Henry M. Jackson Hydroelectric Project

(Federal Energy Regulatory Commission Project No. 2157)

Project Effects on Anadromous Salmonids and Bull Trout in the Sultan River

Prepared for

Public Utility District No. 1 of Snohomish County

City of Everett, Washington

April 2005

CH2MHILL

Contents

Appendices

Figures

Tables

Executive Summary

This report documents the results of an evaluation of the effects of the Jackson Hydroelectric Project on salmon, steelhead trout, and bull trout in the Sultan River. Specifically, the report 1) describes current anadromous fish mitigation and enhancement measures for the Jackson Hydroelectric Project, 2) assesses how well those measures have worked, 3) provides an update of the status of the fish in the river based on spawning surveys conducted since the late 1970s, and 4) describes several additional fisheries enhancement measures recently implemented by the Licensees. Information presented in the report is also intended to inform and assist stakeholders who will be participating in the upcoming relicensing process for the Project.

In 1961 the Federal Energy Regulatory Commission (FERC) issued a license to the Public Utility District No. 1 of Snohomish County and the City of Everett (Licensees) for what was to become the Jackson Hydroelectric Project on the Sultan River. The Project was completed in two stages. The first stage consisted of the construction of Culmback Dam and its reservoir, Spada Lake, in 1965. The Stage I reservoir was initially managed to meet City of Everett water supply needs and to maintain downstream river flows. The second stage, completed in 1984, included the addition of power generation facilities and enlargement of Spada Lake.

On the basis of studies conducted between 1979 and 1982, the Joint Agencies (state and federal fisheries agencies and Tulalip Tribes) and the Licensees collaboratively developed fisheries mitigation measures for the Project. These measures and a Settlement Agreement with the Joint Agencies were included in the license. It was also stipulated that the Licensees conduct several additional studies, continue ongoing monitoring, and adopt an adaptive management approach to fisheries concerns that best could be addressed after the Project began operating. Subsequently, several of the fisheries mitigation measures were modified collaboratively with the fisheries agencies and implemented. These measures included:

1) seasonally-adjusted minimum instream flows for each reach of the river,
2) maximum flow constraints during peak salmon spawning,
3) water temperature control to maintain historical patterns,
4) conservative down ramping rates designed to minimize salmonid fry stranding, and
5) increased active water storage in Spada Lake reservoir to conserve water, reduce flow fluctuation frequency, and reduce the magnitude and frequency of peak flows during the salmon egg incubation period.

Based on 20 years of post-operation data, the fisheries mitigation measures appear to have been successful in both protecting and enhancing all salmonids in the Sultan River that are being monitored. Comparisons of spawner escapement estimates from before and after the hydroelectric facilities began operating in 1984, indicate that the numbers of Chinook, pink, and chum salmon using the Sultan River have increased substantially. As a percentage of the Snohomish system (to factor out trends in marine survival and harvest rate), the Sultan River's contribution to spawner escapement for these salmon species also has increased. Escapement data for the less abundant coho salmon and steelhead trout are limited but seem to indicate that these species also are doing well in the Sultan River.

Bull trout are only occasionally observed foraging in the lower river and, therefore, no data exists regarding trends in their use of the Sultan River. However, status of the Snohomish basin bull trout population is considered healthy. Field studies conducted in 2004 verified that bull trout do not occur in the river between the diversion dam and Culmback Dam.

The analysis of effects of the Project on anadromous salmonids and bull trout in the Sultan River is organized along the following environmental pathways associated with salmonids and their habitat: 1) water quality and temperature, 2) habitat access, 3) streamflow, and 4) channel conditions. Basic conclusions include:

Water Quality/Temperature

- All water quality parameters in the Sultan River meet Washington State AA standards. Thus, the Sultan River is not Clean Water Act (CWA) Section 303(d) designated for any water quality limitation.
- A multi-level outlet structure in the Spada Lake reservoir allows water temperatures to be maintained within the range of pre-Project conditions in the river downstream of the diversion dam at RM 9.7.
- The existence of the Project reservoir has caused a slight seasonal shift in the water temperature regime in the Sultan River such that Chinook salmon fry emergence time has been advanced by about 3 weeks. Because of the flow regulation provided by the Project during this period, the slightly earlier emergence is not believed to be a problem and may, in fact, benefit Chinook salmon by providing a longer time period for the fry to grow prior to emigration.

Habitat Access

- The City of Everett's water supply diversion dam at RM 9.7 blocks upstream fish passage to about 6 miles of high gradient stream. Restoring anadromous fish production above the diversion dam was considered at length by the Joint Agencies during Stage II planning from 1978 to 1981. The Joint Agencies decided to not prescribe fish passage at the diversion dam based on the prospect of greater overall salmonid production in the river with implementation of the Project's fisheries mitigation plan. Results of spawning surveys and monitoring of gravel quality and temperature have demonstrated the success of these mitigation measures.
- Various lines of evidence indicate that sustainable runs of anadromous fish did not historically occur in the upper Sultan basin above the present site of Culmback Dam at RM 16. This area of the river contained several steep cascades and falls up to 10 feet high that blocked upstream fish movement. There is a possibility that steelhead trout had access to the upper basin sometime after the last glaciation period, thus accounting for the presence of resident rainbow trout. Evidence also suggests that bull trout never occurred in the upper basin.

- Results of a radio-telemetry study, empirical observations, and spawner surveys have shown that the tailrace conditions at the powerhouse do not impede successful fish migration and spawning success to areas above the powerhouse.

Streamflow

Instream Flows

- Operation of the Project has generally maintained the pre-Project seasonal pattern of flow in the lower Sultan River. Highest flows occur in the winter, with a secondary peak during the late spring snowmelt period, followed by lower summer flows. Springtime flows have decreased by about 25 percent in response to the filling of the reservoir during this period. This storage provides water to augment summer streamflow and meet municipal water supply needs.

- The minimum flows for the Project were developed collaboratively with the Joint Agencies for areas downstream of the diversion dam based on results of an incremental instream flow study. The minimum flows provide near optimal habitat conditions for salmonid spawning downstream of the diversion dam based on the study results.

- Flows in the lower Sultan River during the summer and early fall have been augmented by releases of stored water from Spada Lake. Compared to historical natural conditions (measured above the diversion dam), flows in the lower river are now higher during the approximately 100 driest days of the year, and the degree of flow augmentation increases as natural conditions become drier. Coho salmon and steelhead trout, both of which rear in the river during the summer, have likely benefited from the increased base flow. Also, the flow augmentation during otherwise drought conditions in September and October likely has benefited Chinook and pink salmon spawning.

Peak Flows

- The construction of Culmback Dam has reduced the amplitude and frequency of peak flow events in the Sultan River. These changes occurred after Stage I in 1965, again in 1983 when the enlarged reservoir was first filled, and again in 1989 when the active storage capacity of the reservoir was increased by agreement with the Joint Agencies. The increased reservoir storage capacity was accepted by the Joint Agencies because the resulting reduction of peak flows in the winter and spring would potentially benefit salmon by increasing the survival rate of incubating eggs and because the frequency of needed flow changes (ramping) at the powerhouse would be reduced. The observed increase in salmon production in the Sultan River, especially for pink and chum salmon, is believed to be primarily due to this reduction of peak flows during the egg incubation and fry emergence period. Because peak flows influence the quantity and quality of spawning gravel over time, field studies and annual monitoring of gravel quality have been performed by the Licensees (see below).

Flow Fluctuations (Ramping)

- Operation of the Project has modified the pattern of short term flow changes in the Sultan River below the powerhouse. Flows now are generally more stable; however, the rate of flow change can sometimes be more rapid than what would occur under natural conditions. “Ramping” is the term used to describe flow changes made at the powerhouse. If flows are ramped down too rapidly, salmonid fry along the margins of the river can become stranded or isolated from the river. Because the Project is not operated as a power peaking facility, however, flow reductions are not frequent nor rapid compared to those at most hydroelectric peaking projects. Flow changes at the Jackson powerhouse are driven primarily by changing hydrologic conditions and the need to maintain the level of Spada Lake within prescribed elevation limits.

- The potential for powerhouse down ramping to strand salmonid fry was the subject of studies conducted from 1985 to1987 in the lower Sultan River. Results of these studies were used to establish a conservative down ramping rate regime for powerhouse discharges. The rates vary depending on species present, time of year, time of day, and initial river stage. As is the case during natural declines in flow, the possibility of some fry becoming stranded or entrapped cannot be totally eliminated during Project operations. However, it has been observed that only a very few fry are now stranded in the river during normal operations. The reduced frequency of flow changes with the Project and the reduction of peak flow events, which are usually associated with rapid flow changes, have likely decreased the stranding of fry to a level below that which would have occurred naturally under pre-Project conditions.
- The greatest risk of salmonid fry becoming stranded in the lower Sultan River occurs during unintentional events that force the powerhouse to shut down rapidly. The two most common reasons for these events have been equipment failures and lightning storms. Several equipment modifications have been made to address those failures. To address concerns regarding forced outages during lightning storms, the Licensees now require that operators be present at the powerhouse during forecasted electrical storms to help prevent outages or to restore flow to the river quickly following such events. Also, to limit the number of lightning-strike outages, the Project contains redundant transmission lines leading from the powerhouse to the Snohomish substation. The system was included in the Project to allow the powerhouse to continue operating in the event of a lightning strike on one of the lines. Until recently this redundant transmission line system has not always worked as intended. However, upgrades to the equipment and its calibration have now demonstrated that the system can perform satisfactorily.

Channel and Riparian Conditions

- The reduction in the frequency and magnitude of peak flow events resulting from the operation of Spada Lake as a storage reservoir has altered the downstream channel-forming process associated with these events. The possibility of long term changes in spawning gravel quantity and quality in the Sultan River became the subject of studies that were conducted during pre-Stage II planning and led to the requirement for annual monitoring of gravel quality at several locations downstream of the diversion dam and powerhouse. The major sources of gravel supply and recruitment for the Sultan River occur in the canyon reach downstream of Culmback Dam. Historically, the area now inundated by Spada Lake was a low gradient sediment depositional zone and probably contributed little to the recruitment of coarse sediment to the lower river. Channel-bed scour studies, gravel quality studies, and annual gravel quality monitoring have documented no significant trends in gravel quantity or quality since the hydroelectric facilities began operating 20 years ago. Gravel quality (based on percent fines) for salmonid spawning has remained excellent. If the annual monitoring indicates a decrease in gravel quality, the Licensees are required to pass a high flow event at Culmback Dam to create sufficient water velocities for streambed scour and gravel flushing.

- Riparian conditions that could be affected by the changes in peak flows, have not been formally addressed on the Sultan River. However, examination of aerial photographs taken in 1984 and cursory observations made along the lower river during annual spawning surveys indicate no major changes to side channels or other off-channel habitats important to anadromous fish for spawning and rearing. Vegetation has encroached onto some stream bank areas, but no obvious changes have been observed to the adjacent stream channel widths or substrate conditions. The most evident vegetation growth has occurred just above the river mouth on bars that were actively mined for gravel prior to 1980.
- Woody debris occurs in the stream channel at numerous locations along the river. Major sources of wood exist in the canyon areas above the powerhouse. Woody debris that collects at the diversion dam is periodically passed downstream. Until recently, wood collected at Culmback Dam has not been passed downstream.

New Enhancement Measures

Based on the results of the recent assessment documented in this report and input from the Joint Agencies, several additional measures were identified that would further reduce the risk of the Project adversely affecting fish. These include:

1) adopting down ramping rates for the occasional flow changes made at the diversion dam
2) limiting the frequency of down ramping events at the powerhouse when emergent Chinook salmon fry are present
3) staffing the powerhouse during predicted lightning storm events to facilitate a more rapid response to forced power outages
4) developing a woody debris management plan for use of wood collected at Culmback Dam for placement downstream in the Sultan River or for use elsewhere in the Snohomish basin for restoration projects.

These measures have been implemented by the Licensees with concurrence of the Joint Agencies and FERC.

Conclusion

After 20 years of operation, the Jackson Hydroelectric Project appears to have had positive effects on the aquatic resources of the Sultan River as indicated by increased anadromous fish use of the river. This result reflects the quality of the original facility design, the success of the Project’s fisheries mitigation plan, and the Licensees’ continued attention to the river’s aquatic resource needs in balance with the needs for power and water supply.

CHAPTER 1

Introduction

The Henry M. Jackson Hydroelectric Project (Project), located on the Sultan River, is licensed by the Federal Energy Regulatory Commission (FERC) to Public Utility District No. 1 of Snohomish County (District) and City of Everett, Washington (City) (together, the Licensees). The Sultan River is in the Snohomish River basin, which is part of the Puget Sound region in Washington state. The Project was first licensed in 1961 and the initial dam and reservoir were completed in 1965. However, power generation facilities and enlargement of the Project's reservoir, Spada Lake, were not completed until 1984 due to unfavorable economics for Project power generation in the regional power market before that time. Planning and design for the second phase began in the late 1970s. Additional licensing studies between 1979 and 1982 primarily addressed fisheries and terrestrial wildlife mitigation associated with proposed power facilities.

The Project has a fish mitigation plan per FERC License Articles 53, 54, 55, and 56 and an operating plan per FERC License Article 57. These plans were developed in consultation with and were accepted by the "Joint Agencies" (then Washington Departments of Fisheries and Game—now Fish and Wildlife [WDFW], NOAA Fisheries, Fish and Wildlife Service [FWS], and the Tulalip Tribes) in fulfillment of a Settlement Agreement, which was subsequently approved by FERC on February 9, 1983, and amended into the Project license (Appendix A). Since Project operations began in 1984, the fisheries mitigation plan has been implemented to protect and enhance salmon and steelhead trout, as well as other salmonid species. Some aspects of Project operations designed to benefit fisheries include maintenance of instream flows, which have augmented natural low flows and provided near optimal spawning habitat; limitation of flood events to reduce the potential for salmon egg scour; and control of water temperatures within historic ranges. In addition, the frequency and rate of Project down ramping has been reduced based on results of field studies conducted after the Project began operation. Even though fisheries benefits have been demonstrated, areas of continuing interest or potential concern include down ramping, water temperature effects on timing of salmon fry emergence, and unintended rapid flow changes.

After 20 years of experience operating the Project and monitoring fish returns, the Licensees, with the assistance of the Joint Agencies, have re-evaluated Project operations for the possibility of incidental adverse effects on anadromous salmonids and potentially-occurring bull trout in the Sultan River. The results of that evaluation are presented in this report.

There are three primary reasons why the Licensees elected to prepare this assessment report at this time. First, the Project's FERC license expires in 2011, and the Licensees plan to initiate the relicensing process in 2004. The report, therefore, is intended to be a document to inform and assist the stakeholders that will be participating in the relicensing process by providing them a description of current mitigation/enhancement measures, an assessment of how well those measures have worked, and an update of the status of the fish in the river based on spawning surveys conducted since the late 1970s.

The second motivation for preparing this assessment is the listing of Puget Sound fall Chinook salmon and bull trout in 1999 as threatened species under the Endangered Species Act. Because of the heightened concern over these species and the knowledge that they will be a major focus during relicensing, the Licensees decided that it would be prudent to conduct an early assessment of Project effects on the listed fish. Although fall Chinook salmon and bull trout are emphasized in the assessment, other non-listed anadromous salmonids in the system (chum, pink, and coho salmon and steelhead trout) share many of the same ecological requirements and thus are assessed concurrently.

The third reason for this assessment is to address an issue related to operation of the diversion dam flow control gates. During required Project monitoring, the Licensees have observed that certain operations cause periodic flow changes (particularly decreases) at the Sultan River diversion dam that could potentially affect downstream fish resources. At the request of the Joint Agencies, the Licensees agreed to evaluate the situation and, if feasible, make changes to the Project operating plan to address the fisheries concern.

The Licensees initially started this assessment with the intent to prepare a Biological Assessment for use in ESA consultations with the Services (NOAA Fisheries and FWS). However, given the closeness in time to the start of relicensing, the Licensees, with concurrence with FERC and the Services, decided not to submit this assessment to the Services (via FERC) as a formal Biological Assessment. The Licensees did, however, informally consult with the Joint Agencies on several occasions to seek their assistance in the evaluation of Project effects and especially in the development of additional management measures designed to further reduce risks to fish. Several drafts of this document were distributed to the Joint Agencies for review and comment prior to consultation meetings, and this final report has incorporated their comments and suggestions.

The additional enhancement and risk reduction measures described in this report have already been implemented voluntarily by the Licensees. They have determined in consultation with FERC that these measures were logical refinements to the existing license conditions and thus would not require license amendments. Therefore, there is no proposed federal action requiring ESA consultation.

Although this document is not a formal Biological Assessment, it generally follows the guidelines used in preparing Biological Assessments recommended by NOAA Fisheries. Chapter 2 briefly describes the Project history, facilities, and operation. A description of the fish species, their habitat, and spawning survey results for the Sultan River are presented in Chapter 3. The Project's current mitigation measures related to fisheries are described in Chapter 4. The analysis of effects of Project operations is presented in Chapter 5. The newly adopted enhancement measures are described in Chapter 6. Finally, a brief conclusion is presented in Chapter 7.

CHAPTER 2

Project Description

2.1 Location

The Project is located on the western slopes of the Cascade Mountains on the Sultan River in Snohomish County, Washington (Figure 2-1). The Project is approximately 24 miles east of the City of Everett, Washington, between elevations 400 and 1,470 feet. The Project occupies approximately 2,300 acres of land: 340 acres for the tunnel, powerhouse, and pipelines; 50 acres of roads and transmission lines; and 1,870 acres of Spada Lake and riparian areas.

The District owns 4,311 acres of Project-related land, mostly in the upper watershed at Spada Lake. The City owns 2,657 acres of Project-related lands around Lake Chaplain. Other Project land is owned by the State of Washington (170.8 acres), Snohomish County (0.5 acre), Town of Sultan (5.5 acres), and private citizens (133.4 acres).

2.2 Project History

Since the early twentieth century, developers sought to utilize the water supply and power potential of the Sultan basin. In 1929, the City of Everett completed the present water supply diversion dam at RM 9.7, where water was diverted to Lake Chaplain via a pipeline and tunnel. The dam was necessary to raise water surface elevation for gravity flow to an offsite reservoir (Lake Chaplain). In the early 1960s, the PUD collaborated with the City to obtain a Federal license for development of a hydroelectric project on the river that would also enhance water supply reliability.

The Project (originally called the Sultan River Project) was planned and constructed in two stages. Stage I consisted of constructing Culmback Dam to a crest elevation of 1,408 feet, a supporting road network, and limited recreational facilities in the upper Sultan River watershed above RM 16.5. The dam was initially designed and built with the provision for a later increase in height. Stage I was licensed by FERC in June 1961 and constructed from 1962 to 1965. The surface water elevation of Spada Lake, the reservoir created by the dam, was 1,360 feet when full. Stage I of the Project was operated by the City from 1965 to 1983 for municipal water supply only.

Stage II of the Project was authorized by license amendment in October 1981 and constructed from 1982 to 1984. This stage raised Culmback Dam 62 feet, raised Spada Lake's level 90 feet, added the hydropower facilities, and revised water delivery to the City's other reservoir, Lake Chaplain. The 1929 diversion dam and facilities were incorporated into the Project license because their modification allowed instream flow augmentation at RM 9.7. These facilities are still needed and used for municipal water supply when the power tunnel or pipeline are shut down for inspection/maintenance. The amended license also provided additional instream flows for fisheries, incidental flood water storage and recreational facilities at Spada Lake and elsewhere in the Sultan River watershed, and wildlife habitat

154984.A1.01_e042000017sea Fig 2-1 Proj Location Map 10-16-03 gr/lw

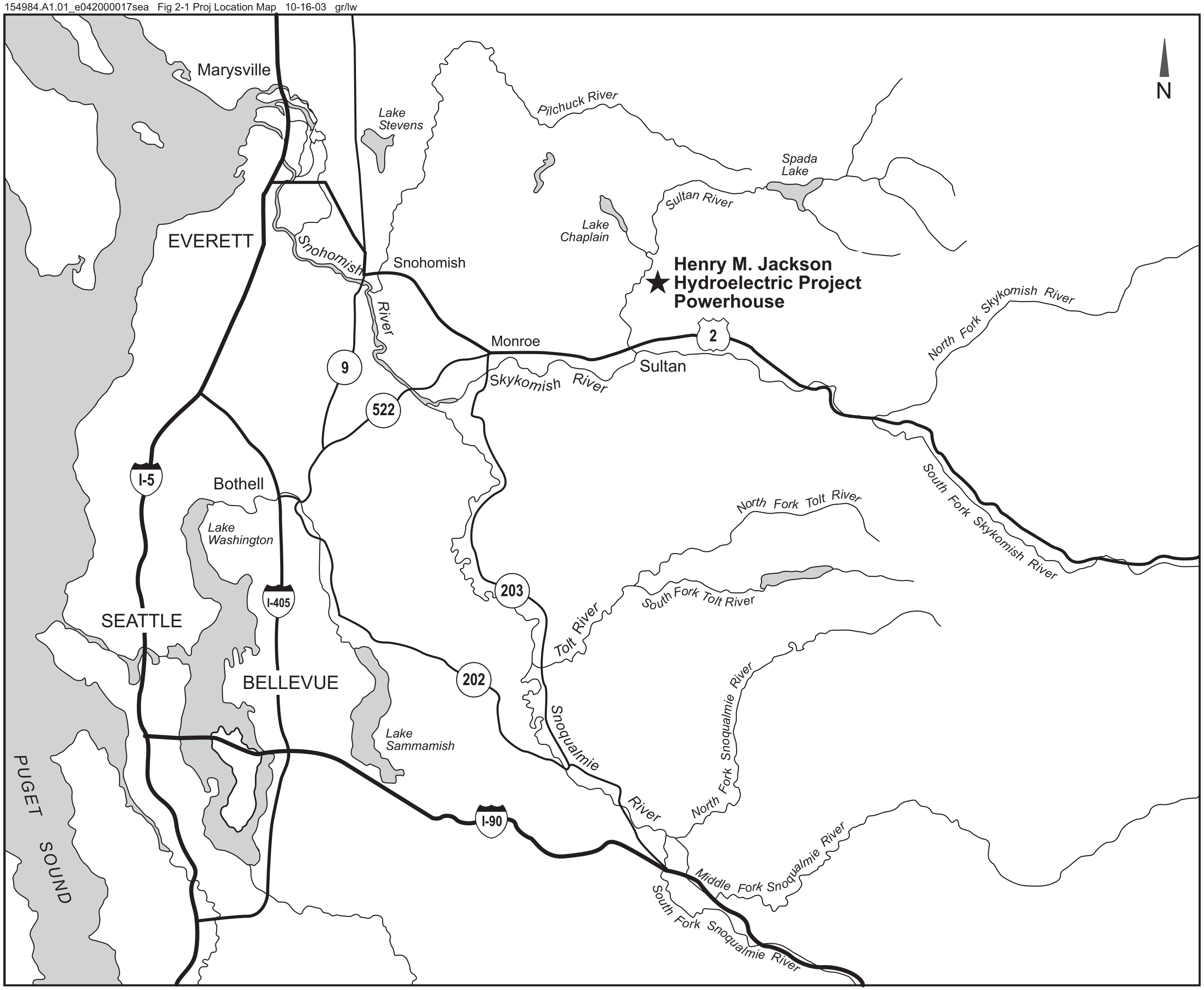


FIGURE 2-1
Project Location Map

management to mitigate for habitat lost to the reservoir. The District currently operates the Project for multiple purposes in accordance with an agency-approved operating plan (see Section 4.1).

The 19-year delay in completion of the hydroelectric facilities was due to the initial economic infeasibility of marketing power from the Project. Originally, about a 5-year delay was anticipated for Project completion.

2.3 Project Facilities

Located at RM 16.5 of the Sultan River, Culmback Dam impounds Spada Lake, which has a storage capacity of 153,260 acre-feet. Culmback Dam is a compacted rock-fill, impervious clay core structure with a crest length and width of approximately 640 and 25 feet, respectively. The dam crest elevation is 1,470 feet, which is 262 feet above the original streambed.

A concrete, morning glory spillway with an inside diameter of 38 feet is located within the reservoir approximately 250 feet from the right bank. The spillway has a 94-foot-diameter ogee crest, vertical shaft, and a horizontal tunnel section.

Existing reservoir outlet works consist of two 48-inch-diameter conduits embedded in the concrete plug of the diversion tunnel that join the horizontal tunnel section of the spillway. The downstream ends of the conduits are equipped with three 42-inch slide gate valves and one 48-inch Howell-Bunger valve. A 16-inch-diameter pipeline runs through the right abutment at elevation 1,360 feet and down the downstream dam face. This pipeline provides 20 cubic feet per second (cfs) minimum flow releases during dewatering of the spillway tunnel for maintenance or safety inspections. Normal flow releases of 20 cfs are accomplished through a 10-inch cone valve piped upstream of the 48-inch Howell-Bunger valve. A 60 kW turbine-generator at the dam provides onsite electrical power, and the associated water contributes about 5 cfs to downstream flows below Culmback Dam in addition to the 20 cfs discharged through the cone valve.

The intake structure is located near the left abutment, approximately 250 feet upstream of the dam. The 110-foot-tall concrete structure has moveable panels. Positioning of these panels selectively withdraws stored water from various depths to facilitate the control of water temperature in the Sultan River below the powerhouse and the diversion dam.

The power conduit consists of a 3.8-mile, unlined 14-foot-diameter power tunnel that extends from the intake structure to a 10-foot-diameter, 3.7-mile buried pipeline. Together, they deliver water to the powerhouse located on the Sultan River at RM 4.3 (Figure 2-2).

The semi-outdoor powerhouse located on the left bank of the Sultan River houses two multi-jet Pelton turbines and two Francis turbines with a total capacity of 111.8 MW. The Pelton units together discharge 1,300 cfs directly to the river when operating at full power.

The City's water supply requirements are mainly met by diverting water from Spada Lake to the powerhouse's Francis units, where sufficient water pressure is retained to facilitate continued routing of the water upgradient to Lake Chaplain through a 72-inch pipeline. The two Francis turbines are sized to meet both the required delivery to Lake Chaplain and the

154984.A1.01_E092003011SEA Fig 2-2 Jackson Project Hydro Features 1-25-05 dk

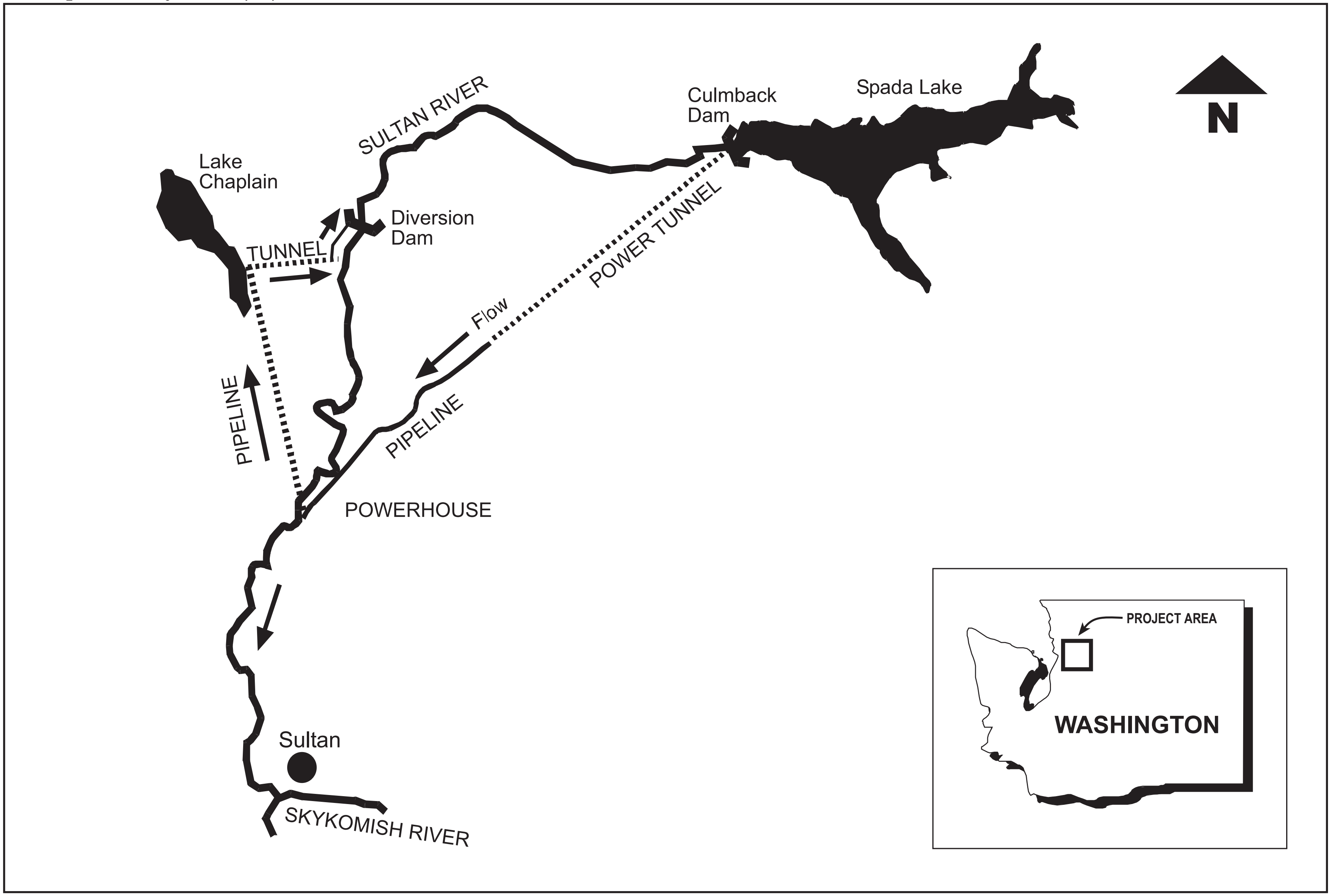


FIGURE 2-2
Jackson Hydroelectric Project Features

instream flow requirements ("fish flows") between the City's diversion dam and the powerhouse. These units use the hydraulic head available between Spada Lake and Lake Chaplain for energy generation. Everett's water requirements can also be met or partially met by diverting through the pre-existing Sultan River diversion works at a dam located at RM 9.7 when the power conduit is not available for normal operation. Fish flows are returned to the river at the diversion dam via a standpipe structure at the terminus of the Lake Chaplain pipeline, and back-flowed through a pre-existing diversion tunnel. A 42-inch, 2,000-foot-long pipeline connects the upstream tunnel portal to the diversion dam where fish flows are discharged into the Sultan River.

CHAPTER 3

Description of Species, Habitat, and Surveys

3.1 Chinook Salmon

Naturally spawning Chinook salmon of the Snohomish River basin are composed of two stocks: Skykomish and Snoqualmie. Stock delineation is based on genetic, geographic, and timing differences of spawning individuals. These Chinook salmon stocks are considered part of the Puget Sound Evolutionarily Significant Unit (ESU), which was listed as a threatened species in 1999. Chinook salmon using the Sultan River are from the Skykomish stock (Haring 2002). This stock also spawns in the Snohomish River, Pilchuck River, Woods Creek, and Elwell Creek. Spawning begins in September and continues through October (WDF et al. 1993). In 2002 the Skykomish Chinook salmon stock status was listed as "depressed" by Washington Department of Fish and Wildlife, primarily due to low stock escapement. The mean number of Skykomish Chinook salmon spawners from brood years 1988 through 1997 was 2,687 fish (Haring 2002).

The estimated spawning escapement of the Snohomish River Chinook salmon stocks (Skykomish and Snoqualmie combined) between 1965 and 2003 averaged 4,978 fish, which is slightly below the Snohomish system escapement goal of 5,250 (Appendix B). Escapement goals have been exceeded since 2000 in part due to reduced harvest. Prior to 1996 the combined harvest rates of Snohomish system Chinook salmon from United States and Canadian sport and commercial fishing ranged from 42 to 73 percent (NMFS 2004). In recent years the combined harvest rates have been reduced to about 20 percent.

Over the past 27 years, an average of about 500 fall Chinook salmon have spawned in the Sultan River annually (see below). They begin entering the Sultan River in mid-September. Peak spawning activity occurs around October 1; however, spawning individuals have been documented as late as the last week in November. Chinook salmon spawn in the Sultan River from the mouth upstream to the City of Everett's diversion dam (at RM 9.7), which is the limit of upstream migration for all salmonids. Surveys conducted annually since 1985 indicate that spawning distribution is proportionate to available habitat above and below the powerhouse.

Fall Chinook salmon fry emerge from the gravel as early as January, with peak emergence occurring in March. The fry disperse and rear along the stream margins for up to several months before migrating downstream. The bulk of the migration is complete by June, although some individuals may remain in the river system until the following spring.

The lower 3 miles of river from the mouth to the Bonneville Power Administration power-line crossing is a low gradient, depositional reach with a nearly unrestricted flood plain. Several side channels and off-channel areas are available for fish use. The habitat has been mildly impacted by shoreline residential development and bank hardening (riprap) in a short reach near the mouth. From RM 3.0 upstream to the powerhouse (RM 4.3), the river has a steeper gradient and is confined within bedrock banks. Prescribed minimum instream flows for this reach range from 165 cfs to 200 cfs depending upon the time of year. Actual instream flows are modified by powerhouse discharge, storm runoff, and uncontrolled reservoir releases (spill).

The Sultan River from the powerhouse to the diversion dam is a moderate gradient sediment transport reach, deeply incised in a gorge. The habitat is mostly undisturbed. River flows closely follow a prescribed minimum instream flow schedule that varies from 95 to 175 cfs, except during times of surface runoff from rainstorms and infrequent spill at Culmback Dam.

Additional descriptions of riverine habitat specific to stream flows, water quality, habitat access, and channel conditions are presented in Chapters 4 and 5.

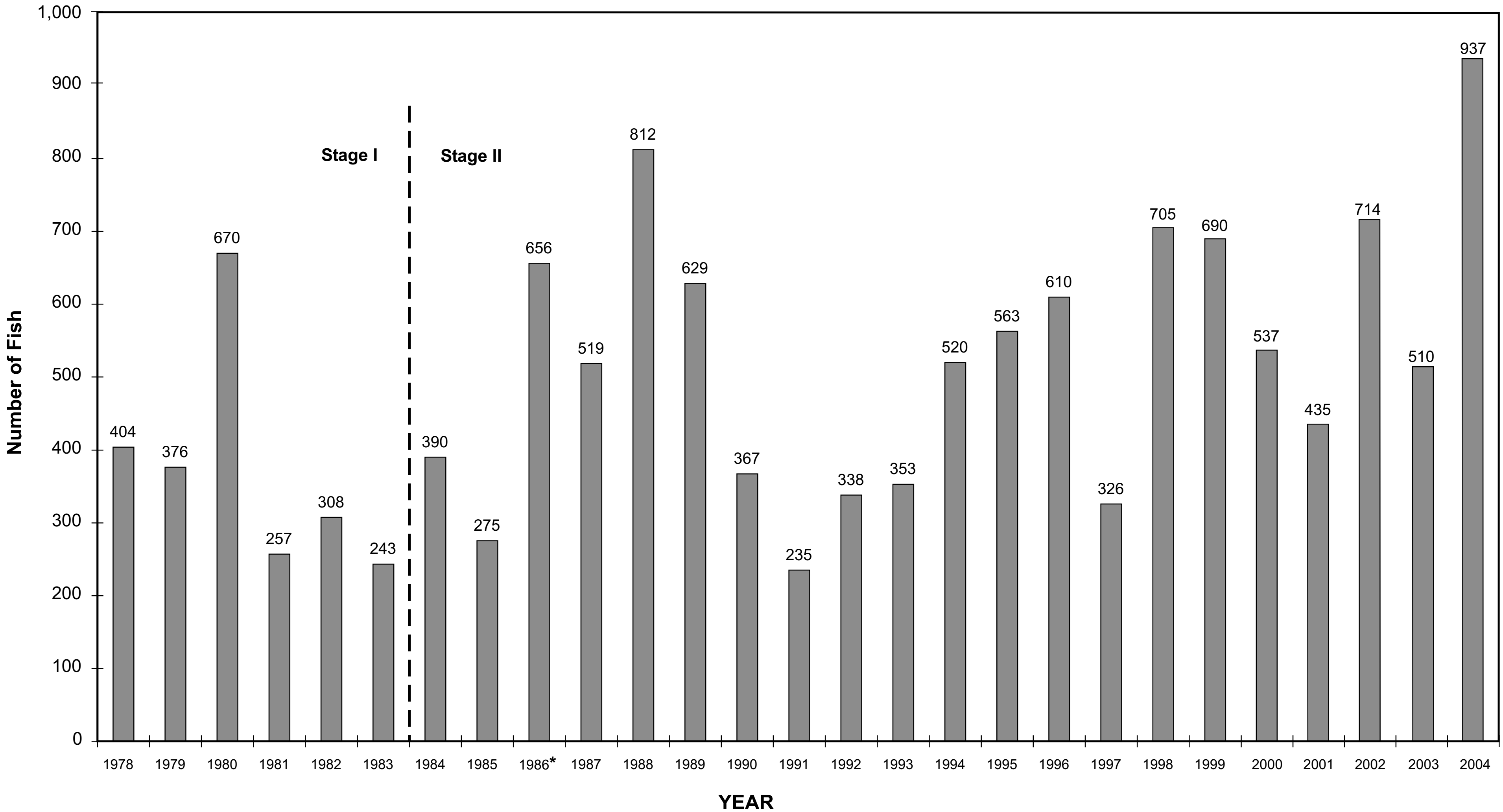
Spawning surveys for Chinook salmon by the Washington Department of Fisheries began in 1978. Those surveys were performed once during the presumed peak of spawning activity on or about October 1. More recently, the District in cooperation and coordination with the Joint Agencies conducts annual salmon and steelhead trout spawning surveys in the lower Sultan River. The District's surveys are in accordance with Article 55 in the license issued by FERC for Stage II, which states that:

> Licensee shall … study to determine the effects of powerhouse discharge and flow fluctuations on migration, spawning, and rearing of resident and anadromous trout and salmon populations in the Sultan River.

