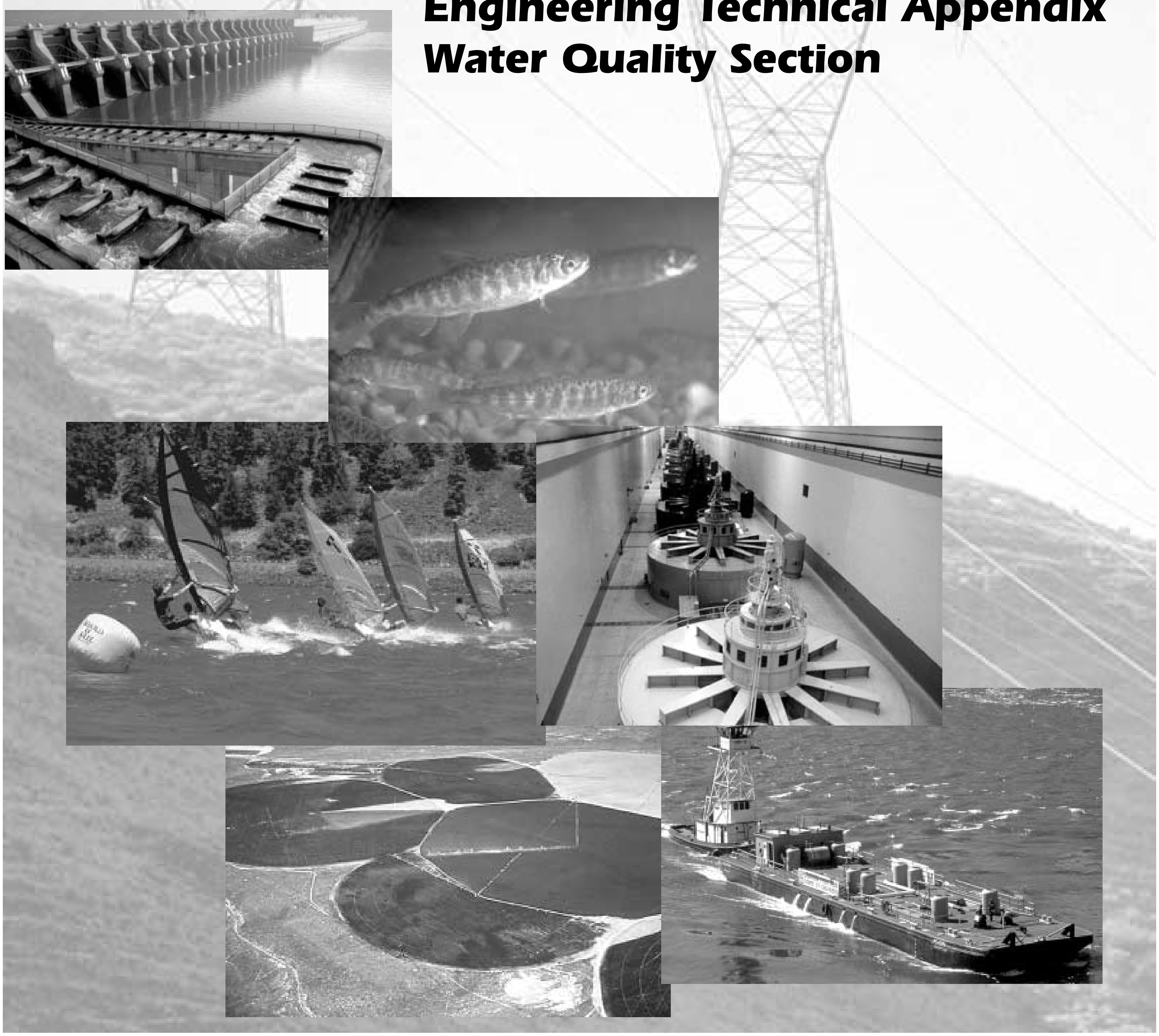
US Army Corps
of Engineers ®
Portland District

Salmon Recovery through John Day Reservoir

John Day Drawdown
Phase I Study

Engineering Technical Appendix
Water Quality Section



September 2000

Table of Contents

Tables

Figures

Section 1. Introduction

This technical appendix section documents the results of the water quality evaluation for the John Day Drawdown Phase I Study. This Phase I Study is a reconnaissance-level evaluation of the potential consequences and benefits of the proposed drawdown of the John Day Reservoir. This technical appendix section supplements the main report, which describes more fully the alternatives, purpose, scope, objectives, assumptions, and constraints of the study.

Section 2. Background of the Project

In 1991, the National Marine Fisheries Service (NMFS) proposed that Snake River wild sockeye, spring/summer chinook, and fall chinook salmon be granted "endangered" or "threatened" status under provisions of the Endangered Species Act. Natural resource agencies believe that the drawdown of the 76-mile John Day Reservoir may provide substantial improvements in migration and rearing conditions for juveniles by increasing river velocity, reducing water temperature and dissolved gas, and restoring riverine habitat. It is also speculated that drawdown may improve spawning conditions for adult fall chinook by restoring spawning habitat and the natural flow regimes needed for successful incubation and emergence.

