, requiring modifications. The analysis of adult returns assumed that this redesign had been done and would provide adult survival rates similar to juvenile downstream passage rates. Under these scenarios, adult returns decreased because of the overall decrease in juvenile downstream survival.

Problems for other river uses would generally be similar to but not as severe as those under SOS 5. Resident fish and wildlife would suffer as a result of drawdowns, as described under SOS 5. Cultural resources would not be as badly affected because drawdowns would not be as low, exposing less area each year; damage at the lower Snake projects would still be extensive. Erosion would increase, about one-third as much as under SOS 5.

SOS 6 would eliminate some power generation, but it would have less effect on load shaping than several of the other alternatives. SOS 6 would be a comparatively low-cost way to operate the hydroelectric system after SOSs 1 and 2. Total system generation cost would increase by \$17 million (SOS 6d) or \$35 million (SOS 6b).

Irrigation would also suffer under SOS 6, with increased costs of \$2.6 million (SOS 6b) or \$1.4 million (SOS 6d) annually. Most of this would fall on irrigators who rely on water from the Ice Harbor and John Day pools, particularly for SOS 6d and John Day. Municipal and industrial water supply costs could go up \$3.6 million or \$4.1 million annually under SOS 6.

SOS 9—Settlement Discussion Alternatives

The three SOS alternatives that were derived from the Marsh process settlement discussions during 1994 incorporate varying themes for operation of the system, and therefore would have effects that would differ considerably

among the projects and resources. SOSs 9a and 9c have several similarities, as they both incorporate fixed drawdown of the four lower Snake River projects and operation of John Day at MOP. As a result, the impacts from these two alternatives would be similar in many respects to those of SOS 6b. SOS 9a or 9c would provide relatively high in-river survival for juvenile anadromous fish, while SOS 9b would also improve conditions somewhat over current conditions.

SOS 9 options, particularly SOS 9a, would provide the worst conditions among all of the alternatives for several resources. These include water quality, with consistently high exceedances of temperature and dissolved gas standards; resident fish, with particularly poor conditions at Libby, Hungry Horse, Grand Coulee, and John Day; aesthetics; and recreation, with the largest decreases in visitation and benefits at several of the projects. However, SOS 9b would generally improve conditions for resident fish, and would provide wildlife benefits similar to those for SOS 4c.

Irrigation, navigation, and M&I water supplies would be disrupted and experience increased costs under SOS 9a or 9c. The costs to these resources would generally be comparable to those for SOS 6b. Flood damage costs would also be increased from current conditions under SOS 9a or 9c. SOS 9b would generally have little or minimal impact on this group of river uses, although it would be one of the more expensive alternatives in terms of power; SOS 9b would increase system power generation cost by \$213 million compared to SOS 2c.

SOS PA—Preferred Alternative

SOS PA reflects the recommendations of the 1995 NMFS and USFWS Biological Opinions with respect to listed salmon and Kootenai River white sturgeon. This alternative is comparable to other non-drawdown alternatives in terms of juvenile salmon survival (with transport). Its overall survival results for Snake River stocks were among the higher of the alternatives. This

would also represent an improvement for Indian treaty fishing rights and trust assets. SOS PA would also provide substantial improvement in conditions for Kootenai River sturgeon.

The effects of SOS PA on other resources would be mixed. It would result in comparatively high dissolved gas exceedances on the lower Columbia River, although exceedances on the mid-Columbia and lower Snake would be about average. The most significant consequence for wildlife would be the loss of large areas of wetland, riparian, backwater and pond habitats at John Day as a result of year round operation at MOP. However, the permanent nature of this operation would provide the opportunity for restoring some lost habitat over the long term. Recreation visitation would decrease by about 6 percent compared to SOS 2c. Total system generation cost would increase by \$126 million per year under SOS PA.

Irrigation and M&I water supply costs would increase significantly under SOS PA, as a result of operating John Day at MOP year round. These cost increases would be comparable to those for SOS 6d, amounting to about \$1.5 million and \$4.3 million annually, respectively. SOS PA would have minor to minimal changes, or offsetting positive and negative effects, for navigation, flood control, erosion, air quality, and aesthetics.

4.3.2 Key Relationships Among Resources

Complementary Resource Needs

As might be expected, the original uses of the Federal projects analyzed in the SOR—power, flood control, navigation, and in some instances irrigation—generally have complementary system needs. These uses represent the primary multiple-purpose objectives for which the projects were originally authorized, and their needs have long been integrated into system operations. Those river uses that were built up around traditional project operations—recreation, water supply, water quality—and, to some extent, resident fish,

wildlife, air quality, cultural resources, and aesthetics also tend to complement traditional use needs. For example, navigation, irrigation, and M&I water supply have complementary requirements for river levels sufficient to accommodate barges and water intake pumps.

Water quality needs complement those of anadromous and some resident fish. High levels of gas supersaturation in the water can cause gas bubble disease and threaten fish survival. Excessive sediment in the water creates problems for rearing fish. Anadromous fish need cooler water temperatures. Warmer temperatures increase overall predation of downstream migrants, a cause of mortality equal to or greater than that caused by passage at dams, and can delay upstream passage of adult fish.

Recreation, resident fish, wildlife, aesthetics, erosion protection, and air quality all complement each other because of their need for relatively high reservoir levels (and/or reduced fluctuations) at certain times of the year for optimum conditions. In season, recreation needs include reservoir levels high enough to allow full use of existing boat ramps, swimming beaches, and moorage facilities. Resident fish require water levels high enough to allow spawning and support food growth. In addition, these water levels need to be maintained after spawning so that redds (nests) are not dried out. Wildlife require water levels that enable them to avoid exposure to predators and to maintain habitat conditions. The visual attractiveness of reservoirs is improved if they are kept full and less land is exposed. Full reservoirs minimize nuisance dust from exposed land, reduce the area exposed to erosion, and help to moderate water temperatures. Cultural resources can suffer erosion damage and vandalism if they are exposed by lower water levels.

Federal agencies have a trust responsibility to consider and protect the interests of Native Americans. To a degree, the needs of Native Americans dovetail with the needs of cultural resources, anadromous fish, resident fish, and wildlife. There is strong tribal interest in

cultural resource management. Indian treaty rights are directly tied to the health and welfare of resident and anadromous fish, as well as other resources. And, fishing and hunting are an integral part of the traditional way of life for Native Americans associated with the river.

Competing Resource Needs

The ESA listings require the Federal operating agencies to develop operating plans that will not further jeopardize threatened or endangered stocks. This essentially means that the need to recover threatened or endangered salmon, has taken precedence over other considerations. As resource needs are examined, it becomes readily apparent that the recovery of endangered runs of wild salmon on the Snake River competes to some degree against almost every other river use.

Many of the SOS alternatives address the need for salmon recovery actions by attempting to increase river velocities during juvenile salmon migration periods. Depending on the SOS, this increased velocity would be accomplished either through flow augmentation, using additional water releases from upstream projects, or through drawdown of one or more run-of-river projects.

SOSs with significant levels of flow augmentation involve a degree of inherent tradeoff or competition between upstream and downstream resources. In general, the effects of flow augmentation typically include diminished conditions for resident fish, wildlife, and recreation at affected storage reservoirs, which are located in the upstream portions of the basin. Flow augmentation benefits anadromous fish that use the downstream reaches of the system for migration. But reliance on flow augmentation to aid salmon recovery would mean the effects of other potential actions (primarily drawdowns) that are detrimental to river uses in the downstream areas could be avoided.

The other primary operational tool to increase river velocity is drawdown. SOSs 5, 6, 9a, and 9c employ this action to speed flows and

enhance juvenile fish migration. These alternatives would provide benefits to anadromous fish migrating in-river, but would have significant adverse effects on a number of other resources in the downstream portions of the system (primarily the lower Snake River reach). While storage reservoirs would not be totally unaffected by these alternatives, drawdown would generally be used in place of flow augmentation.