Chinook salmon spawning surveys include repeated streambank observations of index areas, floating the lower 2.9 miles of the river, and aerial counts of redds. Since 1991, live adult and redd counts are performed every ten days, including an aerial survey at the peak to count Chinook salmon redds in otherwise unsurveyable areas. Chinook salmon escapement estimations from 1978 to 1990 use a peak count multiplication factor developed from the 1990 to 1999 data. Survey results are reported to the Joint Agencies and FERC.

From 1978 through 2004 the Sultan River Chinook salmon escapement estimates average 496 fish, and range from 235 in 1991 to 937 in 2004 (Figure 3-1). Chinook salmon spawning escapement in the Sultan River has accounted for about 10 percent of the total for the Snohomish River system. The Sultan River contribution increased from 7 percent to 12 percent following implementation of the Stage II flow regulation (first affecting 1986 brood).

In the late 1990s, the District cooperated with WDFW and the Tulalip Tribes in a study to determine the straying rates of hatchery-origin fall Chinook salmon in the Snohomish River basin. This study included the collection of otoliths from Chinook salmon carcasses in the Sultan River and tributaries in the Snohomish River basin. Study results indicate some straying of hatchery fish into the Sultan River from the adjacent Wallace River basin, where hatchery-reared Chinook salmon originate. However, because fall Chinook salmon production at the Wallace River Hatchery was curtailed after 1998, the number of adult fall Chinook salmon spawners in the Sultan River attributable to hatchery strays would have diminished in 2001 and been noncontributing by 2002. The Wallace River Hatchery still releases juvenile summer Chinook salmon, and it is possible that some of the returning adults may enter the Sultan River. Summer Chinook salmon tend to spawn earlier than fall Chinook salmon, although there is some overlap in late September.



* Stage II flow regulation commenced in Fall 1983, thus affecting returns starting in 1986.

FIGURE 3-1

Sultan River Fall Chinook Salmon Escapement Estimates

3.2 Coho Salmon

The Puget Sound population segment of coho salmon is considered a candidate species for listing under the ESA. However, most coho salmon stocks in the Snohomish River system, including those in the Skykomish River, were considered healthy as late as 1992 (WDF et al. 1993), and spawning escapement to the system has continued to increase since then (see Appendix B). The Snohomish River system escapement goal of 70,000 spawners has been met in 7 of the last 10 years, and escapement numbers reached a record high of 262,000 in 2001 (see Appendix B). Coho salmon spawning escapement to the Snohomish system is strongly influenced by commercial and recreational fisheries in Puget Sound and British Columbia.

The Sultan River provides spawning and rearing habitat for only a limited number of coho salmon. The steep gradient and incised channel in most of the anadromous zone limits the spawning habitat preferred by this species. All but two tributaries have waterfall barriers to upstream migration at their mouths. During the late fall/early winter when coho salmon spawn, the Sultan River's high flows and frequent turbidity inhibit accurate counts of adults and redds. Thus, historical coho salmon spawning survey data are fragmented; however, annual escapement is believed to be 300 to 500 adults.

Coho salmon fry emerge from the gravel in April and May. Juveniles remain in the river and associated off-channel habitats until the following spring when they emigrate as smolts. Some juvenile coho salmon remain in the Sultan River whereas others undoubtedly move downstream to rear in the Skykomish River. Suitable winter-rearing habitat exists in the lower 3 miles of the Sultan River, primarily in side channels, small tributary confluences, and other off-channel areas (Olson 1990).

3.3 Pink Salmon

The Snohomish River and its major tributaries support two pink salmon stocks: Snohomish odd-year pink and Snohomish even-year pink. The odd-year stock spawns from mid-September through October. The even-year stock spawns primarily in September. The vast majority of pink salmon returning to Puget Sound streams are the odd-year stock (i.e., they return to spawn in odd-numbered years). Only a relatively small number of pink salmon return in even-numbered years. The even-year pink salmon escapement to the Snohomish River system generally has been less the 5,000 fish compared to more than 100,000 fish in odd-numbered years (see Appendix B). Both the odd-year and even-year stocks returning to the Snohomish system increased dramatically in the last few years, with the odd-year returns exceeding 1,000,000 fish in 2001 and 2003. These large returns are primarily attributed to the absence of floods during spawning and incubation periods and to favorable ocean conditions. Most populations of Puget Sound odd-year pink salmon appear to be healthy, with overall abundance close to historic levels.

In the Sultan River, pink salmon spawning has been documented only for the odd-year cycle. Most spawning in the river occurs in the lower 3 miles of the mainstem. Prior to the Jackson Hydroelectric Project going online in late 1983, pink salmon escapement averaged 3,000 fish per odd-year cycle (1971 through 1983). Post-Project escapement has averaged

51,563 fish per cycle (Figure 3-2). Pink salmon returning to the Sultan River reached record numbers in 2001, totaling 151,800 fish. In 2003, returns totaled 139,800 fish.

As a percentage of the Snohomish system pink salmon escapement, the Sultan River's contribution increased from an average of 2 percent pre-Project to 16 percent post-Project.

All pink salmon spawn as 2-year-old fish. Fry emerge from the gravel in late winter and early spring, and the fry tend to emigrate to marine waters immediately after emergence. Therefore, their residency in the Sultan River is short.

3.4 Chum Salmon

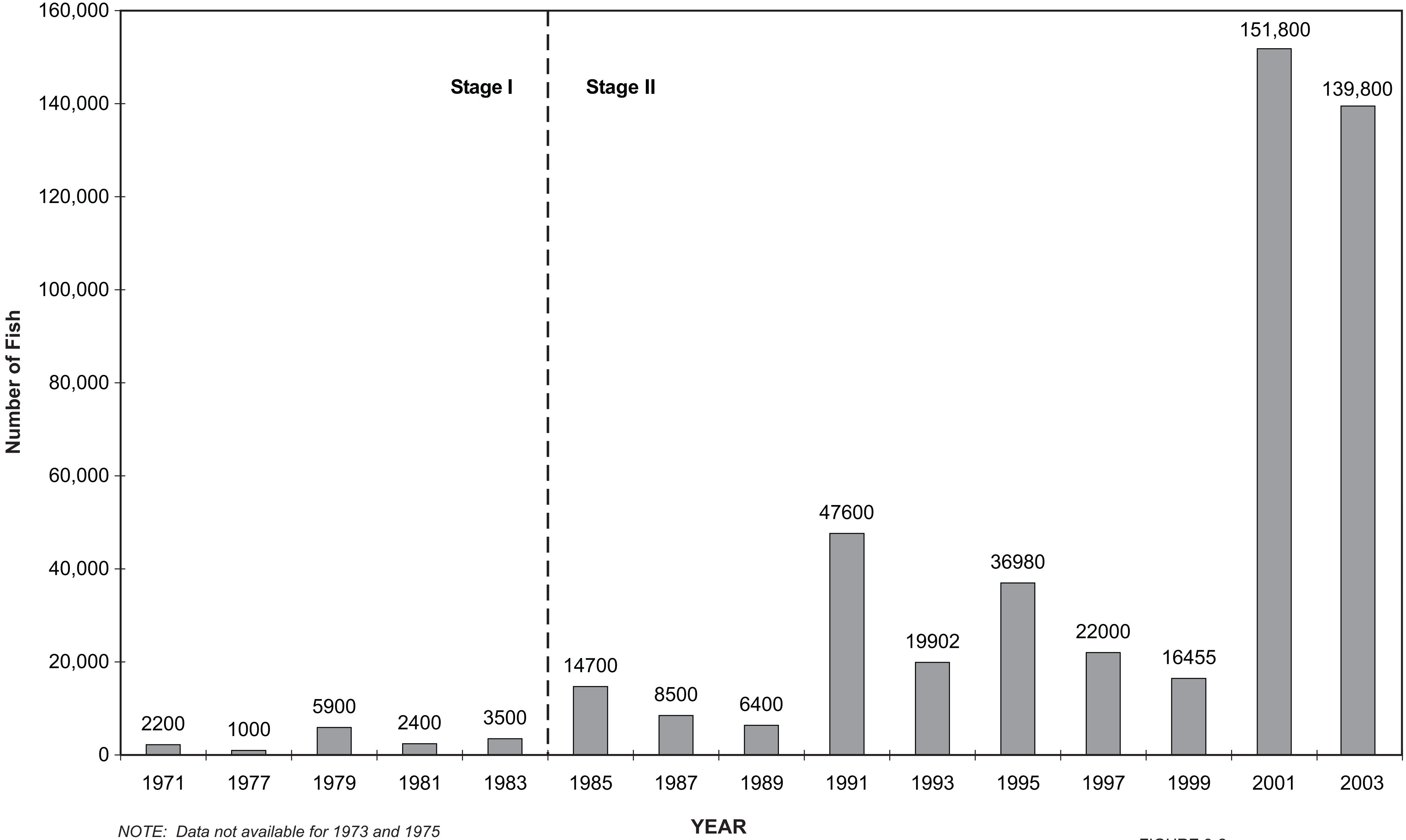
Chum salmon spawn primarily in the lower sections of large river systems, using a diverse array of habitat, from large mainstem channels to drainage ditches and sloughs. Since chum salmon fry migrate to the estuarine environment immediately after emergence, freshwater rearing habitat is not critically important; however, functional estuarine and marine habitat is critical for their growth and survival.

The chum salmon found in the Sultan River are of the Skykomish fall chum stock. Chum salmon spawn each year, but in Puget Sound streams they tend to have lower escapement in odd-numbered years as a result of a complex competitive interaction with pink salmon (Gallagher 1980). The Skykomish fall chum stock status is considered "healthy" based on increasing trends in spawning escapement levels (see Appendix B). The chum salmon spawning escapement goals for the Snohomish system have been achieved in 8 of the last 10 years (1994 – 2003).

In the Sultan River, chum salmon spawning activity is concentrated in the mainstem and side channels downstream of RM 2.7. Spawning occurs in November and December, with the peak in early to mid-December. Chum salmon escapement in the Sultan River has been tracked regularly since 1992. Over the past 12 years, escapement has averaged approximately 2,500 fish with the greatest yearly abundance of 7,573 fish observed in 2002 (Figure 3-3). Occasional spawning surveys for chum salmon between 1968 and 1976, prior to the Jackson Hydroelectric Project going online, indicated that very few chum salmon historically spawned in the Sultan River. The highest one-day count during this period was three fish. Surveys conducted since 1992, however, typically note one-day counts of several hundred fish during the peak of the run.

3.5 Steelhead Trout

Winter steelhead trout spawn in the Sultan River both above and below the powerhouse. Escapement estimates of native fish have been made annually by the District in cooperation with WDFW since 1993. Estimates have ranged from 66 to 574 adult spawners, averaging 259, during these 12 years (Figure 3-4). Estimates for 1987 and 1989 were 250 and 170, respectively (WDFW file data). These numbers compare to 150 and 85 native spawners estimated for 1979 and 1980, respectively, during pre-Stage II licensing studies (WDG 1982). Although the period of record is short, steelhead trout escapement to the Sultan River appears to closely track what is occurring in the Snohomish River system (see Appendix B). While escapement to the Snohomish system dropped substantially in 2000, recent data



NOTE: Data not available for 1973 and 1975

** Stage II flow regulation commenced in Fall 1983, thus affecting returns starting in 1985.

FIGURE 3-2
Sultan River Pink Salmon Escapement Estimates

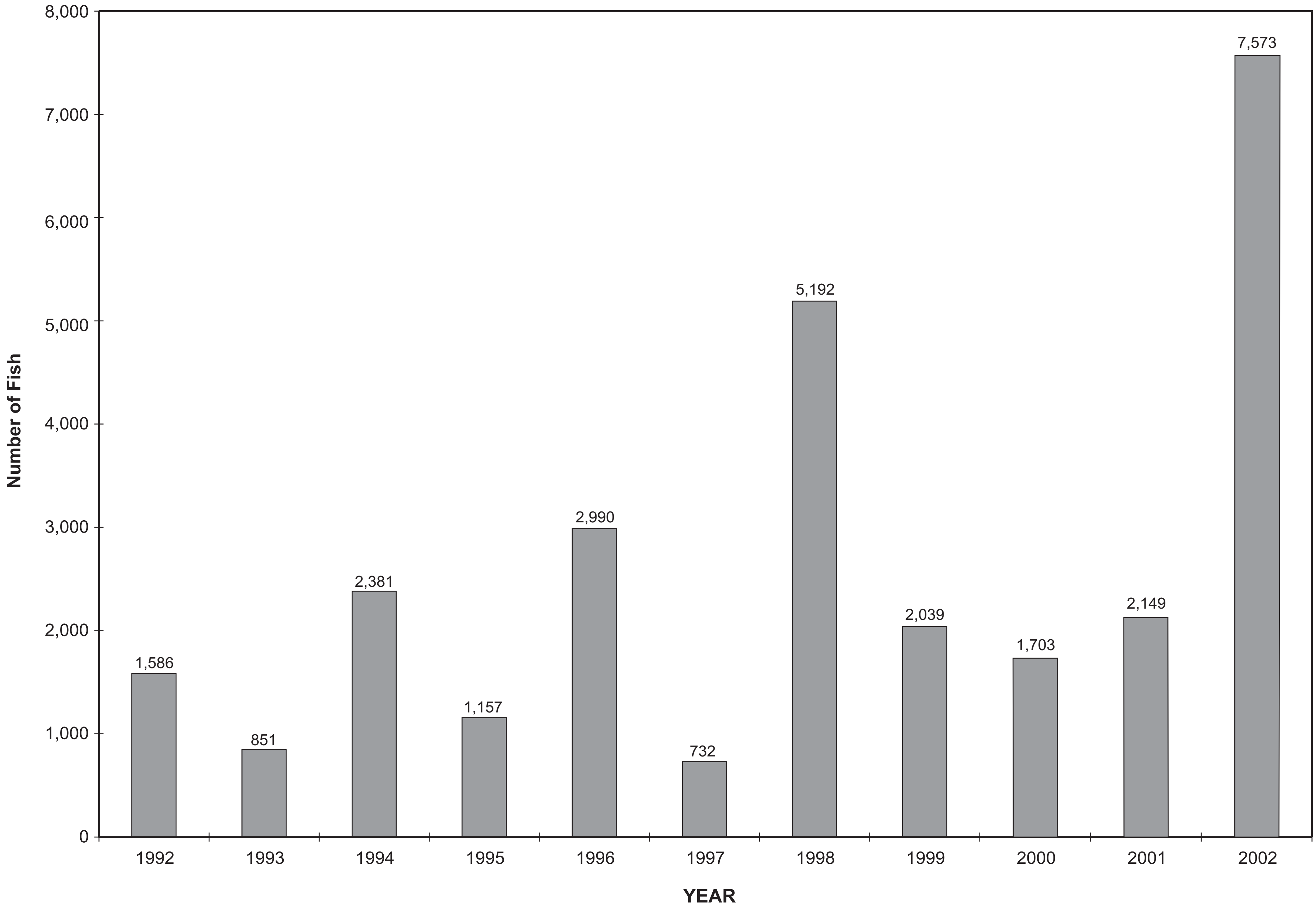
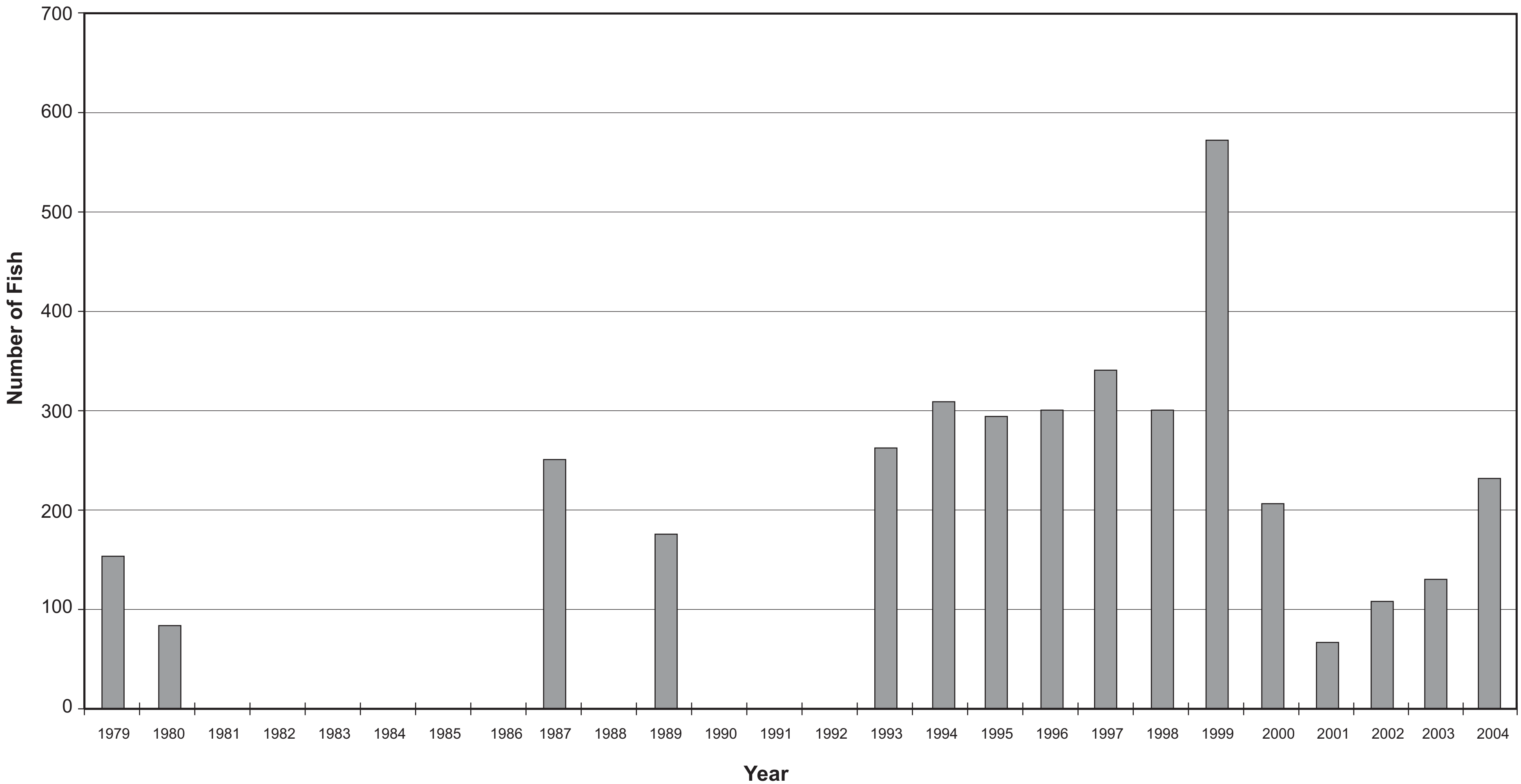


FIGURE 3-3
Sultan River Chum Salmon Escapement Estimates



Note: No estimates for 1981-1986, 1988, and 1990-1992.

FIGURE 3-4
Sultan River Winter Run Steelhead Trout Spawning Escapement Estimates

suggest that populations are starting to recover. The escapement goal of 6,500 spawners for the Snohomish River system has not been achieved since 1995.

Per the Settlement Agreement with the Joint Agencies, the District annually provides WDFW funding for the planting of 30,000 hatchery-reared steelhead smolts (winter and summer run combined) in the Sultan River. Planting has occurred at both the mouth of the river and at the powerhouse.

Non-hatchery steelhead trout in the Sultan River spawn primarily in April and May. Fry begin to emerge from the gravel in early June. Most steelhead trout in the Puget Sound region rear for 2 years in freshwater before migrating to the ocean as smolts. Downstream migration occurs primarily in April and May. In the Sultan River, steelhead trout spawn and rear in the mainstem river below RM 9.7. The few tributaries in this reach are small and short, thus containing very limited steelhead trout rearing habitat.

3.6 Bull Trout

The coastal-Puget Sound bull trout population was listed as "threatened" under the ESA on November 1, 1999, by the Department of Interior. However, stock status in the Snohomish system, which includes the Sultan River, is considered healthy (WDFW 1998), and the State allows a limited sport harvest of char (bull trout or Dolly Varden) over 20 inches in length (WDFW 1999a). The char that occasionally enter the lower Sultan River may be Dolly Varden rather than bull trout, but the genetic and morphological-meristic analyses have not yet been performed on these fish. To provide more protection for listed bull trout, on January 9, 2001, the FWS proposed protection of Dolly Varden char under the “similarity of appearance” provision of the ESA because they closely resemble the listed bull trout.

Bull trout/Dolly Varden are the only char in the family Salmonidae native to Washington. Anadromous, fluvial, and resident life history forms are all found in the Snohomish River system (Kraemer 1994). However, until genetic analysis or other procedures show otherwise, all native char in the Snohomish River basin are managed as a single stock. Reproducing populations have been documented only in the higher elevations of the North and South Forks of the Skykomish River (Kraemer 1994), and the numbers of spawners in index areas have trended upward since surveys began in 1988 (see Appendix B). Bull trout were introduced to the upper South Fork Skykomish River following construction of a fishway at Sunset Falls.

Results of ten intensive creel surveys on the Spada Lake resident trout fishery over the past two decades have failed to identify a single bull trout. Also, resident bull trout have not been documented in tributaries above Spada Lake (WDG 1982, Pfeifer et al. 1999). Therefore, the species is presumed not to exist upstream of Culmback Dam. This conclusion is supported by WDFW, which has never documented native bull trout above any historic anadromous barrier in the Snohomish basin except Troublesome Creek in the North Fork Skykomish basin (WDFW 1999b). In addition, there appears to be no evidence suggesting that bull trout occurred in the upper Sultan basin historically (Mongillo 1993).

Native char have been observed in the Sultan River only below RM 9.7 in the reach accessible to anadromous fish. Char in this reach have been documented by a District fisheries biologist and reportedly caught by anglers interviewed along the lower river (Murray Schuh, District, personal communication, 1999). These fish are presumed to be foraging individuals. Because potential prey for bull trout (mostly juvenile salmonids) is present year-round in the Sultan River, it is assumed that bull trout also could be present year-round in the river reach accessible to anadromous fish. However, their presence most likely occurs during the salmon fry emergence period from late winter through spring. They may also enter the river during times of salmon spawning (September through December) to forage on eggs and other food items stirred up by spawning activity.

It is doubtful that the Sultan River downstream of the diversion dam contains suitable spawning and incubation habitat for bull trout on the basis of its water temperature regime and low elevation. Successful spawning requires water temperatures below 46°F (8°C) during the late summer and fall (WDFW 1999b). Successful egg incubation requires temperatures below 40°F (4.4°C). Because of these requirements for cold water, bull trout spawning usually occurs upstream of the normal winter snow line (approximately 2,500 feet) in the Puget Sound region (WDFW 1999b). Water temperatures in the Sultan River below the diversion dam barely meet these criteria, and the elevation of the dam’s spillway crest is 655 feet.

Also on the basis of water temperature and elevation, it is unlikely that a self-sustaining population of bull trout could exist in the reach between Culmback Dam (base elevation 1,200 feet) and the diversion dam. To verify this conclusion, extensive surveys for bull trout were conducted in 2004 in this reach of river using sampling protocol recently established by the American Fisheries Society designed specifically for determining bull trout presence (Peterson et al. 2002). Surveys consisted of snorkeling observations over a 6-week period at 37 randomly selected 100-meter-long sites in the 6.4-mile reach between dams. No bull trout or Dolly Varden char were observed during any of the surveys (Snohomish PUD 2004 – Appendix C).

CHAPTER 4

Mitigation and Enhancement

The Federal license issued for the Project contains numerous requirements for environmental protection and mitigation (Appendix A). These requirements were developed with the Joint Agencies during Project planning and design prior to licensing and are now reflected in the Project facilities. Thus, besides current Project operations and management related to mitigative actions, some past mitigation-related features are still pertinent to the protection of fish and thus are also reviewed in this document.

4.1 Operations Plan

At the time FERC issued the Project's license for Stage II, the operational guidelines for the potential use of Spada Lake for flood control were still pending with the U.S. Army Corps of Engineers. Thus, Article 57 in the license required that the "Licensee and the Corps of Engineers shall enter into an agreement providing a reservoir operating rule curve for flood control, if any, and power operations." Because of this article and Article 60, the Joint Agencies and the Licensees negotiated requirements in the Settlement Agreement that were favorable to fisheries protection and mitigation, as follows:

> As specified by Article 57, Licensee and the Corps of Engineers shall enter into an agreement providing a reservoir operating rule curve for flood control, if any, and power operations. <u>Any agreement between the Licensee and the COE shall be preceded by a full consultation with the Joint Agencies. Licensee shall make no agreement to provide flood control other than provided by normal Project operation if it would substantially impair the ability to protect, mitigate and enhance anadromous and resident fisheries and wildlife resources</u> (emphasis added). If the rule curve proposed by Licensee or COE would include Project operation in a peaking mode, or a different ramping rate than specified in paragraph 5 above, or at different minimum flows than specified in paragraph 2 above, the Joint Agencies and each of them shall have the right to hearing before the Commission on objections to the rule curve proposed and to seek judicial review of the Commission's determination if contrary to the position advocated by the objecting joint agency.

The reservoir rule curves were the key element in the Project's operating plan, which fulfilled the requirements of Article 57. The design of the rule curves was based on two elements: (1) physical storage capacity of Spada Lake, and (2) upper Sultan River basin hydrology. Developing the rule curves relied on a model developed by the Project engineer and modified by the District. The model was used earlier for determining the size of power generation facilities (e.g., power tunnel, power pipeline, turbine size, etc.). Simulation model output, as verified by historical hydrological records, was essential in developing the required Project operating plan in close coordination with the Joint Agencies and the Corps of Engineers (Meaker and Metzgar 1990).

The Project is operated according to the rule curves shown in Figure 4-1. Spada Lake is divided into four states, which shift throughout the July to June water year to provide winter flood storage, water for municipal supply, instream flows, and higher summer lake levels for recreation. In States 1 and 2, the Project is required to discharge 1,300 cfs into the Sultan River. In State 4, the Project is operated to maintain Lake Chaplain within a specified range of elevation and to provide minimum fishery flows below the diversion dam and powerhouse. State 3 is a discretionary zone where the Project may be operated between the extremes of States 2 and 4 depending on the needs for power generation. Thus, State 3 is the District's target zone for operations.

Fundamental requirements of the reservoir rule curves were that they would satisfy Project safety (and thereby public safety), municipal water supply, fish protection and mitigation (e.g., minimum instream flows), flood control, and recreation. The paramount interests of the Joint Agencies, as reflected by the stipulation from the Settlement Agreement (quoted above), were addressed by running various hydrologic "worst-case" scenarios (droughts) through the model. Embedded in the model are current and projected water withdrawals to meet demand for municipal water supply in the Everett service area. From the resultant modeling output, the Joint Agencies agreed to the shape of the rule curves, as well as the related and implied operational situations that would be expected with the Project. Specifically, the minimum instream flow schedule can be met in the future based on present modeling scenarios using historical hydrology from 1899 to 1999.

Project operations have, except for August, altered the seasonal flow pattern in the Sultan River (Figure 4-2). Most storage and release of water for power production is done within the same water year; however, the natural hydrograph has been changed. The reservoir rule curves are shaped to minimize spill (uncontrolled release of water via the spillway) and allow storage of some spring runoff for municipal water supply and instream flow augmentation later in the year. Relatedly, longer periods of above-natural-average flow occur with delayed release of the temporarily stored high flows. This strategy also provides incidental floodwater storage. With the same total volume of runoff from basin rainfall and snow melt, the historically higher peak flows that occurred previously in late fall, early winter, and spring have been reduced in both amplitude and frequency.

4.2 Minimum Instream Flows

The District and Joint Agencies examined the instream flow issue at length because of its importance to Sultan River fisheries and power production. Article 54 in the license issued by FERC for Stage II states:

> Licensee shall consult and cooperate with the Washington Department of Fisheries and Game, the Tulalip Tribes, the National Marine Fisheries Service, and the U.S. Fish and Wildlife Service to determine the minimum flow release needed at the Culmback Dam and at the discharge point of the fish water return line to ensure protection and enhancement of fishery and wildlife resources.

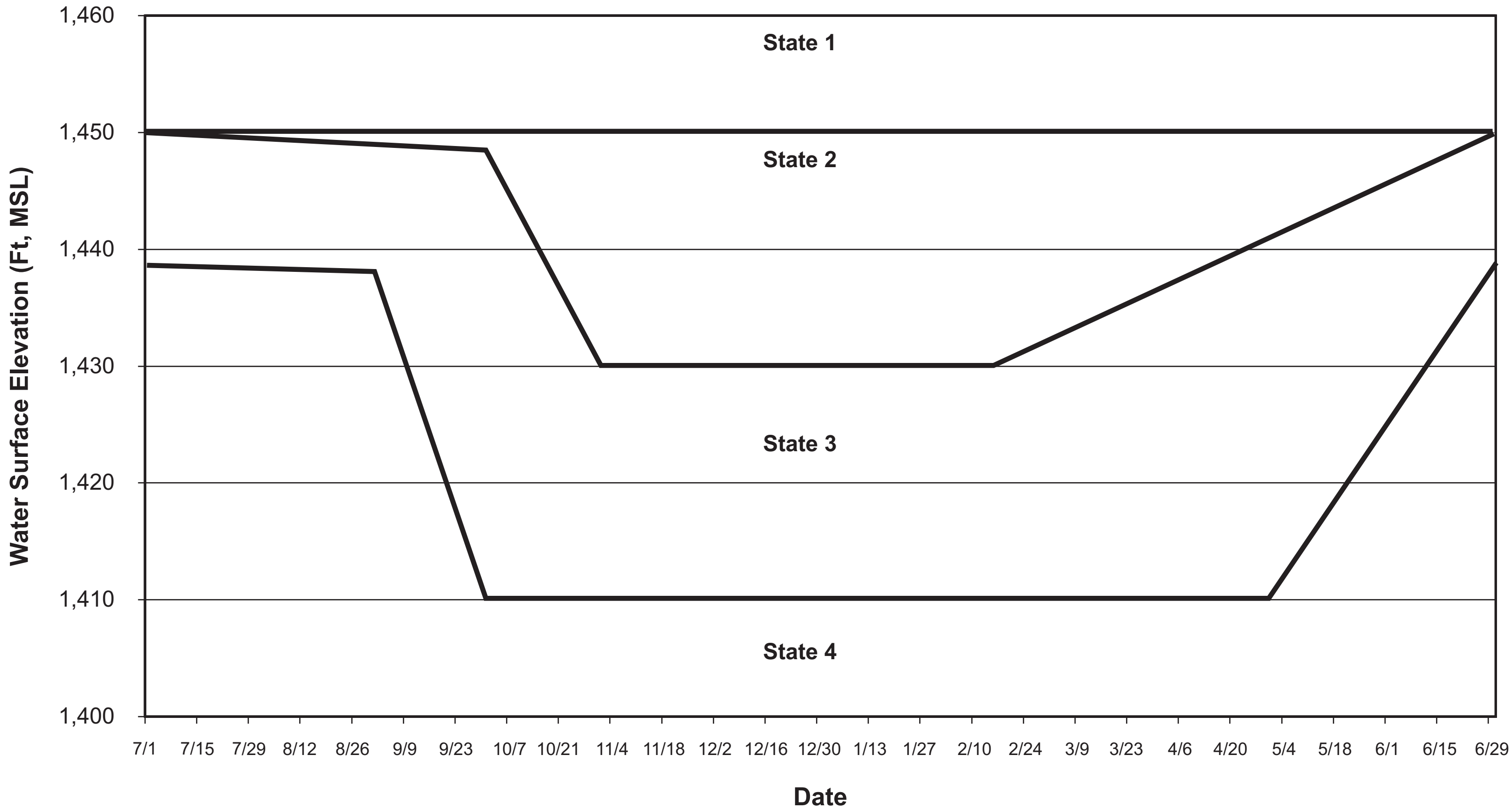


FIGURE 4-1
Spada Lake Rule Curves

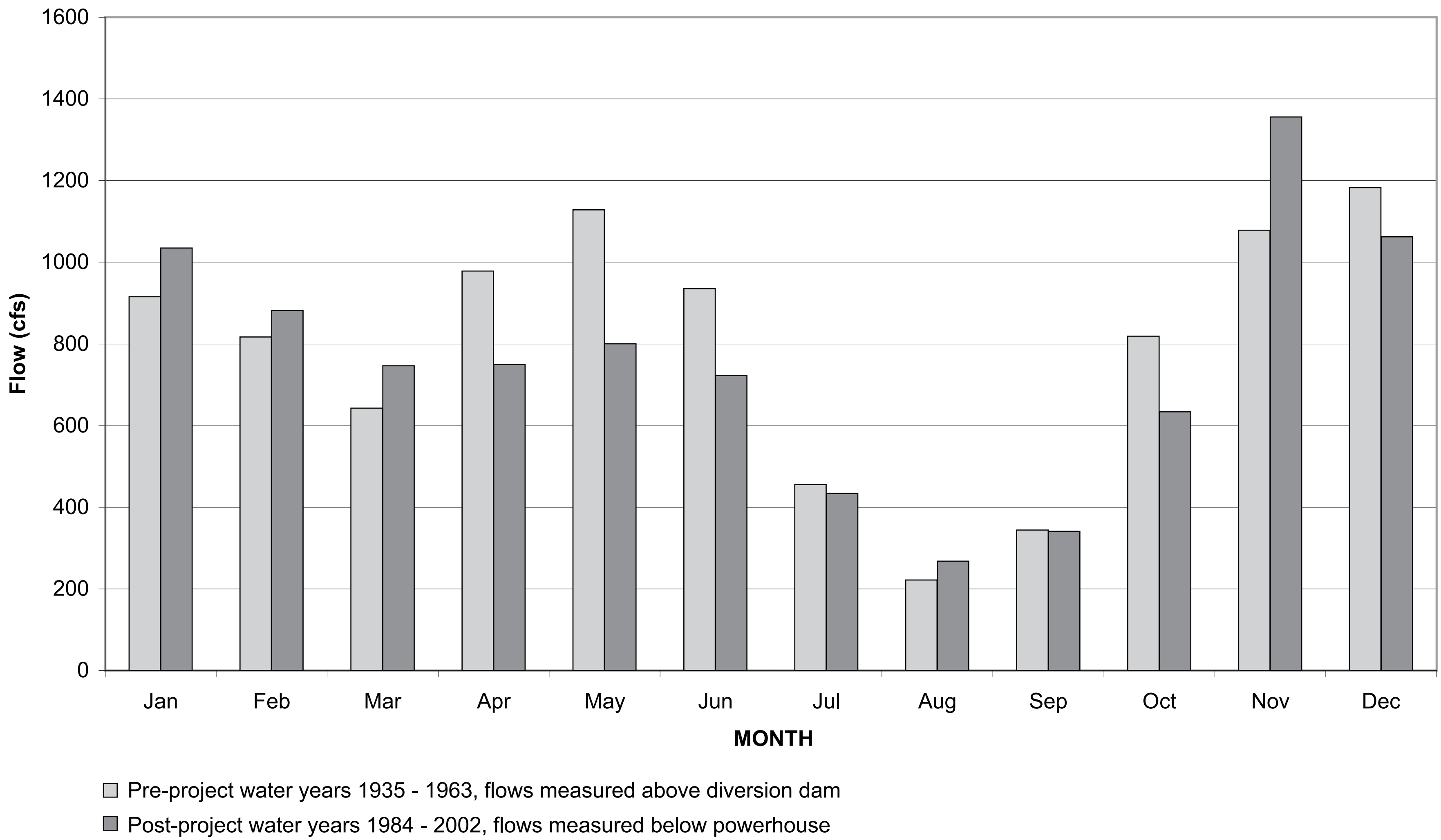


FIGURE 4-2
Sultan River Average Monthly Flows, Pre-Project vs. Post-Project

However, it was Article 60 that led to a Settlement Agreement with the Joint Agencies specifying a minimum instream flow schedule for the Sultan River.