As a result, the NMFS Reasonable and Prudent Alternative Action #5 of its' Biological Opinion on Operation of the Federal Columbia River Power System (FCRPS), and subsequent reports recommended that USACE investigate the feasibility of lowering John Day Reservoir. In compliance with appropriation conditions, only two alternatives were to be evaluated: reduction of the current water surface elevation 265 to the level of the spillway crest that would vary between elevations 217 and 230, or reduction to natural river level elevation 165. Both alternatives were proposed by NMFS. These two alternatives were then expanded to consider each alternative with 500,000 acre-feet of flood storage and without such storage. Flood storage and hydropower are the current approved authorizations for the John Day project.

Section 3. Description of the Study Area

The Columbia River originates in Canada and flows for 300 miles through eastern Washington to Oregon and continues west to the Pacific Ocean, as shown in Figure 1. The adjoining region is mostly open country, with widely scattered population centers. The climate of the region is semiarid. Agriculture, open space, and large farms are prevalent. Lands adjacent to the reservoir are used to grow grains and other crops. The reach of the Columbia River under consideration in this report extends from John Day Lock and Dam at river mile (RM) 215.6, to McNary Lock and Dam RM 291. The body of water impounded by John Day Dam, Lake Umatilla, is referred to as the John Day Reservoir throughout this report. The John Day is the second longest reservoir on the Columbia River, extending 76 miles upstream to McNary Dam.

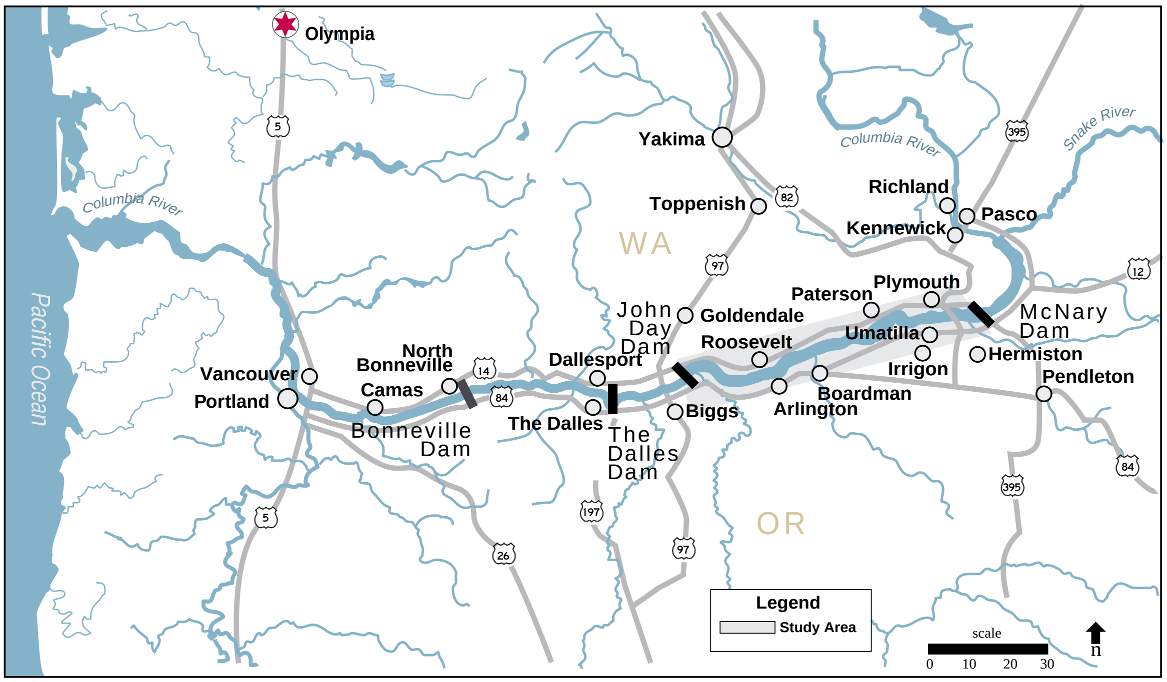


Figure 1. John Day Drawdown Phase 1 Study Area

John Day Dam and Reservoir are part of the Columbia-Snake Inland Waterway. This shallow-draft navigation channel extends 465 miles from the Pacific Ocean at the mouth of the Columbia River to Lewiston, Idaho. The entire channel consists of three segments. The first is the 40-foot-deep water channel for ocean-going vessels that extends for 106 miles from the ocean to Vancouver, Washington. The second is a shallow-draft barge channel that extends from Vancouver to The Dalles, Oregon. Although this section is authorized for dredging to a depth of 27 feet, it is currently maintained at 17 feet. The third section of the channel is authorized and maintained at a depth of 14 feet and extends from The Dalles to Lewiston. In addition to the main navigation channel, channels are dredged to numerous ports and harbors along the river.

The middle Columbia River area is served by a well-developed regional transportation system consisting of highways, railroads, and navigation channels. Railroads and highways parallel the northern and southern shores of the reservoir. Interstate 84 (I-84), a divided multilane highway, runs parallel on the south shore with the Columbia River from Portland, Oregon, to points east. Washington State Route 14 (SR-14) also parallels the Columbia River from Vancouver to McNary Dam on the north shore. Umatilla Bridge at RM 290.5, downstream from McNary Dam, is the only highway bridge linking Oregon and Washington across the Columbia River in the John Day Reservoir.

The study area includes lands directly adjacent to the reservoir as well as those directly and indirectly influenced by the hydrology of the reservoir (e.g., irrigated lands). It includes the reservoir behind the John Day Dam, and adjoining backwaters, embayments, pools, and rivers.