The effect of variations in water level on spawning success for resident fish has a greater influence on fish production than any other factor. Drawdown would degrade shallow-water spawning and rearing habitat for most resident fish species in the SOR reservoirs.

Lower pool elevations on the four lower Snake projects also would compete with water levels required for recreation, navigation, irrigation, wildlife, cultural resources, and air quality. Fixed water-based facilities, such as boat ramps, swimming beaches, and moorage facilities, can function in only very specific ranges of elevation (within 5 feet [1.5 m] of full pool at the lower Snake projects). Likewise, navigation, irrigation, and water supply pumps on the lower Snake River require water depths within the normal operating range. Cultural resource protection, visual quality, erosion protection, and air quality would be diminished as a result of exposure from severe drawdowns.

The SOS analyses also indicated one other prominent general pattern among the distribution of effects. SOSs 2 through PA are all intended to benefit either anadromous fish or the fish, wildlife, and recreational resources at the upstream storage reservoirs. These alternatives would accomplish their objectives to varying degrees, and all would result in increased system power costs relative to SOS 1. In addition, the economic analysis indicated that power was the dominant factor among the system operating costs that could be quantified. These observations highlight one of the fundamental tradeoff relationships inherent and unavoidable in evaluating system operations.

4.3.3 Mitigation for SOS Alternatives

This section outlines NEPA and regulatory guidance on mitigation, describes possible measures to mitigate impacts on system resources resulting from various SOS options, and addresses agencies' mitigation policies.

Council on Environmental Quality Guidance on Mitigation

The Council on Environmental Quality (CEQ) requires agencies, in preparing EISs, to address appropriate mitigation measures not already included in the proposed action or alternatives (40 CFR 1502.14 and 1502.16). Mitigation can include: (a) avoiding the impact altogether by not taking a certain action or parts of an action; (b) minimizing impacts by limiting the degree or magnitude of the action and its implementation; (c) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and (e) compensating for the impact by replacing or providing substitute resources or environments.

For any proposed action that would adversely affect the environment (either significantly or insignificantly), a range of mitigation measures must be considered and developed. Each adverse impact discussed in the EIS must have accompanying mitigation measures proposed, even if the impacts by themselves would not be considered significant (46 FR 18031). All reasonable mitigation measures, even if they are outside the jurisdiction of lead or cooperating agencies, must be identified. Agencies with jurisdiction would be notified of potential measures (46 FR 18031). To ensure that environmental effects of a proposed action are fairly assessed, the potential mitigation measures must also be discussed. Therefore, the EIS and the Record of Decision will provide information regarding implementation plans, responsible agencies, and the likelihood that mitigation will be accomplished.

Potential Mitigation Options

This section summarizes potential mitigation options that have been identified to date by the SOR work groups. The material is organized by resource or subject area, and is presented in the same order used in Section 4.2.

The measures identified are potential options that could be used to mitigate impacts. These measures have not yet been recommended, proposed, or adopted as mitigation for the consequences of river system operations. Proper consideration of mitigation requires that a full range of measures be identified (including, where appropriate, alternative means to mitigate the same impact), along with the cost of the measures and their effectiveness in reducing the level of impact. The SOR agencies will evaluate the potential mitigation options presented in the Final EIS, and will identify measures that they have adopted in the Record(s) of Decision. Recommended mitigation measures will be justified on critical habitat-based analyses conducted according to agency requirements.

In determining appropriate mitigation measures to implement, the SOR agencies will consider the extent to which mitigation for hydrosystem impacts is already occurring or planned through the NPPC's Fish and Wildlife Program and ongoing efforts by the Federal agencies. Fish and Wildlife Program activities undertaken to date have included extensive actions to increase fish and wildlife populations and replace habitat lost through construction of the Federal dams (effects that pertain to the existence of the dams, and not to their operation). The amended Program also includes a number of measures intended to mitigate some of the operational effects that have been occurring for some time and are discussed in this EIS. In determining mitigation for the selected SOS, the responsibility of the SOR agencies is to identify measures that correspond specifically to the incremental operational impacts of the selected SOS, and that do not address construction-related impacts or duplicate actions that are already planned through other regional processes.

The incremental operational impacts of SOS PA would be concentrated at the John Day project, and the status of mitigation for John Day impacts warrants specific discussion. Consistent with NMFS' 1995 Biological Opinion, SOS PA provides that John Day will be operated at MOP year-round. The Biological Opinion specifically states that this operation will begin by March 1996, or the earliest possible date after appropriate mitigation measures are assured. The Biological Opinion recognizes that, without additional authority, the Corps can not completely mitigate for impacts that may be caused by operation at MOP. The Corps can not assure mitigation until all mitigation measures have been identified and the appropriate authority needed to implement those measures has been enacted by Congress. Therefore, mitigation for the impacts of operating John Day at MOP (and the operation itself) will depend upon further action and documentation beyond the Record(s) of Decision for the SOS.

As noted in Section 4.3.2, competing needs among resources indicate that the ability to mitigate some impacts will be limited. SOS-induced impacts to fish and wildlife will be mitigated to the extent justified, although implementation of some alternatives would result in different levels of environmental impacts and associated mitigation.

Earth Resources

All of the SOS alternatives involve continued operation of the dams on the Columbia River system, which would continue significant erosion, mass wasting, and sedimentation caused by construction of the dams. In general, potential mitigation measures would be designed to stabilize the shorelines, a feat more easily accomplished on run-of-river projects than storage projects.

Implementation of a yearly landslide and erosion monitoring program is a mitigation measure that could apply to all reservoirs.

Monitoring programs could not only predict where new slides might occur, but also give operating agencies a chance to acquire property and/or establish setbacks before the slides occur. With all alternatives, adding rock walls to critical areas, such as active landslides, could protect the toes of slides from waves and buttress them from future movement. In addition, diverse combinations of biotechnical (such as willow wattling) and mechanical stabilization methods exist for mitigating severely eroded areas. Shoreline revegetation/stabilization programs could also effectively mitigate some of the effects from any of the alternatives.

Under SOSs 5, 6, 9a, and 9c, slope protection would likely be needed on the upstream side of each embankment of the dams. Riprap or grouted geotextile blankets could be extended from current wave protection zones to the lowest parts of the dam on all four lower Snake reservoirs. This type of mitigation would presumably be incorporated, as good engineering design, in the construction of dam modifications. Structural measures undertaken to allow operations under SOSs 5, 6, 9a, and 9c will be determined through the Corps' SCS.

Additional possible treatments include a variety of wave dissipation structures, including log booms, pontoons, log mats, and A-frame booms. Other off-shore, non-floating breakwaters are made of stacked sand- or concrete-filled bags, stone structures, and gabions (rock-filled mesh boxes). These methods have all been used to control shoreline erosion, although they can have limited applicability, depending upon the location and physical conditions.

Water Quality

Potential mitigation measures were identified for water temperature, total dissolved gases, sediment, and other pollutants. These options

and their intended effects are summarized as follows:

Water Temperature:

- Careful selection of release ports, at storage projects that currently have multi-level intakes, could improve downstream temperature conditions during thermal stratification periods.
- Selective withdrawal facilities could be constructed at storage projects that currently lack this temperature control capability.
- Underwater dams could be constructed within reservoirs to trap cool water.
- In cases where project discharges tend to be too cold for aquatic life, pumping from the reservoir surface could reduce the temperature of water released from the project.

Gas Supersaturation:

- Dissolved gas levels could be reduced somewhat by carefully monitoring flows and spill levels and attempting to distribute spills to projects with flip lips.
- More flip lips could be constructed and existing flip lips could be modified.
- Power exchanges or related techniques might be able to more closely match power system load and high flow periods.

Sediment Transport:

- Slower reservoir drafting and faster refilling could be prescribed to reduce bank erosion.
- Sediment deposition at the confluence of the Snake and Columbia Rivers resulting from lower Snake reservoir drawdowns may require dredging of navigation channels.