> The Licensee shall, for the conservation and development of fish and wildlife resources, … operate and comply with operations as may be ordered by the Commission upon its own motion, or upon the recommendation of the Secretary of the Interior or the fish and wildlife agency or agencies of any State in which the Project or a part thereof is located.…
>
> … what measures, if any, should be required and included in this license to protect or enhance the fishery in the Sultan River. Such measures may include … flow releases.…

On December 17, 1980, the Joint Agencies informed the District of their position on instream flows. It was based on results of an incremental instream flow study of the river below Culmback Dam (Snohomish PUD 1980), a fish production simulation model by the Joint Agencies, a river water temperature study below Culmback Dam by the District, and a power generation model by the District. Subsequently, a key follow-up meeting on January 14, 1981, established this minimum instream flow schedule (Table 4-1) in fulfillment of FERC license requirements.

TABLE 4-1
Sultan River Minimum Instream Flow Requirements

Dates	Point of Discharge	Minimum Flow (cfs)
All Year	Culmback Dam[a]	20
11/1 - 1/15	Diversion Dam[b]	95
1/16 - 2/28	Diversion Dam[b]	150
3/1 - 6/15	Diversion Dam[b]	175
6/16 - 9/14	Diversion Dam[b]	95
9/15 - 9/21	Diversion Dam[b]	145
9/22 - 10/31	Diversion Dam[b]	155
6/16 - 9/14	Powerhouse[b]	165
9/15 - 6/15	Powerhouse[b]	200

[a] Cone value discharge verified by the U.S. Geological Survey on August 28, 1990.

[b] Telemetry gages are installed immediately below the diversion dam and powerhouse to monitor these flows.

4.3 Powerhouse Down Ramp Rate Regime

To fulfill specific requirements for fish protection and mitigation related to river flow changes, the District conducted field studies on the effects of flow decreases on young salmonids. The scope of the field work was based on a study plan developed cooperatively with the Joint Agencies.

Article 55 in the license for Stage II issued by FERC states:

> Licensee shall consult and cooperate with the Washington Department of Fisheries and Game, the Tulalip Tribes, the National Marine Fisheries Service, and the U.S. Fish and Wildlife Service in developing and implementing a study to determine the effects of powerhouse discharge and flow fluctuations on migration, spawning, and rearing of resident and anadromous trout and salmon populations; … and evaluation of proposed maximum changes in flow rates (ramping rates) below the powerhouse.

The Settlement Agreement is specific to ramping rates under pre- and post-construction studies stating:

> Licensee shall develop, conduct and analyze … a study to determine whether and under what operating conditions a ramping rate slower than six inches per hour is appropriate to avoid adverse impacts upon critical life stages of anadromous fish (e.g., spawning, emergence, and rearing). Such study shall be conducted over one season following initial Project operation and may require an additional year of study upon demonstration of good cause for such extension. If study findings indicate adverse impacts, the Joint Agencies shall recommend and Licensee shall implement appropriate lower ramping rates immediately notwithstanding any provisions herein to the contrary.

As a result of fulfilling the requirements of Article 55 and the Settlement Agreement, FERC approved the powerhouse down ramping rates recommended in Olson (1990):

> The down ramping rates described in Table 1 of the study results filed on October 26, 1990, are approved. These down ramping rates may be temporarily modified if required by operating emergencies beyond the control of the licensees, and for short periods of time upon mutual agreement between the licensees and the Washington Department of Fisheries (FERC Approval Order 57 FERC 62, 006 October 8, 1991).

Project operation is dictated by Spada Lake elevation rule curves (see Figure 4-1). Most down ramping occurs when the reservoir is in State 3, which is the operational discretionary zone. Down ramping rates are limited to the schedule presented in Table 4-2. The down ramping regime varies from 1 to 4 inches per hour depending on the season, time of day, and river stage. The point of compliance is the water surface elevation measured immediately downstream of the powerhouse. However, going farther downstream, the rate of change in water surface elevation decreases because of the dampening effect of distance, time, and bank water storage. Because the Project is operated on an intermediate-cycle basis rather than a load-following basis, powerhouse water discharges to the river do not fluctuate frequently on a daily basis.

TABLE 4-2
Jackson Hydroelectric Project Down Ramping Rate Schedule[a]
(Water surface elevation decreases are in inches per hour)

Flow Range (cfs/day)	March 1[b] to May 31		June 1[b] to September 15	
	Day	Night	Day	Night
1,500 to 750	4	4	2	1
750 to 600	2[c]	2[c]	2[c]	1[c]
600 to 300	2	4	2	1[d]
300 to minimum	2	2	2	1[d]
	September 16 to October 31		**November 1 to February 28**	
	Day	**Night**	**Day**	**Night**
1,500 to 750	2	1	4	4
750 to 600	2[c]	1[c]	2[c]	2[c]
600 to 300	2	2	4	4
300 to minimum	2	2	4	4

[a]For normal operation. Not for power-generation equipment failures or forced outages. Units are in inches per hour at the powerhouse. Rates are tracked on a 15-minute basis by USGS for compliance. No one 15-minute down ramping value will exceed half the hourly rate shown in the table. No four consecutive down ramping rates shall exceed the hourly rates shown in the table.

[b]This date may be adjusted annually by determining time of emergence with cumulative water temperature information. Upon notification to the District from WDFW that either salmon or steelhead trout fry are expected to emerge from the river gravel, based on water temperature unit calculations (see River Temperature), the District will shift to the designated slower down ramping rates.

[c]If river flow prior to down ramping has exceeded 1,000 cfs for more than 72 hours, down ramp through this flow range (750 to 600 cfs) only after holding flow constant between 750 and 850 cfs for at least 6 hours of daylight and one overnight period.

[d]Avoid any scheduled flow reduction.

For many cases, different down ramping rates are recommended for day and night. However, if down ramping is to occur during the twilight period (one hour before to one hour after sunrise or sunset), the lower of the two stipulated day or night rates should be used. For example, a 4-inches-per-hour springtime down ramp intended for night should not be initiated at the powerhouse until one hour after sunset. As another example, if a summer afternoon down ramp initiated at 2 inches per hour is to extend past sunset, the ramping rate should be reduced to 1 inch per hour at one hour before sunset. These precautionary guidelines should minimize the potential for stranding during the twilight hours when the juvenile fish are shifting their diurnal behavior patterns.

4.4 Adult Upstream Migration Past the Powerhouse

Due to the siting, design, and contemplated operation of the Project's powerhouse, the Joint Agencies expressed concern about potential delay and injury to returning adult salmonid spawners. Thus, FERC License Article 55 also states that a study "shall include an evaluation of the proposed fish berm and associated powerhouse tailrace structures."

The Settlement Agreement also addressed fish passage "studies to determine whether the powerhouse berm facilitates successful upstream migration of anadromous fish and whether entry into powerhouse draft tube outlets causes injury to such anadromous fish."

To aid the upstream passage of adult fish past the powerhouse, a fish berm was constructed immediately upstream of the powerhouse (Figure 4-3). This berm provides a low-flow concentration slot near the left abutment adjoining the powerhouse to guide adult fish upstream past the powerhouse, particularly during high-flow discharges from the powerhouse, accompanied by lower flows above the powerhouse.

To evaluate fish berm effectiveness, follow-up studies included: (1) trapping and radio/ acoustic tagging of steelhead trout, (2) spawner surveys for distribution of redds above and below the powerhouse (compare pre- and post-Project operation redd distribution), and (3) frequent empirical observations of the powerhouse tailrace area by District staff and consultant fishery biologists. Study results and subsequent observations have indicated that the fish berm performs as intended. No species experience either delay or difficulty in locating the concentrated flow created by the fish berm, and fish migrate upstream past the powerhouse and upstream through the fish berm without difficulty (Schadt 1989).

Additionally, the Joint Agencies were concerned about potential injury of adult fish entering the discharge canals (draft tubes) for the Pelton turbines during periods of high discharge. This potential problem was researched using radio-tagged steelhead trout. An electronic monitoring field was set at the mouth of both canals during the fish tagging effort. No tagged fish were recorded entering the canals during the study, nor were injured or disoriented fish observed.

The Project operational and technical staff continue to randomly monitor the tailrace for distressed or injured adults, as agreed upon in the final report on fish passage submitted to FERC (Schadt 1989). No problems have been observed since monitoring began; spawner surveys continue to document the distribution of adults and redds in the Sultan River. Survey results are reported annually to the Joint Agencies. The fish berm is and will be maintained by the District on an as-needed basis.

4.5 River Channel (Spawning)

The FERC license does not contain specific reference to river gravel and sediment analysis. However, this fish mitigation issue was recognized and discussed by FERC in the Final EIS (FERC 1981) because changes in river flow caused by Project operations would affect habitat conditions.

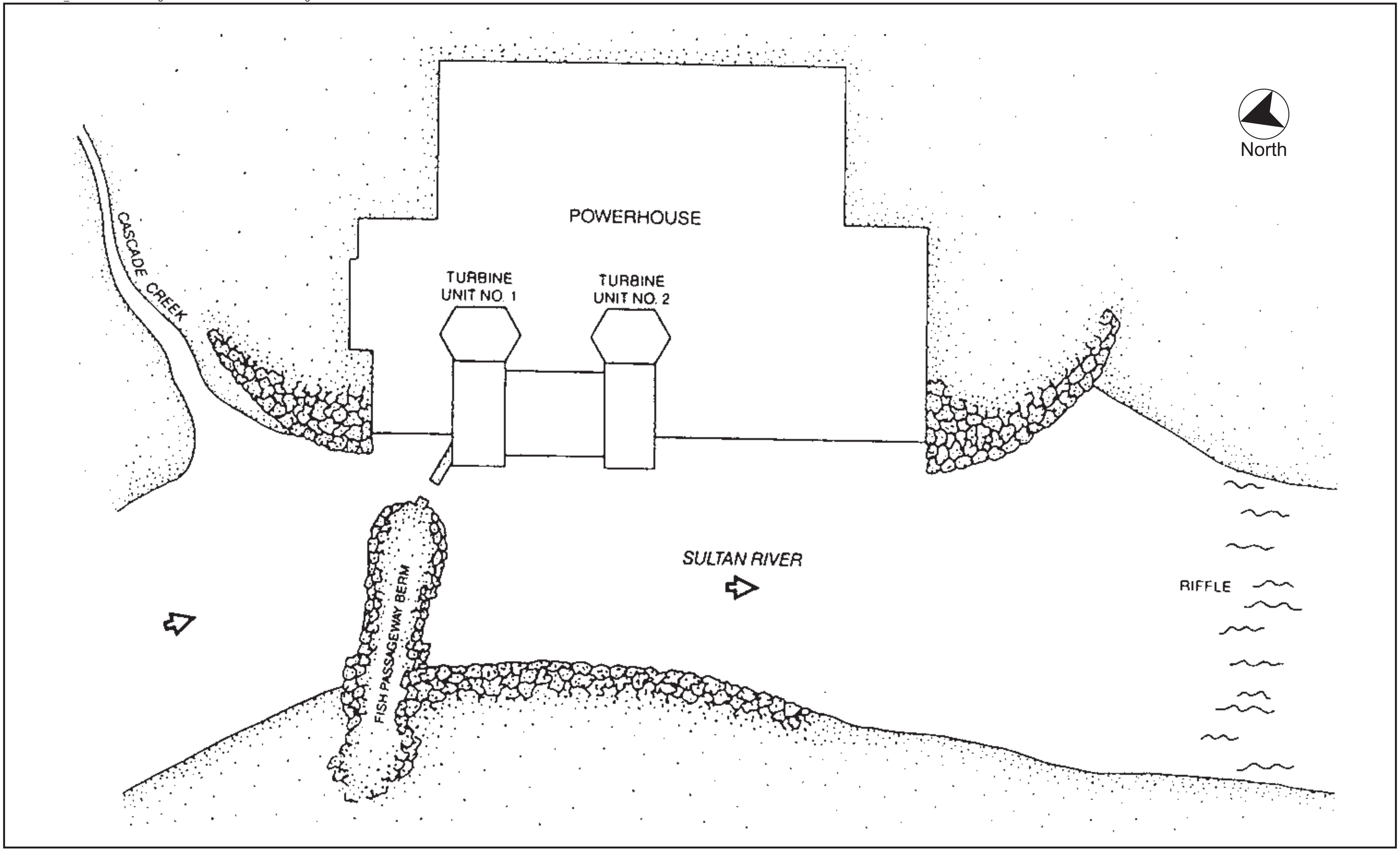


FIGURE 4-3
Powerhouse and Fish Passageway Berm

> Maximum flows … would be reduced in duration and magnitude. An adverse impact of reducing peak storm event flows would be the reduction in gravel movement within the stream. The scouring and redistribution of gravel associated with high runoff are important in cleaning, loosening, and recruitment of gravel from upstream areas.
>
> A reduction of this process could result in armoring of salmon and trout-spawning areas, and a loss of important spawning and incubation habitat.

In the FERC license, this issue was addressed by Article 60 negotiations between the District and Joint Agencies that produced the Settlement Agreement:

> Licensee shall develop, conduct and analyze … studies to determine short-term and long-term impacts of sedimentation, gravel compaction and spawning gravel reduction in the Sultan River due to construction and operation of the Project:

Sediment Analysis—An initial study shall be conducted as soon as Sultan River conditions permit after January 1, 1982, to determine the percentage of fines in spawning gravel from the Diversion Dam to Skykomish River confluence. This percentage shall again be determined upon completion of construction but prior to Project operation, and again 3 years after initial Project operation. If Project construction or operation causes a significant build-up of fines and/or causes adverse impacts at critical life stages of anadromous fish, Licensee and the Joint Agencies shall jointly determine appropriate remedial measures. Licensee shall implement such measures within 6 months after they are jointly determined. If the Licensee and the joint agencies are unable to agree on joint recommendations, Licensee shall implement the joint agency recommendations within 6 months of such joint agency recommendations subject to disapproval or modification by the Commission.

Gravel Analysis—A study to determine whether Project operation causes significant depletion of spawning gravels in the Sultan River from the Diversion Dam to confluence with the Skykomish River. Baseline data shall be gathered prior to initial Project operation. After 3 years and again after 10 years of Project operation, Licensee and Joint Agencies shall jointly determine whether and the extent to which Project operation has caused significant depletion of spawning gravels. If any such depletion shall have occurred, then Licensee agrees to fund a gravel placement program subject to reasonable jointly determined locations, methods, cost, and timing for such gravel placement.

In accordance with the Settlement Agreement, several studies were performed between 1982 and 1994 on sediment and gravel issues. Results of these studies (Wert et al. 1982, 1984, Miller et al. 1984, Wert and Stables 1988, Luchessa and Wert 1995) indicated that adequate quantities of gravel of suitable quality were available in the Sultan River to yield a high level of embryonic survival of salmonids. The District will resume monitoring streambed sediment quality, if 6 or more consecutive years pass without a flushing flow in excess of 4,000 cfs at the powerhouse.

The District will also continue to raise the diversion dam sluice gate when a freshet event (i.e., spill or rain causing flows to exceed 800 cfs at the Diversion Dam) occurs to allow the continued downstream movement of bedload that would otherwise accumulate upstream of the diversion dam. The current operating procedure is to raise the gate on the receding side of a peak flow. As previously agreed with the Joint Agencies, the District will notify them in advance of sluice gate operations.

In 1994, the City enacted Ordinance No. 2020-94 establishing regulations for "a safe and environmentally sound public access program" for areas surrounding the Chaplain Reservoir and including the reach of the Sultan River within the City-owned Chaplain Tract, located 3 to 5 miles north of the Town of Sultan. Section 2q of this ordinance states: "All mineral prospecting is prohibited on or from City of Everett property. Possession of prospecting equipment on City-owned land is prohibited." The effect of this ordinance has stopped destructive prospecting practices with river channel gravel and shoreline areas located within City-owned property. Larger reaches of the river channel and shoreline beyond City limits are also protected through the prohibition of possession of prospecting or mining tools and equipment on City land, because some river reaches are accessible only through City property. Prior to enactment of Ordinance No. 2020-94, significant damage was occurring to spawning areas, and large shoreline potholes with fish entrapment potential were created and left unreclaimed by prospecting. Both are/were contrary to State regulations to protect fish habitat. The City's ordinance is enforced by watershed patrols, routine transiting of the City's property by staff to and from the water filtration plant, and field work by the City's watershed forester.

4.6 Water Temperature

Protecting Sultan River fisheries requires consideration of water temperatures. The capability of the Project to maintain pre-Project water temperature conditions was subject to studies during licensing and subsequently led to design and construction of appropriate facilities. After Project operations commenced, monitoring and cooperative planning with the Joint Agencies was done to implement temperature control protocols.

Article 56 in the FERC license issued for Stage II of the Project states:

> Licensee shall … prepare … studies to determine the effects of river temperature changes on the trout and salmon populations of the Sultan River between the diversion dam and the confluence with the Skykomish River.

Similarly, the Settlement Agreement stipulates that:

> Licensee shall develop, conduct, and analyze … a study of river temperatures based upon continuous monitoring by thermograph at a point below the diversion dam where return flows are fully mixed with stream flows. Annual reports of temperature studies will be provided to the Commission and to the Joint Agencies by the licensee.

The Settlement Agreement also stipulated under Project Operations that the Licensees should construct a specific water withdrawal structure at Spada Lake and further:

> … shall operate said intake structure so that the temperature of combined fishwater return flows and river flows passing the diversion dam approximate to the fullest extent possible [it is understood that meteorological and hydrological conditions may affect reservoir temperatures such that meeting the daily mean temperature standard may be impossible], the daily mean of recorded temperatures as recorded at the diversion dam for the years 1969-79, and also remain within the recorded daily minimum-maximum temperature range. Licensee shall notify the Joint Agencies of deviations from said minimum-maximum temperature range whenever such deviations occur for more than one monitoring period. What constitutes a "monitoring period" shall be jointly agreed upon by the Licensee and the Joint Agencies prior to Project operation.

Subsequently, it was jointly agreed that one monitoring period means 24 continuous hours. Thus, whenever river water temperature does not remain within the 10-year historical range, the District notifies the Joint Agencies.

Maintaining water temperature of the Sultan River within the historical range (pre-Stage II) at the diversion dam is an important requirement for the Project. Water temperature influences anadromous fish during the freshwater phase of their life cycle. Temperature control is achieved via a withdrawal structure located at Spada Lake (as specified by the Settlement Agreement). Reservoir water temperature profiles are monitored monthly. Movable panels in the structure are positioned on the intake structure based on reservoir water temperature levels to achieve the desired temperature at the diversion dam. However, water temperature control is only possible during reservoir thermal stratification, which typically occurs from May through October. Average water temperature for pre- and post-Stage II time periods are shown in Figure 4-4.

The District monitors water temperature at the diversion dam and powerhouse on an hourly basis throughout each year. Annual reports are prepared and submitted to the Joint Agencies and FERC. In 1996, FERC determined that the Licensees no longer had to submit those reports (FERC Correspondence No. 2157-118 July 23, 1996). However, these reports are still submitted annually to the Joint Agencies.

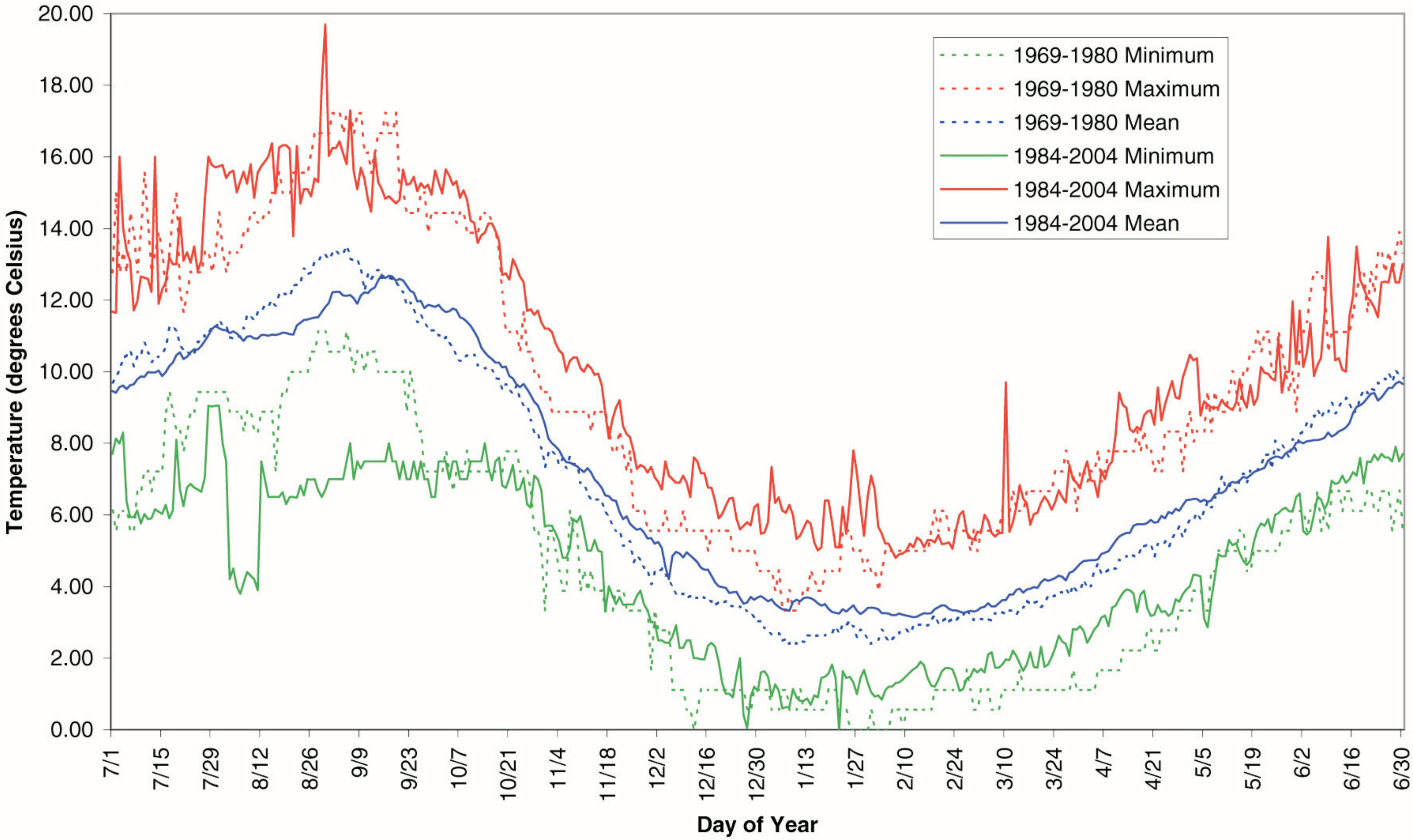


FIGURE 4-4
Comparison of Sultan River Temperatures at RM 9.7 (1969-1980 vs. 1984-2004)

CHAPTER 5

Analysis of Effects

This chapter presents an analysis of the effect that Project operations have had on anadromous salmonids and bull trout. Information on bull trout and coho salmon in the Sultan River is limited. As a result, most of the analysis focuses on fall Chinook salmon and to a lesser degree steelhead trout. The environmental pathways and indicators used in the analysis, however, pertain to all salmonids and their habitat; therefore, bull trout and coho salmon are addressed indirectly in most cases, as are other fish species dependent upon the same ecosystem functions.

The analysis is organized along the lines of environmental pathways and indicators used in other recent biological assessments involving salmonids in the Pacific Northwest. The use of these pathways and indicators facilitates the analysis of effects on the species and their habitats. The indicators were tailored to conditions for the Sultan River and operation of the Project, as was suggested by the Joint Agencies.

The analysis focuses on the current operations of the Project as licensed by FERC. The substantive issues presented in this chapter are organized along the following four pathways:

- Water Quality/Temperature
- Habitat Access
- Streamflow
- Channel Conditions

5.1 Water Quality/Temperature

All water quality parameters in the Sultan River meet Washington State AA standards. Thus, the Sultan River is not Clean Water Act (CWA) Section 303d designated for any water quality limitation. Although water temperatures are also maintained within state and CWA standards, they are modified somewhat by Project operations and, therefore, are addressed below.

Sultan River temperature control is feasible only during times of reservoir thermal stratification, typically May through October. The ability to maintain water temperatures within the historical range of temperatures established during Stage I of the Project (1969-1980) varies from year to year depending upon meteorological conditions. Temperature variances outside the historical range occur mostly during November and December when reservoir water temperatures sometimes exceed the historical maximums for more than a 24-hour period. On average, water temperatures are about 0.6°C (1.0°F) above the historical means as measured at the diversion dam (based on data depicted in Figure 4-4) during the October through March period when salmon eggs are incubating and alevins are in channel gravel. The pre- and post-Project water temperature differential becomes less in the lower river as ambient air temperature continues to influence water temperature. Water temperatures at the powerhouse tend to be 1 to 2°C warmer compared to those at the diversion dam (Snohomish PUD 1991). The higher-than-historical water temperatures during the egg incubation period affect egg hatching and fry emergence timing, and perhaps the timing of downstream movement of juvenile salmon.

Cumulative temperature units (a temperature unit equals 1 degree-day above 32°F) for the Chinook salmon incubation period were computed for pre- and post-Project water temperature conditions as measured at the diversion dam (Figure 5-1). These data indicate that the warmer water temperatures would be expected to accelerate incubation by about 3 weeks on average in this upper section of river. In an unregulated stream, a shift in fry emergence time closer to the winter flood season would increase the risk of fry being killed or displaced downstream as a results of the flood conditions. In the Sultan River, however, the Project has greatly reduced the probability of floods occurring at this time of year. Thus, under these regulated flow conditions, early fry emergence caused by warmer winter water temperatures may, in fact, benefit Chinook salmon by providing a longer time period for the fry to grow prior to emigration.

5.2 Habitat Access

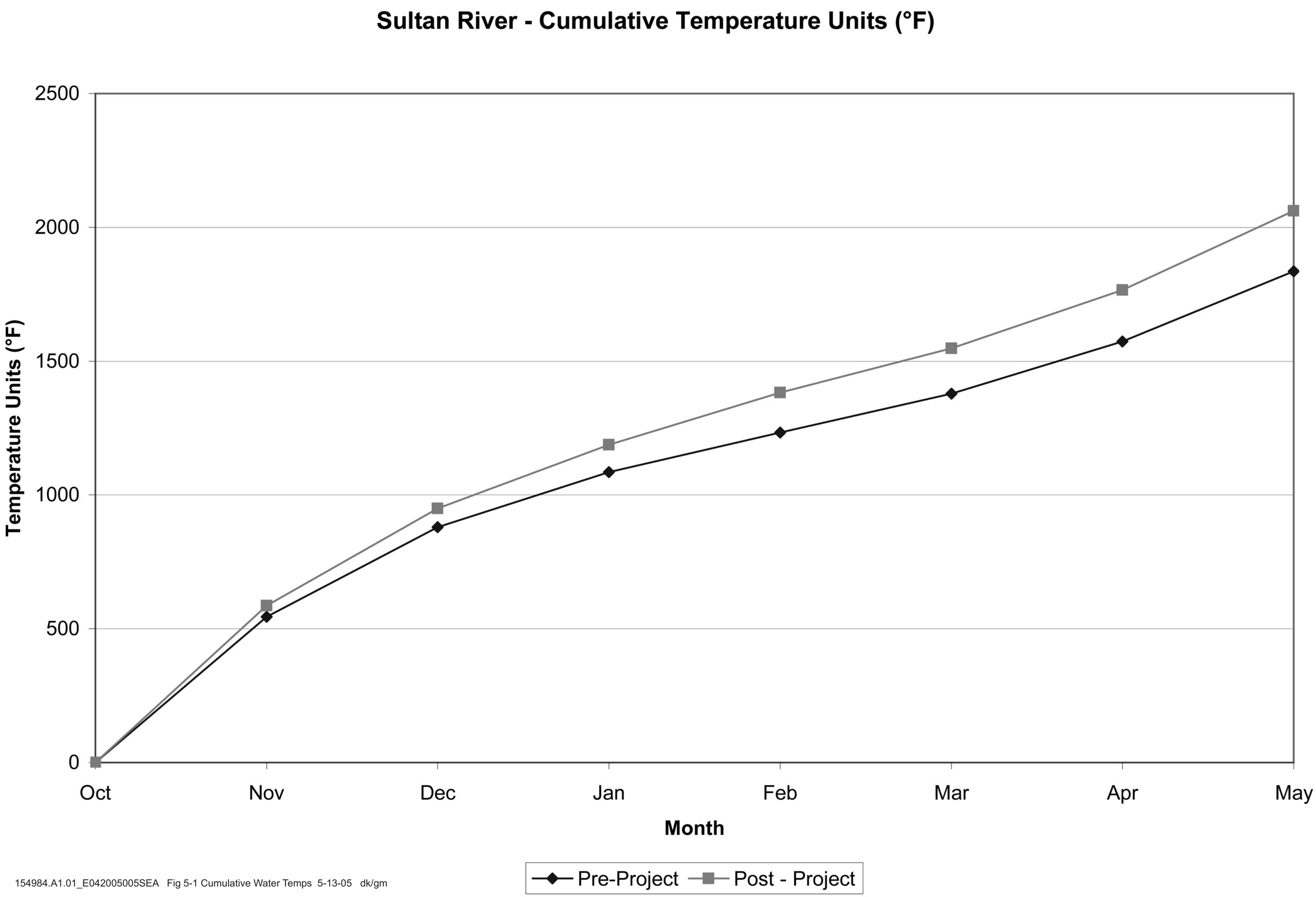
5.2.1 Powerhouse

The fish berm at the powerhouse (RM 4.3) has been shown to provide successful upstream passage conditions for adult salmonids (Schadt 1989). Also, numerous years of multispecies adult escapement survey estimates have documented a continuing pattern of spawning redd distribution in the river both upstream and downstream of the powerhouse. Therefore, the flow conditions in the powerhouse tailrace, as modified with the fish passage facility, do not appear to impede upstream migration and spawning success for salmon and steelhead trout above the powerhouse (see Section 4.4). Although bull trout behavior has not been observed at the tailrace, it is assumed that their access to potential foraging areas upstream of the powerhouse is not impeded, based on the observed behavior of other salmonids.

5.2.2 Diversion Dam

The City of Everett's water supply diversion dam, which was built in 1929 at RM 9.7, and earlier dams farther downstream have blocked upstream fish passage since the early 1900s. Prior to the presence of these diversion structures, salmon, steelhead trout, and bull trout were able to access the river upstream of the current diversion dam. However, channel morphology undoubtedly dictated the distance to which these species would have been able to migrate. The steep gradients, confined channel, and numerous cascades and chutes undoubtedly limited habitat access above RM 9.7. The first substantial increase in gradient, to 2.7 percent, occurs near RM 12.5. Farther upstream near RM 16, which is about 0.5 mile below the Culmback Dam site, the channel gradient increases dramatically, averaging 7.1 percent (over a distance of 1,700 feet), and reaching 13.7 percent over 146 feet at one location (USGS Topographic Map and Digital Elevation Model, Wallace Lake Quadrangle).

Steelhead trout, by virtue of their superior swimming and leaping abilities, likely penetrated farther upstream into the 6.4-mile reach (between the diversion dam and Culmback Dam) than Chinook or coho salmon. Because of the highly unstable gravel beds above the



154984.A1.01_E042005005SEA Fig 5-1 Cumulative Water Temps 5-13-05 dk/gm

FIGURE 5-1

Cumulative Water Temperature Units in the Sultan River at RM 9.7 (October through May)

diversion dam, probably few salmon historically returned to spawn in the accessible portion of this reach. However, because steelhead trout spawn in the spring after the winter flood season, they were more likely than salmon to have successfully spawned in this reach. Still, high-flow events occurred in some years in the spring when steelhead eggs would have been susceptible to scour. Also, high winter flows would have impacted any juvenile salmonids attempting to over-winter in the canyon, especially since this reach contains no refuge habitat such as side channels or off-channel ponds.

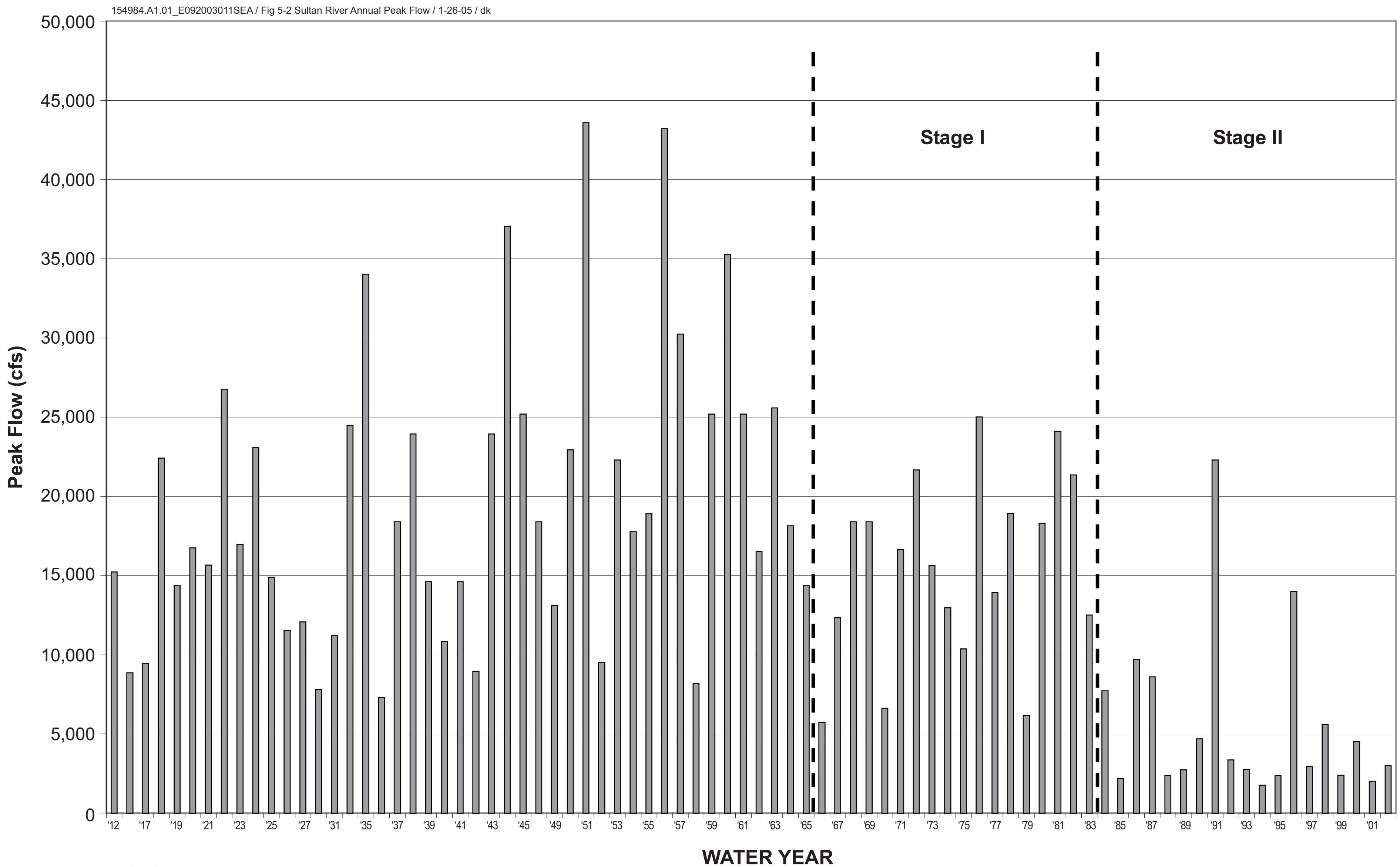
Various lines of evidence indicate that sustainable runs of anadromous fish did not historically occur in the upper Sultan basin. Eicher (1981) identified the high gradient drop near RM 16 as a possible natural barrier. In addition, historic photographs and pre-construction drawings depict another particularly narrow, steep chute beneath the present dam site that was also a likely obstruction to fish passage (PUD Photo Archives, RW Beck & Associates General Excavation Plan, 1962). Russ Orrell, a retired WDF fisheries biologist for the region, quoted in Pfeifer et al. (1999), noted a barrier in the upper canyon (near present day Culmback Dam) that consisted of a vertical drop of roughly 10 feet over a bedrock shelf. In reference to the possibility that the rainbow trout in the upper basin might be of steelhead origin, Mr. Orrell opinioned that it was "pretty unlikely." Pfeifer et al. (1999), in their review of mostly anecdotal information, concluded that the origin of the upper basin rainbow trout most likely was "some combination of relic stocks present since the last glaciation with some additions of unknown stock origin." They also concluded that while the 10 foot vertical falls would have certainly stopped all salmon, summer run steelhead may have been able to clear such a hurdle if flow and plunge pool conditions were just right. Therefore, it is possible that some steelhead trout were historically able to reach the upper basin and thereby account for the current presence of resident rainbow trout. Similar reasoning would suggest that bull trout, which currently do not occur in the upper basin, did not have access to the area historically.