Section 4. Alternatives

The Phase 1 Study includes a preliminary evaluation of the impacts of the drawdown scenarios relative to the "without project condition," which is defined as the condition that would prevail into the future in the absence of any new federal action at John Day. The four alternatives are summarized below. One of the most important constraints on the alternatives is the requirement to pass fish for river flows up to the 10-year flood flow of 515,000 cfs. Under the four alternatives, John Day Reservoir would be drawn down at a rate of one foot per day. For greater detail, please refer to the main report, *John Day Drawdown Phase 1 Study*, and *John Day Drawdown Phase 1 Study, Engineering Technical Appendix, Structural Alternatives Section*.

4.1. Spillway Drawdown without Flood Control (Alternative 1)

The first drawdown alternative is based on requirements for improved downstream fish passage conditions during both low and flood flow conditions on the Columbia River. The existing 20-bay spillway will be operated differently from current operations, but without any structural modifications. All project inflows will be directly passed through the dam spillway with the spillway gates fully opened in free overflow condition, resulting in a pool elevation that will vary from elevation 217 to 230. Impacts downstream from John Day Dam were not studied.

4.2. Spillway Drawdown with Flood Control (Alternative 2)

The second study alternative is based on requirements for improved downstream fish passage conditions during low flow periods, while maintaining authorized flood control for the John Day Project. The existing 20-bay spillway will be operated differently from current operations, but without any structural modifications. During low flow periods, project inflows will be directly passed through the dam spillway with the spillway gates set in fully open, free overflow condition. During a flood event, however, the spillway gates will be controlled to reduce downstream flood flows based on using 500,000 acre-feet of allocated project storage space. Ponding will occur upstream from the dam. Impacts downstream from John Day Dam were not studied.

4.3. Natural River Drawdown without Flood Control (Alternative 3)

The third study alternative is based on a natural river drawdown for fish passage “without flood control” condition. Natural river conditions pertain to an opening at the John Day Dam that permits acceptable upstream fish passage conditions. The size of the total dam opening must conform to two criteria based on an invert elevation at the dam of 135. The first criterion is that the opening must be sufficiently large to meet maximum allowable stream velocity criteria for sustained swim speed for the weakest salmon species, which is estimated to be 10 feet per second (fps). The second criterion is that fish passage for this opening must correspond to the 10-year annual flood peak (515,000 cfs). This alternative will require extensive modifications to John Day Dam even beyond modification of the 1,228-foot long spillway structure. Impacts downstream from John Day Dam were not studied.

4.4. Natural River Drawdown with Flood Control (Alternative 4)

This fourth study alternative is based on natural river conditions for fish passage and includes the “with flood control” condition. It requires natural fish passage conditions for both upstream and downstream directions at the dam and includes a requirement for full authorized flood control. The calculated width of the total dam opening will correspond to that previously calculated for natural river conditions without flood control (Alternative 3). Impacts downstream from John Day Dam were not studied.

Section 5. Introduction

The literature search undertaken to support this study included reports, technical papers, and environmental impact statements related to Columbia River watershed water quality and limnological investigations, as well as dam drawdown studies on other projects. These investigations provide physical, chemical and biological conditions of Columbia River water. The collected information will be used to establish pre-drawdown conditions in the reservoir to compare to conditions that may occur under the considered alternatives.

In addition to information from the John Day reservoir, data from the free-flowing Hanford Reach of the Columbia River, between Priest Rapids Dam and Richland, Washington has been collected. Water quality in the Hanford reach is of high quality and is characterized as having cool temperatures, very low suspended load, low nutrient content, and an absence of microbial contaminants (National Park Service, 1994). The water quality within the Hanford

Reach is characteristic of free-flowing river conditions (Alternatives 3 and 4). The water quality data collected as part of this effort is included in Table 1, found at the end of this study. For purposes of this study, Alternatives 1 and 2, and Alternatives 3 and 4 have been grouped together.

Section 6. Turbidity/Suspended Solids

All four drawdown alternatives will increase turbidity and suspended solids in John Day and downstream reservoirs. Multiple processes will increase the amount of suspended sediments in the water that will make it appear turbid or cloudy. Increased turbidity levels could have negative effects on aquatic life. Under existing conditions, turbidity is not a major issue of concern within John Day reservoir.

Exposure of previously submerged sediments to erosion by precipitation, wind, and wave action will cause increased levels of sediment within the water. Suspended sediments and turbidity of this origin will particularly be acute after erosion generating storms or high river flows immediately after drawdown. Deltaic sediment fans located at tributary mouths will be exposed and become major sources of sediment. Suspended sediments and turbidity of this origin will reduce over time and reach equilibrium after multiple events have eroded the newly exposed sediments into the reservoir.

During reservoir drawdown, groundwater from newly exposed banks will drain into the reservoir reducing slope stability of the banks. During the 1992 reservoir drawdown test of Lower Granite and Little Goose reservoirs, a drawdown limit of 2-feet-per-day was followed to reduce slope failures and slumps. Despite this precaution, slope failures and slumps did occur and caused increased levels of sediment within the reservoirs.

Increased levels of suspended sediments and turbidity will accompany a geomorphic transformation from a lacustrine to a riverine environment as water reestablishes a hydraulic channel. Extensive cutting and scouring of the drawdown river channel would likely create high turbidities for an extensive period.