In addition to mitigation measures, the Water Quality Work Group identified extensive

information needs for water quality. These needs included continued monitoring (real-time and periodic) and analysis of whole river dynamics and processes, and further assessment of the source, cause, transport, fate, and effects of water pollution in the system. In addition to the parameters specifically addressed in the SOR model analysis, one objective of monitoring would be to detect any potential effects of system operations on the ability of point-source dischargers to comply with the terms of their NPDES permits.

Air Quality

Dust-control measures could theoretically be used to mitigate the air quality effects of the SOSs. Dust-control measures would be intended to decrease the amount of dust generated when reservoir sediments are exposed. Such mitigation could include seeding or planting vegetation along shorelines so that less shoreline is exposed, or erecting wind barriers along the shoreline in the primary wind direction. These types of measures, if effective, would provide long-term mitigation following the initial construction effort. Alternatively, shorter-term but recurring or ongoing measures could be considered. For example, dust is typically controlled at construction sites by periodically spraying water on roads and disturbed surfaces. Restricting use of all-terrain vehicles (ATVs) or other vehicles on exposed reservoir sediments would also decrease dust, because this would prevent or reduce disturbance of the crust on the sediments.

Dust-control measures have been successfully applied to small-scale projects, but not to projects the size of a typical SOR reservoir. For the large reservoirs in the Columbia River System, comprehensive application of these measures would likely be too costly. The technical success of measures such as seeding would also be questionable, while wind barriers would have aesthetic drawbacks and technical limitations. Restricting vehicle use along shorelines during drawdown periods would be difficult to implement and enforce.

While comprehensive use of dust-control measures in all areas of significant shoreline exposure throughout the system would not be feasible, it might be practicable to reduce reservoir dust emissions on a localized basis. The SOR agencies can monitor particulate conditions near the system reservoirs as the selected SOS is implemented, and attempt to determine whether and where reservoir drafting is contributing noticeably to particulate concentrations in populated areas. If the agencies determine that to be the case, they can evaluate whether control measures in the immediate vicinity of areas of concern would likely be effective.

Overall, the need for and applicability of air quality mitigation measures would vary significantly among the SOS alternatives. The analysis of potential PM₁₀ emissions demonstrated that one of the primary concerns would be as a result of natural river or drawdown operations at one or more mainstem run-of-river reservoirs. With the partial exception of operating John Day near MOP, SOS PA does not include such operational features so the air quality concerns related to mainstem drawdown would generally not apply. In the case of John Day, the potential exposure of existing shallow-water areas would be mitigated somewhat by the 3 to 5 feet (0.9 to 1.5 m) of pool fluctuation above MOP. Monitoring of particulate conditions at John Day would be appropriate, but the depth of drawdown proposed should not be sufficient to create significant dust problems.

The other primary concern from the air quality analysis involves normal seasonal drafting of the storage reservoirs. A significant degree of seasonal drafting is unavoidable if the storage reservoirs are to fulfill their storage functions. However, the fall and winter storage operations incorporated in SOS PA would generally serve to maintain or reduce the degree of storage reservoir drafting compared to existing or historical operations. In addition, SOS PA includes limits on the depth of storage reservoir drafting in the summer. While these features were not specified to counter air quality

concerns, the summer draft limits will serve to mitigate air quality impacts at the storage reservoirs during the most critical portion of the operating year (because weather conditions are generally drier and more people are present during the summer). Continuation of the Corps' air quality monitoring program at Libby will help the SOR agencies develop more specific assessments of air quality concerns at system reservoirs.

Resident Fish

The Resident Fish Work Group identified possible mitigation measures on a project-by-project basis applicable to SOS PA. These measures are summarized below.

Koocanusa and Kootenai River—Current mitigation for the reservoir operations include lake stocking, hatchery operations and a selective water withdrawal to regulate downstream temperatures. Future mitigation will include habitat enhancement in tributaries and off-site fisheries improvements. For the Kootenai River endangered white sturgeon several mitigation actions are being considered. These include goals to meet flow targets based on an Integrated Rule Curve during May, June, and July, considering available water designed to enhance sturgeon spawning while balancing needs of other regional aquatic resource needs. While SOS PA does enhance sturgeon flows, they do not always meet these flow targets. Hatchery operations are being considered for this stock. The use of spillway flows to meet flow targets should be minimized to reduce harmful gas supersaturation in the river. Flow releases during critically low-flow years to enhance salmon smolts should be shaped to benefit sturgeon.

Hungry Horse—Mitigation measures will be implemented under current ongoing mitigation programs adopted by the NPPC in 1992 and the Excessive Drawdown Mitigation Program begun in 1994. These measures include fish passage at human-caused barriers and reconstruction of spawning and rearing areas to increase natural recruitment of juvenile fish and shoreline

revegetation. However none of these measures will completely mitigate for project operations under SOS PA. The primary mitigation objective for the Flathead River is to install and operate a selective withdrawal structure on Hungry Horse Dam to control discharge temperatures. The Resident Fish Work Group has not identified additional mitigation options beyond the current program.

Pend Oreille, Brownlee, and Lower Granite—Mitigation measures may include, but are not limited to, habitat enhancement in tributary streams, fish passage improvements at migration barriers, off-site fisheries improvements, project site selection and monitoring, and operation strategies which maintain full and stable reservoir elevations.

Lake Roosevelt—Potential mitigation measures include stream and riparian zone improvements, benthic invertebrate structure placement, and sonic avoidance mechanisms. Stream and riparian improvements would create more useable shoreline and tributary habitat for fish population use, thereby potentially decreasing entrainment numbers.

Riparian improvements and benthic invertebrate structure placement would increase the number of terrestrial and benthic insects within the reservoir, which would create an alternate food source. Sonic avoidance structures in the forebay might decrease the number of salmonids congregating in the area and lead to entrainment reductions.

Additionally, monitoring systems could be set up to aid in determining effects that could not be predicted based on current models and data. Mitigation measures should focus on on-site development; however, in the event that on-site mitigation is not possible, off-site mitigation could occur on the Spokane and Colville Indian Reservations.

Dworshak—Potential mitigation measures include revegetating the drawdown zone in areas of more gently sloping banks. Aerial photography and a digitized reservoir contour

map could aid in the identification of suitable areas. Shoreline revegetation could partly offset the food and habitat deficits caused by pool level fluctuations.

Small subimpoundments near full pool elevation would also provide a permanently wetted, relatively stable environment to promote the production of aquatic and semi-aquatic vegetation. This vegetation would provide food and substrate for aquatic insect production and would also provide a nursery area for forage fish. The subimpoundments would also partly offset the food and habitat deficits caused by pool-level fluctuations. Both of the programs mentioned above would require monitoring to ensure effective results. Additional water from Snake River above Hell's Canyon and/or lower pool levels in the lower Snake River would reduce the drawdown requirements for Dworshak. Reducing prescribed releases for flood control and power production would also reduce Dworshak drawdown requirements.

John Day—Leaving the pool level to MOP year round would allow aquatic vegetation to establish in just below the new drawdown zone within 3 to 5 years, enhancing the aquatic food base, and improving habitat conditions for resident fish. Habitat and population surveys will need to be conducted to determine the extent of habitat that may be established at the new lower reservoir elevation of 257 feet (78.3 m) with SOS PA. Current bathymetric information is necessary before the type, quality, and size of expected future habitat can be determined.

Wildlife

Generic mitigation options include land purchases, development of additional habitats to replace affected habitats in adjacent or other locations, development of springs, artificial cover, perennial grass seedings, and habitat restoration using irrigation seepage.