Restoring anadromous fish production above the diversion dam was considered at length by the Joint Agencies during Stage II planning from 1978 to 1981. The effort culminated in a Settlement Agreement in 1983, wherein the Joint Agencies accepted measures to enhance salmon production in the lower Sultan River downstream of the diversion dam, rather than restoring anadromous fish access to the reach above the dam. This outcome relied on several factors discussed below:

1. The 6.4-mile reach above the diversion dam has a relatively high gradient (averaging 90 feet per mile) and is in a steep-walled canyon. As a result, the channel contains mostly bedrock and large-sized bed material with few areas of suitable spawning gravel.

2. Before construction of Stage II, spawning gravel areas in the canyon experienced frequent scour events. Flows exceeding 2,500 cfs caused considerable gravel movement and some higher flows scoured down to bedrock (Miller et al. 1984). Under natural conditions, peak flows exceeded 5,000 cfs about 5 times yearly (Eicher 1981) and 10,000 cfs in 8 out of 10 years based on stream gaging since 1912 (Figure 5-2). Because these high flows occurred during the salmon egg incubation period, salmon production was probably very limited in this reach historically, when access was possible.

3. After completion of Culmback Dam in 1965, water temperatures in the reach above the diversion dam became too cold for productive salmon and trout growth (Eicher 1981).



USGS Gages: 1911 - 1932 312138000
1935 - 1974 312137500
1975 - 1984 312138150
1985 - 1998 312138160

Note: All flows adjusted to gage no. 31218160 (powerhouse) based on drainage area.

FIGURE 5-2
Sultan River Annual Peak Flow

Also, the cooler water released at Culmback Dam in September and October would have delayed Chinook salmon egg development by several weeks if adults were allowed to spawn above the diversion dam. The cold water originates from outlet works withdrawals at Culmback Dam. Colder-than-natural discharge temperatures occur at the base of the dam whenever the reservoir is stratified, typically May through October. Stage II of the Project, however, has a multi-level withdrawal capability from the reservoir that provides temperature control for all water discharged at the diversion dam and powerhouse. It is not possible, however, to discharge water of controlled temperature at the base of Culmback Dam.

4. A provision for upstream fish passage for salmon and steelhead would have required considerably higher instream flows in the reach above the diversion dam. Those increased discharges from Culmback Dam would continue to flow to the river mouth and contribute to unfavorable water temperatures for all salmonid rearing and steelhead trout egg incubation in the most productive downstream reaches. The lower water temperatures would have likely reduced the growth potential for all anadromous salmonids rearing in the lower 9.7 miles of the river.

5. A requirement for higher instream flows above the diversion dam for salmonid habitat would reduce potential power production enough to make the hydroelectric project infeasible.

In summary, the Joint Agencies in 1981 decided to not prescribe fish passage at the diversion dam based on the prospect of greater salmonid production (especially Chinook salmon) in the lower Sultan River with implementation of the Project’s fisheries mitigation plan. That decision also recognized that a requirement for higher instream flows above the diversion dam would make the Project economically infeasible and thus unable to provide the agency-preferred enhancement measures, as well as resolve long-existing fish habitat condition problems with Stage I. These measures include (1) augmenting streamflows during natural dry conditions (see Section 5.3.1), (2) providing near optimal spawning flows for salmon (see Section 5.3.1), (3) increasing egg-to-fry survival rates by reducing the frequency and severity of flood flows (see Section 5.3.3), and (4) maintaining the preferred water temperature regime in the lower 9.7 miles of river (see Section 4.6). Licensee-sponsored annual planting of 30,000 steelhead trout smolts in the lower river is the mitigation for lost steelhead trout production above the diversion dam. Results of spawning surveys (see Chapter 3) and monitoring of gravel quality (see Section 5.4.1) and temperature have demonstrated the success of the protection and mitigation measures.

5.3 Streamflow

5.3.1 Minimum Flows

The minimum flows stipulated in the Project license (see Table 4-1) were developed collaboratively with the Joint Agencies during the licensing process. These flows were based on an incremental instream flow study done by WDF (Easterbrooks and Gerke 1978) and a review of historical flows, coupled with the known lifestage timing and habitat requirements of the species of concern. Based on the Joint Agencies’ analysis, the minimum flows established in the Settlement Agreement and included in the FERC license were those that provided optimal or near optimal habitat conditions for salmonids.

5.3.1.1 Below Diversion Dam

The effects of the current minimum flows on fisheries are best understood by comparing them to historical flows. The minimum base flow at the diversion dam (June 16 to September 14 and November 1 to January 15) is maintained at or above 95 cfs. Summer flows (July and August) have averaged 124 cfs since Stage II began operating in 1984 (USGS Gage No. 12138160). Historically, natural flows above the City diversion dam dropped below this level nearly every year, often down to 50 cfs during the late summer low-flow period (USGS Gage No. 1213800). Thus, the required 95 cfs has enhanced flows during the low-flow periods. The flow increase provided by reservoir storage has been most beneficial for coho salmon and steelhead trout that rear through the summer.

During the Chinook salmon spawning season (September 15 to October 31), minimum flows are maintained at 145 to 155 cfs at the diversion dam. These flows provide the maximum amount of spawning area based on the WDF instream flow study (Easterbrooks and Gerke 1978). Flows greater than 95 cfs are maintained throughout the egg incubation period (to January 15) to provide suitable flow conditions over Chinook salmon redds. Minimum flows released at the diversion dam are increased to 150 cfs on January 16 and to 175 cfs on March 1 (through June 15) to coincide with steelhead trout spawning and the period of greatest salmonid fry emergence and early rearing. Additionally, natural inflow between the diversion dam and the powerhouse ranges from about 20 cfs in the driest months to about 100 cfs in the wettest months. Marsh Creek at RM 7.6 contributes most of the inflow. Consequently, minimum instream flows are maintained even during operational events that would lower flows below requirements.

5.3.1.2 Below Powerhouse

Below the powerhouse, summer minimum instream flows are required to be maintained at or above 165 cfs, thus at times augmenting natural flows. Flow augmentation is best demonstrated by comparing the post-Project flow exceedance curve to the pre-Project natural flow exceedance curve (Figure 5-3). Flows with the Project operating have increased during the approximately 100 driest days of the year (70 to 100 percent exceedance), and the augmentation increases as natural conditions become drier. For example, a drought condition flow in August (90 percent exceedance) would equate to a natural flow of 74 cfs, which compares to 176 cfs now provided by the Project (see Table 5-1).

Minimum flows below the powerhouse during Chinook salmon spawning (September 15 to November 1) are maintained at or above 200 cfs (see Table 5-1). Actual post-Project flows during this period have exceeded natural flows during the driest conditions (>50 percent exceedance in September and > 75 percent in October). Chinook salmon especially have benefited because flows prior to the Project were often too low to allow spawners to access portions of the river.

In addition to the 200-cfs minimum flow below the powerhouse, flows are not allowed to exceed 400 cfs during the Chinook salmon spawning season (September 15 to October 15). This flow limit prevents spawning adults from building redds in areas that might subsequently dewater when flows return to the minimum, thus ensuring that the 200-cfs

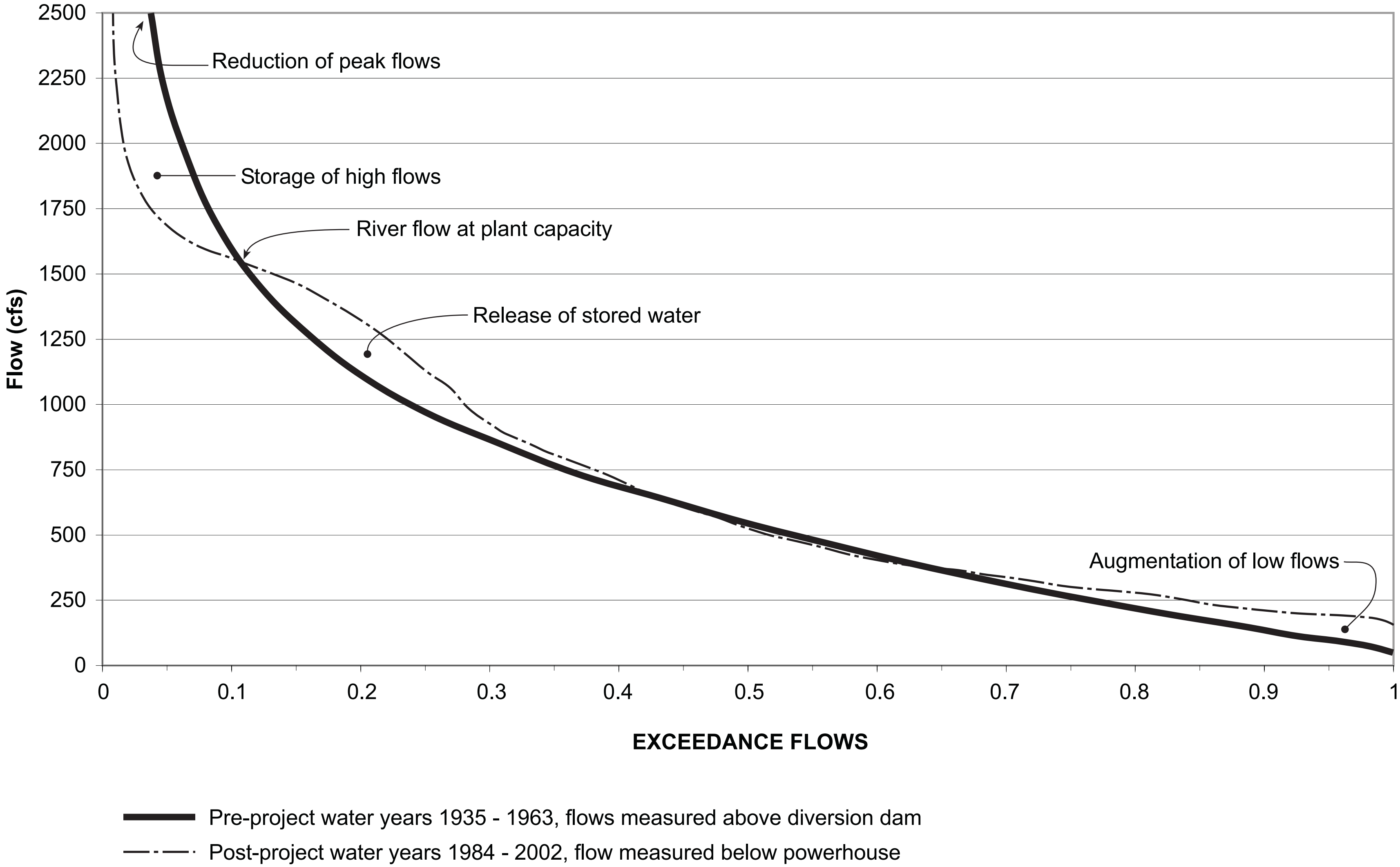


FIGURE 5-3
Sultan River Pre-Project and Post-Project Flow Exceedance Curves

TABLE 5-1
Pre- and Post-Project Exceedance Flows (cfs) in the Sultan River (above diversion dam)

Pre-Project Water Years 1935–1963[a]

Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
10% exceedance	2,000	1,590	1,140	1,590	1,810	1,620	865	408	819	1,890	2,160	2,400	1,600
25% exceedance	990	910	770	1,140	1,370	1,180	612	246	333	930	1,250	1,380	970
50% exceedance	477	492	506	790	999	810	372	156	161	439	655	750	544
75% exceedance	272	262	327	560	750	550	222	101	106	200	383	448	265
90% exceedance	173	192	221	424	555	398	135	74	72	110	245	294	135
Monthly Average	916	817	643	979	1,128	936	456	222	344	819	1,079	1,183	792

Post-Project Water Years 1984–2002[b]

Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
10% exceedance	1,750	1,580	1,480	1,470	1,450	1,410	863	377	518	1,530	1,870	1,740	1,560
25% exceedance	1,570	1,380	1,070	1,040	1,020	1,080	521	282	379	664	1,590	1,530	1,130
50% exceedance	884	755	581	617	735	581	304	208	290	372	1,330	1,050	524
75% exceedance	463	407	376	393	480	318	216	194	210	292	654	570	301
90% exceedance	332	338	306	287	331	262	192	179	193	232	268	304	212
Monthly Average	1,035	882	746	750	801	723	434	268	341	634	1,356	1,063	751

[a]USGS Gage No. 12137500 Sultan River near Startup, Washington (above diversion dam).

[b]USGS Gage No. 12138160 Sultan River below powerplant near Sultan, Washington.

= Periods for comparison of pre- and post-project low flow augmentation.

minimum flow will cover redds during egg incubation. If flows intentionally are allowed to exceed 400 cfs during the Chinook salmon spawning season, the District is obligated to protect redds with a higher minimum flow. This protection and enhancement measure was implemented in 1989 (58 FERC 62, 224 March 19, 1992).

5.3.2 Minimum Flow Compliance

The District is required to monitor compliance of the licensed minimum flows with continuous gaging. All variances, even as little as 1 cfs, must be reported to FERC and the Joint Agencies. A summary of all incidents of minimum flow variance since 1988 is provided in Appendix D. The District must also determine the cause of each variance and report any actions taken to correct or avoid recurrences.

Of the 40 incidents reported since 1988, 30 occurred at the diversion dam (Table 5-2). Ten of these incidents occurred in 1990 and were associated with an alarm-setting problem that caused minor variances. Most other incidents occurred because of equipment failure and human error. Excluding the 10 alarm-setting incidents in 1990, the diversion dam has had about one minimum instream flow compliance incident per year. The Licensees expect to experience the same or a lower rate of compliance incidents in the future, based on the recent enhancement measures (see Chapter 6). Only one or two of these incidents in the next 10 years would be expected to cause a variance greater than 10 percent below the minimum flow.

TABLE 5-2
Incidents of Minimum Flow Variance (1988-2003)

Location	Total Variances	Variances (> 10% flow)
Diversion Dam	30	9
Powerhouse	10	5

Incidents of minimum flow variance typically lasted for only a few minutes. In fact, only one lasted for more than an hour (75 minutes, 18 cfs variance). Also, most flow variances were less than 10 percent of the minimum flow. For flow variances to affect fish populations, the duration of the new flow condition must be several weeks or longer to influence the associated space and food limitations important to the fish. For Puget Sound coho salmon, for example, a 60-consecutive-day low-flow index has been found to correlate well with rearing capacity and subsequent smolt production (Zillges 1977, Mathews and Olson 1980, Seiler 2000). Thus, none of the out-of-compliance minimum flow incidents to date have been long enough and/or of enough magnitude to have adversely affected salmonid rearing capacity.

The fact that some of the minimum flow incidents also occurred suddenly meant that ramping rates could have been out of compliance as well. The potential effects of out-of-compliance ramping rates are discussed in Section 5.3.4.5.

5.3.3 Peak Flows

The peak flow regime of a watershed is ecologically important because of the instream biota, riparian vegetation, and many channel-forming processes that are tied to the frequency and amplitude of hydrologic events. Peak flow events are necessary to allow fish access to spawning grounds, to trigger downstream or instream fish movements, to prevent spawning gravel embeddedness, and to recruit large woody debris into the channel. Excessive peak flows, such as those occurring during floods, however, can scour spawning beds and cause extensive losses of incubating salmon eggs. Also, floods during fry emergence can cause high mortality and untimely downstream displacement of fry. Numerous studies have documented the correlation between high discharge and low returns of salmon to unregulated streams (Neave 1953, Wickett 1962, Koski 1966, McNeil 1969). Studies of several flow-regulated streams also have documented the strong inverse relationship between peak winter flows and egg-to-fry survival. Miller (1976) noted an inverse correlation between peak flood discharge in the Cedar River and the number of pre-smolt sockeye salmon later observed in Lake Washington. A two-fold decrease in peak discharge correlated approximately with a doubling of sockeye production. A similar response in egg-to-fry survival was noted for Chinook and chum salmon in the Big Qualicum River in British Columbia (Lister and Walker 1966). There it was noted that the years of highest egg-to-fry survival for Chinook salmon were accompanied by an earlier downstream migration of fry, presumably because of density-dependent factors associated with the stream's capacity to rear juvenile Chinook salmon at that stage. Probably the best available information specific to Chinook salmon egg survival affected by peak flows are those data collected by WDFW on the Skagit River (Seiler et al. 2004). Analysis of 14 years of survival estimates for the 1989 through 2002 brood years found that 80 percent of the variability in egg-to-migrant survival was explained by the severity of peak flows during incubation (see Appendix B).

The construction of Culmback Dam has clearly reduced the amplitude of peak flow events in the Sultan River (see Figure 5-2). Changes occurred after Stage I in 1965, and again in 1983 when the enlarged reservoir was first filled. Annual peak flows prior to completion of Culmback Dam exceeded 10,000 cfs in most years (52 of 62). In the past 15 years, peak flows have exceeded 10,000 cfs only twice, reaching 22,000 cfs in water year 1991 and 14,000 cfs in water year 1996.

In 1989, the District came to an agreement with the Joint Agencies and the Corps of Engineers to change the reservoir rule curves to allow more discretionary operation between September 1 and June 30. The new rule curves were accepted by the Joint Agencies because of the potentially significant fisheries benefits due to reduced peak flows and reduced frequency and amplitude of down ramping from the powerhouse. Prior to then it was recognized, however, that the reduced peak flows could adversely affect the quantity and quality of spawning gravels over time. Therefore, field studies and gravel monitoring were required and conducted to address this issue. Results of these studies and a discussion of effects on spawning gravel are presented in Section 5.4.

Egg-to-fry survival studies have not been conducted on the Sultan River. However, the increase in salmon returns observed since about 1985 (see Figures 3-1, 3-2, and 3-3) may be largely attributed to the reduction of peak flows during egg incubation and fry emergence. This enhancement seems particularly evident for pink and chum salmon (see Sections 3.3

and 3.4). Applying the flow-to-egg survival relationship for Chinook salmon from the Skagit River to the Sultan River would suggest that the reduction of annual peak flows attributable to the Project since 1984 could have doubled average fry production during this period. The average Chinook salmon escapement to the Sultan River has, in fact, increased by 51 percent since the first brood year affected by the Project, and as a component of the Snohomish system, the Sultan River contribution increased from 7 to 12 percent following implementation of the Stage II flow regulation. This comparison of pre- and post-Project Sultan/Snohomish spawner contribution percentage tends to factor out the effects of variable harvest rates and marine survival, which would similarly affect all returns to the Snohomish system. The Chinook salmon return trends to the Sultan River also may have been affected by a reduced number of strays of hatchery-reared fish resulting from the reduced production at the nearby Skykomish Hatchery on the Wallace River (see Appendix B), and compensatory mortality during their freshwater residency.

5.3.4 Down Ramping

When salmon fry emerge from streambed gravel, they tend to seek the quiet, shallow waters near the shoreline. During this period, which generally lasts from late January to early June in the Sultan River, the fry are susceptible to sudden flow changes from the powerhouse. If reduction of flow is too rapid, the young fry can be trapped or stranded in shallow areas along the shoreline. Once stranded, they either die from lack of water or, if caught in shallow depressions, become susceptible to bird predation and elevated temperatures. Repeated flow reductions can cause cumulative mortality.

From 1985 through 1987, the District conducted a series of down ramping tests to assess the potential for fry stranding. This study, performed during 22 down ramp events, consisted of a rigorous inspection by a four-person field crew of the major low-gradient gravel bars in the lower 3 miles of the river immediately following each test ramp. The 2-mile reach between the study area and the powerhouse was not inspected because stranding potential was believed to be minimal there due to the confined banks and high gradient. Stranding tests intentionally were not initiated until large numbers of Chinook salmon fry were observed along the stream margins. Therefore, tests did not begin until March, which was probably near or after the peak date of fry emergence. Consequently, the number of fry observed stranded during the later tests in April and May were not absolutely comparable to the numbers observed under similar test conditions in March. Fry present during the later tests were larger and thus presumably less susceptible to stranding. Also, the numbers of Chinook salmon fry present in the test area were undoubtedly diminishing during the testing period as they emigrated downstream to the Skykomish River. As a consequence of these test conditions, fewer of the smaller stranding-vulnerable fry would have been present during the later tests. Based on the results of that study (Olson 1990), a ramping rate regime was developed and initiated in 1985 with rates varying from 1 to 6 inches per hour depending on season, time of day, and river stage, and with no restriction on the frequency of down ramping events.

In 1989, the District, in consultation with the Joint Agencies, modified the reservoir rule curves to improve flexibility for fish protection and Project operations. Outcomes of this change were reduced flow fluctuations in the Sultan River and more conservative down ramping rates from 6 inches per hour to rates now varying between 1 and 4 inches per hour depending on conditions (see Table 4-2).

An assessment of the effects of down ramping (flow fluctuations) on fish must account for four primary factors: (1) ramping rate; (2) timing; (3) frequency; and (4) amplitude of the flow change. These are discussed below as they relate to potential effects on Chinook salmon in the Sultan River.

5.3.4.1 Ramping Rate

The rate of down ramping was a primary focus of the studies conducted on the Sultan River in 1985 through 1987. Initial springtime tests at 6 inches per hour during the day and 8 inches per hour at night stranded up to 32 Chinook salmon fry (observed) per event in the lower 3 miles of river inspected (Table 5-3). Subsequent daytime tests at 2 inches per hour and 4 inches per hour and nighttime tests at 6 inches per hour greatly reduced the number of stranded Chinook salmon fry observed in the study area. Coho and chum salmon fry were also present in the study area during testing, but they appeared to be less susceptible to gravel bar stranding than Chinook salmon. These test results indicated that daytime rates of 4 inches per hour and nighttime rates of 6 inches per hour were relatively safe for all salmon fry. These rates were initially proposed to the Joint Agencies for Project operations under the most commonly encountered flow conditions during the Chinook salmon fry period. At that time, it was necessary for the Project to ramp up and down frequently to keep the reservoir within the targeted State 3 elevation range, thus prompting the District to seek maximum down ramping rates within acceptable fisheries protection limits. The Joint Agencies, while acknowledging the apparent safety of the 4- and 6-inches per hour rates based on the study results, noted that two of the four tests at 4 inches per hour were conducted late in the season when most of the Chinook salmon fry had left the river or had reached a size at which they were less prone to stranding. Also, the 4-inches per hour tests were conducted at relatively high flows, when presumably fry are at less risk of stranding. Therefore, the Joint Agencies suggested that the Project operate under more conservative rates (2 inches per hour and 4 inches per hour) until additional studies could be conducted to verify the acceptability of the 4- and 6-inches per hour rates. About this time the District, working with the Joint Agencies and the COE, agreed to expand the reservoir State 3, thus reducing the need to down ramp as frequently. Furthermore, the District decided that the costs of conducting additional down ramping tests were not warranted given the reduced need to down ramp at faster rates in order to conserve water and, thus, remain longer within reservoir State 3. Therefore, the District agreed to accept the more conservative rates suggested by the Joint Agencies, and these rates were subsequently included in the FERC approval order (58 FERC 62, 224 March 19, 1992).

In the six springtime tests conducted during daylight hours at the current 2-inches per hour and 4-inches per hour rates, a total of only seven stranded Chinook salmon fry, or about one per down ramp event, was observed (Table 5-3). At these ramp rates and at the current frequency of ramping (see Section 5.3.4.3), the number of Chinook salmon fry stranded during any controlled down ramp event is assumed to be negligible compared to total fry production. The Sultan River probably produces in excess of 120,000 Chinook salmon fry on an average year (250 female spawners x 4,000 eggs per female x 12 percent egg-to-fry survival rate), based on survival estimates in the nearby Skagit and Cedar rivers (Seiler et al. 2003, Seiler et al. 2004).

During the steelhead trout fry period in early summer of 1985, stranding tests were conducted in the lower Sultan River at down ramping rates ranging from 2-inches per hour to 6-inches per hour. Generally, more steelhead trout fry were stranded per test than were Chinook salmon fry in previous tests at similar rates. However, the steelhead tests were conducted at lower stream flow ranges (<610 cfs) compared to the salmon fry tests (most >1,000 cfs) and this probably contributed to the relatively greater number of observed stranded steelhead fry. Also, there may have been more steelhead fry present in the river during testing compared to Chinook salmon fry in the earlier tests.

TABLE 5-3
Chinook Salmon Fry Stranded in Lower 3 Miles of the Sultan River During Down Ramping Tests, 1985–1987[a]

Down Ramp Rate (inches per hour)	Test Date	Tested Flow Range (cfs)	Number Stranded [b]	Number Stranded per Flow Change of 100 cfs [c]	Average Number Stranded per Flow Change of 100 cfs
Daytime Tests					
6	April 4, 1985	1,300-750	17	3.1	4.1
6	April 23, 1985	1,300-750	28	5.1	
4	March 26, 1987	1,460-750	4	0.6	0.15
4	March 27, 1987	1,460-750	0	0	
4	May 23, 1986	1,250-750	0	0	
4	June 3, 1986	1,000-500	0	0	
2	April 27, 1985	670-530	1	0.7	0.65
2	May 11, 1985	600-260	2	0.6	
Nighttime Tests					
8	April 6, 1985	1,300-750	32	5.8	5.8
6	April 25, 1985	1,300-750	1	0.2	0.65
6	May 17, 1985	600-230	4	1.1	

[a] Source: Olson (1990).
[b] Actual count by field observers after completion of down ramp conducted specifically to strand fry.
[c] Stranding data standardized per change in flow of 100 cfs to account for different test flow ranges.

Steelhead fry stranding was greatest at the 6-inches per hour and 4-inches per hour ramping rates and least at the 2-inches per hour rate (Table 5-4). Unlike Chinook salmon fry, which were more susceptible to stranding during the day time, steelhead fry appeared more likely to be stranded at night. These findings lead to the agreement to restrict daytime down ramping rates to 2-inches per hour and nighttime rates to 1-inches per hour for the June 1 through September 15 period (see Table 4-2). The allowable ramp rates become less restrictive in the fall and winter as the steelhead trout juveniles grow and become less susceptible to stranding. Currently, the flow control valves at the powerhouse cannot reliably reduce flows at a rate equivalent to 1-inch per hour stage change when measured at 15-minute intervals. Therefore, down ramping during the steelhead fry period currently is done during the day time when the allowable rate is 2-inches per hour. It should be noted that the 2-inches per hour rate at the powerhouse equates to only a 1- to 1.5-inches per hour stage change in the downstream reaches where stranding potential occurs. This rate attenuation is primarily due to the wider channel morphology in the potential stranding areas compared to the confined channel at the tailrace compliance point. River stage decreases of 1 to 2 inches per hour during non-flood conditions are not uncommon in unregulated western Washington streams (Hunter 1992) and it is reasonable to assume that salmon and trout have adapted to survive such events.

In unregulated streams in western Washington it is not uncommon to observe stage declines of 6 to 10 inches per hour following normal high flow events each year (Hunter 1992). Because salmonid fry tend to inhabit the shallow margins of streams and often seek shelter near vegetation, it is likely that some stranding of fry occurs during these natural events. On the Sultan River high flow events occur only when the reservoir is full and freely passing water over the spillway at Culmback Dam. Downstream stage changes are allowed to occur

TABLE 5-4
Steelhead Trout Fry Stranded in Lower 3 Miles of the Sultan River During Down Ramping Tests in 1985[a]

Down Ramp Rate (inches per hour)	Test Date	Tested Flow Range (cfs)	Number Stranded[b]	Number Stranded per Δ 100 cfs[c]	Average Number Stranded per Δ 100 cfs
			Daytime Tests		
4	June 28	610-360	19	7.6	7.6
3	Aug 1	560-190	3	0.8	0.8
2	July 14	545-195	10	2.9	1.85
2	July 28	570-210	4	0.8	
			Nighttime Tests		
6	July 2	575-285	90	31.0	31.0
4	July 3	610-330	55	19.6	19.6
2	July 9	610-345	37	14.0	10.2
2	July 26	530-170	23	6.4	

[a]Source: Olson (1990).
[b]Actual count by field observers after completion of down ramp conducted specifically to strand fry.
[c]Stranding data standardized per change in flow of 100 cfs to account for different test flow ranges.

naturally per the unregulated inflow to the reservoir. Although the potential for fry stranding during these natural stage changes has not been studied in the Sultan River or elsewhere, the fact that the Project has reduced the frequency of high-flow events would suggest that the probability of naturally-occurring stranding has been reduced in the Sultan River.

5.3.4.2 Timing

The results of the 1985 to 1987 studies, as well as other studies in the region indicate seasonal and diurnal differences in the susceptibility of fry to stranding during down ramp events. The seasonal factor is most likely related to fish size (i.e., growth). Chinook salmon fry in the Sultan River seem to grow out of the high-risk stage when they reach about 50 mm in length, which occurs by late May or early June in the Sultan River (Olson 1990). This led to the springtime down ramp rates for the Project to end on May 31 (followed by more restrictive down ramping rates for steelhead trout fry).

The Project's spring ramping rates beginning on March 1 are primarily for fall Chinook salmon fry. That date corresponds with the time after which most Chinook salmon fry begin emerging from the gravel based on field observations in 1985. However, some emergent Chinook salmon fry have been observed as early as mid-January in other Puget Sound streams. Thus, it is possible that stranding of a few early fry could be occurring when the Project down ramps in January and February at the allowed 4-inches per hour rate. The District is committed to implementing footnote b of Table 4-2 as a means of adjusting the start date for the March 1 to May 31 downramping rates to protect early emerging Chinook salmon fry.

Steelhead trout fry in the lower Sultan River begin emerging from the gravel in early June, and this is the time when they are most susceptible to stranding during stage reductions. Newly-emerged steelhead fry are about 25 to 30 mm long. Their susceptibility to stranding declines as they grow, and no steelhead larger than 40 mm were observed stranded during the Sultan River testing even though many fish of this size were present during several of the tests (Olson 1990). Sampling of steelhead with electrofishing along the stream margins indicated that 94 percent of the juvenile steelhead trout were >40 mm by late August and by early October all were >50 mm. On the basis of these findings, the steelhead trout fry period, when ramping rates are most restrictive, extends from June 1 to September 15.

The other timing factor associated with ramping effects is the diurnal difference in stranding susceptibility. Chinook salmon fry have been shown to be more susceptible to daytime stranding in the Skagit River at down ramping rates exceeding 10 inches per hour (Woodin et al. 1984, R.W. Beck and Associates 1989). This same response was documented in the Sultan River when ramp rates exceeded 6 inches per hour (see Table 5-3). On the basis of these observations, the Joint Agencies at a review meeting on July 4, 2000, suggested that the Licensees explore the alternatives of further reducing the daylight down ramping rate from 2 inches per hour to 1 inches per hour, or avoiding down ramping entirely during daylight hours when Chinook salmon fry are present. However, results of the 1985-1987 studies do not provide support for these alternatives, as discussed below.

When daytime rates were reduced to 4 inches per hour on the Sultan River, Chinook salmon fry stranding was nearly eliminated. A total of only 4 fry were observed stranded during the 4 daytime tests conducted at 4 inches per hour. With the small numbers observed, it would not have been possible to discern a diurnal difference in stranding susceptibility at these rates. Therefore, nighttime tests at rates less than 4 inches per hour were not deemed necessary. To be conservative, however, the final (approved) down ramping rate schedule for the Project restricts daytime ramping to 2 inches per hour during the Chinook salmon fry period. Two tests conducted at 2 inches per hour during the day stranded three Chinook salmon fry. Thus, some minor stranding probably still occurs under these approved ramping rates. With only about 15 scheduled down ramp events occurring during the peak Chinook salmon fry period (see Section 5.3.4.3 below), the total number of fry stranded is clearly small compared to the large number of fry produced from the several hundred adults that spawn in the Sultan River each year.

5.3.4.3 Frequency

The potential for salmonid fry to become stranded exists during any stage reduction event occurring either naturally or controlled. Therefore, the Project's conservative ramping rates cannot prevent all stranding of fry. Although small losses during a single event may be insignificant, repeated down ramping events may produce cumulative losses. The current license for the Project has no restrictions on the frequency of down ramping.

During the 6 years of operation (1984 to 1989) prior to the revised State 3 reservoir rule curve, the Project down ramped (>2 MW/1 hr) 7.7 percent of the operating time during the January 1 to May 31 period, when Chinook fry are present and vulnerable (Table 5-5). The desire to operate within the original State 3 prompted most of these ramping events. Following the expansion of State 3, down ramping frequency was reduced by about half, averaging 3.8 percent of the operating time between 1990 and 2003 (Table 5-5), and ranging from 0.9 percent to 8.9 percent (Appendix E). Most of this annual variability was the result of water conditions but, especially in the higher frequency years (1997 and 1998), it was partly influenced by operator discretion.

TABLE 5-5
Frequency and Magnitude of Hourly Down Ramping, January through May 1985-2003

Operating Condition	Pre-State 3 Expansion 1985-1989		Post-State 3 Expansion 1990-2003	
	Hours	**Percent**	**Hours**	**Percent**
All Flows				
Season Total Time	3,629	100.0	3,633	100.0
Not Operating	319	8.8	117	3.2
Operating	3,310	91.2	3,515	96.8
Up Ramping	426	12.9 [b]	497	14.1 [b]
No Change in MW [a]	2,320	70.1 [b]	2,732	77.7 [b]
Down Ramping > 1 MW/hr	559	16.9 [b]	286	8.1 [b]
Down Ramping > 2 MW/hr [c]	256	7.7 [b]	133	3.8 [b]
Down Ramping > 3 MW/hr	181	5.5 [b]	85	2.4 [b]
Down Ramping > 4 MW/hr	147	4.4 [b]	59	1.7 [b]
Flows Below 750 cfs				
Down Ramping > 2 MW [c]	106	3.2 [b]	48	1.4 [b]
January	26	--	9	--
February	35	--	14	--
March	19	--	11	--
April	16	--	7	--
May	11	--	7	--

[a] Less than 1 MW or 12 cfs.
[b] Percent of total operating hours.
[c] 2 MW/hr = 0.6 to 0.8 inches per hour (average 0.7 inches per hour) stage change at flows between 300 and 750 cfs.

Because fry stranding can occur during any down ramp event, reducing the frequency of down ramping would reduce the risk to fry. Therefore, the potential cumulative effect of multiple down ramping events in the Sultan River clearly has decreased as a result of the reduced frequency of down ramping following the expansion of State 3.

Fry emigration is another biological consideration that may be associated with the frequency as well as amplitude of flow fluctuations. For chinook salmon fry, McPhee and Brusven (1976) found that a 17-fold flow fluctuation caused 60 percent of the chinook salmon fry to leave the experimental stream channel. When the flow fluctuations were reduced to 3-fold, the emigration rate was reduced to 14 percent. The flows used in the experimental channel, however, were very small, ranging from 1.8 cfs to 0.1 cfs, thus raising the question as to whether the emigration was due to the fluctuation or a lack of sufficient rearing space at the lower flows.

In a similar experiment using larger flows and replicate stream channels, Irvine (1986) found that the emigration of recently emerged Chinook salmon fry (average length 35 mm) was increased by fluctuating discharge but only when flows were increasing and when average water velocities exceeded 1.0 fps at the peak discharge within the cycle. Although exposed to flow fluctuations for 6 weeks, the increased emigration occurred in the first two cycles and not during subsequent flow changes. All emigration occurred at night. He also found that fluctuating flows most affected emigration rates from the experimental stream section when fry were tending to migrate anyway, based on observations in the control stream. The conclusion of the study was that flow fluctuations did increase emigration rates for Chinook salmon fry but only during the first 2 or 3 weeks following emergence when fry are tending to disperse naturally and only when water velocities available to the fry exceeded about 1.0 fps.