Construction activities, including the installation and removal of cofferdams, installation of riprap and the dredging of sediments, will also be a source of increased suspended solids and turbidity.

All increased levels of suspended solids will flow through John Day reservoir more quickly due to increased water velocities under all drawdown conditions. Greater velocities allow water to transport increased volumes of suspended solids. Upon reaching slack water of the Dalles reservoir, water velocities will decrease reducing the amount of suspended solids the water can transport. Sedimentation of fine particles such as clays and silts will likely occur at this interface of lacustrine and riverine environments. Larger particulates will not be transported as far and will have likely settled out of the water column up river of this point.

Analysis of turbidity data from the 1992 drawdown of Lower Granite reservoir shows turbidity levels rising from seven Nephelometric Turbidity Units (NTU) to 35 NTU within the reservoir. Turbidity at Lower Granite Dam rose from 7 NTU to 12 NTU. Longitudinal profiles of reservoir turbidity depict a downstream shift in maximum turbidity values over time. This represents downstream transportation of silts and clays that became suspended in the water column at the initiation of drawdown. Turbidity levels decreased at Lower Granite Dam due to reduced velocities and increased sedimentation within the slack water immediately upstream of the dam. Turbidity increases at the head of Lower Granite reservoir associated with the scouring/resuspension of coarser sediments was observed as well as turbidity peaks originating from tributary stream delta fan erosion and slope failures. A lack of storm events during the month long drawdown minimized erosion of newly exposed sediments which could have been a major source of suspended solids. Similar conditions may be observed upon drawdown of John Day reservoir.

Estimates of the amount of sediment deposited in John Day reservoir are presented in another appendix. Some of this deposited sediment will erode, adding suspended sediment to the water, until equilibrium is attained. Estimates as to how long river systems require to reach equilibrium after such drawdown events include, anywhere from two to seven years (Olympic National Park 1996), within five years of repeated annual drawdowns (United States Army Corps of Engineers Walla Walla District 1997) and within 5 to 15 years (United States Army Corps of Engineers North Pacific Division 1995). More precise predictions concerning the magnitude, duration, and spatial and temporal variations of suspended solids and turbidity will require additional studies.

As shown in Table 1, turbidity measurements in John Day reservoir have ranged from 1.3 to 41.8 NTU. At such background levels any activity which increases turbidity by a total of 5 NTU is a violation of water quality standards. Such violations are highly likely to occur after the initiation of drawdown.

It has been observed that fish can survive high concentrations of suspended solids for short periods. Prolonged exposure for most species, however, results in complications with respiration (United States Army Corps of Engineers North Pacific Division 1990). Suitable spawning areas will be limited within John Day reservoir until equilibrium is attained. Although adult and juvenile salmon and steelhead will immediately be migrating through the reservoir following drawdown, spawning will not occur in the reach until areas that were inundated experience flow events of high enough magnitude to dislodge compacted gravels and cleanse fine sediments from them. Increased turbidity may decrease salmonid losses to predation.

6.1. Alternatives 1 and 2

For all the sources of suspended sediments and turbidity noted, conditions likely to arise under Alternatives 1 and 2 will be less severe than those under Alternatives 3 and 4. Less sediment will be exposed to possible erosion and the reservoir will return to pre drawdown conditions more quickly. Highly elevated levels of suspended sediments and turbidity are still likely and are of concern.

6.2. Alternatives 3 and 4

Of the alternatives, Alternatives 3 and 4 will expose more sediment to erosion and hence should cause greater turbidity levels for a greater duration. Alternatives 3 and 4 will expose a greater volume of bank material and likely increase the occurrence of slope failures. Alternatives 3 and 4 will return the entire reservoir into a riverine environment and cause more erosion and turbidity than Alternatives 1 and 2. Alternatives 3 and 4 will cause higher velocities that will be able to transport more sediment than Alternatives 1 and 2.

Section 7. Total Dissolved Gas

Elevated levels of dissolved atmospheric gases in Columbia River water are caused by the operation of spillways at most dams. Dissolved gas levels below projects often exceed state and federal standards of 110 percent saturation. These elevated levels can cause mortality in juvenile and adult migratory fish, resident fish, and other aquatic organisms. Any reductions in total dissolved gas levels will be a benefit to aquatic life.

John Day Dam has historically been a high dissolved gas producer with levels greater than 140 percent saturation leaving the project. To reduce this dissolved gas generation, flow deflectors (flip lips) were installed on 18 of the 20 spillbays at the dam. Data has shown that the flow deflectors have reduced the dissolved gas levels at the project by roughly 20 percentage points.

Factors that effect the amount of dissolved gas in a projects tailwater include spill discharge volume, spill discharge pattern, spillway shape, water depth in stilling basin, geomorphic conditions downstream of the stilling basin, total river discharge, mixing characteristics of powerhouse and spillway flows, water temperature, and barometric pressure. A factor that appears to be of particular importance to John Day Dam is geomorphic conditions downstream of the stilling basin. A deepwater channel, with elevations up to 35 feet deeper than surrounding topography, extends well downstream from below spillbays six through eight. Dissolved gas levels within the vicinity of this channel have been observed to be consistently higher than surrounding waters for a majority of spill patterns (Schneider and Wilhelms 1998) with observations reaching 140 percent even with operating flow deflectors that are designed to reduce gas levels.