Because considerable uncertainty exists concerning the actual magnitude of effects of SOS PA on wildlife habitats, the Wildlife Work Group recommends monitoring and follow-up

studies. These efforts would determine actual effects and might result in additional mitigation being determined to be necessary. To more efficiently design mitigation and monitoring programs, the Wildlife Work Group recommends developing an effective quantitative modeling technique that more accurately predicts the degree of impacts in system-wide wildlife populations and wildlife habitats from changes in system-wide river operations. Recommended monitoring efforts and comprehensive studies include:

- Joint U.S./Canadian system-wide inventories of plant and animal populations and long-term population trends in each of the physiographic regions affected by system-wide river operations.
- Identification of effects of daily fluctuations at each SOR project and reach.
- Identification and monitoring of effects of system-wide streamflows on quality and abundance of water-dependent wildlife habitat.
- Bathymetric mapping of selected reaches and projects, as necessary to design habitat restoration projects and predict drawdown impacts.
- Development of quantitative evaluation measure(s) or ecosystem health indicators that display the magnitude of system-wide impacts on wildlife values.
- Monitoring and analysis of system-wide streamflow and reservoir elevation data to assess the adequacy of (SOS hydroregulation) average end-of-month reservoir elevations and monthly streamflow averages to model wildlife impacts.
- Monitoring and analysis of long-term plant and animal responses to system-wide operational changes through use of photopoints, air photographs, satellite (LandSat) data and documentation of data on regional GIS and other available environmental data base digital information systems, as necessary to facilitate evaluation and understanding of long-term physical changes to habitats and population indicator species.
- Identification and evaluation of cumulative effects of river operations, including the rate of wetland and riparian habitat conversions and recreation, benthic invertebrate, and resident and anadromous fish effects on wildlife resources.
- Monitoring the effectiveness and costs of site-specific mitigation measures.
- Evaluation of the impacts from mitigation. Coordinate the development of site-specific mitigation projects through the NPPC's existing Fish and Wildlife Program.

For site-specific mitigation, the Wildlife Workgroup determined a general ratio of 3:1 for system-wide habitat acreage replacement purposes. This ratio will increase, however, in areas with special circumstances that are significant to wildlife, and for locations identified through public comment as pertaining to regional importance for wildlife. The most significant example of this exception is at the John Day pool. Existing wildlife values at the John Day pool are considered among the highest in the Pacific Northwest because of the great extent of wetland habitat that is supported in an otherwise desert environment. Significant concentrations of waterfowl associated with the nationally important "Pacific Flyway" use this area primarily for wintering purposes. Because SOS PA would result in significant wetland habitat losses and critically impact existing migratory waterfowl populations, the John Day Project interagency team recommends a range from 4:1 to 8:1 or as necessary to replace existing habitat conditions.

Based on currently available information and assumptions used in the EIS analyses, mitigation measures for individual projects in addition to monitoring/investigation include the following:

- Libby Project—Identify and acquire 432 acres of off-site wetland/riparian cover types including habitats for: nesting waterfowl, aquatic and terrestrial furbearers, bald eagles and ospreys, big game, reptiles, and amphibians.
- Hungry Horse Project—Facilitate the on-going efforts to re-vegetate exposed mudflats in the vicinity of Spotted Bear. This will require continued coordination among USBR, USFS and Montana FWP.
- Clearwater River—Acquire/manage 690 acres riparian habitat upstream of the Clearwater project to replace high priority riparian habitat presently managed under the Lower Columbia Basin Wildlife Mitigation Plan.
- Lower Snake Projects, Including McNary Project Mitigation for SOS PA— Acquire/manage up to 1,288 acres of riparian and 152 acres of emergent wetlands to replace high-priority riparian and wetland habitat areas and target species currently managed under the Lower Columbia Basin Wildlife Mitigation Plan and which will be affected by changes to existing irrigation practices. Riparian forest and scrub-shrub wetlands that were not compensated under the initial mitigation program for the lower Snake River should be the focus of mitigation acquisitions.
- John Day Project Mitigation for SOS PA— Wildlife values at the John Day pool are considered among the highest in the Pacific Northwest because of the great extent of wetland habitats that are supported in an otherwise desert environment. Significant waterfowl concentrations associated with the nationally important “Pacific Flyway” use this area primarily for wintering. SOS PA results in changes to existing irrigation practices and significantly impacts water availability for existing emergent marsh/riparian habitats. The following

habitat replacement and on-site mitigation recommendations are recommended (off-site measures are identified in Appendix N, wildlife:

1. Habitat Replacement

Mitigation Summary:	<u>4:1</u>	<u>8:1</u>
Emergent Marsh/Riparian	11,416	22,832
Shallow Water	2,264	4,528
Total	13,680	27,360

Mitigation acreage acquired must be provided permanent protection, full restoration of habitat quality (to the level that was lost as a result of SOS PA), and long-term operations and maintenance budgets.

2. On-Site Mitigation

Willow Creek:

- Dredge silted areas
- Levee creek on both sides to eliminate silt deposits
- Fill embayment with dredge material to elevation that encourages riparian/emergent marsh development.
- Pump required water to maintain pond levels within the wetland

Additional mitigation actions immediately adjacent to John Day pool include:

- Construct dikes to form protected backwaters and control carp, pump water to maintain existing backwater areas, and dredge and/or deposit dredged materials to form emergent marsh, riparian, and shallow-water habitat. The feasibility of these actions is currently being determined. These proposed actions could significantly reduce the off-project requirement for mitigation lands if they are feasible and cost-efficient.

McCormack Slough:

Option #1

- Pump to maintain water levels within slough
- Add silt liner to hold water as practical and dependent on economic feasibility

Option #2

- Dredge to elevation 256 to 254 (approximately 4 to 6 feet deep). This action would generate approximately 2.5 million cubic yards of dredged material. Where this material can be placed without further affecting environment, costs and cultural resources are outstanding questions. The estimated dredge material far exceeds levee material requirements.

Long Walk

Option #1 Standard Design Levees

- Construct levees of standard design, riprap to elevation 265.
- Construct inlet upstream at elevation 263.5. The inlet would be placed at this elevation to allow for gradual filling during flood events and to prevent overtopping and introduction of carp and to decrease erosion of existing levees.

Option #2 Sheet Pile Dikes

- Construct inlet upstream at elevation 263.5. The inlet would be placed at this elevation to allow for gradual filling during flood events and to prevent overtopping and introduction of carp and to decrease erosion of existing levees. No pumping required

Option #3 Combination of Options 1 and 2.

Paterson Slough

- Construct standard levees, riprap to elevation 265.
- Excavate to provide levee materials.
- Construct inlet upstream at elevation 263.5

Irrigon

Option #1

- Pump to maintain water levels

Option #2

- Dredge and excavate to increase water depth

Crow Butte

No mitigation actions recommended

Reservoir Drawdown Area

- Re-establish native shrubs and grasses

Three Mile Island

Dredge an area between the east tip of the island and the mainland to maintain current level of access difficulty for mammalian predators and protection for the colonial nesting bird colonies on the island.

Cultural Resources

The usual final step in the impact assessment process for cultural resources under the NHPA requires preparation of a MOA or PA among the Federal agencies, SHPOs, Indian tribes, and the ACHP, which addresses adverse effects to cultural resources under the authority of Sections 106 and 110 of the NHPA. After two years of meetings and discussions among the parties involved in the SOR cultural resources studies, it has become apparent that common agreement among all parties cannot be achieved in a single agreement document. Instead, documentation for the undertaking and its effects will be forwarded without an agreement to the ACHP for comment under 36 CFR Part 800.6. ACHP comments will be addressed in the Records of Decision, if applicable, and in follow-on agreements for SOR implementation.