Whether the amplitude and frequency of artificial flow fluctuations in the Sultan River are great enough to produce unnaturally high rates of fry emigration is unknown. As currently operated, the Project maintains stable flows about 75 percent of the time during the period when emergent salmon fry are present and potentially vulnerable. This stabilization of flow, compared to a natural flow regime, may tend to offset any accelerated emigration that might occur during Project-induced fluctuations.

5.3.4.4 Amplitude

The amplitude of the flow change during a ramping event directly affects the amount of gravel bar area exposed. In addition, a large flow change can increase the number of side channels that would be dewatered. In the case of the Sultan River, flows can be decreased from 1,500 cfs to 165 cfs below the powerhouse, but must be "paused" for 24 hours when flows reach 750 cfs to allow fry to leave several side channels, which begin to dewater at flows below 750 cfs. This "pause" limits the amplitude of flow fluctuations from 1,500 cfs down to 750 cfs, and from 750 cfs down to minimum flow. Because the current amplitude is limited by powerhouse capacity at the high end and adequate minimum flows at the low end, this flow range, especially with the "side channel pause," provides a relatively safe regime when coupled with the current low frequency of ramping.

Another issue associated with ramping amplitude (and to some degree frequency) is spawning interference. Several studies have found that dewatering areas where Chinook salmon are attempting to spawn often causes the fish to move to potentially less desirable locations (Bauersfeld 1978) or to spawn in incomplete redds (Hamilton and Buell 1976).

Other studies have found that dewatering redds for several hours a day still permitted successful spawning at those locations when the flows returned (Stober et al. 1982, Chapman et al. 1986). For the Sultan River, the concern over dewatering Chinook salmon redds and potential redd sites has been addressed via streamflow restrictions during the spawning season. Flows in the lower river are maintained between 200 cfs (minimum flow) and 400 cfs to prevent Chinook salmon from spawning in areas that might subsequently become dewatered, provided that reservoir storage can retain high runoff from fall rains and that tributary inflows downstream from Culmback Dam are not excessive. Thus, the controllable flow and ramping regimes for the Project are not likely to be adversely affecting Chinook salmon spawning success.

5.3.4.5 Down Ramp Compliance

As with minimum flow compliance, the District continuously monitors down ramp rates and reports all variances exceeding the required rates to FERC and the Joint Agencies. Since May 1988, 33 incidents of down ramp variance have been reported (see Appendix D). Most of them were the result of equipment failures that caused immediate generation reductions at the powerhouse.

The effects of rapid down ramp incidents on fish depend on the duration, amplitude of flow change, initial river flow, and the season. Most incidents (25 of 33) lasted less than 15 minutes. While it is reasonable to assume that many small fish find temporary refuge in watered pockets during such incidents, it is possible that some stranding mortality also occurs. Most incidents on the Sultan River, however, occurred when emergent Chinook salmon fry were not present. During the past 12 years, only eight incidents occurred during the January 1 through May 31 peak Chinook salmon fry period (Table 7-5).

Of the eight incidents since 1988 lasting longer than 15 minutes, three involved small stage changes (3.25, 0.31, and 1.68 inches). Of the other five longer-duration events, two were caused by a rapid plant shutdown (January 9, 1996, and May 26, 2000) resulting from intake gate closure at Culmback Dam. For the January 9, 1996 event, few Chinook salmon fry would have been present (emerged) and the 5-hour duration was not long enough to adversely affect incubating salmon eggs given the cool water and air temperatures at that time of year. During the incidents on May 26, 2000 and May 5, 2001, some Chinook and coho salmon fry undoubtedly were still present and vulnerable to the effects of the stage decreases. However, most of the Chinook salmon were probably large enough by these dates to avoid stranding.

The two other longer duration events occurred on August 3, 1999, and July 22, 2000, at which times most Chinook salmon fry would have already left the river, but coho salmon and steelhead trout fry were present. For both events, the powerhouse remained offline for 50 minutes. The August 3, 1999 event was unusual because the powerhouse was operating at maximum discharge, which was unprecedented for August, due to the large volume of water still in the reservoir (1999 was a “wet” year). In each event both powerlines connecting the plant to the Bonneville Power Administration’s Snohomish substation were tripped offline, isolating the powerhouse, apparently due to a miscalibration of the surge

TABLE 5-6
Down Ramp Incidents Occurring During the Chinook Salmon Fry Period (January 1 through May 31, 1988-2003)

Date	Total Stage Decrease (inches)	Initial Flow (cfs)	Final Flow (cfs)	Duration (minutes)
January 3, 1991	14.3	--	--	4
May 1, 1993	10.5	1,527	829	5
February 12, 1995	18.1	1,350	431	5
January 9, 1996	25.6	1,753	358	360
March 20, 1996	1.8	720	640	15
April 14, 1998	2.3	430	354	15
May 26, 2000	28.8	1,600	235	50
May 5, 2001	13.8	767	239	57

protection system. When working properly, the surge protectors should shut down only one of the two powerlines, thus allowing the second line to keep the powerhouse operating. Since the last incident the District has collaborated with BPA to recalibrate the surge protection relays. Also, as a result of consultation with the Joint Agencies, the District has adopted a policy to staff the powerhouse when lightning or high wind storms are forecast for the area. Onsite staff would be able to respond more quickly to put the powerhouse back on line following a forced outage than if the plant were being operated remotely from the District's control center. The policy of staffing the powerhouse under such circumstances will remain in place until a lightning strike or fault on one of the two system lines demonstrates that the recalibrated surge protectors are working properly by isolating only a single line (see Section 6.3).

5.4 Channel Conditions

5.4.1 Gravel (Quality and Quantity)

Gravel quality and quantity are crucial to the reproduction of fall Chinook salmon, as well as other salmonids spawning in the Sultan River. The reduced frequency and amplitude of peak flow events due to Project operations (see Section 5.3.3) can adversely affect spawning gravels over time. This issue has been studied several times on the Sultan River, including pre-Project evaluations and continued monitoring.

Gravel suitable for spawning purposes by anadromous fish is distributed in two different patterns within the river. The lower 3.3 miles of the Sultan River is characterized by an average gradient of approximately 20 feet per mile, and the river in this area consists of a series of pools, riffles and gravel bars. Gravel within and adjacent to the riffles is generally suitable for spawning.

Between RM 3.3 and 9.7, the river is confined within a steep-walled valley and has an average gradient of approximately 70 feet per mile. Gravel suitable for spawning in this reach generally occurs as "patch gravel" located within isolated pockets in the river. The abundance and distribution of the patch gravel is a major limiting factor to spawning activity. The limited distribution of patch gravel deposits between RM 3.3 and 9.7 existed prior to Stage II project operation, and probably prior to Phase I construction of Culmback Dam (Miller et al. 1984).

The sources of gravel supply and recruitment have been identified through aerial and field reconnaissance of the Sultan River upstream from the mouth to Culmback Dam. "Based on the helicopter reconnaissance, it was apparent that the major area of gravel recruitment for the lower Sultan River is located between the diversion dam and Culmback Dam. In particular, the north flank of Blue Mountain was observed to be a major source of sediment, along with the south flanks of the Pilchuck-Sultan Ridge. The major source of bed material for the Sultan River lies in the reach of the valley between RM 1.2 and Culmback Dam" (Miller et al. 1984). Follow-up reconnaissance in that area, as well as other areas downstream, verified the aerial observations, described the material provided by the source area, and estimated the river's capability to transport sediment from sources to downstream fish-spawning habitat areas.

"The fact that only the largest boulders (larger that 256 mm in diameter) remain in landslide areas gives evidence that the Sultan River is very effective in transporting landslide debris downstream." Landslides and the tributary creeks carry the sediment to the Sultan River. Sand, silt, and clay comprise the bulk of the glacial till carried to the Sultan River and transported through the system as suspended load (Miller et al. 1984). The suspended load transport rate for the Sultan River has been estimated to average about 44,000 tons per year (Nelson 1971 and Miller et al. 1984).

Spada Lake currently traps all coarse sediment derived from the uppermost portion of the Sultan River Basin. However, a similar condition has probably existed throughout postglacial times. The 1957 USGS topographic map (scale 1:62,500) indicates that the riverbed within much of the present Spada Lake area had a gentle slope (less than 20 feet per mile) prior to the construction of Culmback Dam. The slope and braided pattern of the pre-Culmback river channel in the Spada Lake area suggest that deposition was occurring in this reach and that relatively little coarse sediment was transported downstream of about RM 17. These factors suggest that the present source of coarse sediment to the lower Sultan River is probably now similar to that for the pre-Culmback conditions. The rate of coarse sediment supply to the river downstream of Culmback may even be higher today than for pre-Culmback conditions, as a result of land surface disturbances caused by road construction and logging operations on the flanks of Blue Mountain and the Pilchuck-Sultan Ridge (Miller et al. 1984).

Based on records of gravel flushing operations at the diversion dam, observations of a gravel flushing event and subsequent measurements and calculations, an estimate was made of annual bedload material available to be transported by the Sultan River. At least 3,000 cubic yards of coarse bedload material are estimated to be transported annually by the Sultan River at the location of the diversion dam. This value is an approximate value, but it provides a useful starting place for evaluating the rate of bedload transport in the study area (Miller et al. 1984).

The bedload volume estimate was corroborated by analysis of previous gravel bar mining (now discontinued) by the City of Sultan just upstream from the mouth of the river. Aerial photographs of the borrow area were examined for the years 1958, 1965, 1969, 1976, 1978, and 1984 to examine the morphology of the gravel bar in the vicinity of the extraction site for evidence of changes potentially related to gravel removal. The aerial photographs do not indicate any significant changes in gravel bar morphology, even after 1974 and 1975, when a relatively large volume of gravel extraction occurred. These data suggest that the Sultan River probably transports at least 3,000 cubic yards (3,900 tons) of coarse sediment annually at the location of the gravel extraction site (Miller et al. 1984).

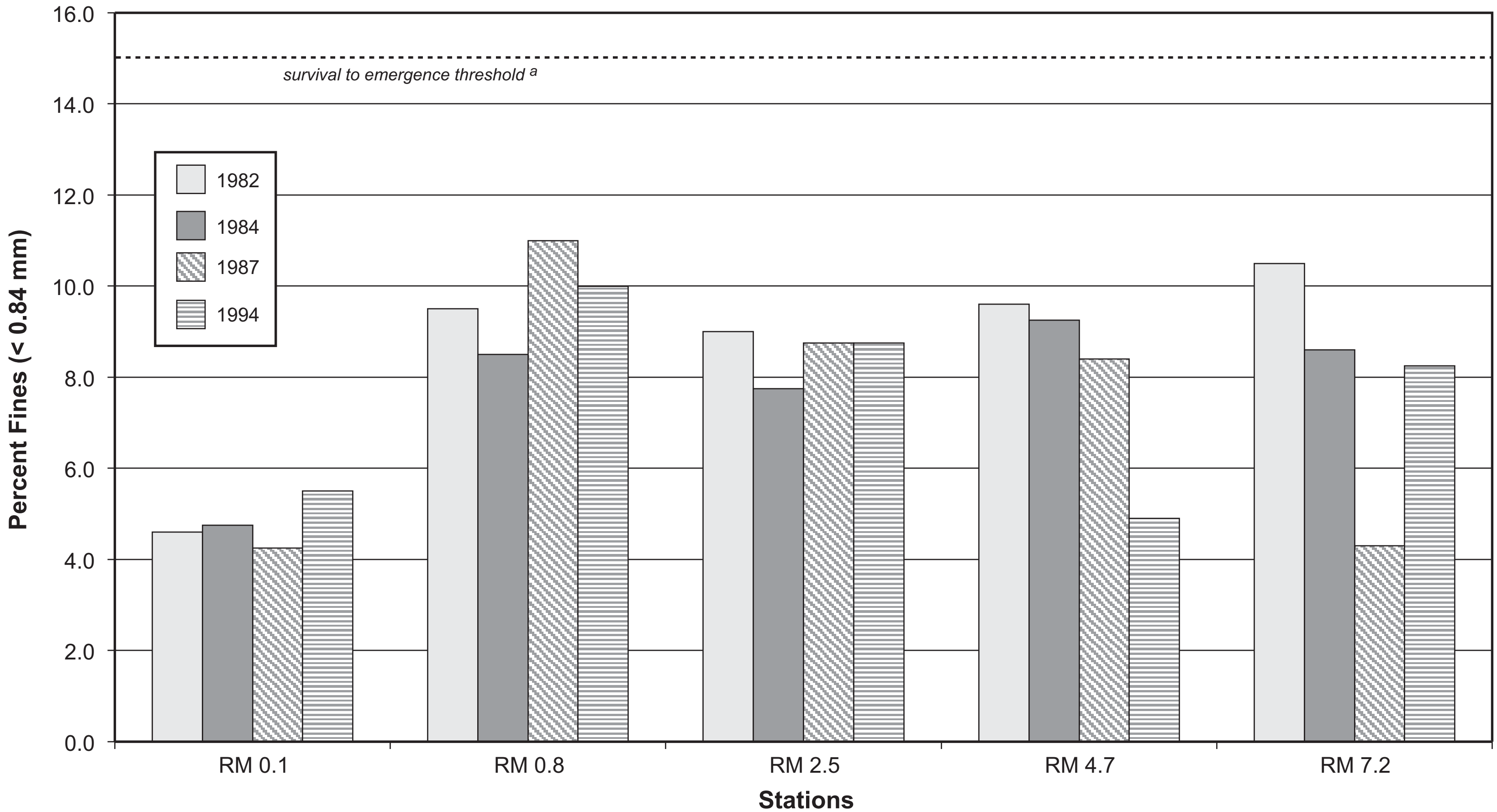
The estimate of the annual flux of Sultan River bedload is based on the evaluation of gravel flushing through the diversion dam as corroborated by the analysis of gravel bar mining by the Town of Sultan. At least 3,000 cubic yards (3,900 tons) of gravel accumulated behind the diversion structure annually under pre-Project conditions, while repeated annual mining of gravel (1968 through 1978) caused no consistent reduction in the size or pattern of gravel bars. This "stable gravel bar pattern confirms the diversion dam analyses and indicates that the lower Sultan River is capable of replenishing 3,000 cubic yards of gravel per year without resulting in significant changes in gravel bar morphology. This value is a lower limit for the quantity of gravel arriving in downstream reaches of the Sultan River. An unmeasured, and probably much greater quantity of coarse sediment, travels through the reach and enters the Skykomish River" (Miller et al. 1984).

Bedload transport in the Snohomish River basin typically ranges between 5 percent and 12 percent of the rate of suspended load transport (Nelson 1971 in Miller et al. 1984). Using this range, Miller et al. (1984) computed the bedload transport rate for the Sultan River to range between 2,200 and 5,300 tons per year, which brackets the bedload transport estimate they developed for the Sultan River. Notably, "bedload transport in the Sultan River occurs only during flood flows. Project operation will reduce the frequency at which floods and bedload transport occur from a period of months for pre-Project conditions to years for project operation" (Miller et al. 1984).

The key common factor for sediment and gravel quality and quantity is the frequency of the "flushing flow." Flushing flow is defined as river flow that is sufficient to disrupt streambed armor and to transport sediment downstream. Flushing flow thresholds for the Sultan River have been estimated at 2,500 cfs at the diversion dam and 4,000 cfs at the powerhouse (Miller et al. 1984). Assuming these flows occur periodically from Culmback Dam downstream, then Sultan River gravel quality and quantity should remain in satisfactory condition for fish production.

To verify the flushing flow threshold values, the District began a monitoring program in 1989 on Sultan River channel-bed scour. Scour detectors were installed at indicator sites above and below the powerhouse that allow the District to document scour depth and sediment deposition related to flows.

A 1994 gravel quality study (Schuh and Meaker 1995) documented that percent fines in the Sultan River remain well below threshold levels known to decrease salmonid survival to emergence (Bjornn and Reiser 1991). No significant trends in gravel quality have been observed since before the Project began operating in 1984 (Figure 5-4). The 1994 tests were conducted after a period of 4 years without a spill event or scouring flows in the Sultan



[a] *Source: Bjornn and Reiser (1991)*

FIGURE 5-4
Average Percent of River Gravel Fines at Five Stations on the Sultan River for Study Years 1982-1994

River. After 16 years of monitoring, it appears that the new frequency and magnitude of high-flow events create sufficient scour and flushing to maintain the high quality of Chinook salmon spawning areas.

Another factor contributing to the maintenance of good spawning gravel quality in the Sultan River may be the increased spawning activity itself. Presumably as a result of improved spawning flows and reduced flood flows, populations of pink and chum salmon in the lower Sultan River have expanded substantially since the Project began operating (Schuh and Metzgar 1994). Recent estimates indicate up to 151,800 pinks have spawned in the lower river, and their spawning distribution appears to be expanding upriver due to overcrowding in the lower river. Chum salmon were rarely observed in the Sultan River prior to the Project. Now several thousand spawn each year in the lower river. Because there is considerable overlap in the spawning substrate requirements for Chinook salmon and the other species, especially chum, it is likely that the high density of spawning helps maintain low levels of fines in spawning areas for all species.

In the gravel monitoring plan, the District agreed to conduct a gravel quality evaluation after a period of 6 years without flushing flows (Schuh and Meaker 1995). If streambed sediment quality were to decline to an unacceptable level, a flow release could be made from Culmback Dam. The timing of the release would occur to replicate historical winter season high flow, as agreed previously with the Joint Agencies. A flushing flow release would be coordinated in advance with the Joint Agencies.

Evidence to date suggests that Project operations are not adversely affecting the quality or quantity of salmonid spawning gravel. However, this is a long-term issue, and changes to streambed conditions may not become evident for several decades. Therefore, monitoring will continue and adaptive mitigation measures (flushing flows) will be used, if necessary.

5.4.2 Riparian Conditions

Riparian conditions along the Sultan River have been undisturbed for over 60 years and are now essentially pristine upstream of RM 4, except in the small areas occupied by the powerhouse and diversion dam. Vegetation in this reach is limited, however, by the steep banks and bedrock surfaces. The reason for this favorable habitat condition is that most of the riparian management zone in this area is in public (State or Federal) ownership. The approved Final Habitat Conservation Plan (DNR 1997, Chapter IV.D) prepared by the Washington Department of Natural Resources for State lands under its jurisdiction has a riparian conservation strategy. Similarly, the U.S. Forest Service has developed aquatic conservation strategies for Mt. Baker- Snoqualmie National Forest lands in the riparian management zone (USFS 1990, FEMAT 1993). The City also owns and manages lands in the riparian zone of the lower Sultan River. Those lands are protected from timber harvest according to the Wildlife Habitat Management Plan (Snohomish PUD 1988) developed in cooperation with resource agencies and Tulalip Tribes; approved by FERC; and incorporated into the Project's Federal license. Additionally, State Forest Practices and local governmental shoreline management regulations apply to the Sultan Basin. Thus, the riparian management zone for 12 RMs (between RM 4 and RM 16) is expected to remain as an unaltered natural process, except as potentially affected by flow regulation.

Along the lower 4 miles of the river the riparian corridor is largely intact and continuous, except for a few areas where the banks have been riprapped to protect a road and a few residential lots from flood waters. Together, these areas represent less than 5 percent of the total streambank in this lower 4-mile reach.

Large woody debris is recruited into the river channel from the riparian zone along the lower 16 miles of river below Culmback Dam. The recruitment rate probably has declined since Culmback Dam was constructed in the early 1960s because of blockage at the dam and reduced bank-scouring flows below the dam. However, the longevity of accumulated woody debris has undoubtedly increased as a result of reduced peak flows. All woody debris that reaches the diversion dam is allowed to pass downstream intact without being cut.

Channel maintenance and riparian encroachment, as potentially influenced by changes in peak flows, have not been formally addressed on the Sultan River. However, aerial photographs taken in 1984 (the first year of Project operation) are available to monitor changes over time. Cursory observations during spawning surveys conducted annually since 1984 indicate no significant changes to the side channels that provide important spawning and rearing habitat. Some vegetation encroachment is apparent on Kien's gravel bar and Kien's Island (near RM 1.5) over the last 15 years, but no obvious changes can be discerned to the wetted channel or the quality of the substrate adjacent to these areas. Both the side and main channels adjacent to these bars remain as some of the most densely spawned areas in the river, especially for Chinook and chum salmon.

5.4.3 Off-Channel Habitat and Connectivity

The creation, maintenance, and flow access to off-channel habitat is a dynamic process that changes over time. It is largely controlled by episodic events, primarily major floods. The fact that the Project has affected the frequency and amplitude of at least the moderate flood events suggest that these habitats may become altered over time. Changes to the riparian dynamics discussed above can also influence the creation of and access to off-channel habitat.

Nearly all off-channel habitat (e.g., side channels and tributaries) in the Sultan River occurs in the lower 3 miles downstream of the Bonneville Power Administration line crossing. From this point upstream to the diversion dam at RM 9.7, the river is largely constrained by steep rock banks. Within the lower 3 RM, 12 side channels and 4 small tributaries were identified during the down ramping studies conducted in 1985 (Olson 1990).

Observations made during November 1999 indicate that there have been no obvious changes to the side channels in the lower river since 1984, except for a small channel on the left bank near the river mouth. Before 1984, the large gravel bar associated with this channel was subject to occasional gravel mining activities. Since this activity has ceased, vegetation growth and gravel accumulation appear to have increased to the point of cutting off flow access to this side channel, except during high-flow events.

Access to the four small tributaries in the lower river does not appear to have been affected by Project operations. However, the lowermost tributary (ephemeral, unnamed, unmapped), which was noted in 1985 to support overwinter coho salmon, was ditched in the early 1990s to accommodate development of a park. This altered the habitat quality and perhaps fish access as well.

Because the dynamics of off-channel habitat is long term, the District will continue to monitor any changes in the lower river. To date, however, no adverse changes attributable to the Project operation have occurred to off-channel habitat or its connection to the main stream channel.

CHAPTER 6

Recent Enhancement Measures

Some aspects of routine Project operations may have the potential to result in adverse effects to individual salmonid fry. Other uncontrolled events potentially could pose a risk of additional adverse impacts. Most of these potential adverse effects are associated with flow reductions at the powerhouse and occasionally at the diversion dam. To further reduce the risks associated with these potential effects, the Licensees have adopted five enhancement measures. Measures specific to bull trout have not been identified because Project operations do not directly affect that species. These enhancement measures have been developed cooperatively with the Joint Agencies during several meetings.

6.1 Down Ramping Rates for Diversion Dam

Down ramping rates were not originally established in the License for Project operations at the diversion dam because flow changes there are not associated with hydropower production. However, decreases in flow occasionally can occur at the dam as a result of required operational activities such as maintenance and changing of minimum flows. Such activities occur only about two to four times a year. Although no stranding incidents have been documented below the diversion dam, the Licensees and Joint Agencies agreed that a protective ramp rate schedule should be established for this stream reach to reduce the probability of future incidents. Therefore, to protect against potential stranding of salmonid fry, the Licensees have adopted down ramping rates for the diversion dam. The rationale for these rates is discussed below.

There is less risk of fry stranding in the upper reaches of the Sultan River than in the reach below the powerhouse because the channel is incised, gradients are steeper, and fewer gravel bars and side channels are present. However, a section of the river above the powerhouse between RM 4.5 and RM 5.7 contains low gradient gravel bars similar to those downstream from the powerhouse. Therefore, for the 5-mile section of river between the diversion dam and powerhouse, the Licensees have applied down ramping rates similar to those in place downstream from the powerhouse, but adjusted for the U.S. Geological Survey (USGS) gage just below the diversion dam for compliance purposes. A correlation between the USGS gage below the powerhouse (RM 4.5, Station 12138160) and the gage at the diversion dam (RM 9.5, Station 12137800) indicates that at flows below 1,000 cfs, changes in stage per unit flow are less by a factor of about 0.65 at the diversion dam gage compared to the powerhouse gage (Appendix F). Therefore, the Licensees have implemented the down ramping rates that currently apply to the powerhouse flow range of "300 cfs to minimum," multiplied by 1.5 (~1/.65) to account for the different stage-discharge relationships at the two gages. These rates are presented in Table 6-1.

TABLE 6-1
Proposed Diversion Dam Down Ramping Rate Schedule[a]

	Jan 1 [b] to May 31		June 1 to Sept. 15 [c]	
	Day	Night	Day	Night
Ramp Rate (inches per hour) [d]	3	3	3	1.5
	Sept. 16 to Oct. 31		Nov. 1 to Dec. 31	
	Day	Night	Day	Night
Ramp Rate (inches per hour)	3	3	6	6

[a]For normal operations in the flow range between 95 cfs (minimum flow) and 1,000 cfs, not during power-generating equipment failures, forced outages, or gravel flushing/enhancement actions requiring manual operation of the sluice gate at the diversion dam.

[b]Chinook salmon fry emergence schedule will be determined yearly in consultation with WDFW.

[c]Avoid any scheduled flow reduction.

[d]Units are in inches per hour as measured at the USGS gage downstream from the diversion dam. Rates are tracked on a 15-minute basis. No single 15-minute down ramping value will exceed one half the hourly value shown in the table. The average of four consecutive 15-minute down ramping rates shall not exceed the hourly rate shown in the table.

6.2 Powerhouse Down Ramp Frequency Limits from First Emergence of Chinook Salmon Fry to May 31

Powerhouse down ramping is a potential source of stranding mortality of Chinook salmon fry from normal Project operations during and shortly after the emergence of the fry from the gravel. Under current license conditions, down ramping rates are restricted, but there are no restrictions on the frequency of regulated-flow down ramping at the powerhouse. Recognizing the potential for stranding of Chinook salmon fry during any down ramp event, and thus the potential for cumulative losses from frequent down ramping, the District has adopted limitations on the frequency of powerhouse down ramping under conditions when fry are most vulnerable to stranding. These conditions include:

- The times when river flows are less than 750 cfs.
- The time between Chinook salmon fry emergence and May 31 of each year.
- When down ramping is being conducted at rates greater than 1 inches per hour (slightly more than 2 MW/hr).

The Licensees have now limited the frequency of down ramping under these conditions to 48 hours during this season (Table 6-2). This limitation equates to approximately 1.4 percent of the typical operating time in this 5-month period (see Table 5-5). The 48-hour limitation is consistent with the average of the reduced frequency of ramping that has occurred at the Project since the revision of the State 3rule curve in Spada Reservoir in 1990 (see Section 5.3.4.3). Although this new 48-hour limitation was exceeded in 5 of the last 14 years of post-State 3 operation (see Appendix E), the Licensees now intend to impose the limitation on all years. Also, for added protection, no more than 16 hours of the seasonally allotted 48 hours are allowed in any one month. The monthly restriction is intended to prevent the over-accumulation of allowable hours and their subsequent use in a single month.

TABLE 6-2
Proposed Down Ramping Frequency Limitations from First Emergence of Chinook Salmon Fry (approximately January 1) through May 31

	Limit on Down Ramp Hours When Down Ramping > 1 inches per hour	
Time Period	**River Flows <750 cfs**	**River Flows >750 cfs**
Season (January through May)	48 hours	No limit
Monthly:		
January	16 hours	No limit
February	16 hours	No limit
March	16 hours	No limit
April	16 hours	No limit
May	16 hours	No limit

Definitions that clarify this down ramp frequency limitation are found in the Glossary provided in Chapter 9 of this document. Powerhouse down ramping frequency during the Chinook salmon fry period will be reported each year in the District's annual operations report, which is submitted to the Joint Agencies and the FERC.

6.3 Staff Powerhouse During Storms

Storm events have the potential to cause emergency shutdowns of the powerhouse. These shutdowns could occur if lightning strikes powerlines, thereby overloading circuits and triggering plant isolation. Tree fall from high winds also can cause isolation of the powerhouse if one of the two electrical lines connecting to the BPA Snohomish Substation is taken out of service. In 16 years of powerhouse operation, only two emergency shutdown incidents have occurred because of storm activity, making the probability of storm-related emergency shutdowns very low. However, the probability for adverse effects on fish from powerhouse outages can be high depending on the time of year, level of fish activity, and amount of generation at risk.

Therefore, during storm events the District shall staff the powerhouse when an emergency shutdown could have detrimental effects on the Sultan River fishery. Specifically, the District shall staff the powerhouse during nonworking hours when all of the following conditions exist during each of the two periods listed below:

- January 1 to July 31 (fry emergence period)
  - Wind gusts are forecast to exceed 40 miles per hour or electrical storms are forecast for the service area.

- One of the two lines connecting the powerhouse to the BPA Snohomish Substation is out of service.

- August 1 to December 31
  - The combined Pelton unit flow is greater than one-third of the Sultan River flow measured below the powerhouse, and
  - Wind gusts are forecast to exceed 40 miles per hour or electrical storms are forecast for the area between the Project and the BPA Snohomish Substation, and
  - One of the two lines connecting the powerhouse to the BPA Snohomish Substation is out of service.

6.4 Woody Debris Management Plan

Large woody debris is important to stream ecosystems because it helps with formation of pool habitat, creates channel complexity, and provides cover for juvenile fish. The presence of Culmback Dam restricts the supply and transport of all woody debris from the upper Sultan Basin to the lower 16 miles of the Sultan River and locations further downstream. Woody debris is still available to the lower Sultan River system from the heavily wooded gorge downstream from Culmback Dam. The volume of material collected at Culmback Dam varies annually and is comprised of mostly small pieces of wood. Currently, all woody debris that impinges on the dam face is collected and stockpiled onsite. will In addition to collecting all woody debris, the Licensees will characterize and sort it by size, and make the large, woody debris component available for placement at locations downstream. A management plan will be developed to address the distribution and placement of any large woody debris from Culmback Dam in the Snohomish Basin, including identification, screening, and prioritization of candidate sites for introduction of large woody debris.

CHAPTER 7

Conclusions

The Jackson Hydroelectric Project, which began generating electric power in 1984, has implemented fisheries mitigation measures developed collaboratively with the Joint Agencies. Some of these measures have been modified over the years based on an adaptive management approach, which has taken into consideration knowledge gained from operating experience, results of new studies, and ongoing monitoring. These mitigation measures have been successful in meeting their objectives based on the results of the Licensees recent assessment. Conclusions regarding the status of fish populations using the Sultan River and the effects of the Project on these species and their habitat are presented below.

7.1 Fisheries Status

7.1.1 Chinook Salmon

From 1978 through 2004, the Sultan River Chinook salmon escapement estimates averaged 496 fish, and ranged from 235 to 937. The Sultan River contribution to the Snohomish basin fall Chinook salmon escapement has increased from 7 percent to 12 percent following flow regulation associated with power generation (first affecting 1986 brood). Because WDFW began phasing out fall Chinook salmon production from the nearby Wallace River Hatchery in 1998, the number of stray hatchery-origin fish contributing to the Sultan River escapement has undoubtedly declined in recent years and should have been eliminated after 2001. The relatively high returns of now all native fall Chinook salmon to the Sultan River in recent years is an encouraging trend for this ESA-listed species.

7.1.2 Pink Salmon

Prior to the Jackson Hydroelectric Project going online in 1984, pink salmon escapement to the Sultan River averaged 3,000 fish per odd-year cycle (1971 through 1983). Post-Project escapement has averaged 51,563 fish per cycle. Pink salmon returning to the Sultan River reached record numbers in 2001, totaling 151,800 fish. In 2003, returns totaled 139,800 fish. As a percentage of the Snohomish system pink salmon escapement, the Sultan River's contribution increased from an average of 2 percent pre-Project to 16 percent post-Project.

7.1.3 Chum Salmon

Occasional spawning surveys conducted prior to the Jackson Hydroelectric Project going online indicated that only a few chum salmon spawned historically in the Sultan River. Larger numbers began using the river in the late 1980's. Since regular surveys began in 1992 chum salmon escapement has averaged approximately 2,500 fish with the greatest yearly abundance of 7,573 fish observed in 2002.

7.1.4 Coho Salmon

The Sultan River provides spawning and rearing habitat for only a limited number of coho salmon. The steep gradient and incised channel in most of the anadromous zone limits the spawning habitat preferred by this species. All but two tributaries have waterfall barriers to upstream migration at their mouths. Historical coho salmon spawning survey data are fragmented; however, annual escapement is believed to be 300 to 500 adults. Coho salmon stocks in the Snohomish River system, which includes the Sultan River, are considered healthy, with record spawning escapements observed in recent years.

7.1.5 Steelhead Trout

Post-Project estimates of native winter steelhead trout spawning in the Sultan River are available for 1987, 1989, and each year since 1993. Estimates for 1987 and 1989 were 250 and 170 spawners, respectively. Estimates since 1993 have ranged from 66 to 574 adult spawners, averaging 259. By comparison, pre-Project estimates, available only for 1979 and 1980, averaged 118 spawners. Steelhead trout escapement trends to the Sultan River since 1993 appear to closely track what is occurring in the Snohomish River system.

7.1.6 Bull Trout

Native char, either bull trout or Dolly Varden, are occasionally observed in the Sultan River downstream of the diversion dam. They are believed to be foraging individuals that move into the Sultan River from the Skykomish River. Elevation of the Sultan River downstream of the diversion dam is much below that which is known to support bull trout reproduction in the Snohomish basin. Extensive snorkeling surveys in 2004 verified that bull trout do not occur in the reach of river between the diversion dam and Culmback Dam.

7.2 Water Quality/Temperature

- All water quality parameters in the Sultan River meet Washington State AA standards. Thus, the Sultan River is not Clean Water Act (CWA) Section 303d designated for any water quality limitation.
- A multi-level outlet structure in the Spada Lake reservoir allows water temperatures to be maintained within the range of pre-Project conditions in the river downstream of the City of Everett’s water supply diversion dam at RM 9.7.
- The existence of the Project reservoir has caused a slight seasonal shift in the water temperature regime in the Sultan River. Average water temperatures during the Chinook salmon egg incubation period have increased about 0.6°C as measured at the diversion dam, and this has accelerated egg incubation and fry emergence time by about 3 weeks in the upper river. Because of the flow regulation provided by the Project during fry emergence, the slightly earlier emergence is not believed to be a problem and may, in fact, benefit Chinook salmon by providing a longer time period for the fry to grow prior to emigration.

7.3 Habitat Access

- Results of a radio-telemetry study, empirical observations, and spawner surveys have shown that the tailrace conditions at the powerhouse do not impede successful upstream fish migration and spawning success.
- The diversion dam at RM 9.7 blocks upstream fish passage to about 6 miles of high gradient stream. During Stage II planning from 1978 to 1981, the Joint Agencies decided to not prescribe fish passage at the diversion dam. They based their decision on the prospect that salmonid production would increase in the lower Sultan River after implementation of the Project's fisheries mitigation plan contained in the Settlement Agreement. Results of spawning surveys and monitoring of gravel quality and temperature have demonstrated the success of these mitigation measures.
- Sustainable runs of anadromous fish did not historically occur in the upper Sultan basin above the present site of Culmback Dam at RM 16 because this area contained several steep cascades and falls up to 10 feet high that blocked upstream fish movement. There is a possibility that steelhead trout had access to the upper basin sometime after the last glaciation period, thus accounting for the presence of resident rainbow trout. Several lines of evidence suggests that bull trout never occurred in the upper basin.

7.4 Streamflow

7.4.1 Instream Flows

- Operation of the Project has generally maintained the pre-Project seasonal pattern of flow in the lower Sultan River. Highest flows occur in the winter, with a secondary peak during the late spring snowmelt period, followed by lower summer flows. Springtime flows have decreased by about 25 percent because of the filling of the reservoir during this period. The stored water is used to augment summer streamflow downstream of the diversion dam and meet municipal water supply needs.
- The minimum flows established in the Settlement Agreement and included in the FERC license provide optimal or near optimal habitat conditions for salmonid spawning downstream of the diversion dam based on results of an instream flow study conducted by the state in 1978.
- Flows in the lower Sultan River during the summer and early fall have been augmented by releases of stored water from the Spada Lake reservoir. Compared to historical natural conditions (measured above the diversion dam), flows in the lower river are now higher during the approximately 100 driest days of the year, and the degree of flow augmentation increases as natural conditions become drier. Coho salmon and steelhead trout, both of which rear in the river during the summer, have likely benefited from the increased base flow. Also, the flow augmentation during otherwise drought conditions in September and October has benefited Chinook and pink salmon spawning.

7.4.2 Peak Flows

- The construction of Culmback Dam reduced the amplitude and frequency of peak flow events in the Sultan River. These changes occurred after Stage I in 1965, again in 1983 when the enlarged reservoir was first filled, and in 1989 when the active storage capacity of the reservoir was increased by agreement with the Joint Agencies. The Joint Agencies accepted the increased reservoir storage capacity because the resulting reduction of peak flows in the winter and spring would potentially benefit salmon by increasing the survival rate of incubating eggs and by reducing the frequency of needed flow changes at the powerhouse. The observed increase in salmon production in the Sultan River, especially for pink and chum salmon, is believed to be primarily due to this reduction of peak flows during the egg incubation period. Because peak flows influence the quantity and quality of spawning gravel over time, the Licensees are continuing to conduct field studies and annual monitoring of gravel quality, as discussed below.