7.1. Alternatives 1 and 2

Near-field study at John Day Dam has shown dissolved gas generation to be highly related to discharge per spillway and spill pattern. An exponential relationship expressing dissolved gas saturation as a function of unit spillway discharge is developed in Schneider and Wilhelms 1998. It was also observed in the 1992 drawdown of Lower Granite Reservoir that dissolved gas levels were most dependent upon spillway discharges. Dissolved gas levels will increase as the amount of spill increases. Lower forebay elevations in Alternatives 1 and 2 will cause lower flows and hence lower levels of dissolved gas downstream of the project. Unregulated flow over the spillways, however, may increase the frequency of high spill rates that generate increased levels of dissolved gas. The developed relationship between unit spillway discharge and dissolved gas saturation is not appropriate for prediction at higher flows that may be encountered during flood events. The frequency and magnitude of dissolved gas saturation of such events requires further investigation.

Observations from the 1992 Lower Granite reservoir drawdown as well as from near-field studies at Ice Harbor and The Dalles Dams indicate that tailwater elevations are also a determining factor in dissolved gas generation. Tailwater elevations are an important variable in the effectiveness of flow deflectors. Flow deflector efficiency is a factor of discharge per spillway and tailwater elevation (submergence). To maintain these optimum efficiency of flow deflectors, tailwater levels may need to be kept within current normal operating ranges. A loss in efficiency of the flow deflectors due to low tailwater elevation may be compensated by the fact that low flows inherently produce less dissolved gas in the first place.

The deepwater channel that appears to accommodate higher dissolved gas levels should be considered in the design of Alternatives 1 and 2. Perhaps spillway flows can be prevented in the vicinity of the channel or it can be accounted for structurally. It is proposed in Schneider and Wilhelms 1998 that a raised tailrace channel of 140 feet (current invert elevation 114 feet) below the John Day Dam could reduce dissolved gas levels by as much as 5 percent saturation. Further investigations of dissolved gas levels below John Day Dam resulting from Alternatives 1 and 2 are needed.

7.2. Alternatives 3 and 4

Under Alternatives 3 and 4 the problem of elevated dissolved gas generation at John Day Dam would be eliminated. Removal of the spillway and north embankment will allow water to flow freely past the dam. Dissolved gas levels in exceedance of standards will still be a possibility in the John Day vicinity due to residual increased gas levels from upstream projects. Unimpounded river flows through John Day reservoir may cause increased flows downstream of John Day Dam, which could increase spillway use and dissolved gas levels below The Dalles and Bonneville Dams. This requires further study.

7.3. Effects upon McNary Dam

Under all drawdown scenarios tailwater elevations at McNary Dam will be significantly reduced. Tailwater elevations will vary from 251 feet above mean sea level (ft msl) to 270 ft msl as opposed to the current range of 262 ft msl to 280.5 ft msl. These lower elevations will strand the current McNary tailwater deflectors requiring their removal and relocation. The shallower tailwater conditions under drawdown conditions will change the type of TDG exchange that occurs towards what is observed at The Dalles and Ice Harbor Dams which both possess shallow tailraces. If the new deflectors are optimally sited, the net effect may be lower TDG levels at McNary Dam (Mike Schneider, United States Army Corps of Engineers Waterways Experiment Station, personal communication).

Section 8. Temperature

Effects of drawdown upon water temperature are hard to predict due to competing mechanisms resulting from drawdown. Heating and cooling rates vary inversely with changes in water volume. That is, as the volume of a body of water is reduced, it will absorb and dissipate heat more quickly. However, increased water velocities inherent with any drawdown reduces the retention time of the water providing less time to absorb or dissipate heat. Increased stream flows inherent with drawdown will generally result in shallower water depths and reduced volumes, which will heat and cool more quickly counteracting the effects of higher velocities. High volume stream flows tend to result in less fluctuation in water temperatures while lower volume stream flows are more susceptible to fluctuations such as diel cycles. Increases and decreases in reservoir surface area also effect temperature since any heat exchange must occur through this boundary. The major effect dams have upon water temperature in the Columbia River is to delay the occurrence of maximum temperatures in late summer as well as delay early autumn cooling.

The governing equation for the heat budget of a well-mixed water body is:

$$\Delta(TV) = (\Sigma Q_{in}T_{in} - \Sigma Q_{out}T + \Phi_n V/h\rho c_p)\Delta t$$

Where

- T = water temperature of John Day reservoir
- T_{in} = water temperature of tributaries
- V = volume
- t = time
- Q_{in} = flow rate of tributaries
- Q_{out} = flow rate of withdrawals
- Φ_n = net surface heat flux
- ρ = density of water
- c_p = specific heat of water
- h = depth of water.

This shows that the temperature of a water body is a function of inflows, outflows, volume, depth and surface heat flux which is a function of local climatic conditions. A drawdown of John Day reservoir will change volume, depth and Δt, retention time, in the governing equation. To predict the effects each drawdown alternative may have upon water temperature a model incorporating a heat budget must be developed. This model must also account for varying operations of the remaining Columbia and Snake River system including possible drawdown of the Lower Snake projects. Water temperature modeling at John Day Dam was performed as part of the Columbia River System Operation Review Environmental Impact Statement however none of the alternatives in that study match the proposed alternatives in this study.