Several important steps are involved in the preparation of IPs. These include a process for the identification and evaluation of the significance of affected cultural resources and the development of coordinated plans taking into account and mitigating the adverse effects to significant resources. Mitigation or treatment refers to actions designed to lessen or offset the loss of significant resources due to the adverse effects of an agency undertaking. The individual IPs will describe the anticipated project impacts on cultural resources and identify the approved mitigation or treatment plans, including stipulations and conditions for identification, evaluation and management, as well as recommendations for protection, monitoring,

data recovery, site stabilization, and curation of recovered artifacts. In addition, the IPs will contain provisions for Native American consultation and coordination under the authorities of the AIRFA and NAGPRA, and will establish curation provisions.

According to the "Criteria of Effect and Adverse Effect" established in 36 CFR Part 800.9, a variety of reservoir operations would have adverse effects on cultural resources. Therefore, the adverse effects from operations at the Federal reservoirs in the Columbia River system must be addressed at the individual project level in IPs by each managing agency. The adverse effects of SOS alternatives would be increments beyond those occurring as a result of the current authorized operating limits at each Federal project. The comparison of effects for different SOS alternatives indicates that most of the proposed alternatives fall within existing authorized limits for most Federal projects. The problem in this analysis is that the majority of inventoried cultural resources sites at the Federal projects have not been evaluated for their significance or National Register eligibility (36 CFR Part 63). Discussion of mitigation or treatment for adversely affected cultural resources at the Federal dams in the Columbia River system must be addressed in IPs by the agencies on a facility-by-facility basis, considering the extent of each facility's compliance with Sections 106 and 110 of the NHPA.

The usual subjects for mitigation or treatment are National Register eligible sites threatened by adverse impacts such as construction impact, inundation, erosion or vandalism. This study has pointed out that the majority of inventoried cultural resource sites in the Federal reservoirs of the Columbia River system have not yet been evaluated (through Determinations of Eligibility for the National Register). However, the SOR affords an opportunity to advance the site evaluation process for mitigation or treatment planning at the individual Federal projects. Therefore, accelerated site evaluation studies are recommended as essential components in the development of IPs for each Federal project.

Mitigation or treatment planning hinges upon this site evaluation process. Actual mitigation or treatment measures may vary. Some of the common options are discussed below.

Avoidance or Protection—Whenever possible, Federal agencies attempt to plan projects in such a way as to avoid impacts to cultural resources. Only as a last resort, when destructive effects cannot be avoided, will the agency conduct data recovery. In the case of reservoirs, it is often difficult to avoid impacts to resources. Some measure of protection can, however, be secured through bank stabilization programs or protective levees at locations where significant cultural resource sites occur and bedrock and soil characteristics permit such treatment. Covering sites or erecting barriers around them are other protective measures used in managing cultural resources. Site protection also includes intensive management efforts such as signage, public education programs and law enforcement efforts.

Monitoring—Reservoir monitoring, with special attention to site conditions, is a key means by which the operating agencies manage cultural resources. Site evaluation is not part of monitoring. Rather, monitoring describes on-the-ground activity to document impacts or changes to cultural resource sites over time, which can assist in the development of appropriate protection measures. Site observation and protection are directed specifically to areas of erosion impact, such as streambanks and the drawdown zone, and to preventing unlawful artifact collection and vandalism.

Data Recovery, Curation, and Site Stabilization—When an evaluated cultural resource from a geological deposit is threatened by loss due to erosion, vandalism or construction activity, strictly controlled scientific data recovery may constitute the only way to document the significance and offset the loss. All scientific excavation is conducted under site-specific research plans developed in consultation with the appropriate parties. A key legal requirement of the data recovery process

involves the curation of all recovered artifacts and associated documentation in a facility meeting the standards of 36 CFR part 79. This is to insure the preservation in perpetuity of such cultural resource collections for their scientific research and educational value. If the level of significance is high and geologic and soils conditions are favorable, significant sites may be protected by stabilization efforts such as site capping, slumpage control and stream-bank stabilization rather than excavation.

Coordination with Indian Tribes—Any mitigation or treatment effort undertaken by the managing agencies will require coordination with affected Indian tribes. Such coordination must take into account the Federal agency government-to-government and tribal trust responsibilities. Discussions need to include mitigation or treatment and management measures that are sensitive to tribal concerns, yet responsive to scientific data recovery and curatorial needs and requirements. Affected Indian tribes will participate in direct and meaningful ways in cultural resource management, including planning and implementation efforts, and tribes may contribute to the development of IPs at specific reservoirs.

Coordination with Mitigation Efforts for Other Resources—Other SOR work groups also are developing mitigation plans to address SOR impacts on a variety of natural resources and Federal project activities. These include anadromous and resident fish, wildlife, recreation, and irrigation. In some situations, cultural resources appear in the same physical context as these other resources or activities. Where such overlaps occur, planners need to coordinate mitigation activities so that actions benefiting one resource do not inadvertently harm another. IPs for the treatment of cultural resources will attempt to address issues common to mitigation for multiple resources at a project. The reader is referred to other SOR technical appendices for their discussions of mitigation actions.

Aesthetics

Potential mitigation measures for aesthetics have not been identified. Aesthetic impacts result from shoreline exposure caused by reservoir drafting, which is an unavoidable consequence for several SOSs and projects.

Recreation

The Recreation Work Group considered mitigation for recreation impacts as part of their full-scale analysis process. Recommended mitigation actions are described in Appendix J. For each final alternative, the level of recreation impact that could be expected was analyzed. Opportunities for avoidance and/or minimization of recreational impacts were identified.

Several types of generic recreation mitigation concepts could be applied to any of the individual projects or to the system as a whole. They include:

- 1) Improve Public Information
 - provide better real-time information about operations (such as "flow phone" recorded messages on current conditions)
 - plan and identify annual operations in advance
 - promote alternative use activities that are not affected by operations
- 2) Modify Operations
 - reduce short-term (daily/weekly) fluctuations
 - train operators to have increased sensitivity to impacts of operations on recreation
- 3) Provide/Modify Facilities
 - modify existing facilities (in place) to operate over a wider range of conditions (e.g., extend boat ramps)
 - replace facilities at the same location or elsewhere at the same project
 - develop new facilities at alternative water resource projects in the region
 - acquire and develop alternative facilities off-project
- 4) Provide Additional Storage.

These mitigation concepts are listed in increasing order of cost and difficulty to implement. Improvement of public information and operational refinements are relatively easy to implement and probably ought to be considered for any of the alternatives. Structural modifications of facilities can range considerably in cost and difficulty to implement. As long as the reservoirs are maintained within their "normal" operational ranges, structural modifications of recreation facilities can probably be accommodated at a relatively low cost. For more severe drawdown ranges, the degree of difficulty and costs for structural modification of facilities increases dramatically.

Ultimately, there will be a point at which drawdown is so severe that it is not feasible to modify recreational facilities on-site. This point most clearly occurs where it becomes physically impossible to modify facilities to accommodate the range of fluctuations considered. However, a point can also be reached at which drawdown so diminishes aesthetics and other parameters of recreation suitability that facility modification is not a reasonable mitigation option. When drawdowns result in impacts that are severe, the only feasible mitigation options may include relocation or replacement of facilities in-kind elsewhere in the region.

Using these generic concepts, the Recreation Work Group identified mitigation options specific to individual projects or river reaches. These options are identified in the sections below.

Libby and Hungry Horse—SOS PA would result in drawdowns at the Libby Project in excess of those experienced under the No Action Alternative. These drawdowns would affect facilities around the lake to varying degrees. The potential exists at Libby to modify many of the existing recreational facilities to make them usable over a wider operational range than they currently are so that they would be operational with SOS PA. However, because of physical and cost constraints, it would not be possible to modify all of the existing sites, particularly facilities at the upper end of the project. These

facilities are dewatered when drawdowns exceed 20 feet.

Mitigation efforts at Libby should focus on improving the use of swimming beaches at Rexford Beach and the McGillivray Recreation Area. Extending or relocating the developed swimming beaches to make them usable at pool elevations as low as 20 feet below full pool elevation would make swimming safer and would allow both beaches to remain open longer. Extending the beaches would allow use of them for an average of 4 months under SOS PA. Alternative mitigation measures include developing swimming areas at other nearby lakes or building a swimming pool at a local community.