7.4.3 Flow Fluctuations (Ramping)

- Operation of the Project has modified the pattern of short-term flow changes in the Sultan River below the powerhouse. Flows now are generally more stable; however, the rate of flow change can sometimes be more rapid than what would occur under natural conditions. "Ramping" is the term used to describe flow changes made at the powerhouse. If flows are ramped down too rapidly, salmonid fry along the margins of the river can be stranded or isolated from the river. Because the Project is not operated as a power peaking facility, however, flow reductions are neither frequent nor rapid compared to those at most hydroelectric peaking projects. Flow changes at the Jackson powerhouse are driven primarily by changing hydrologic conditions and the need to maintain the level of the Spada Lake reservoir within prescribed elevation limits.

- The potential for powerhouse down ramping to strand salmonid fry was the subject of studies conducted from 1985 to 1987 in the lower Sultan River. Results of these studies were used to establish a conservative down ramping rate regime for powerhouse discharges; this rate varies depending on species present, time of year, time of day, and initial river stage. As is the case during natural declines in flow, the possibility of some fry becoming stranded or entrapped cannot be totally eliminated during Project operations. However, it has been observed that very few fry are now stranded in the river during normal operations. The reduced frequency of flow changes at the powerhouse and the reduction of peak flow events, which typically produce rapid flow changes, have likely decreased the number of fry that would have been stranded naturally under pre-Project conditions.

- The greatest risk of salmonid fry becoming stranded occurs during unintentional events that force the powerhouse to shut down rapidly. The two most common reasons for these events have been equipment failures and lightning storms. Several equipment modifications have been made to address those failures. The Licensees now require that operators be present at the powerhouse during forecasted electrical storms to help prevent outages or to restore flow to the river quickly following such events. To limit the number of lightning strike outages, the Project also contains redundant transmission lines that connect the powerhouse to the Snohomish substation. The system was included in the Project to allow the powerhouse to continue operating in the event of a lightning strike on one of the lines. Until recently, this redundant transmission line system has not worked as successfully as intended. However, with recent equipment upgrades and recalibration, the system is now performing satisfactorily.

7.4.4 Channel and Riparian Conditions

- The reduction in the frequency and magnitude of peak flow events resulting from the operation of Spada Lake as a storage reservoir has altered the downstream channel-forming process. The possibility of long-term changes in spawning gravel quantity and quality in the Sultan River became the subject of studies that were conducted during pre-Stage II planning; these studies led to the requirement for annual monitoring of gravel quality at several locations downstream of the diversion dam and powerhouse. The major sources of gravel supply and recruitment for the Sultan River occur in the canyon reach downstream of Culmback Dam. Historically, the area now inundated by Spada Lake was a low gradient sediment depositional zone and probably contributed little to the recruitment of course sediment to the lower river. Channel-bed scour studies, gravel quality studies, and annual gravel quality monitoring have documented no significant trends in gravel quantity or quality since the hydroelectric facilities began operating 20 years ago. Gravel quality (based on percent fines) for salmonid spawning has remained excellent. If the annual monitoring indicates a decrease in gravel quality, the Licensees are required to pass a high-flow event at Culmback Dam to create sufficient water velocities for streambed scour and gravel flushing.

- Riparian conditions that could be affected by the changes in peak flows have not been formally addressed on the Sultan River. However, examination of aerial photographs taken in 1984 and cursory observations made along the lower river during annual spawning surveys indicate no major changes to side channels or other off-channel habitats important to anadromous fish for spawning and rearing. Vegetation has encroached on some stream bank areas, but no obvious changes have been observed to the adjacent stream channel widths or substrate conditions. The most evident vegetation growth has occurred just above the river mouth on bars that were actively mined for gravel prior to 1980.

- Woody debris occurs in the stream channel at numerous locations along the river. Major sources of wood exist in the canyon areas above the powerhouse. Woody debris that collects at the diversion dam is periodically passed downstream. Until recently, wood collected at Culmback Dam has not been passed downstream.

7.5 New Enhancement Measures

After 20 years of operation, the Jackson Hydroelectric Project appears to have had positive effects on the aquatic resources of the Sultan River as indicated by increased anadromous fish use of the river. This outcome reflects the quality of the original facility design, the success of the Project’s fisheries mitigation plan, and the Licensees’ continued attention to the river’s aquatic resource needs in balance with the needs for power and water supply. In furtherance of this commitment, the Licensees, based on the results of the recent assessment documented in this report and input from the Joint Agencies, have identified several additional measures that would further reduce the risk of the Project adversely affecting the fishery resources. These include:

1) adopting down ramping rates for the occasional flow changes made at the diversion dam,
2) limiting the frequency of down ramping events at the powerhouse when emergent Chinook salmon fry are present,
3) staffing the powerhouse during predicted lightning storm events to facilitate a more rapid response to forced power outages, and
4) developing a woody debris management plan to place wood collected at Culmback Dam downstream or elsewhere in the Snohomish basin for restoration projects.

These measures recently have been implemented by the Licensees with concurrence of the Joint Agencies and FERC.

CHAPTER 8

References

Bauersfeld, K. 1978. The Effect of Daily Flow Fluctuations on Spawning Fall Chinook in the Columbia River. Technical Report. Washington Department of Fisheries, Olympia, WA.

Bjornn, T.C., and D.W. Reiser. 1991. Habitat Requirements of Salmonids in Streams. Amer. Fish. Soc. Special Pub. 19:83-138.

Chapman, D.W., D.E. Weitkamp, T.L. Welsh, M.B. Dell, and T.H. Schadt. 1986. Effects of River Flow on the Distribution of Chinook Salmon Redds. Trans. Amer. Fish Soc. 115:537-547.

DNR. 1997. Final Habitat Conservation Plan. Washington Department of Natural Resources, Olympia, WA.

Easterbrooks, J.A. and R.J. Gerke. 1978. Sultan River Flow Study. Washington Department of Fisheries. Report Prepared for Snohomish County Public Utility District.

Eicher, G.J. 1981. Impact Analysis of Sultan Project Flows on Salmon and Steelhead. Report prepared for Snohomish County Public Utility District.

FEMAT. 1993. Forest Ecosystem Management: An Ecological, Economic and Social Assessment. Report by the Forest Ecosystem Management Assessment Team.

FERC. 1981. Final Environmental Impact Statement. Sultan River Project FERC No. 2157. Washington Division of Public Information, Federal Energy Regulatory Commission, Washington, DC.

FERC. 1993. Hydropower Licensing and Endangered Species. Federal Energy Regulatory Commission.

FWS. 1998. Bull Trout Interim Conservation Guidance. U.S. Fish and Wildlife Service, U.S. Department of Interior, Lacey, WA.

FWS. 1999. Biological Assessment Preparation and Review. U.S. Fish and Wildlife Service.

Gallagher, A. F. 1980. An Analysis of Factors Affecting Brood Year Returns of the Wild Stocks of Puget Sound Chum (*Oncorhynchus keta*) and Pink Salmon (*Oncorhynchus gorbuscha*). M.S. Thesis, U. Washington, Seattle WA. 152 p.

Hamilton, R., and J.W. Buell. 1976. Effects of Modified Hydrology on Campbell River Salmonids. Technical Report Series No. Pac/T-76-20. Canada Department of the Environment, Fisheries and Marine Service. Vancouver, BC.

Haring, D. 2002. Salmonid Habitat Limiting Factors Analysis, Snohomish River Watershed, Water Resource Inventory Area 7. Final Report. Washington State Conservation Commission.

Hunter, M.A. 1992. Hydropower Flow Fluctuations and Salmonids: A Review of the Biological Effects, Mechanical Causes, and Options for Mitigation. Technical Report No. 19. Department of Fisheries, Olympia, WA.

Johnson, R.E. and K.H. Cassidy. 1977. Terrestrial Mammals of Washington State. Location Data and Predicted Distributions. Washington State Gap Analysis Project Final Report, Volume 3.

Koski, K.V. 1966. The Survival of Coho Salmon (*Oncorhynchus kisutch*) from Egg Deposition to Emergence in Three Oregon Coastal Streams. Master's thesis. Oregon State University, Corvallis, OR.

Kraemer, C.R. 1994. Some Observations on the Life History and Behavior of the Native Char Dolly Varden (*Salvelinas malma*) and Bull Trout (*Salvelinus confluentus*) of the North Puget Sound Region. Washington Department of Fish and Wildlife.

Kraemer, C.R. 2000. Compilation of Coho Escapement. Unpublished data. Washington Department of Fish and Wildlife, Olympia, WA.

Lister, D.B., and C.E. Walker. 1966. The Effect of Flow Control on Freshwater Survival of Chum, Coho and Chinook Salmon in the Big Qualicum River. The Canadian Fish Culturist, Issue 37.

Luchessa, S., and M. Wert. 1995. Evaluation of the Textural Composition of Sultan River Salmonid Spawning Gravels Following Hydroelectric Project Construction. FERC Project No. 2157. Public Utility District No. 1 of Snohomish County, Everett, WA.

Mathews, S.B. and F.W. Olson. 1980. Factors Affecting Puget Sound Coho Salmon Runs. Can. J. of Fish and Aquatic Sci., Volume 37: 1373-1378.

McNeil, W.J. 1969. Survival of Pink and Chum Salmon Eggs and Alevins. pp. 101-117. In Symposium on Salmon and Trout in Streams. Northcote, T.G. (ed.). University of British Columbia, Vancouver, BC.

McPhee, C., and M.A. Brusven. 1976. The Effect of River Fluctuations Resulting from Hydroelectric Peaking on Selected Aquatic Invertebrates and Fish. Submitted to the Office of Water Research and Technology, U.S. Department of Interior. Idaho Water Resources Research Institute, University of Idaho, Moscow, ID. (as cited in Hunter 1992.)

Meaker, B., and R. Metzgar. 1990. Simulation Computer Model as a Basis for Revising a Project Operating Plan. Presented at the Transferring Models To Users Symposium, American Water Resources Association. pp. 365-373.

Miller, J.A., M.A. Wert, and T. Dunne. 1984. River Gravel Quantity Study. Henry M. Jackson Hydroelectric Project (Sultan River), Snohomish County, WA. FERC Project No. 2157. Public Utility District No. 1 of Snohomish County, Everett, WA.

Miller, J.W. 1976. The Effects of Minimum and Peak Cedar River Streamflows on Fish Production and Water Supply. Master's thesis. University of Washington, Department of Civil Engineering, Seattle, WA.

Mongillo, P.E. 1993. The Distribution and Status of Bull Trout and Dolly Varden in Washington State, June 1992. Report No. 93-22. Washington Department of Wildlife, Olympia, WA.

National Marine Fisheries Service (NMFS). 2004. Biological Opinion and Incidental Take Statement. Effects of Programs Administered by the Bureau of Indian Affairs Supporting Tribal Salmon Fisheries Management in Puget Sound. NMFS Sustainable Fisheries Division. June 10, 2004. 80 pp.

Neave, F. 1953. Principles Affecting the Size of Pink and Chum Salmon Populations in British Columbia. J. Fish Res. Bd. Canada, 9:450-491.

Nelson, L.M. 1971. Sediment Transport by Streams in the Snohomish River Basin, Washington, October 1967-June 1969; U.S. Geological Survey Open-File Report, Tacoma, WA.

NOAA Fisheries. 1999. A Guide to Biological Assessments *from* Final ESA Section 7 Consultation Handbook. National Oceanic and Atmospheric Administration Fisheries, formerly known as National Marine Fisheries Service. pp. 3-10.

Olson, F.W. 1990. Down Ramping Regime for Power Operations to Minimize Stranding of Salmonid Fry in the Sultan River. FERC Project No. 2157. Public Utility District No. 1 of Snohomish County, Everett, WA.

Peterson, J., J. Dunham, P. Howell, R. Thurow, and S. Bonar. 2002. Protocol for Determining Bull Trout Presence. American Fisheries Society. Bethesda, MD.

Pfeifer, B., et al. 1999. Spada Lake Biological Assessment and Sport Fishery Evaluation. Technical Report No. FPT99-05. Washington Department of Fish and Wildlife, Olympia, WA.

R.W. Beck and Associates. 1989. Skagit River Salmon and Steelhead Stranding Studies. Report prepared for Seattle City Light. 300 pp.

Schadt, T. 1989. Adult Fish Passage (Powerhouse Berm) Study: Final Report. FERC Project No. 2157. Public Utility District No. 1 of Snohomish County, Everett, WA.

Schuh, M., and B. Meaker. 1995. Gravel Quality and Quantity Study: Final Report. FERC Project No. 2157. Public Utility District No. 1 of Snohomish County, Everett, WA.

Schuh, M., and R. Metzgar. 1994. Hydropower Project Fisheries Mitigation: A Success Story. Presented at the poster session of Pacific Salmon and Their Ecosystems, Seattle, WA.

Seiler, D. 2000. 2000 Wild Coho Forecasts for Puget Sound and Washington Coastal Systems. Washington Department of Fish and Wildlife, Olympia, WA.

Seiler, D., G. Volkhardt, and L. Fleischer. 2003. Downstream Migrant Chinook Production Evaluation in the Cedar River and Bear Creek. Washington Department of Fish and Wildlife. Abstract and slides presented at the 2003 greater Lake Washington workshop.

Seiler, D., L. Kishimoto, and S. Neuhauser. 2004. Annual Report, 2003 Skagit River Wild O+ Chinook Production Evaluation. Prepared for Seattle City Light by Washington Department of Fish and Wildlife, Olympia, WA.

Snohomish County Public Utility District No. 1. 1980. Sultan River Project: Evaluation of Instream Flows for the Sultan River from Culmback Dam to the Diversion Dam. Unpublished report.

Snohomish County Public Utility District No. 1. 1988. Wildlife Habitat Management Plan. Henry M. Jackson Hydroelectric Project, FERC No. 2157.

Snohomish County Public Utility District No. 1. 1991. Sultan River Temperature Study for the Period October 1989 – September 1990. Annual Report No. 6. Henry M. Jackson Hydroelectric Project, FERC No. 2157.

Snohomish County Public Utility District No. 1. 2005. Bull Trout Distribution in the Sultan River Watershed.

Stober, Q.J., S.C. Crumley, D.E. Fast, E.S. Killebrew, and R.M. Woodin. 1982. Effects of Hydroelectric Discharge Fluctuation on Salmon and Steelhead in the Skagit River, Washington. Final Report to Seattle City Light. University of Washington, Fish. Res. Inst., Seattle, WA.

USFS. 1990. Land and Resource Management Plan: Mt. Baker-Snoqualmie National Forest. U.S. Forest Service.

USGS. 1978. Water Resources Data for Washington, Water Year 1977. Water-Data Report WA-77-1. U.S. Geological Survey.

WDF, Washington Department of Wildlife, and Western Washington Treaty Indian Tribes. 1993. 1992 Salmon and Steelhead Stock Inventory. Washington Department of Fisheries, Olympia, WA.

WDFW. 1998. 1998 Washington Salmonid Stock Inventory: Bull Trout and Dolly Varden Appendix. Washington Department of Fish and Wildlife, Olympia, WA.

WDFW. 1999a. Management Brief: Evaluation of the 20-inch Minimum Size Limit for Native Char of the North Puget Sound Rivers. (Submitted by Curt Kraemer, WDFW District Fish Biologist.)

WDFW. 1999b. Bull Trout in the Snohomish River System. Washington Department of Fish and Wildlife, Olympia, WA.

WDG. 1982. Sultan River Project, Stage II Fish and Wildlife Studies, Final Report. Washington Department of Game (now Washington Department of Fish and Wildlife), Olympia, WA.

Wert, M.A, and T. Brock Stables. 1988. Evaluation of the Textural Composition of Sultan River Salmonid Spawning Gravels Following Hydroelectric Project Construction. FERC Project No. 2157. Public Utility District No. 1 of Snohomish County, Everett, WA.

Wert, M.A. 1984. Evaluation of the Textural Composition of Sultan River Salmonid Spawning Gravels Following Hydroelectric Project Construction. Public Utility No. 1 of Snohomish County, Everett, WA.

Wert, M.A., C.R. Steward, III, and F. Winchell. 1982. Baseline Evaluation of the Textural Composition of Sultan River Salmonid Spawning Gravels. FERC Project No. 2157. Public Utility District No. 1 of Snohomish County, Everett, WA.

Wert, M.A., C.R. Steward, III, and F. Winchell. 1984. Evaluation of the Textural Composition of Sultan River Salmonid Spawning Gravels Following Hydroelectric Project Construction. FERC Project No. 2157. Public Utility District No. 1 of Snohomish County, Everett, WA.

Wicket, W.P. 1962. Environmental Variability and Reproduction Potentials of Pink Salmon in British Columbia. pp. 73-86. In: Symposium on Pink Salmon. Wilimonsky, N.J. (ed.). University of British Columbia, Vancouver, BC.

Woodin, R.M., S.C. Crumbley, Q.J. Stober, G. Engman. 1984. Skagit River Interim Agreement Studies. Volume II. Salmon and Steelhead Studies. Draft Report for City of Seattle, Department of Lighting, Office of Environmental Affairs, Seattle, WA. University of Washington, School of Fisheries, Seattle, WA.

Zillges, G. 1977. Methodology for Determining Puget Sound Coho Escapement Goals, Escapement Estimates, 1977 Pre-Season Run Size Prediction and In-Season Run Assessment. Tech. Rep. No. 28. Washington Department of Fisheries.

CHAPTER 9

Glossary

Down Ramping—Project activities causing decreases in river flow and associated river stage (water surface elevations). For purposes of this assessment, powerhouse down ramping is defined as a decrease in combined Pelton Unit generation, resulting in an hourly change in river stage greater than 1 inch. This level of change in stage typically occurs when generation is reduced at a rate of at least 2 MW per hour, though the rate can be somewhat variable depending on river flow.

Fry Emergence Period (Chinook salmon)—Each year from the time of first emergence until May 31. The date of first emergence will be estimated each year by WDFW fisheries biologists in cooperation with the District fisheries biologist. The estimate of first emergence each year will be based on the timing of Chinook salmon spawning and application of subsequent water temperature unit calculations, as currently accepted and used by NOAA Fisheries and the Washington Department of Fish and Wildlife.

Powerhouse Down Ramping Event (for the purpose of calculating down ramping frequency)—A decrease in combined Pelton Unit generation greater than 3 MW during any 24-hour period in the flow range 1500 cfs to 165 cfs. Three megawatts on the Pelton units constitutes a river flow change of approximately 36 cfs and equates to about 0.48-inch change in river stage at the powerhouse when river flows are 1500 cfs, and about 1.68 inches when river flows are 165 cfs.

Project Operation—All activities directly associated with the Project's power production.

APPENDIX A

Selected License Articles and Settlement Agreement

Preface

This license document is a compilation of findings and orders of the Federal Energy Regulatory Commission and its predecessor the Federal Power Commission, which pertain to project 2157. Each paragraph is followed by a date(s) in parentheses which designates the date of the order which has created or altered the language. In some cases a string of dates indicate the evolving nature of that particular license component by separate regulatory or administrative action.

Revision dates for each page are shown in the lower right hand corner.

The Henry M. Jackson Hydroelectric Project, formerly called the Sultan River Project, was issued major license No. 2157 by the Federal Power Commission on June 6, 1961. This license expires 50 years from its effective date, June 1, 2011.

Bruce F. Meaker
Senior Manager
Regulatory Affairs

Article 53 Fish and Wildlife Mitigation Plan (Exhibit S)

Licensee shall consult with the Washington Departments of Fisheries, Game, and Ecology, the Tulalip Tribes, the U.S. Forest Service, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service and, prior to initiation of project construction, file for Commission approval a plan to mitigate effects of construction on aquatic and terrestrial resources. Licensee shall further consult with the above listed agencies, and within one (1) year following the date of issuance of this order, file for Commission approval a revised Exhibit S that contains an overall an overall fish and wildlife mitigation and enhancement plan for construction and operation of the Sultan River Project.
(10/16/81)

(A) The aquatic resources mitigative plan described on pages 6-7 through 6-22 of the revised Exhibit S, filed on February 9, 1983 is approved.
(08/22/84)

(B) Licensee shall, after consultation with the Washington Department of Game, the U.S. Fish and Wildlife Service, the U.S. Forest Service, and the Tulalip Tribes, file for Commission approval, within 24 months of the date of this order, a revised terrestrial resources mitigative plan to protect and enhance terrestrial resources in the Henry M. Jackson Project area. The plan shall include, but not be limited to: (1) identification of the type of habitat to be used for replacement; (2) a determination of the location and number of acres of habitat to be used for replacement; (3) a schedule of implementation; and (4) a monitoring program to determine the effectiveness of the mitigative measures. Documentation of agency consultation on the mitigative plan, the agency comments on the adequacy of the plan, shall be included in the filing.
(08/22/84)(09/30/85)(12/17/85)

The revised wildlife habitat management plan filed on May 25, 1988, as modified by paragraph (B), is approved.
(05/19/89)

(B) The licensees shall file with the Commission their annual reports on Phase I and their 5-year progress reports on Phase II of the revised wildlife habitat management plan. Each report shall contain the information listed in section 4.11.4 of the revised wildlife management plan filed on May 25, 1988, and shall contain comments from the U.S. Forest Service, U.S. Fish and Wildlife Service, the Washington Department of Wildlife, and the Tulalip Tribes. A progress report shall be filed yearly by April 30 from 1991 through 1996, and at 5-year intervals beginning in the year 2001 (i.e. 2006, 2011, etc.). The Commission reserves the right to require modifications to the plan and the reporting requirements.
(05/19/89) (06/27/90) (2/9/96)

(A) The final 1995 Annual Report for the Henry M. Jackson Project Wildlife Habitat Management Program, filed pursuant to Ordering Paragraph (B) of the Order Approving with Modification Revised Wildlife Habitat Plan, issued May 19, 1989 and amended February 9, 1996, is approved.
(9/27/96)

(B) Annual reports for the Henry M. Jackson Hydroelectric Project Wildlife Habitat Management Program shall be filed with the Commission by April 30, 1997 and 1998. Each report shall contain information listed in section 4.11.4 of the revised wildlife management plan filed on May 25, 1988, and shall contain comments from the U.S. Forest Service, the U.S. Fish and Wildlife Service, the Washington Department of Fish and Wildlife, and the Tulalip Tribes.
(9/27/96)

(A) The wildlife habitat management plan supplement for the Spada Lake Tract, filed on February 3, 1997, is approved.
(4/18/97)

Article 54 Minimum Flow Releases at Culmback and Diversion Dams

Licensee shall consult and cooperate with the Washington Department of Fisheries and Game, the Tulalip Tribes, the National Marine Fisheries Service, and the U.S. Fish and Wildlife Service to determine the minimum flow release needed at the Culmback Dam and at the discharge point of the fish water return line to ensure protection and enhancement of fishery and wildlife resources. Further, Licensee shall, within 6 months from the date of issuance of this order, file a report on the results of the agency consultations, with copies to all the aforementioned agencies, and, for Commission approval, recommendations for minimum flow releases from the project, to include but not limited to, information used to formulate the recommendations, and copies of agency comments on the minimum flow recommendations.
(10/16/81)

Article 55 Powerhouse Fish Passage and Ramping Rates

Licensee shall consult and cooperate with the Washington Department of Fisheries and Game, the Tulalip Tribes, the National Marine Fisheries Service, and the U.S. Fish and Wildlife service in developing and implementing a study to determine the effects of powerhouse discharge and flow fluctuations on migration, spawning, and rearing of resident and anadromous trout and salmon populations; and on the steelhead sport fishery in the Sultan River. This study shall include an evaluation of the proposed fish berm and associated powerhouse tailrace structures, and evaluation of proposed maximum changes in flow rates (ramping rates) below the powerhouse. ~~Licensees, by June 1, 1990, after completion of mitigation studies for the aquatic resources of the Sultan River, shall file a final report and, for Commission approval, recommendations for further measures needed, if any, to protect aquatic resources of the Sultan River. The licensees shall file with the Commission annual reports on the status of the studies beginning June 1, 1987, including comments from the Washington Departments of Game and Fisheries, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and Tulalip Tribes.~~
(10/16/81)(03/17/87)

(A) The deadline for filing the final report on the aquatic fish mitigation studies according to Article 55 is extended to June 30, 1994. The licensee shall continue to file annual reports on the status

of the studies, the next report shall be due June 30, 1991, including comments from the Washington Department of Wildlife and Fisheries, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the Tulalip Tribes.
(12/06/90)

(A) The (Adult Fish Passage) mitigative plan developed jointly by the licensee and the Joint Agencies included in the final report filed on July 25, 1990, and supplemented on December 10, 1990, is approved.
(03/27/91)

(A) The downramping rates described in Table 1 of the study results filed on October 26, 1990, are approved. These downramping rates may be temporarily modified if required by operating emergencies beyond the control of the licensees, and for short periods of time upon mutual agreement between the licensees and the Washington Department of Fisheries.

(B) The Commission reserves the right to modify the ramping rates if necessary to protect Salmonid fry from excessive stranding. (10/08/91)

(A) The deadline to file the final aquatic resources mitigation report as required by license Article 55 is extended to June 30, 1995. (7/29/94)

(A) The deadline to file the two final aquatic resource reports required by article 55 is extended to September 30, 1995. (8/31/95)

DISCUSSION

B. Article 55 Proposals

The licensees' final report addresses those items required by article 55 and the SA (Settlement Agreement). The licensees indicate that monitoring compliance with the established ramping rates will continue as required by the license. Further, the licensees state that annual spawning surveys will continue to be conducted in cooperation with WDFW.

The five access sites to improve steelhead fishability, located upstream and downstream of the powerhouse, were approved as part of the licensees' recreation plan. [9/] This improved public access, combined with providing information to the Steelheader's Hotline and modifying operations during the winter steelhead fishing season, as proposed in the final operating plan, should enhance recreational fishing at the project.

The final report on gravel quantity and quality, in general, indicated textural composition of sediment was similar throughout the 10-year study period. However, the licensees plan to continue to monitor gravel quantity and quality to determine if flow and modifications due to project operations result in the degradation of streambed habitat downstream of the project and to evaluate when modifications to project operations may be necessary. The licensees plan to evaluate the scour monitors annually. Further, the licensees plan to monitor gravel quality after six years (or less, if events occur that may alter streambed quality, as recommended by FWS)
without a flushing flow. These additional measures, along with continued consultation with the agencies, should allow the licensees to adequately evaluate streambed quality in the project area.

The licensees' proposals for continued monitoring, as required by article 55, should be approved. (7/23/96)

The Director orders:

(C) The licensees' proposed recommendations for continued monitoring, filed on September 29 (final report on Steelhead Fishability) and October 2 (final report on Aquatic Resources Studies) and 5 (final report on Sultan River Gravel Studies), 1995 are approved. (7/23/96)

[9/] See Order Approving Revised Recreational Use Plan with Modification, issued December 5, 1994 (69 FERC ¶ 62,188).

Article 56 Flow Release and Water Temperature Studies

Licensee shall, in consultation and cooperation with the Washington Department of Fisheries and Game, the Tulalip Tribes, the National Marine Fisheries Service, and U.S. Fish and Wildlife Service, prepare mutually satisfactory plans and implementation schedules for pre and post-operational studies to determine the effect of the flow releases to be recommended in Article 54 and the effects of river temperature changes on the trout and salmon populations in the Sultan River between the Diversion Dam and the confluence with the Skykomish River. Within one (1) year from the date of issuance of this order, the Licensee shall file the study plans with the Commission for approval, with copies of the plans to the agencies consulted. The Licensee shall conduct the studies as approved by the Commission and submit progress reports annually to the Commission and agencies consulted. Within 90 days after completing the studies, Licensee shall file for Commission approval, with copies to the agencies consulted, its recommendations for changes in project operations or facilities including flow releases, that are necessary to ensure maintenance and protection of the fishery resources in the Sultan River between the Diversion Dam and the Skykomish River.
(10/16/81)

Article 57 Reservoir Operating Plan (Flood Control)

Exhibit H, Section 3 of the Licensees' Application for Amended License is adopted as the interim reservoir operating plan, except: (1)this approval does not constitute priority determination of water rights existing under State law or claimed under treaty or other Federal law; (2) the five operating criteria priorities shown on page H-17 are not included as part of the reservoir operating plan and are expressly excluded from the above reference to Exhibit H, Section 3; (3) nothing in this order of license shall be deemed to modify terms or conditions of the Joint Agency Settlement Agreement as approved by Commission orders of February 9 and April 13, 1983, and in the event of any conflict between the terms and conditions of said Joint Agency Settlement Agreement and/or orders and the approved reservoir operating plan, the terms and conditions of said Joint Agency Settlement Agreement and/or orders shall control; (4) no power shall be generated from the Pelton turbines when the reservoir level is at or below elevation 1,380 feet msl; (5) only flood storage that occurs strictly incidental to water releases through the power tunnel for power generation, Everett water supply, or fishery flows is permitted under this order; and (6) without limiting the generality of the foregoing, no water releases shall be made through the Howell-Bunger valve for flood control purposes, unless required by operating emergencies beyond the control of the Licensees.
(10/16/81)(08/10/83)(08/17/83)(08/15/84)(03/19/92)

(A) The licensees' proposed revised reservoir operating plan (ROP), filed on April 16, 1990, as modified in paragraphs B through B, is approved.

(B) The four operating criteria priorities proposed by the licensees in the April 16, 1990, filing, are not included as part of the revised ROP. (03/19/92)

(A) The deadline to file the final Interim Operating Plan required by license Article 57 is extended to March 31, 1996. (1/25/96)

DISCUSSION

A. Proposed Final Operating Plan

The licensees' proposed final operating plan reiterates specific operating provisions, i.e., ramping rates and minimum flows, that have been established in previous Commission orders and is comparable to the approved revised ROP. The licensees propose to retain the same rule curves and continue to operate the project as it has been operated in the past five years. The licensees' continued control of flow releases during the fall salmon spawning and steelhead fishing seasons should further protect fishery resources and enhance recreational fishing.
The licensees agree to provide for real-time data retrieval at the powerhouse gage by including this gage on the GOES system, as recommended by the Tribes and WDFW. This should provide the agencies and Tribes easier access to flow records at this location. Further, the agreed upon evaluation of downramping criteria at the diversion dam should provide the licensees, agencies, and Tribes with additional information to be used to further protect the fishery resources of the Sultan River.

The proposed final operating plan includes operating criteria in order of priority which establishes a co-priority between instream flow requirements and the City of Everett's water supply demand. The WDFW and the Tribes recommend that instream flow requirements have first priority.

Similar operating criteria were proposed by the licensees in the interim and revised ROPs filed with the Commission. Upon Commission approval of these plans, the prioritized operating criteria were excluded from the interim ROP and from the revised ROP. [7/] As discussed in the Order Approving and Modifying Revised Reservoir Operating Plan, issued on March 19, 1992, if conflicts on the use of water releases at the project occur in the future, the licensees, agencies, and the Tribes may petition the Commission for an amendment of the minimum flow requirements. Therefore, the licensees' proposed prioritized operating criteria need not be approved.

The licensees' proposed plan includes a schedule for submitting the annual reports on water temperature to the agencies and the Commission, as required by the SA. Submitting these reports to the agencies provides the agencies an opportunity to review the effects of project operation on water temperature. Therefore, the licensees should continue to submit annual reports to the agencies and Tribes.

In the past, the licensees provided a number of annual water temperature reports to the Commission. [8/] These reports indicated that, in general, water temperatures are maintained within the historical range, to the extent practicable. The licensees attempt to control water temperatures at the project by using the movable panels on the selective withdrawal structure at Culmback dam. Temperature control is only possible when the reservoir is thermally stratified. Given the licensees have demonstrated that, in general, water temperatures are maintained within the accepted range, continuing to provide annual reports to the Commission is not necessary.

The licensees' proposed final ROP, with the modifications discussed, should be approved. (7/23/96)

B. Article 55 Proposals

7/ See ordering paragraph (c) of the August 15, 1984 order (28 FERC ¶62,215) and ordering paragraph (B) of the March 19, 1992 Order.

8/ For example, see the Sultan River Temperature Study Annual Reports Nos. 9 and 10, filed with the Commission on May 23, 1994, and May 30, 1995, respectively.

The licensees' final report addresses those items required by article 55 and the SA. The licensees indicate that monitoring compliance with the established ramping rates will continue as required by the license. Further, the licensees state that annual spawning surveys will continue to be conducted in cooperation with WDFW.

The five access sites to improve steelhead fishability, located upstream and downstream of the powerhouse, were approved as part of the licensees' recreation plan. [9/] This improved public access, combined with providing information to the Steelheader's Hotline and modifying operations during the winter steelhead fishing season, as proposed in the final operating plan, should enhance recreational fishing at the project.

The final report on gravel quantity and quality, in general, indicated textural composition of sediment was similar throughout the 10-year study period. However, the licensees plan to continue to monitor gravel quantity and quality to determine if flow and modifications due to project operations result in the degradation of streambed habitat downstream of the project and to evaluate when modifications to project operations may be necessary. The licensees plan to evaluate the scour monitors annually. Further, the licensees plan to monitor gravel quality after six years (or less, if events occur that may alter streambed quality, as recommended by FWS) without a flushing flow. These additional measures, along with continued consultation with the agencies, should allow the licensees to adequately evaluate streambed quality in the project area.

The licensees' proposals for continued monitoring, as required by article 55, should be approved. (7/23/96)

The Director orders:

(A) The licensees' final operating plan, filed on April 30, 1996, as modified in paragraph (B), is approved. (7/23/96)

(B) The operating criteria priorities included in the April 30, 1996 filing are not included as part of the final operating plan. (7/23/96)

Article 60 Conservation and Development of Fish & Wildlife Resources

The Licensee shall, for the conservation and development of fish and wildlife resources, construct, maintain, and operate, or arrange for the construction, maintenance and operation of such reasonable facilities, and comply with such reasonable modifications of the project structures and operations as may be ordered by the Commission upon its own motion or upon the recommendation of the Secretary of the Interior or the fish and wildlife agency or agencies of any State which the project or a part thereof is located after notice and opportunity for hearing.
(10/16/81)

[9/] See Order Approving Revised Recreational Use Plan with Modification, issued December 5, 1994 (69 FERC ¶ 62,188).

Appendix B **Uncontested Offer of Settlement**
(02/09/83)

1. Upon application for amended license for Project No. 2157 by the District and City (hereinafter Licensee) the following state and federal agencies and tribal entity, intervened to raise issues concerning protection mitigation and enhancement of Sultan River Aquatic resources: U.S. Department of Interior, National Marine Fisheries Service, Washington Departments of Fisheries and Game, and the Tulalip Tribes of Washington (hereinafter called Joint Agencies). Licensee and Joint Agencies thereafter engaged in continuous discussions to resolve identified conflicts between said project and Sultan River aquatic resources. Licensees and Tulalip Tribes engaged in separate discussions regarding project impacts on Treaty of Point Elliott fishing rights.

2. By Order dated October 16, 1981, the Commission issued a final order amending the license for the Sultan River Project No. 2157 finding that the project as modified by the terms and conditions of the license would be best adapted to the comprehensive development of a waterway and that issuance of the amendments to the existing license would be in the public interest. Pursuant to the Federal Power Act Sections 10(a), 10(g), 308 and 309, and Commission Rules of Practice and Procedure at 18 CFR Part 1, the Commission ordered a hearing to determine what measures, if any, as discussed in its Order should be included in the license to protect or enhance the fishery of the Sultan River, such as, fish passage facilities, hatcheries, flow releases, and other operational constraints. The order further provided that a prehearing conference would be conducted on November 17, 1981 at the Commission's offices in Washington, D.C.

3. On November 17, 1981, a prehearing conference was conducted before Presiding Administration Law Judge, George P. Lewnes, who, after completion of arguments and submissions pursuant to 18 CFR ¶1.18(b), set the matter for hearing. The proceedings were continued following indications by the Licensee and Joint Agencies that the parties had obtained a settlement in principle of the matters in controversy.

4. After November 18, 1981, the parties continued with meetings and negotiations to resolve issues raised by the Joint Agencies in the various motions to intervene; in the tribes' subsequent Motion for Hearing dated July 17, 1981, and their Supplement to Application for Rehearing; in the Application for Rehearing by National Marine Fisheries Service dated November 12, 1981; in the Commission's Order amending License and Providing for a Hearing dated October 16, 1981; and in the Commission's Final Environmental Impact Statement (FERC EIS 0015), Sultan River Project--Washington, March, 1981). As a result of these meetings and negotiations, the parties have reached Agreement as further enumerated below; and in the case of Licensee and the Tulalip Tribes, an additional Settlement Agreement has been executed simultaneously herewith, the continued effectiveness of which, and the approval and implementation of which by FERC are conditions of the effectiveness of the Tulalip Tribes' approval of this agreement.