As shown in Table 1, water temperatures in John Day reservoir during this decade have ranged from a minimum of 0 to a maximum of 24.7 degrees Celsius. Maximum temperatures of this magnitude are well above all maximum temperature standards for salmonid bearing water bodies. Since John Day reservoir is currently operated as a run-of-river reservoir with relatively short retention times, drawdown effects upon temperature can be expected to be minimal with little benefit to aquatic life. The possibility of higher peak temperatures may actually be detrimental to aquatic life and would require further investigation.

8.1. Alternatives 1 and 2

Calculations have estimated that at a flow of 200,000 cubic feet per second (cfs) a drawdown of John Day reservoir to spillway crest level will reduce water particle travel time through the reservoir from 5.7 to 2.5 days. Water surface elevation would be reduced from roughly 265 feet MSL to 220 feet MSL at the dam. The reduced volume and depth of the reservoir will allow the water to warm or cool more quickly. This could result in higher peak temperatures since the water may be more susceptible to diel solar heating under these conditions. Reduced retention time within the reservoir, however, will allow the water less time to absorb heat. Model results are required to quantify the net result of these competing factors.

8.2. Alternatives 3 and 4

Calculations have estimated that at a flow of 200,000 cubic feet per second (cfs) a drawdown of John Day reservoir to natural river level will reduce water particle travel time through the reservoir from 5.7 to 0.9 days. Water surface elevation would be reduced from roughly 265 feet MSL to 170 feet MSL at the dam. Once again model results are needed to quantify the net results of the reductions in depth, volume and retention time.

Section 9. Pollutants

Data concerning pollutants in John Day reservoir is lacking. From what little data was found, ranges of concentrations for heavy metals were collected and are included in Table 1. The data suggest that some standards for such pollutants have been exceeded. No relevant data concerning organic pesticides and herbicides have been located at this time. Erosion and resuspension of sediments could result in the introduction of pollutants into Columbia River water and subsequent redistribution. Most pollutants will remain absorbed to sediments but some may become dissolved in the water column when levels of suspended sediments increase. Pollutants adsorbed to suspended sediments will likely settle out upon reaching slack waters impounded by The Dalles Dam.

Changes in elevation, flow and circulation patterns in the vicinity of point source pollutant discharges may adversely effect dilution mechanisms. Such pollutant point sources are required, under the National Pollutant Discharge Elimination System (NPDES), to be sufficiently diluted so that water quality standards are not violated beyond a specified mixing zone. Reductions in dilution waters related to drawdown may cause licensed dischargers to John Day reservoir to alter their discharge practices in order to maintain compliance with their NPDES permits. Due to the lower reservoir elevations under drawdown conditions, sewer and discharge outfalls may be exposed and rates of contaminated groundwater seepage into the Columbia River could be increased.

Elevated pollutant levels could be harmful to aquatic and human life. The Columbia River System Operation Review Final EIS (United States Army Corps of Engineers North Pacific Division, 1995) stated that no significant departure from current conditions (in regards to pollutants) is expected at Columbia River locations under any of the alternatives considered. It also stated, however, that “the general lack of data on location and distribution of toxic substances such as PCBs does not allow accurate prediction of health effects or changes to chemical quality of the water.” Further study is required to more reliably quantify the amount of pollutants at present as well as possible under drawdown conditions and to determine to what extent those levels may pose a health threat.

9.1. Alternatives 1 and 2

The duration of drawdown effects upon pollutants under Alternatives 1 and 2 would be similar to that of suspended sediments and turbidity under Alternatives 1 and 2 since the main mechanism of reintroduction and redistribution of pollutants is through suspension of sediments to which they are adhered.

9.2. Alternatives 3 and 4

Likewise, the duration of drawdown effects upon pollutants under Alternatives 3 and 4 would be similar to that of suspended sediments and turbidity under Alternatives 3 and 4.

Section 10. Nutrients

Erosion and resuspension of sediments could result in the introduction of increased levels of total phosphorus, total nitrogen and total carbon into Columbia River water. Increased nutrients could stimulate aquatic growth that could lead to temporary but harmful reductions in dissolved oxygen levels due to increased consumption of oxygen by aquatic microorganisms. This may occur downstream in The Dalles reservoir where the nutrients will tend to accumulate under drawdown conditions. Another source of nutrients may be detritus from benthic, periphytic and other organisms exposed by the drawdown. Data for two important nutrient parameters, phosphate and nitrate, are included in Table 1.

10.1. Alternatives 1 and 2

Alternatives 1 and 2 will erode and suspend less sediment than other alternatives. It will also expose fewer organisms to adverse environmental conditions causing less detritus. Nutrients that do become suspended may remain within John Day reservoir due to intermediate water velocities, especially in the vicinity of John Day Dam.

10.2. Alternatives 3 and 4

Alternatives 3 and 4 will erode and suspend more sediment; expose greater amounts of organisms and will tend to transport more nutrients downstream than other alternatives. This will increase nutrients and detritus, most likely in the slack waters of The Dalles reservoir.

Section 11. Primary Productivity

Primary productivity is the production of organic matter from light energy and nutrients by producer organisms, primarily aquatic plants and phytoplankton. In general water bodies with short detention times have reduced rates of primary production (United States Army Corps of Engineers Walla Walla District, 1997). The uptake of nutrients by phytoplankton, and the subsequent deposition within the reservoirs through sedimentation, would be reduced following the execution of any drawdown upon the John Day reservoir. Under drawdown, fewer nutrients would be retained in the waters of John Day reservoir. Nutrients will tend to be flushed to The Dalles reservoir. In addition, increased turbidity levels will reduce light levels within the water reducing the photic zone and temporarily limiting production. As a consequence, chlorophyll a, an indicator of phytoplankton production, should decrease under all drawdown alternatives.