Kootenai River Below Libby Dam—SOS PA would result in higher summer flows (except in July) on the Kootenai River below Libby Dam. The higher flows would affect recreational access to the river. To improve boating access, several undeveloped Corps sites just downstream from Libby Dam, such as Blackwell Flats, could be developed to provide access at high flows. Fishing piers that extend into the river channel could be constructed to allow safer access to bank anglers during periods of high flow.

Canada—The extension of the concrete boat ramp at Indian Eddy would increase the use of this important facility at low flows. In conjunction with the ramp extension, the mooring docks could also be reconfigured and extended to improve the use of this facility. Dredging some large river cobbles at the entrance of Indian Eddy would improve general access to the facility at low flows.

Construction mooring docks at the Beaver Creek boat launch would improve the use of this facility at high river flows. The mooring docks would improve the ease of loading and unloading boats during high flows when river currents complicate the use of this facility.

The Canada Customs dock at Trail was destroyed by the high flows of 1991, but could be rebuilt in a manner that allows it to

accommodate high flows. Low flows do not pose a problem for a dock at this site.

Hungry Horse Reservoir—SOS PA would provide pool elevations at the reservoir that would be as high or higher than SOS 2c. Recreation facilities would therefore remain usable for longer periods of the summer than with SOS 2c, and no mitigation measures are recommended.

Albeni Falls/Lake Pend Oreille—SOS PA would allow a full, stable pool during the recreation season, which would be almost identical to that associated with SOS 2c. Therefore, no mitigation measures are recommended.

Grand Coulee/Lake Roosevelt—Recreation facilities at Lake Roosevelt have been constructed to accommodate recreation at reservoir elevations that are near full pool. Under SOS 2c, Lake Roosevelt reaches full pool by the end of July and remains there through the fall. SOS PA would result in summer pool elevations that would be from 6 to 9 feet below full pool. Therefore, some mitigation measures, generally at swimming beaches, are recommended.

Chief Joseph Project/Lake Woods—SOS PA would maintain a stable pool elevation, similar to that of SOS 2c, at the Chief Joseph Project. Therefore, no mitigation measures are recommended.

Middle Columbia Public Utility District Projects—There are few opportunities to mitigate for higher flows that would occur under SOS PA compared to SOS 2c. It would be difficult and costly to modify existing recreation sites and facilities. No mitigation measures are recommended.

Hanford Reach—There are few opportunities to mitigate for higher flows that would occur with SOS PA compared to SOS 2c. It would be difficult and costly to modify existing recreation

sites and facilities. Therefore, no mitigation measures are recommended.

Snake River: Hells Canyon Reach—Under SOS PA, flows would remain within the desirable or acceptable range for summer recreation for longer periods than with SOS 2c. Therefore, no mitigation is recommended.

Dworshak Project and Lake—It may be feasible to modify or extend some recreational facilities to make them usable under the wider range of operating conditions that might occur under these SOSs. Where feasible, most of the existing boat ramps on the lake have already been extended to minimum lake elevations; it is not likely that the ramps could be further extended. Given the steepness of the shoreline, it also may not be feasible to modify the existing boat docks and moorage facilities. Some expansion of swimming facilities may be possible. However, these facilities are constrained by the physical characteristics of the site.

SOS PA would result in moderate to severe impacts to recreational facilities at Dworshak during the prime recreation season. Because of the severity of these impacts, mitigation measures at Dworshak might not be practical or feasible. Instead, opportunities for off-site mitigation should be explored. One alternative would be to develop a new state park elsewhere in the Clearwater River drainage.

Clearwater River Below Dworshak

Dam—Most of the recreation sites along the lower Clearwater River are minimally developed and are designed to remain usable under a range of flows. SOS PA would result in river flows during the winter steelhead season and the summer recreation season that would be more beneficial to recreation, compared to SOS 2c. Therefore, no mitigation measures are recommended.

Lower Snake River Projects—Pool elevations at the lower Snake River projects would be higher during the prime summer

recreation season relative to SOS 2c. Therefore, no mitigation measures would be necessary.

John Day Project/Lake Umatilla—Under SOS PA, operation of John Day project at MOP during some or all of the year would have severe impacts on the usability of many of the recreation facilities at Lake Umatilla. Many of these facilities could be modified to improve their usability at MOP. Through the John Day Drawdown Advanced Planning and Design (AP&D) Study, authorized by the Energy and Water Development Appropriations Act of 1993 (Public Law 102-377, October 2, 1992), the Corps of Engineers, Portland District has undertaken advanced planning and design of modifications to public and private facilities, including recreation facilities at John Day Dam at MOP.

Portland District has recommended two levels of recreation mitigation action. The first level would be to implement the minimum actions required to allow drawdown to MOP to occur prior to Spring 1996. The second level would be the maximum mitigation that would be recommended.

Minimum Action/Mitigation Required: The public facilities that are jointly used for Indian treaty fishing access, including Railroad Island, Le Page Park, Sundale Park, Roosevelt Park, Three Mile Canyon, Crow Butte State Park, and Boardman Park, must be renovated to provide river access. The minimum mitigation that must be accomplished prior to drawdown to MOP at these sites is extension of the boat ramps to elevation 253 to provide a minimum of 4 feet of draft. Design for this work could be completed in time for construction in February 1996. The in-water work period is currently February 1 through March 31. It is likely that construction of these boat ramps could be completed during this period.

In addition to the treaty fishing access sites there are five leased sites: Arlington Marina/Park, Crow Butte State Park, Boardman Park, Irrigon Park, and Umatilla Marina/Park. The lease holders will be economically disadvantaged

by drawdown to MOP. Mitigation would likely address these sites. Due to major excavation and/or blasting required to deepen the marinas to accommodate deep draft vessels (10 feet) and to extend boat ramps, the construction of these sites could not be accomplished in one in-water work period. Cofferdams would be constructed to provide year-round construction capability during the first year of drawdown. Construction could be completed during the remainder of that year.

Maximum Action/Mitigation that Would be Provided: The maximum mitigation action would be to extend boat ramps and dock facilities, dredge and excavate to restore swim beaches and to provide adequate depth under floating docks, and blast/excavate to deepen marinas to provide for deep draft vessels at all of the existing (15) recreation/access sites.

The current estimate of costs (from the SCS Phase I Report, Corps 1992, indexed to 1995) to fully modify all existing recreation facilities at Lake Umatilla to mitigate fully for all impacts of operation at MOP during the summer is estimated at approximately \$13.8 million. The largest percentage of that cost would be dredging shallow boat basins at Umatilla and Boardman Parks which have rock bottoms.

Other Lower Columbia Projects—None of the alternative SOSs under consideration involve any specific operational changes at McNary, The Dalles, or Bonneville Projects. Therefore, no recreation mitigation actions are recommended at Lake Bonneville, Lake Celilo, or Lake Wallula under any of the alternative SOSs.

Navigation

Mitigation options for navigation are sorted into three categories: mitigation common to flow augmentation alternatives, mitigation common to drawdown alternatives, and mitigation of stable pool alternatives.

Mitigation Common to Flow Augmentation Strategies (SOSs 1a, 1b, 2c, 2d, and PA)—Mitigation needs for

shallow-draft navigation and Dworshak log transport effects under flow augmentation alternatives have been considered.

Navigation on the Lower Snake and Columbia Rivers: Because the effects on commercial navigation and dependent facilities are negligible, mitigation strategies revolve mainly around dealing with the occurrence of high-flow conditions below Lower Monumental and Ice Harbor Dams. Because this situation has always occurred in the April to June period, mitigation measures would be similar to those currently employed. Currently, the mitigation is primarily operational on the part of the barge and dam operators. Breaking of tows and extreme caution on the part of the barge operator and provision of sufficient tie-off walls both upstream and downstream of the dams by the Corps may be all that is necessary to accommodate the annual occurrence of the high spring flows.