5. Provisions of this agreement respecting settlement between Licensee and the Tulalip Tribes shall not constitute approval of or precedent regarding any principle or issue relating to treaty fishing rights by, or be binding upon, other parties to this agreement.

6. Terms and conditions herein contained, and in the case of Licensee and the Tulalip Tribes as contained in said additional Settlement Agreement between said parties, fulfill the terms and conditions of the Order Amending License for Project 2157, dated October 16, 1981. Terms and

conditions herein contained shall be made part of, included in, and be deemed conditions of said Order. In the event that FERC shall at some future time order project modifications which affect this Agreement, Joint Agencies reserve their rights to object so said modifications.

AGREEMENTS

1. Environmental Monitoring Supervisor

Licensee shall retain the services of the qualified individual who shall function as Environmental Monitoring Supervisor (EMS) in consultation with the joint agencies. The EMS shall monitor all construction activity for compliance with mitigation plans, permit conditions and contract specifications related to environmental protection and pollution control.

The EMS shall work jointly with a Water Quality Control Supervisor (WQCS) to monitor all construction activities in and around waterways and wetlands, including clearing, stream diversions, excavation, stream bed restoration, stream bank protection and revegetation. If the EMS identifies a problem adversely affecting fish and wildlife or their habitat, the EMS shall formulate recommendations for field construction managers regarding construction methods, corrective actions and sequences of work. The EMS shall maintain a log of problems and their disposition, recommendations and their disposition, and shall maintain liaison with joint agencies. The EMS log shall be updated for each day of work; shall be maintained at the Licensee's business office in Everett, Washington; and shall be available for inspection and copying by each of the joint agencies.

Licensee shall comply with mitigation plans, permit conditions, contract specifications and take appropriate corrective action in the shortest possible time after a problem is identified. In the event that EMS recommendations are not implemented, each of the joint agencies shall have the right to seek appropriate relief from Licensee shall hold periodic meetings with its field construction managers, monitoring supervisors and representatives from each of the joint agencies to review the status of construction activities.

The authority and responsibility of the EMS is supplemental to, and does not supplant requirements established in accordance with state hydraulics HPA and other permits or Tribal rights.

2. In-Stream minimum Flow Schedule

In compliance with the provisions of Article 54 of the Amended License, the Joint Agencies and licensee mutually agree that the Licensee shall provide for and maintain the following minimum flow releases to protect, mitigate, and in some instances enhance fishery resources.

Dates	Point of Discharge	Minimum Fishery Flow (CFS)
All Year	Culmback Dam	20
11/1 - 1/15	Diversion Dam	95
1/16 - 2/28	Diversion Dam	150
3/1 - 6/15	Diversion Dam	175
6/16 - 9/14	Diversion Dam	95
9/15 - 9/21	Diversion Dam	145
9/22 - 10/31	Diversion Dam	155
6/16 - 9/14	Powerhouse	165

9/15 - 6/15	Powerhouse	200

3. Pre and Post Project Construction Studies

In compliance with provisions of Articles 55, 56, and 60, the Licensee shall consult and cooperate with the Joint Agencies for the purpose on jointly developing, implementing and analyzing studies of project operation of fishery resources of the Sultan River as set forth below. If said parties cannot agree upon the study methods and parameters to be used for each study, the Licensee and any of the joint agencies may submit their proposed study plan to FERC which shall determine the study to be conducted. In turn, the studies will be used to develop remedial actions or recommendations for the benefit of fishery resources.

Licensee shall file detailed study plans for Commission approval within six (6) months prior to operation of the project, except as may be otherwise noted. Further, Licensee shall conduct the studies within time frames set forth below and to consult and cooperate with the joint agencies to determine any appropriate remedial actions. Such determinations shall be included in final reports to be filed for Commission approval no later than six (6) months after completion of the respective studies. Such final reports shall include comments and recommendations from each joint agency designed to mitigate project impacts upon fishery resources identified by studies.

Licensee shall implement jointly determined and joint agencies' remedial actions and recommendations within six (6) months after submission of each final report subject to approval or modification by FERC. If the joint agencies are unable to agree on joint recommendations Licensee and joint agencies shall submit their respective recommendations to FERC and the Licensee shall implement the recommendation adopted by FERC within six months. *(See letter of 3/11/82).

Licensee shall develop, conduct, and analyze the following studies:

a. Steelhead Fishability: A study to assess whether the recreational steelhead fishery effect and catch in the Sultan River below the powerhouse is adversely impaired as the result of project operations.

Such study shall be conducted during the winter season following initial project operation and may require an additional year of study upon demonstration of good cause for such extension.

If study results indicate that a significant reduction of the steelhead fishery is caused by project operation, then Licensee agrees to develop appropriate remedial or mitigative measures which may include but shall not be limited to additional fishing access, additional planting of steelhead smolts or reduced operation during weekend daylight hours.

b. Studies to Determine Short Term and Long Term Impacts of Sedimentation, Gravel Compaction and Spawning Gravel Reduction in the Sultan River Due to Construction and Operation of the Project:

Sediment Analysis - An initial study shall be conducted as soon as Sultan River conditions permit after January 1, 1982, to determine the percentage of fines in spawning gravel from the Diversion Dam to Skykomish River confluence. This percentage shall again be determined upon completion of construction but prior to Project operation, and again three years after initial Project operation. If Project construction or operation causes a significant build-up of fines and/or caused adverse impacts at critical life stages of anadromous fish, Licensee and the joint agencies shall jointly determine appropriate remedial measures. Licensee shall implement such measures within six months after they are jointly determined. If the Licensee and the joint agencies are unable to agree on joint recommendations, Licensee shall implement the joint agency recommendations within six(6) months of such joint agency recommendations subject to disapproval or modification by the Commission.

Gravel Analysis - A study to determine whether project operation causes significant depletion of spawning gravels in the Sultan River from the Diversion Dam to confluence with the Skykomish River. Baseline data shall be gathered prior to initial Project operation. After three years and again after ten years of Project operation, Licensee and Joint Agencies shall jointly determine whether and the extent to which Project operation has caused significant depletion of spawning gravels. If any such depletion shall have occurred, then Licensee agrees to fund a gravel placement program subject to reasonable jointly determined locations, methods, cost and timing for such gravel placement.

c. Ramping Rate: A study to determine whether and under what operating conditions a ramping rate slower than six (6) inches per hour is appropriate to avoid adverse impacts upon critical life stages of anadromous fish (e.g. spawning, emergence and rearing). Such study shall be conducted over one (1) season following initial project operation and may require an additional year of study upon demonstration of good cause for such extension. If study findings indicate adverse impacts, the joint agencies shall recommend and Licensee shall implement appropriate lower ramping rates immediately notwithstanding any provisions herein to the contrary.

d. Fish Passage: Studies to determine whether the powerhouse berm facilitates successful upstream migration of anadromous fish and whether entry into powerhouse draft tube outlets causes injury to such anadromous fish.

e. River Temperatures: A study of river temperatures based upon continuous monitoring by thermograph at a point below the Diversion Dam where return flows are fully mixed with stream flows. Annual reports of temperature studies will be provided to the Commission and to the joint agencies by the Licensee.

4. Improved Public Access to Sultan River

Licensee shall improve public access to the area above the powerhouse once project operation has begun by removing or relocating exiting gates inhibiting such access in a manner consistent with public safety.

5. Project Operation - Ramping Rate

Licensee shall operate the powerhouse at a ramping rate no greater than 0.5 feet per hour as measured at the powerhouse, and at such lower ramping rate as may be determined per paragraph 3c above. If a ramping rate other than permitted by the terms of this agreement, or operation in a peaking mode, is requested by Licensee, the joint agencies and each of them shall have a reserved right to hearing before the Commission on objections to Licensee's request(s) and to seek judicial review of the Commission's determination if contrary to the position advocated by the objecting agency.

6. Project Operation - Water Temperature

Licensee shall construct a surface withdrawal intake structure at Spada Lake as depicted by Exhibit L, Sheet 42, and contained in Appendix C of FERC Final EIS for Project 2157. Further, Licensee shall operate said intake structure so that the temperature of combined fishwater return flows and river flows passing the Diversion Dam approximate to the fullest extent possible, the daily mean of recorded temperatures as recorded at the Diversion Dam for the years 1969-79, and also remain within the recorded daily minimum-maximum temperature range. Licensee shall notify the joint agencies of deviations from said minimum-maximum temperature range whenever such deviations occur for more than one monitoring period. What constitutes a "monitoring period" shall be jointly agreed upon by the Licensee and the joint agencies prior to project operation.

7. Flood Control

As specified by Article 57, Licensee and the Corps of Engineers (COE) shall enter into an agreement providing a reservoir operating rule curve for food control, if any, and per operations. Any agreement between the Licensee and the COE shall be preceded by a full consultation with the Joint Agencies. Licensee shall make no agreement to provide flood control other than provided by normal Project operation if it would substantially impair the ability to protect, mitigate and enhance anadromous and resident fisheries and wildlife resources. In the event the parties cannot agree on a plan of operation, the Commission reserves the right to specify the rule curve for flood control and power operations taking into consideration all those elements which will maximize the total benefits of Sultan River resources including power, flood control, fish and wildlife, recreational uses and other considerations. If the rule curve proposed by Licensee or COE would include project operation in a peaking mode, or a different ramping rate than specified in paragraph 5 above, or at different minimum flows than specified in paragraph 2 above, the joint agencies and each of them shall have the right to hearing before the Commission on objections to the rule curve proposed and to seek judicial review of the Commission's determination if contrary to the position advocated by the objecting joint agency.

8. Steelhead Planting Program

Upon commencement of project operation and annually thereafter the Licensee agrees to pay costs for production of 30,000 steelhead smolts, or their equivalent, to be produced at an existing Washington Department of Game facility and replanted in the Snohomish Basin. The Washington Department of Game has agree to submit annual budget proposals to Licensee for the program prior to August 1 of each year. After the first such annual proposal, the Department of Game shall submit a report to Licensee on the preceding year's program including allocated costs, location of smolt plants and Sultan River catch records.

9. In the event that the Commission shall at some future time order or allow project modifications, or modifications and conditions of project operation, which differ from the terms and conditions herein, the Joint Agencies, and each of them, shall have a reserved right to object to such modifications.

9.1 The Tulalip Tribes of Washington agree to the foregoing terms and conditions only if FERC enters the order described in paragraph 6.2 and its subparagraphs of a separate Settlement Agreement between licensees and the Tribe executed by the Tribe simultaneously within; PROVIDED, FURTHER, the Tribe's agreement to the foregoing terms and conditions is contingent upon the ratification by FERC of said separate Settlement Agreement between licensee and the Tribe.

EXECUTED this 24 day of March, 1982, at 1:30 p.m., Washington.

Licensees:

PUBLIC UTILITY DISTRICT NO. 1
OF SNOHOMISH COUNTY

By J.D. Manor

CITY OF EVERETT

By William E. Moore

CITY ATTORNEY

By Bruce Jones

CITY CLERK

By Elaine Morchille

Joint Agencies:

NATIONAL MARINE FISHERIES
SERVICE

By. F. Lorraine Bodi

U.S. DEPARTMENT OF INTERIOR

By Donald Lawtz

WASHINGTON DEPARTMENT OF
GAME

By J.M. Johnson

WASHINGTON DEPARTMENT OF
FISHERIES

By J.M. Johnson

TULALIP TRIBES OF WASHINGTON, INC.

By Name Unknown

Appendix C Addendum to Uncontested Offer of Settlement - Joint Agencies

1. WHEREAS the District and City (hereinafter Licensee); and intervening agencies: U.S. Department of Interior, National Marine Fisheries Service, Washington Departments of Fisheries and Game, and the Tulalip Tribes of Washington (hereinafter Joint Agencies) entered into a comprehensive Settlement Agreement pursuant to Article 60 of the October 16, 1981, Federal Energy Regulatory Commission Order Amending License and Providing for a hearing.

2. WHEREAS, Licensee in consultation with the Joint Agencies determined to return minimum stream flows to the Sultan River by way of the City of Everett's pre-existing diversion tunnel immediately below the City of Everett's Diversion dam at river mile 9.7. The original application for amended license proposed to return fish flows downstream of the Diversion dam. Said structures were originally included in the project boundary of Stage I as licensed in 1961, and are yet integral parts of Stage II, as amended. If for any reason the water diversion from Spada Lake by way of the power tunnel and pipeline must be temporarily shut down, water for the City of Everett and for fishery preservation will be released from Culmback Dam. Water for the City of Everett will be diverted back to Lake Chaplain by the Diversion Dam and Diversion Tunnel. Through inadvertence, amended Exhibit K, as submitted to the Commission as a part of the project description and boundary, failed to include said Diversion Dam and Tunnel as a part of the project.

NOW, THEREFORE, BE IN RESOLVED THAT in order to fulfill the terms and conditions of the Order Amending License for Project 2157 of October 16, 1981, the Licensee and Joint Agencies covenant and agree that the Diversion Dam and Tunnel are necessary project structures and recommend that the Commission order them included in the project boundary area by appropriate amendment to Exhibit K.

EXECUTED this 1 day of April, 1982, at Everett, Washington.

Licensees:	Joint Agencies:
PUBLIC UTILITY DISTRICT NO. 1 OF SNOHOMISH COUNTY	NATIONAL MARINE FISHERIES SERVICE
By J.D. Manor	By. F. Lorraine Bodi
CITY OF EVERETT	U.S. DEPARTMENT OF INTERIOR
By William E. Moore	By Donald Lawtz
CITY ATTORNEY	WASHINGTON DEPARTMENT OF GAME
By Bruce Jones	By J.M. Johnson

CITY CLERK

By Elaine Morchille

WASHINGTON DEPARTMENT OF FISHERIES

By J.M. Johnson

TULALIP TRIBES OF WASHINGTON, INC.

By Name Unknown

APPENDIX B

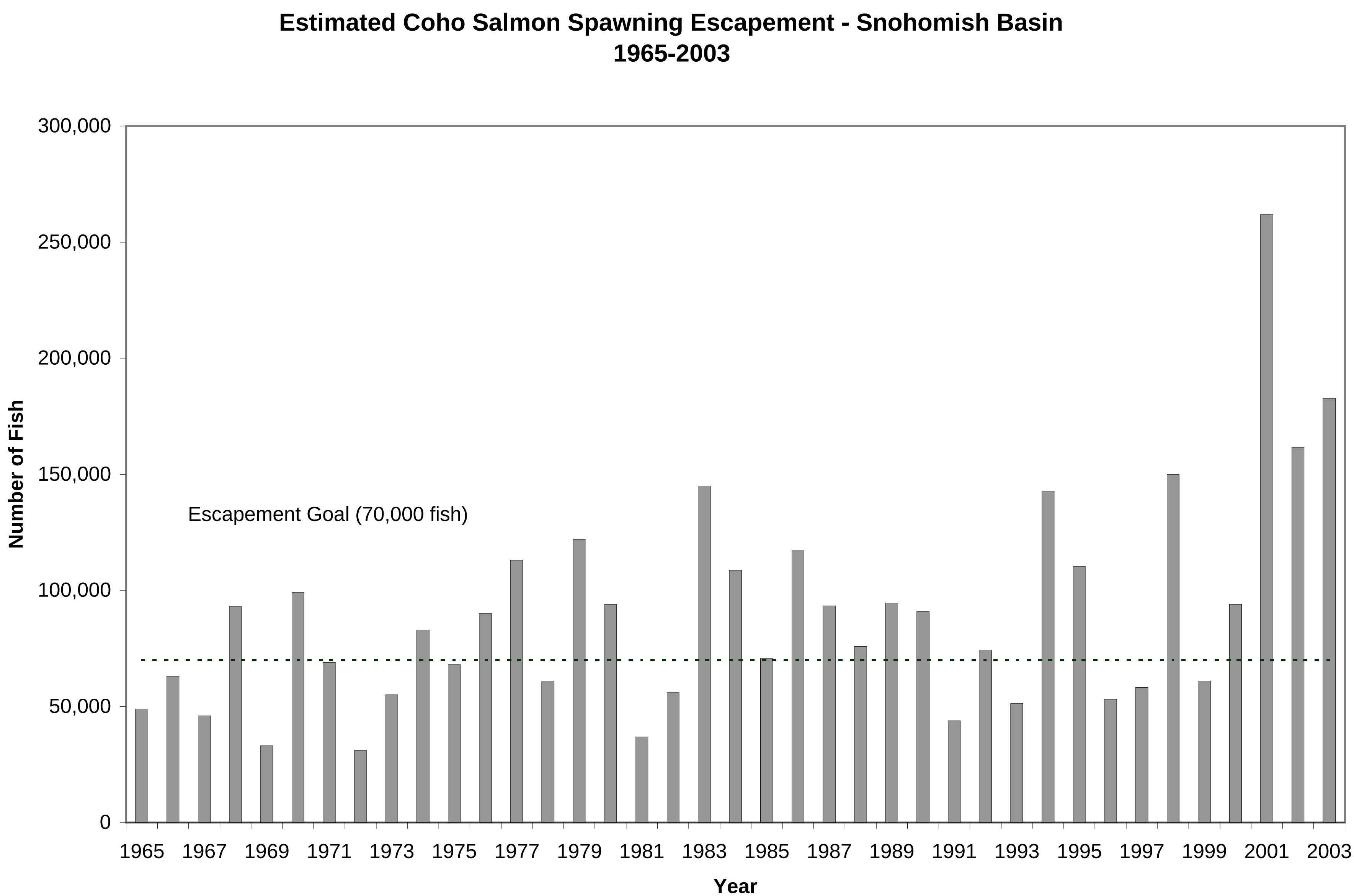
Salmon and Trout Data

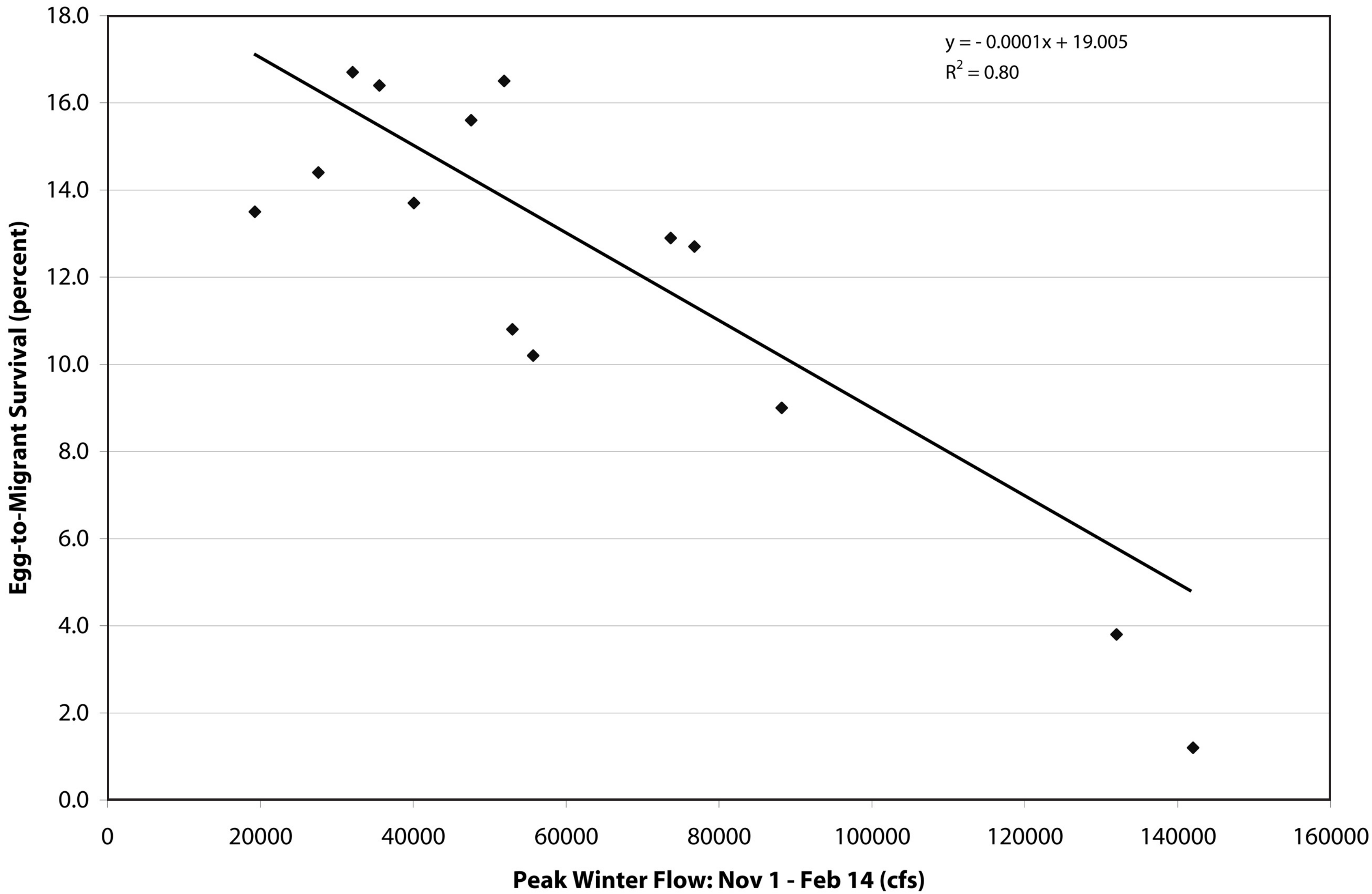
Estimated Natural Spawning Escapement of Chinook Salmon by Stock in the Snohomish River Basin

Year	Snohomish R. Summer	Snohomish R. Fall	Wallace R. Summer/Fall	Bridal Veil Creek Fall	System Total[a]
1965	1,593	850	1,864	911	5,443
1966	2,410	1,807	2,403	959	7,929
1967	510	520	863	1,327	3,320
1968	950	1,145	1,152	1,361	5,214
1969	440	639	525	1,856	3,700
1970	1,532	1,323	539	2,110	5,724
1971	1,793	1,211	2,519	1,981	7,822
1972	605	506	231	1,696	3,128
1973	1,306	1,023	409	1,515	4,841
1974	2,102	1,602	109	1,860	6,030
1975	1,290	1,453	139	1,045	4,485
1976	1,117	2,159	135	1,154	5,315
1977	2,613	1,600	613	691	5,585
1978	1,593	3,174	2,468	573	7,931
1979	2,256	1,089	1,513	851	5,903
1980	1,318	2,317	2,085	779	6,460
1981	500	1,449	748	633	3,368
1982	1,045	1,370	1,823	260	4,379
1983	983	2,106	1,155	293	4,549
1984	560	1,697	940	287	3,762
1985	1,093	N/A	2,055	432	4,873
1986	815	2,287	445	727	4,534
1987	1,650	1,587	885	458	4,689
1988	1,093	1,376	607	791	4,513
1989	361	1,840	373	516	3,138
1990	623	2,685	370	613	4,209
1991	1,142	908	200	603	2,783
1992	413	1,160	203	612	2,708
1993	447	2,725	109	630	3,866
1994	968	1,151	468	564	3,626
1995	546	1,160	280	1,036	3,176
1996	1,315	1,648	713	860	4,851
1997	263	2,447	713	744	4,292
1998	1,113	2,695	1,543	572	6,304
1999	765	2,645	1,280	113	4,803

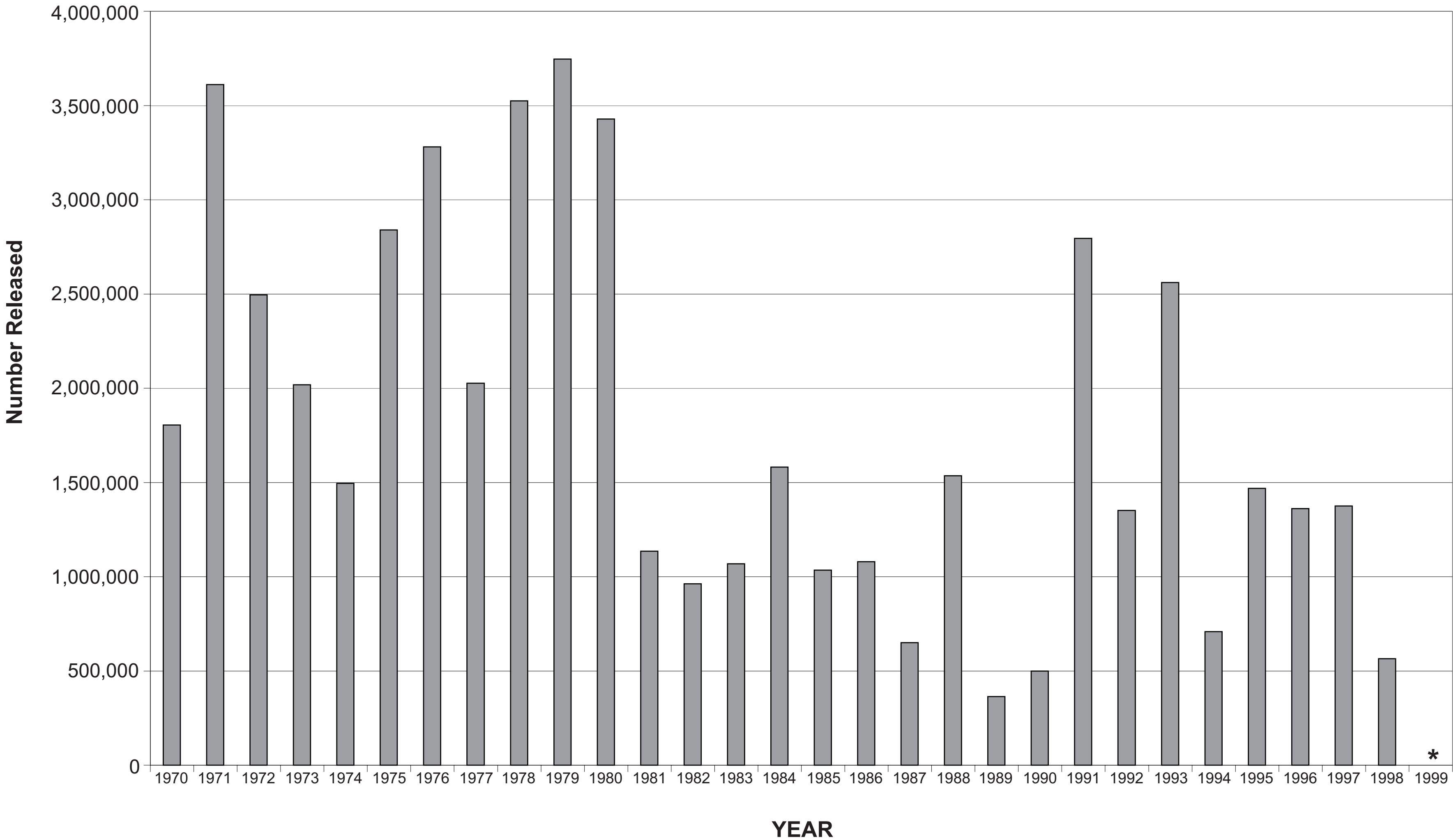
[a]The system total does not equal the sum of the sub-basin estimates because some escapement is not accounted for in any subbasin.

Source: Initial Snohomish River Basin Chinook Salmon Conservation/Recovery Technical Work Plan


Estimated Coho Salmon Spawning Escapement - Snohomish Basin
1965-2003
Number of Fish
300,000
250,000
200,000
150,000
100,000
50,000
0
Escapement Goal (70,000 fish)
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
Year

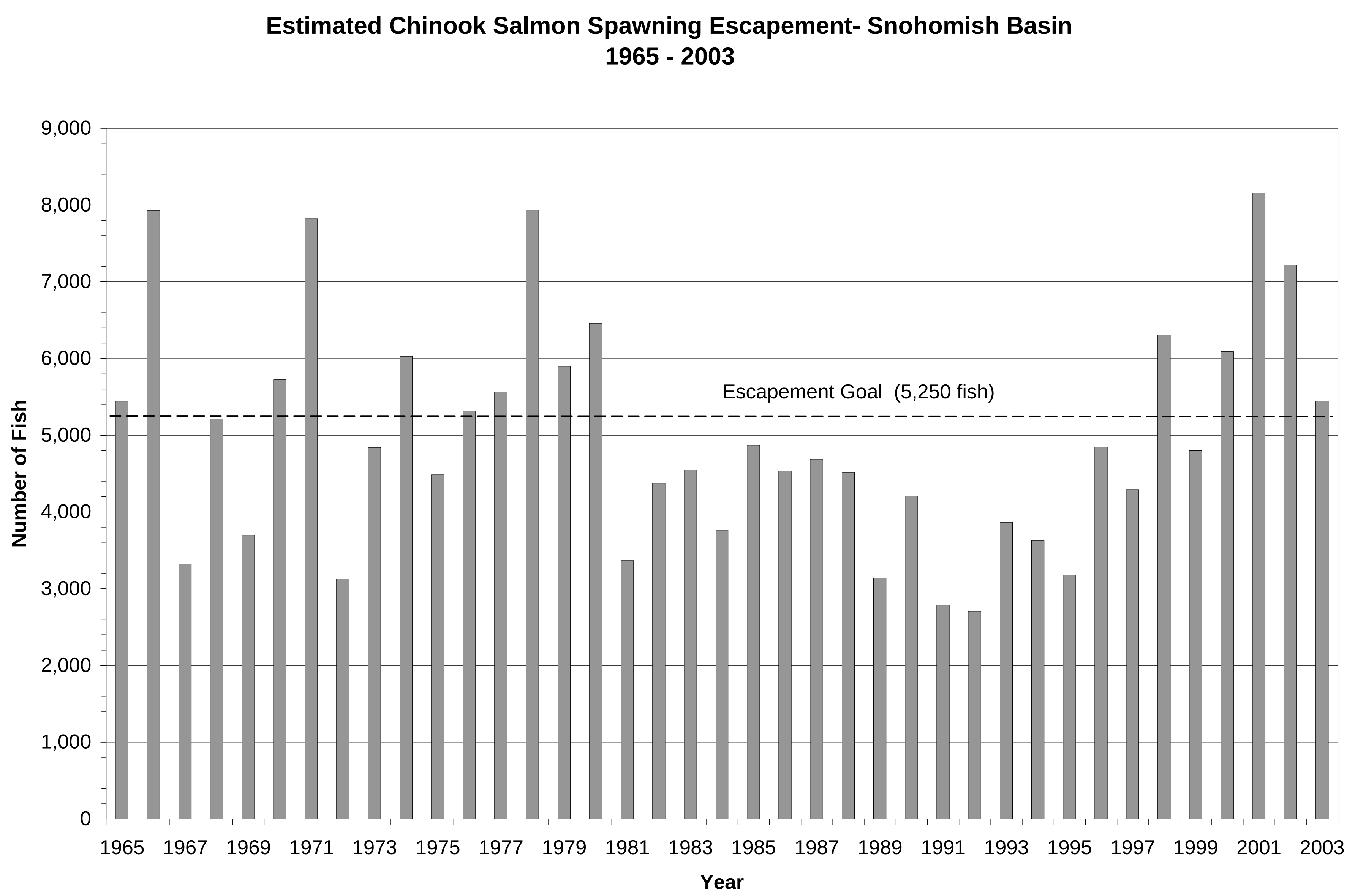


Relationship Between Egg-to-Migrant Survival and Peak Winter Flows for Skagit River Chinook Salmon, 1990 - 2003 (Seiler et al. 2004)

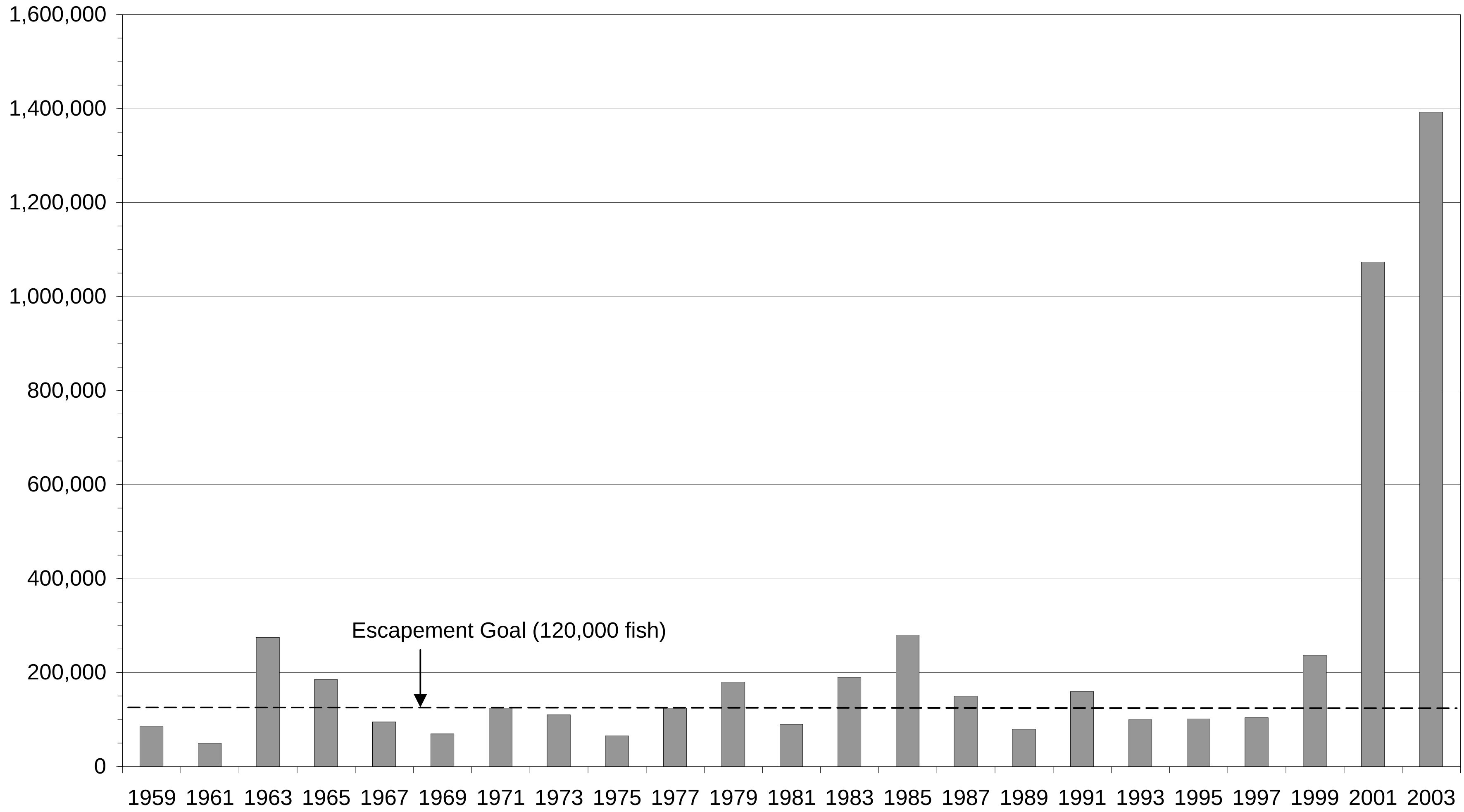


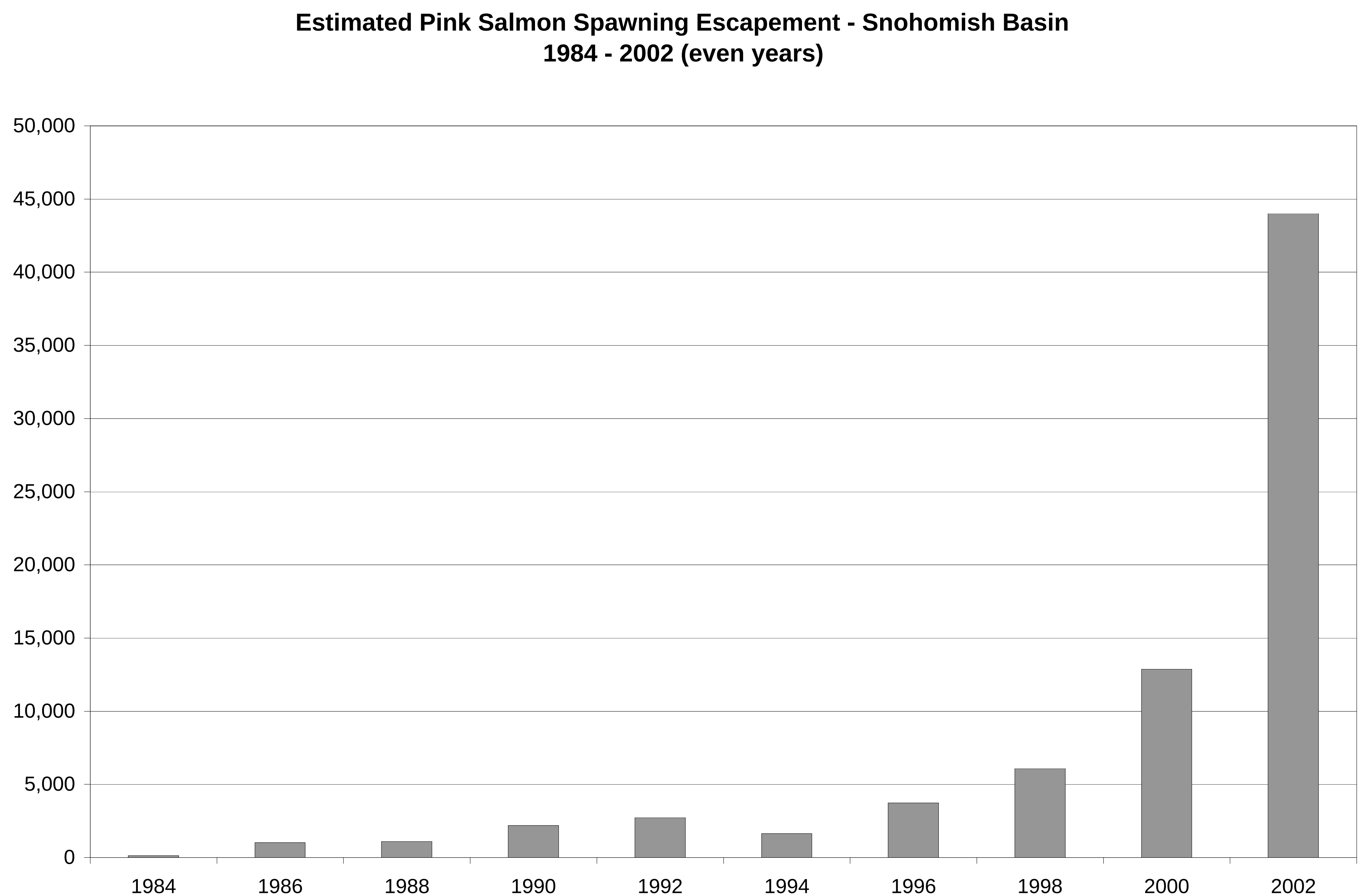
* Fall chinook production curtailed starting in 1999.