After the initial drawdown is completed, lentic (standing water) forms of phytoplankton may decrease due to reduced detention times. Losses of these forms, although probably important to overall primary productivity in the system, could be replaced by more lotic (moving water) forms preferable to salmonids and salmonid prey organisms. Such a shift in community structure would likely contribute slightly to salmonid survival (United States Army Corps of Engineers Walla Walla District, 1997).

Macrophyte beds and periphytic communities would be significantly effected by drawdown in the short term. Assuming suitable environments exist under drawdown conditions, such organisms would reestablish themselves after the completion of drawdown. Communities that find drawdown conditions lethal could prove to be a somewhat significant source of nutrients to John Day as well as downstream reservoirs.

11.1. Alternatives 1 and 2

Alternatives 1 and 2 will reduce retention times and increase water velocities but not to the extent of the other alternatives. An area of reduced water velocities may exist adjacent to John Day Dam under these scenarios. It is unclear whether lentic or lotic communities will be favored in this intermediate environment. Reduced velocities near the dam will allow some nutrients to be contained within John Day reservoir.

11.2. Alternatives 3 and 4

Alternatives 3 and 4 will further reduce retention time and increase velocities favoring establishment of lotic communities and transport of nutrients to The Dalles reservoir.

Section 12. Dissolved Oxygen

Increases in nutrients related to erosion, sediment suspension and detritus might cause short term but harmful reductions in dissolved oxygen in slack waters. Deposits of detritus in slack water in upper Dalles reservoir may result in temporary low DO levels. In the long run, dissolved oxygen levels will remain at their current, healthy levels which roughly range from 8 to 16 mg/L (see Table 1).

12.1. Alternatives 1 and 2

Any dissolved oxygen depletions should be less for Alternatives 1 and 2 since fewer nutrients should be suspended within the water. Depletions may occur within John Day reservoir if the nutrients remain within the reservoir.

12.2. Alternatives 3 and 4

Dissolved oxygen deficiencies may be greater under Alternatives 3 and 4 since more nutrients are likely to be suspended within the water. Nutrients will tend to be transported to The Dalles Reservoir and any dissolved oxygen reductions would likely occur there.

Section 13. Alkalinity, pH, Conductivity, and Hardness

Increases in the concentrations of ionic compounds, such as carbonates, bicarbonates and hydroxides, salts, and organic and mineral acids related to increased erosion and sediment suspension may cause short-term shifts in alkalinity, pH, conductivity and hardness. Short-term increases may be possible for all parameters, however no adverse consequences are expected. After erosion related to drawdown subsides, these parameters will return to their current healthy levels (see Table 1 for pH values).

13.1. Alternatives 1 and 2

Any shifts should be less for Alternatives 1 and 2 since less erosion and sediment suspension will occur. These shifts may occur within John Day reservoir since suspended sediment may tend to remain in the reservoir.

13.2. Alternatives 3 and 4

Effects may be greater under Alternatives 3 and 4 since more erosion will occur and more sediment will be suspended. Suspended sediment will tend to be transported to The Dalles Reservoir and any major shifts in alkalinity, pH, and hardness would likely occur there.

Section 14. Summary

Drawdown of John Day Reservoir under any of the proposed alternatives may negatively impact water quality in the short term. Short-term negative impacts may be related to increased turbidity and suspended solids, resuspension of pollutants, increase in nutrients and possible downstream dissolved oxygen reductions. These will dissipate over time and will return to pre-drawdown conditions. Estimates on the period of time before equilibrium is reestablished range from 2 to 15 years. Long term water quality benefits will be in the form of reduced total dissolved gases, increased water velocities, and water temperature regimes shifting towards pre-impoundment conditions.