Log Rafting Operations at Dworshak: The possible mitigation measures identified for the Dworshak log operations include using alternate methods of log transportation to Lewiston, holding the water level up through the summers and early fall, and extending the length of the log dumps to as low of elevation as possible, without causing damage to the logs.

Mitigation Common to Drawdown Alternatives (SOSs 5b, 5c, 6b, 6d, 9a, 9b, and 9c)—Mitigation needs for shallow-draft navigation and Dworshak log transport under drawdown alternatives have been considered

Navigation on the Lower Snake and Columbia Rivers: Mitigation possibilities are limited for the effects of drawdown below MOP on the lower Snake River pools. Commodities ordinarily shipped by barge can be routed as rail or truck cargo. Additional storage at loading facilities and at the source (farms) can be employed to some degree, delaying the barging until after the outages. Revetments and other stabilization methods could be employed to stabilize the river banks around cargo transfer facilities.

Mitigation measures for drawdown to MOP on the lower Snake River pools and on John Day pool include increased dredging of access channels to facilities, modification of loading and unloading facilities to accommodate 5-foot water level fluctuations, and additional channel markings on the channel through the pool.

Effects on stage below Bonneville Dam can be mainly dealt with by careful scheduling of ships departures during September. The Port of Portland's LoadMax tidal and stage forecasting is currently used for this purpose. If conditions during a particular water year appeared to be causing more severe effects than were identified during the full-scale analysis, the possibility of drafting Columbia River main stem reservoirs to make up flow deficits should be considered.

Log Rafting Operations at Dworshak: The possible mitigation measures identified for the Dworshak log operations include using alternative methods of log transportation to Lewiston, holding the water level up through the summers and early fall, and extending the length of the log dumps to as low as elevation as possible, without causing damage to the logs.

Mitigation for Stable Pool Alternative (SOS 4c)—This alternative is the preferred alternative for navigation purposes and no mitigation measures are necessary for the beneficial effects of this operation.

Power

The power analysis assumes that energy and capacity losses associated with the SOS alternatives would be replaced through acquisition of combustion turbines or purchase of power on the spot market. Either of these responses would essentially represent mitigation for the power impacts. No other mitigation options have been identified.

SOR Agencies' Mitigation Policies

In many instances, the work groups identified preliminary and conceptual mitigation measures associated with the 13 SOSs. These have been

presented in the Final EIS and in the technical appendices. When the agencies formally adopt a preferred alternative, they will also specify mitigation measures designed to address that alternative. Mitigation measures related to the preferred alternative will then be detailed in the Record of Decision.

4.3.4 Cumulative Effects

The NEPA and the CEQ regulations require Federal agencies to consider the cumulative impacts of their actions. Cumulative impacts are defined as the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions, regardless of what other agency or person undertakes the other actions. Cumulative impacts can result from individually minor, but collectively significant actions taking place over a period of time (40 CFR 1506.7).

Assessment of potential cumulative impacts for the SOS alternatives involves two dimensions. One dimension relates to the cumulation of localized or project-specific effects from the SOS actions for the entire river system. The results reported in Section 4.2 for many of the resource areas identify a number of discrete impacts at individual projects or river reaches. In some cases, these individual or localized impacts are not significant, but the aggregate effect over the entire system may be. (Conversely, in some cases, there are considerable changes in multiple locations that tend to balance out at a systemwide level.) Therefore, one level of cumulative impact analysis is already contained in the results for the various resource or subject areas.

The second dimension for cumulative assessment relates to the effects of SOS alternatives within the context of other actions that have been affecting or will affect the same system resources. It is often difficult to determine this context with any precision, particularly with respect to reasonably foreseeable future actions. Nevertheless, the following summary observations attempt to

identify the likely cumulative context of the expected SOS effects for each resource area.

- **Earth Resources**—Erosion caused by reservoir operations will add to sediment contributions from other activities in the basin. It is unknown whether sediment from these other sources will increase or decrease significantly in the future.
- **Water Quality**—Similarly, land use practices elsewhere in the basin affect water temperature conditions in the river system, and it is not known whether these activities will tend to increase or decrease temperatures. While natural sources can cause dissolved gas supersaturation, falling water at river system dams appear to be the primary source of this water quality problem. The cumulative aspects of sediment levels are as described above under earth resources.
- **Air Quality**—Blowing dust generated from exposed reservoir sediments will add to ambient dust from other sources, primarily agriculture and unpaved roads. It is possible that more dust from selected projects could combine with existing ambient levels to cause increased exceedances of air quality standards for particulates in highly localized areas.
- **Anadromous Fish**—River system operations, along with many other sources, have contributed to the historical declines in anadromous fish populations. In the future, however, it is likely that the general direction of change will be positive as recovery measures involving habitat, harvest, and hatchery operations are undertaken. Fish survival benefits associated with the SOSs will add to improvements in other areas, resulting in long-term population levels that will likely be higher than indicated in the SOR life-cycle model results.
- **Resident Fish**—The effects of system operations on resident fish take place within the context of potential changes in sport fishing pressure, water quality, and

management of other aquatic species, among other factors. These other factors vary considerably within the system, making cumulative impact assessment for resident fish a case-by-case situation. Section 4.2.5 identifies pertinent effects from other actions.

- **Wildlife**—The loss of wildlife habitat throughout the region as a result of development and habitat conversion has been widely noted. Consequently, wildlife habitat within the system that can be protected and maintained will take on increasing regional significance, and any loss of this habitat through operational changes would be cumulative.
- **Cultural Resources**—The situation for cultural resources is similar to that of wildlife. The continued loss and degradation of cultural resources in other areas and increases the significance of those resources that can be protected and maintained.
- **Native Americans**—Indian treaty fishing rights, and the trust assets represented by anadromous fish, have been significantly diminished over time. A similar pattern of long-term decline applies to resident fish and wildlife trust assets throughout the Basin, and to cultural resources. Anadromous fish survival benefits from the new SOS should serve to lessen these cumulative impacts. Depending upon the SOS and resource, there could be positive and continued negative changes to other resources of value to Native Americans. Development elsewhere in the Basin will likely continue to diminish Native American resources.
- **Aesthetics**—The visual environment of all of the project areas has been modified to varying degrees by human activities. SOS alternatives that would diminish visual quality would therefore have cumulative effects, although it appears the incremental change would be small.
- **Recreation**—The recreation analysis did not identify trends indicating that there would be significant absolute changes in the recreation resource base. If the supply of recreation opportunities does not keep pace with population growth and demand, the relative significance of the recreation opportunities provided by the river system will increase in the future.
- **Flood Control**—The flood control analysis did not identify other actions that would indicate a potential for cumulative impacts. Based on recent flood events in various portions of the region, it is possible that increased development in some valleys could elevate future flood peaks.
- **Navigation**—Significant trends that would change the context of potential navigation impacts have not been identified.
- **Power**—Power supply costs and electric rates have been increasing in recent years as a result of several factors, including drought and BPA's debt repayment obligations. Cost and rate impacts associated with the SOS alternatives would add to the level of financial strain on the regional electric system and ratepayers.
- **Irrigation**—System operation impacts on irrigators would not be the sole source of increased costs. Irrigation pumping operations are relatively sensitive to energy prices and have been adversely affected by recent electric rate increases.
- **Municipal and Industrial Water Supply**—The water supply analysis did not identify any other actions that would concurrently affect water supplies from system reservoirs. The potential for cumulative effects in this case would involve conditions specific to each water system.
- **Economic and Social Effects**—Some of the adverse economic effects associated with the SOS alternatives would be regionwide, while others would tend to be concentrated in selected rural areas. Some of the communities likely to be affected have been

experiencing long-term economic stagnation or declines through job and income losses in traditional resource-based industries. The cumulative effects of additional cost or employment impacts in these areas could be significant.