Table 1.
Data Summary Table

Parameter	Pre John Day Dam before 1968	Post John Day Dam after 1968	Hanford Reach	Oregon DEQ Standard	Washington DOE Standard	EPA Recommended Criteria
Turbidity	NA	1.3 – 41.8[h]	0.7 – 2.9[c]	< 10% increase over background	< 5 NTU increase if background < 50 NTU or < 10% increase if > 50 NTU	< 5 NTU increase if background < 50 NTU or < 10% increase if > 50 NTU
Temperature	-0.6 - 27.2 °C[a]	0 - 24.7 °C[b]	0.9 - 21 °C[c]	13 °C[o] (maximum)	18 °C[q] (maximum)	SPECIES DEPENDENT
pH	7.2 – 8.2[d]	7.5 – 8.9[e]	6.4 – 8.7[c]	7.0 – 8.5[bb]	6.5 – 8.5[q]	6.5 – 9.0[u]
Dissolved Oxygen	10.2 - 10. 3 mg/L[l]	8.3 - 14.8 mg/L[g] 8.5 - 13.8 mg/L[i] 8.9 - 16.1 mg/L[f] 4.6 - 13.9 mg/L[m]	9.8 - 14.8 mg/L[c] 8.1 - 12.2 mg/L[h]	6 mg/L[p] (minimum)	8 mg/L[q] (minimum)	8 mg/L[aa] (minimum)
Phosphate	0.2 - .28 mg/L[d]	.0001 - .038 mg/L[e] .005 - .199 mg/L[f] .11 - .39 mg/L[g]	.0005 - .016 mg/L[h]	.05 mg/L[z]	r	Narrative Statement
Nitrates	.1 - 2.1 mg/L NO3[d]	0.0 - .84 mg/L NO2-NO3[i] 0.0 - 0.67 mg/L NO2-NO3[e] .01 - .84 mg/L NO2-NO3[f] .2 - 1.9 mg/L NO3[g]	.05 - .33 mg/L NO2-NO3[h]	10 mg/L[x]	NA	10 mg/L Nitrates[u]
Heavy Metals	NA	Arsenic <1 - 3 ug/L[l] 1.44 - 30 ug/L[j] Cadmium ND - 9 ug/L[i] .1 - .39 ug/L[k] Chromium ND - 20 ug/L[i] .02 - 5 ug/L[k] Lead ND - 44 ug/L[i] 1 - 1 ug/L[k] Mercury <.10 - .60 ug/L[i] .001 - .3 ug/L[k] Zinc ND - 170 ug/L[i] 4 - 12 ug/L[k]	Chromium <1 - 1[n]	Arsenic 190 ug/L[w] Cadmium 1.1ug/L[w] Chromium III 210 ug/L[w] Chromium IV 11 ug/L[w] Lead 3.2 ug/L[w] Mercury .012 ug/L[w] Zinc 110 ug/L[w]	Arsenic 190 ug/L[t] Cadmium s,t Chromium III s,t Chromium IV 15 ug/L[t] Lead s,t Mercury 0.012 ug/L[t] Zinc s,t	Arsenic 150 ug/L[v] Cadmium 2.2 ug/L[v] Chromium III 74 ug/L[v] Chromium IV 11 ug/L[v] Lead 2.5 ug/L[v] Mercury 0.77 ug/L[v] Zinc 120 ug/L[v]
Chlorophyll A	NA	0.3 - 42.1 ug/L[e]	1.6 - 13.4 ug/L[h]	15 ug/L[y]	NA	NA
Pollutants	NA	NA	NA	VARIOUS	VARIOUS	VARIOUS

****Key for Table 1 can be found on the next page.****

Key for Table 1

a. Once-daily observations from December 1950 to September 1958 at Maryhill Ferry, near Rufus. Taken from USGS Open-file Report Compilation of Water-Temperature Data for Oregon Streams, 1964.
b. Hourly observations from John Day forebay total dissolved gas fixed monitoring station, 1994 - 1998. Taken from total dissolved gas abatement database.
c. 1985 data taken from Hanford Reach of the Columbia River, National Park Service, 1994.
d. Once monthly USGS data recorded at gage 14019200, McNary Dam in 1960, 1962, 1963, 1966 and 1967.
e. Taken from NMFS database accompanying Limnological Investigation in John Day Reservoir, Including Selected Shallow-Water Habitats: April to December 1994.
f. Once monthly WDOE data recorded at gage 31A070, Columbia River at Umatilla from 10/1991 - 12/1998.
g. Once monthly USGS data recorded at gage 14019200, McNary Dam in 1969.
h. Taken from database provided by NWW. Bi-monthly observations from 6/1997 - 10/1997.
i. Once monthly USGS data recorded at gage 14019250, Columbia River at Umatilla from 1975 - 1980.
j. Six observations of Total Recoverable Arsenic from WDOE gage 31A070, Columbia River at Umatilla from 1994 - 1995.
k. Observations from WDOE gage 31A070, Columbia River at Umatilla from 1991 - 1998.
l. Two readings from USGS gage 14049200, McNary Dam from 10/1967 and 11/1967.
m. Taken from NMFS database accompanying Limnological Investigation in John Day Reservoir, Including Selected Shallow-Water Habitats: April to December 1994. Note that readings taken at depth may account for lower values.
n. Taken from Hanford Reach of the Columbia River, National Park Service, 1994. Data is listed as dissolved chromium.
o. Temperature, which must not be exceeded within salmonid habitat during spawning and rearing, seasons.
p. Absolute minimum for cold water species habitat water bodies.
q. For waters designated Class A (excellent).
r. Criteria for an oligotrophic lake within the Columbia Basin Ecoregion is .01 mg/L. John Day pool is not representative of an oligiotrophic lake however. No other standards found.
s. Calculation dependent upon hardness.
t. Chronic values as listed in "Water Quality Standards for Surface Waters of the State of Washington." This document should be consulted for specific details of each standard.
u. Human health for consumption of water + organism value as listed in "National Recommended Water Quality Criteria - Correction" EPA April 1999.
v. Criterion Continuous Concentration as listed in "National Recommended Water Quality Criteria - Correction" EPA April 1999.
w. Fresh chronic criteria for protection of aquatic life as listed at http://waterquality.deq.state.or.us/wq/wqrules/340Div41Tbl20.pdf
x. Concentration for the protection of human health for water and fish ingestion as listed at http://waterquality.deq.state.or.us/wq/wqrules/340Div41Tbl20.pdf
y. Oregon Administrative Rules 340-41-015.
z. Standard for primary and secondary contact recreation in the state of Utah. No applicable standard for Oregon found.
aa. Coldwater criteria one-day minimum, early life stages.
bb. Oregon Administrative Rules 340-41-0642.
ND Not detected.
NA No available data found.

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