In addition to the potential cumulative effects of the SOS alternatives, the SOR agencies must consider possible cumulative effects from the other SOR actions and the interaction among the SOS, Forum, PNCA and CEAA actions. As discussed in Chapters 5, 6, and 7, the Forum, PNCA, and CEAA actions would not be the sources of identifiable environmental impacts. Environmental effects would result from implementing a given SOS, but not from the process (Forum) used to reach such decisions. Power coordination under a PNCA and the allocation of CEAA return obligations would both occur within the bounds of flexibility established by the selected SOS; therefore, environmental impacts are attributable to the SOS, and not to the other SOR actions. Similarly, the SOR analysis has not identified any potential interaction effects among the SOS, PNCA, and CEAA. That is, there do not appear to be any ways in which a Forum, PNCA or CEAA alternative would cause the impacts of a given SOS to be greater or less than the impacts identified in Section 4.2. Therefore, the SOR agencies do not believe that there would be cumulative impacts attributable to collectively implementing multiple SOR actions, beyond those already identified for the SOS alternatives.

4.3.5 Other Specific NEPA Considerations

This section addresses several environmental impact analysis concepts that are specifically mentioned in NEPA and CEQ regulations (40 CFR 1507.16).

Unavoidable Adverse Effects

Unavoidable adverse effects are those environmental consequences of an action that cannot be avoided, either by changing the nature of the action or through mitigation, if the action is to be undertaken. By and large, the adverse

effects identified for each resource area in Section 4.2 are the unavoidable consequences of operating a large-scale integrated system of dams and reservoirs. Physical laws and processes make erosion and sedimentation unavoidable. If storage reservoirs are to be operated according to their intended function, with pronounced drafting and refilling cycles, it is inevitable that reservoir elevations will fluctuate significantly and reservoir shorelines will be exposed and islands will be bridged. Unavoidable effects from storage reservoir operations include blowing dust from exposed sediments, diminished visual quality, damage to archeological sites, and some degree of disruption to resident fish spawning and food supply. Seasonal limitations on use of recreation facilities could theoretically be avoided by modifying the facilities, but it would be impractical to eliminate all elevation-based recreation effects.

Large changes in elevation are not normal operating conditions at the run-of-river projects, but several types of effects are nevertheless unavoidable with the current configuration of the system. Projected impacts at the mainstem projects would result from operational changes that disrupt established uses dependent upon certain elevation patterns. If operations change those elevation patterns, some degree of impact to the established uses is unavoidable.

Irreversible and Irretrievable Commitments of Resources

Irreversible commitments are decisions affecting renewable resources such as soils, wetlands, and riparian areas. Such decisions are considered irreversible because their implementation would affect a resource that has deteriorated to the point that renewal can occur only over a long period or at a great expense, or because they would cause the resource to be destroyed or removed.

Because the adoption of an SOS involves operation of existing facilities and not construction of new facilities, few of the operational effects identified would be

irreversible. To the extent that a given operation would lead to a decline in the resident fish population at a given reservoir, for example, this decline could conceivably be counteracted by modifying the operation.

Loss of soil due to erosion is an irreversible commitment. Because all of the alternatives, including current operations, involve pool fluctuation at some of the projects, erosion would occur at these projects under all the alternatives. Greater pool fluctuations at storage reservoirs would result in more erosion generally than at the run-of-river reservoirs. Drawdowns under SOSs 5, 6, 9a and 9c would greatly increase soil erosion at the four lower Snake River reservoirs.

The abundance and quality of wetland and riparian habitat depend on water levels and timing. The desiccation of wetland plants due to drafting at storage reservoirs in some cases would be an irreversible commitment. Substantial drawdown at projects under SOSs 5, 6, 9a, and 9c would create irreversible commitments in the form of desiccation of submerged aquatic plants and mud-dwelling fauna and gradual loss of emergent marsh and riparian vegetation. These resources could conceivably be restored with higher water levels and replanting, but the existing resources would be lost.

Loss of cultural resources resulting from accidental damage or vandalism would be an irreversible commitment of resources. All alternatives, including current operations, would expose substantial percentages of known archeological sites to such damage or vandalism.

Irretrievable commitment of natural resources means loss of production or use of resources as a result of a decision. It represents opportunities foregone for the period of time that a resource cannot be used. The primary impacts that would be irretrievable are those involving physical processes and resources—soil eroded from the system could not be retrieved, nor could archeological resources that were damaged through operational factors be restored.

Short-term Uses and Long-term Productivity

This analysis looks at the relationship between short-term uses of environmental resources and the maintenance and enhancement of long-term productivity. River system operations may cause both short-term and long-term impacts to the affected environment that cannot be mitigated.

All of the SOS alternatives would cause some mix of short-term impacts, including soil erosion, dust generation, degradation of water quality, loss of riparian or wetland vegetation, disruption of fish and wildlife habitat, disruption of recreational use, degradation of visual quality, and damage to cultural resources. In general, the extent to which these would be long-term impacts would depend upon how long a given operation was continued. Some of the short-term changes could soon lead to long-term decreases in productivity. For example, periodic drawdowns to levels below those required for irrigation pumps could result in long-term agricultural productivity losses, if irrigators do not modify their pumps.

The short-term and long-term uses of the environment for system operations would, however, have some beneficial effect on long-term productivity. The continued availability of electric power should help maintain the region's economic health. Operations intended to benefit anadromous fish should contribute to the recovery of species listed under the ESA and to the maintenance of other stocks. Some of the SOS alternatives would improve conditions for resident fish and wildlife, and this improve the long-term productivity of these resources.

Energy Requirements and Conservation Potential of Alternatives

SOSs 5, 6, 9a, and 9c involving substantial drawdown of lower Snake River projects, would make the locks at Ice Harbor, Lower Monumental, Little Goose, and/or Lower Granite Dams unusable at certain times of year. Drawdown during the spring or summer could

overlap with much of the current navigation activity, requiring shippers to reschedule shipments, store commodities, and/or use trucks or railways to avoid major disruptions in the delivery of products. Alternate transportation methods needed to move commodities to market would increase fuel consumption.

Increased river velocities resulting from flow enhancement measures could impair navigation at certain locations along the river where physical constraints now exist. Increased difficulties in navigating constricted areas could result in a minor increase in fuel consumption.

A shorter operating season for Dworshak log transport under SOSs 2d, 9b, 9c, and PA would increase annual trucking costs and fuel consumption. On the other hand, SOSs 1a, 1b, 4c, 5, 6, and 9a would extend the operating season for Dworshak log transport, reducing trucking costs and, therefore, fuel consumption.

All of the SOS alternatives would result in some degree of change in the level of hydroelectric generation (see Section 4.2.13). These effects would entail some shifting in the mix of power resources used to meet regional electric demand, but would not directly affect the level of energy consumption.

Natural or Depletable Resource Requirements and Conservation Potential of Alternatives

There are no mining or other mineral resources that would be affected by the alternatives.

Urban Quality, Historic and Cultural Resources, and the Design of the Built Environment

The projects covered by the SOR are generally located away from urban areas; therefore, actions at these projects would have little direct effect on the quality of the urban environment. The primary potential to affect urban quality effects applies to the Lewiston, Idaho-Clarkston, Washington area. Drawdown actions under SOSs 5, 6, 9a, or 9c could lead to increased dust levels, reduced visual quality, and lost local recreation opportunities. These effects would reduce the quality of the local urban environment.

The major concern under this topic involves historic and cultural resources. All of the system operating strategies would result in exposure of cultural sites and subsequent damage. The SOR agencies will develop appropriate monitoring/surveillance methods and awareness programs to prevent or minimize vandalism, as part of overall monitoring and mitigation for cultural resources. The Corps and Reclamation, as the operating agencies for the Federal projects, will develop cultural resources management plans pursuant to Section 110 of the NHPA.