**Wallace River Hatchery,
Fall Chinook Releases**

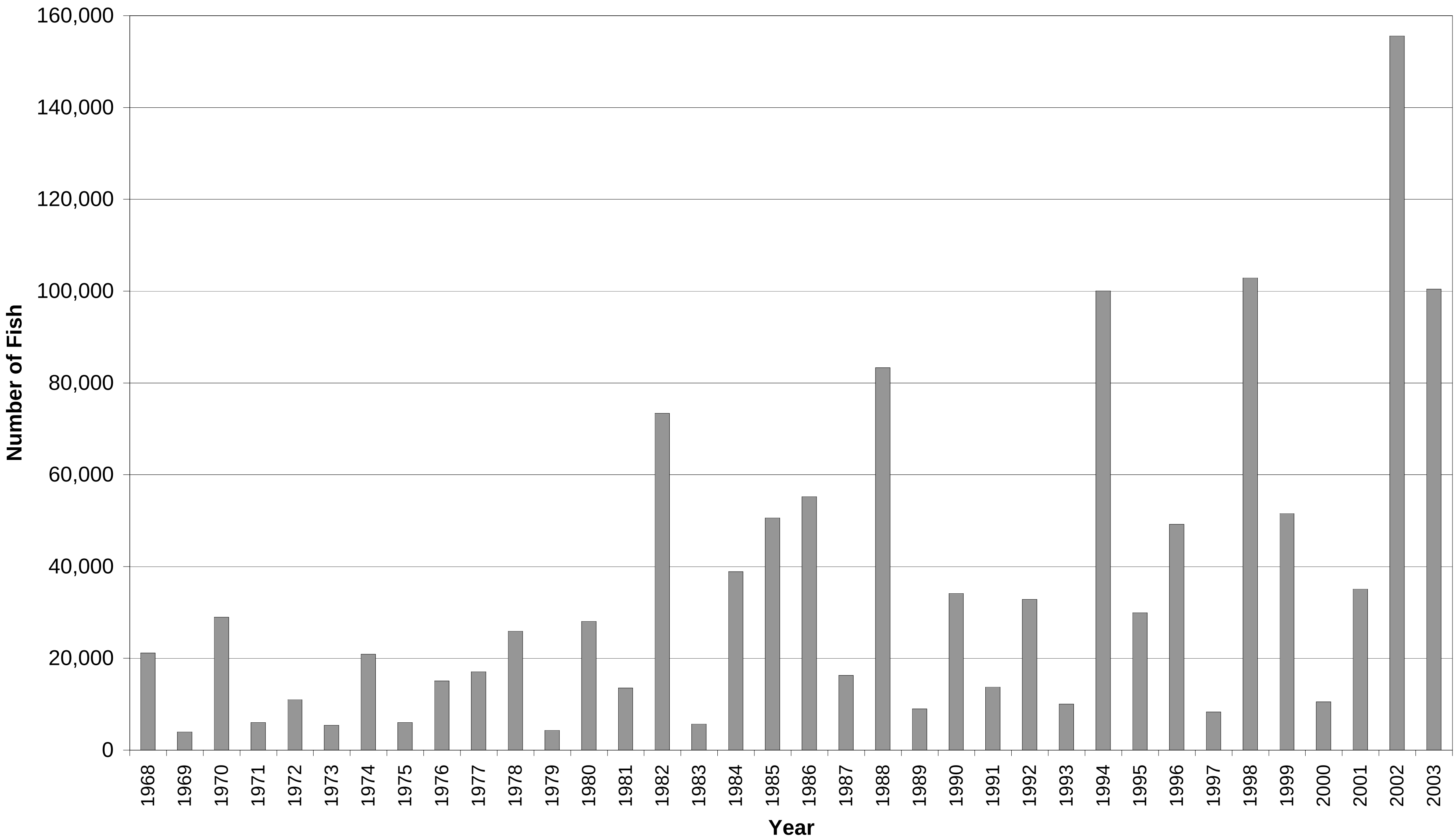

Estimated Chinook Salmon Spawning Escapement- Snohomish Basin
1965 - 2003
Number of Fish
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Escapement Goal (5,250 fish)
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
Year

Estimated Pink Salmon Spawning Escapement - Snohomish Basin
1959 - 2003 (odd years)



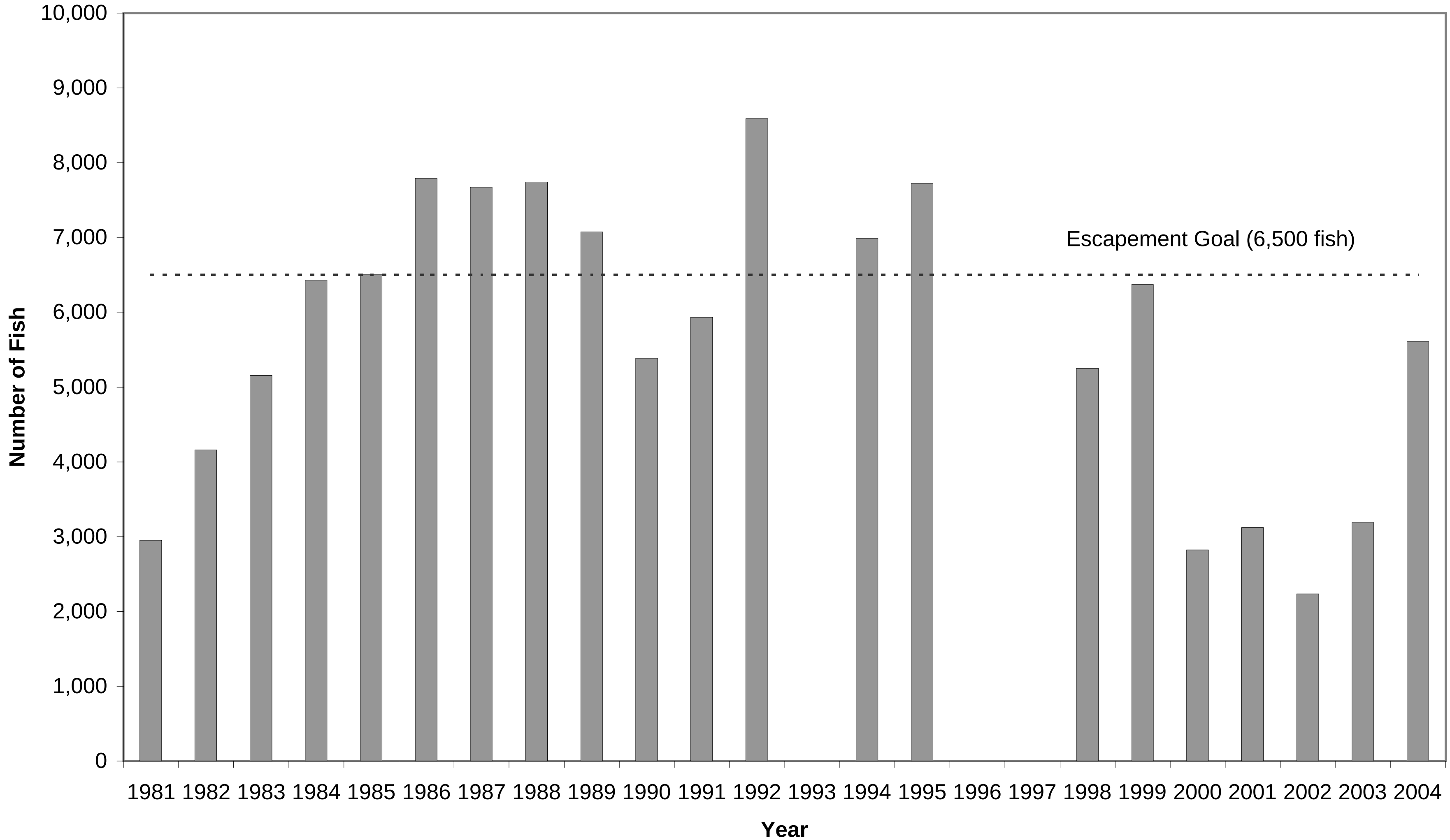

Estimated Pink Salmon Spawning Escapement - Snohomish Basin
1984 - 2002 (even years)
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002

Estimated Chum Salmon Spawning Escapement - Snohomish Basin 1968-2003



Escapment Goals:
odd years - 10, 200
even years - 28,000

Estimated Winter Run Steelhead Trout Spawning Escapement - Snohomish Basin
1981-2004



Trends in Snohomish System Native Char

Year	No. of Redds in the N.F. Skykomish River	Adults over Sunset Falls*
1988	21	
1989	49	
1990	67	
1991	156	
1992	82	
1993	159	
1994		18
1995	75	40
1996	60	45
1997	170	42
1998	177	47
1999	110	45
2000	236	51
2001	319	62
2002	538	90
2003		92

* Fish passed upstream prior to 1/11.

APPENDIX C

Bull Trout Distribution in the Sultan Watershed

Bull Trout Distribution

in the

Sultan River Watershed

Final Report

Snohomish County
Public Utility District No. 1

January 2005

Table of Contents

List of Figures

List of Tables

Introduction

On November 1, 1999, the U.S. Fish and Wildlife Service (USFWS) listed coastal/Puget Sound bull trout as “threatened” under the federal Endangered Species Act (Federal Register, 1999). In order to comply with federal and state recovery efforts, the Joint Agencies[1] overseeing the operation of the Jackson Hydroelectric Project requested that the Snohomish County Public Utility District (PUD)/City of Everett conduct studies to further define the geographic distribution of bull trout in the Sultan River watershed. In response, the PUD implemented a bull trout sampling program in 2004 to document the presence/absence and inventory bull trout populations in a reach of the Sultan River where prior knowledge was lacking.

Existing Information

Bull trout/Dolly Varden are the only char in the family Salmonidae native to Washington. The Washington Department of Fish and Wildlife (WDFW, 1998) identifies a single bull trout/Dolly Varden stock in the Snohomish River watershed, with primary spawning areas identified in the upper North Fork of the Skykomish River and tributaries between Bear Creek Falls and Deer Creek Falls, and in the East Fork of the Foss River, upstream of Sunset Falls on the South Fork of the Skykomish River.

Anadromous, fluvial, and resident life history forms are all found in the Skykomish River watershed, at times spawning at the same time and place (Kraemer 1994, as cited in WDFW 1998). Only resident bull trout/Dolly Varden are found in upper tributary reaches that lie upstream of falls that are adult fish passage barriers (e.g., Troublesome Creek). Skykomish River bull trout/Dolly Varden are native and are maintained by wild production, although bull trout/Dolly Varden found in the South Fork of the Skykomish River have only recently invaded that sub-basin with the construction of the Sunset Falls trap and haul fishway in the late 1950’s. The status of this stock is designated as Healthy (WDFW 1998).

Bull trout/Dolly Varden prefer clean, cold water with abundant, clean spawning gravel and good rearing cover such as clean cobbles and boulders and abundant LWD (Spence et al., 1996; Rieman and McIntyre, 1993). Spawning occurs from late August to early-mid November, but is more typically seen between the first week in October and the first week of November. Spawning commences as water temperature drops to around 8 degrees C, and decreases when the water temperature increases above 8 degrees C.

[1] Joint Agencies include the Tulalip Tribe, the National Marine Fisheries Service (NOAA), the U.S. Fish and Wildlife Service and the Washington Department of Fish and Wildlife.

Sultan Basin

Upper Basin: Upstream of Culmback Dam

Creel surveys of the Spada Lake fishery have been conducted in 1979, 1980, 1985-89, 1992, 1995, and 1997. A total of 28,969 trout (rainbow, cutthroat, and hybrids) were checked into the creel over these 10 years. Results of these ten intensive creel surveys on the Spada Lake resident trout fishery over the past two decades have failed to yield a single bull trout. No char (native or introduced) were encountered. Therefore the species is presumed not to exist upstream of Culmback Dam. This conclusion is supported by WDFW, which has never documented bull trout above any anadromous barrier in the Snohomish basin except above Sunset Falls on the South Fork of the Skykomish River and Troublesome Creek in the North Fork Skykomish basin (WDFW 1999). In addition, there appears to be no evidence suggesting that bull trout occurred in the upper basin historically (Mongillo 1993).

Between 1979 and 1997, numerous fish population surveys were conducted in Spada Lake and its tributaries. The methods employed included gill netting in the reservoir and electroshocking in the tributaries. These surveys yielded a total of 1464 trout (rainbow and cutthroat) and 738 bullhead. No char (native or introduced) were encountered.

Downstream of the City of Everett's Diversion Dam

Native char have been observed by a District fisheries biologist in the lower Sultan River below RM 9.7 in the reach accessible to anadromous fish. Also, other char have been reportedly caught by anglers interviewed along the lower river (Murray Schuh, District, personal communication, 1999). These fish are presumed to be foraging individuals.

Study Area

This survey focused on the reach of the Sultan River between the City of Everett's Diversion Dam (RM 9.7) and Culmback Dam (RM 16.1)(Figure 1). This 6.4 mile reach of the Sultan River, commonly referred to as the bypass reach, has a drainage area of roughly 7.9 square miles. A year-round release of 20 cfs from Culmback Dam provides flow to maintain a resident salmonid fishery. Lateral inflows (side flows) can be significant including short duration flows in excess of 1000 cfs. Big Four Creek is the primary tributary to this reach but numerous intermittent tributaries provide inflows into this reach as well. These tributaries are steep and have impassable barriers to fish passage therefore, surveys were limited to the main channel of the Sultan River.

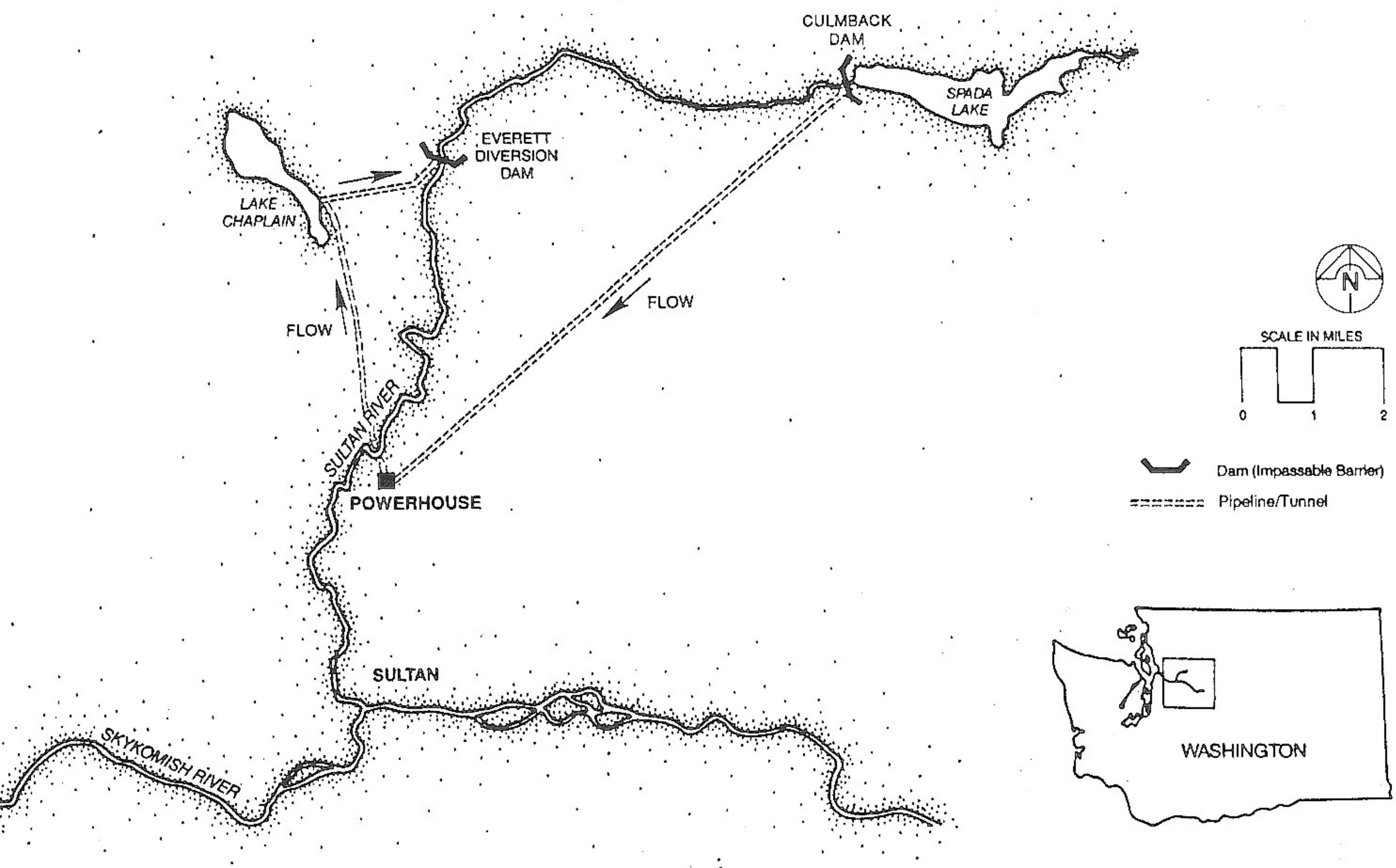


Figure 1.
Jackson Project vicinity map

Methods

Habitat

Reconnaissance level habitat mapping was accomplished by conducting a low elevation / slow speed aerial flight and video taping the river. The video made it possible to rapidly characterize habitat types, enumerate large woody debris, classify substrates, and identify potential impediments to fish passage. The video also aided in determining access routes.

Information on channel gradient and channel confinement was obtained from USGS Topographic Maps.

Temperature

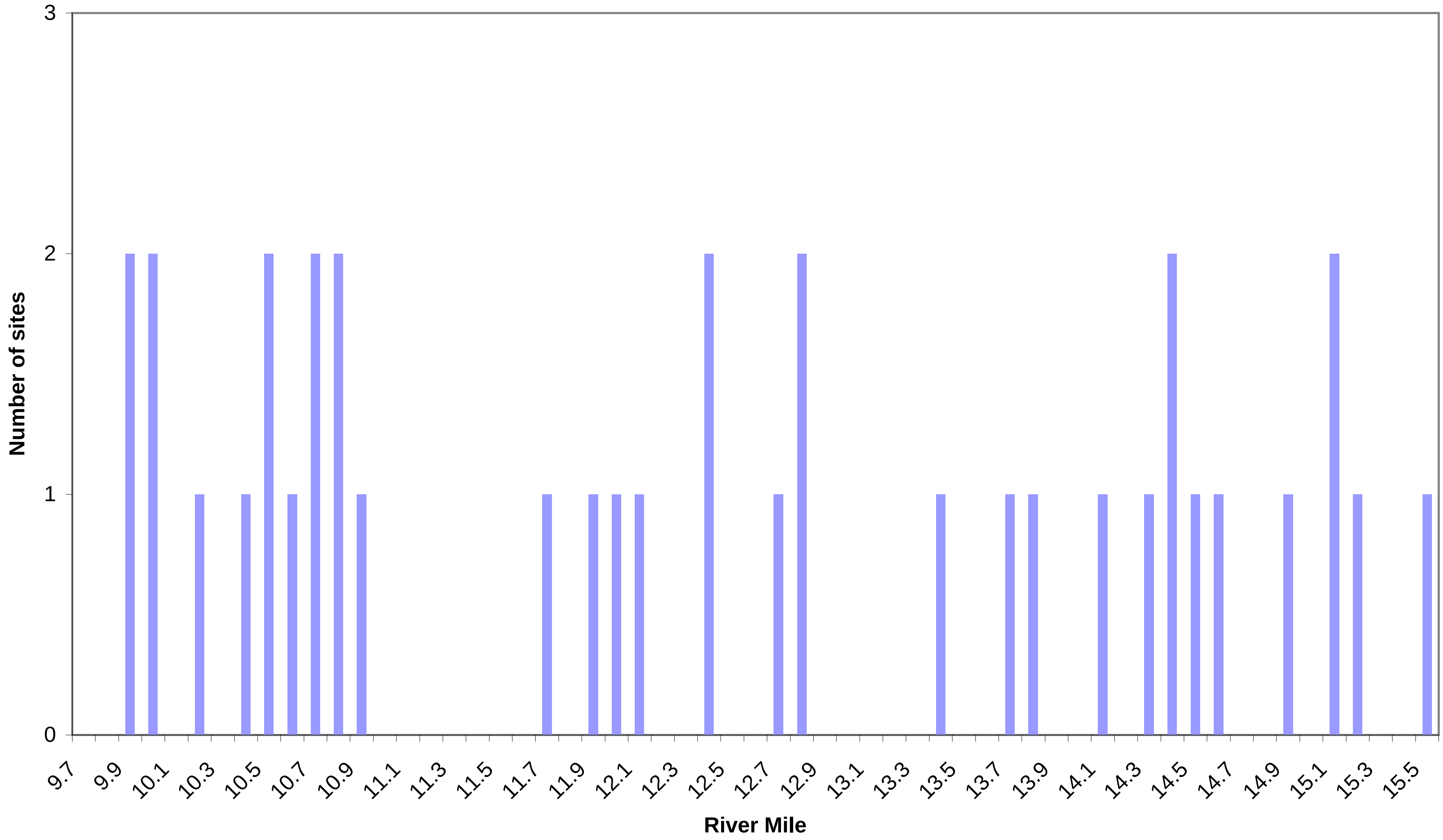
Onset ™ thermographs were installed at the upstream and downstream boundaries of the bypass reach to determine if water temperatures were suitable for bull trout, especially for egg incubation. Thermographs were set to record temperatures on an hourly interval and remained in place throughout the study.

Water temperature was also recorded at each sampling site on the day the survey was conducted using a hand-held pocket thermometer.

Snorkeling Survey

The PUD implemented the protocol developed by the American Fisheries Society (AFS) for detection of both juvenile migratory and stream-resident char (Peterson et al., 2002). Sampling occurred over a six week period between July 27, 2004 and September 10, 2004. This sampling period is adequate to detect bull trout presence, if they were present, because bull trout would be expected to the resident form. The AFS methodology calculates the requisite number of sampling units from 1) water visibility, 2) wood density, 3) water temperature, 4) length of sampling reaches (50 m or 100 m), and 5) day versus night snorkeling. A total of 37 randomly selected sites were sampled in the bypass reach in consideration of the prevailing habitat conditions and the desired 95% probability of bull trout detection. Each site was 100 m in length (Figure 2). Global Positioning System (GPS) coordinates for each site were obtained from Topo ™ software and entered into a handheld receiver to locate sampling sites in the field. Upon arrival at the site, lower and upper site boundaries were delineated. Where possible, boundaries were netted. In some instances, boundaries were adjusted and placed at a natural break between habitat types. Snorkeling commenced at the downstream boundary and was conducted by a team of two observers simultaneously proceeding upstream. Species, size, and number were recorded for each sampling site.

Figure 2: Distribution of 37 randomly selected 100 m sampling sites, Sultan River Bull trout Survey, 2004



Results

Habitat

Within the study area, the Sultan River is largely confined within a narrow canyon. Widths in the canyon range from 15 to 45 feet. Channel gradient in the study area is steep, averaging 1.6 percent and ranging from 0.7 to 13.7 percent (Figure 3). Traveling upstream, the first substantial change in gradient, to 2.5 percent, occurs near RM 12. Further upstream and immediately downstream of the present dam site, channel gradient increases dramatically averaging 6.3 percent, and ranging between 3.6 and 13.7 percent (USGS Topographic Map and Digital Elevation Model, Wallace Lake Quadrangle).

Habitat composition in the study area was dominated by run habitat (35.3%) followed by cascade (26.5%), riffle (22.1%), and pool (16.2 %) habitat types. The combination of steep gradients and confined channel, result in a high energy system characterized by numerous cascades, chutes, and deep pools.

Substrate was predominantly boulder (53.7%) and bedrock (30.6%) followed by rubble (13.2%), cobble (1.5%) and coarse gravel (1.0%). A total of 145 pieces (73 small, 61 medium, and 11 large) of large woody debris were noted in the study area.

Water Quality

Water temperature immediately downstream of Culmback Dam (RM 16.0) averaged 6.4 degrees Celsius and was fairly consistent throughout the study period ranging from 6.1 to 7.0 degrees Celsius (Figure 4). Water temperature immediately upstream of the Diversion Dam (RM 9.8) averaged 12.1 degrees Celsius and ranged from 9.0 to 16.4 degrees Celsius (Figure 4).

Sampling conditions, temperature and turbidity, were recorded during each survey. Point temperature reading were at or above 9.0 degrees C during all but one survey (Table 1). The average of daily turbidity point values obtained at the Diversion Dam (lower end of study area) was consistently below 2.39 NTU’s (Table 1).

Figure 3: Channel Gradient, Sultan River between Diversion Dam and Culmback Dam

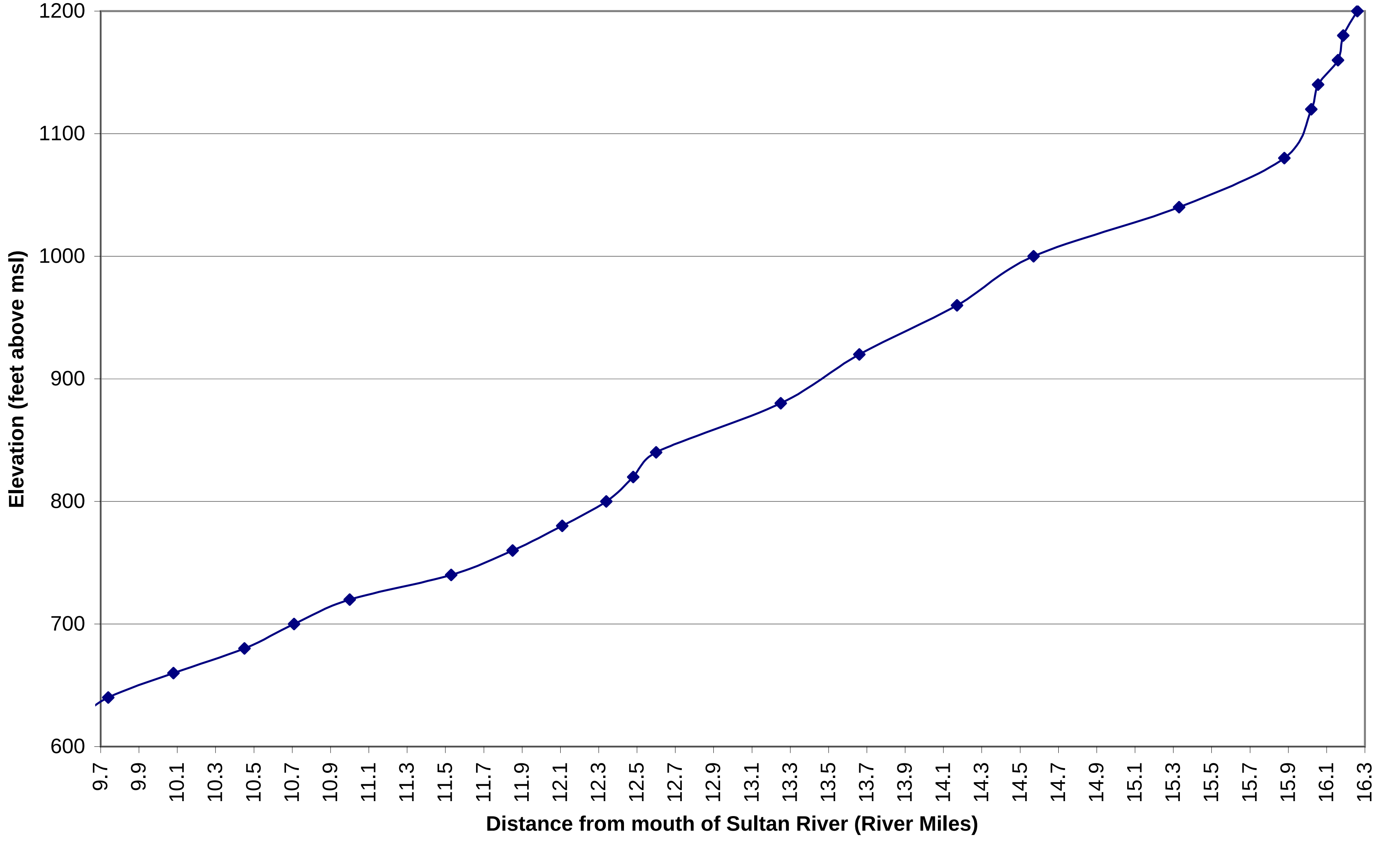


Figure 4: Hourly Water Temperature at Upper and Lower Boundaries of Bull Trout Study Area, Sultan River, Summer 2004

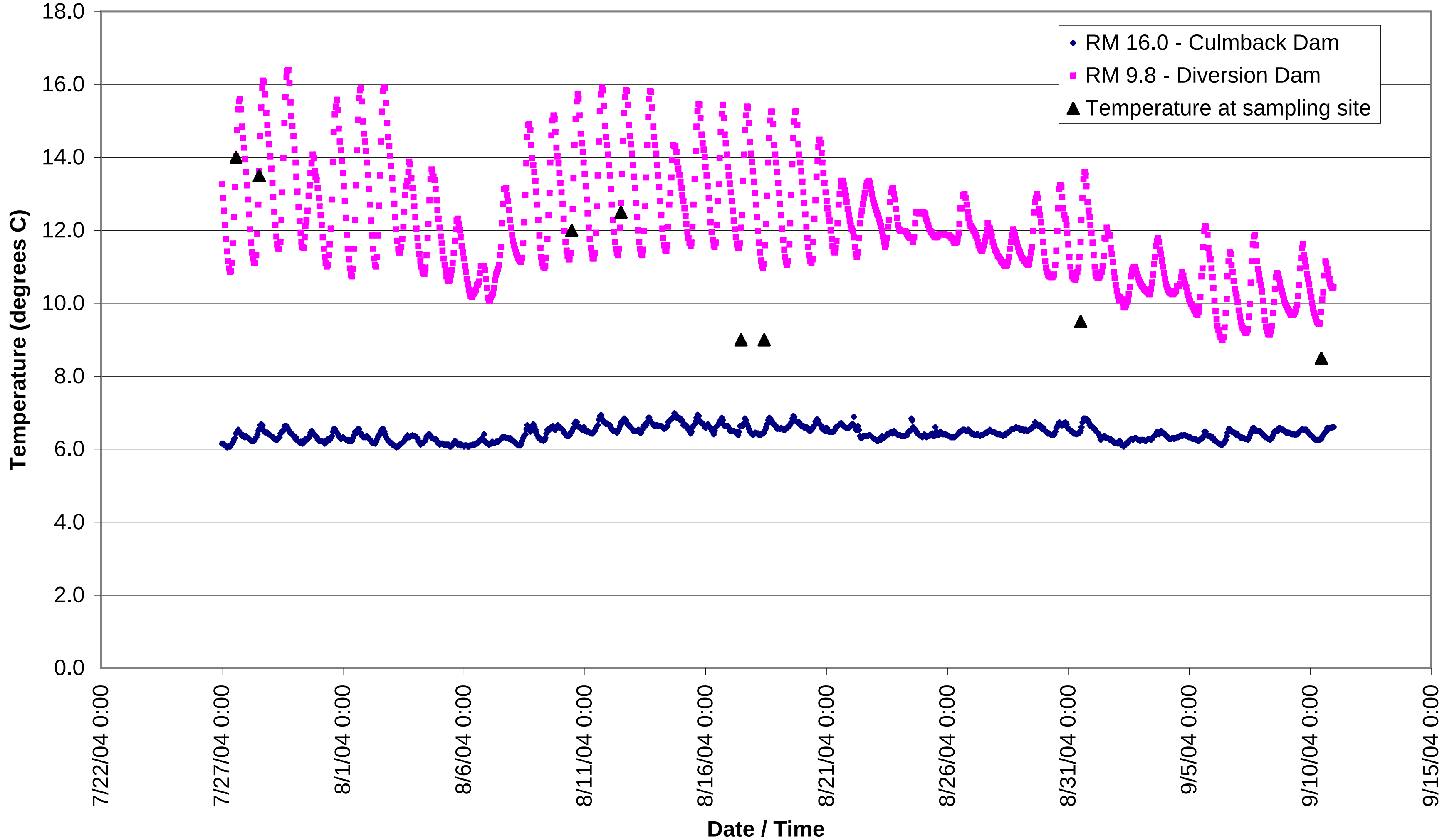


Table 1: Sampling conditions during Bull trout survey, Sultan River, Summer 2004.

Date	Temperature at sampling site	Turbidity at Diversion Dam
7/27/04	14.0	1.17
7/28/04	13.5	1.14
8/10/04	12.0	1.39
8/12/04	12.5	1.45
8/17/04	9.0	1.59
8/18/04	9.0	1.47
8/31/04	9.5	2.15
9/10/04	8.5	2.39

Snorkeling Survey

A total of 1,023 fish were observed within the 37 sites sampled during the survey (Table 2). The assumed sampling efficiency was 22% based of AFS data for the stream conditions present during the survey. Rainbow trout were dominant accounting for 91.1 percent of the fish observed (Table 2). Mountain whitefish accounted for 8.2 percent of the fish observed. A total of 7 sculpin were observed during the survey.

Observed fish were distributed throughout the study area but the greatest concentrations occurred in the lowermost 2.4 miles, upstream of the Diversion Dam. Over 90 percent of the rainbow trout observed were found in this lower section (Figure 5). Similarly, 69 percent of the mountain whitefish observed were found in this lower section (Figure 6).

Table 2: Site location, habitat type, and species observed during Bull trout survey, Sultan River, Summer 2004

				COUNT		SIZE		COUNT		SIZE			
SITE NO.	**RM**	**Site Length (ft)**	**HABITAT TYPE**	**RBT**	**<100mm**	**101-200mm**	**201-300mm**	**MWF**	**<100mm**	**101-200mm**	**201-300mm**	**SCP**	**<100mm**
1	9.9	328	RUN	0				2		2			
2	9.9	328	RUN/POOL/CASC.	43	3	34	6						
3	10.0	328	RUN/ROCK GARDEN/POOL/CASCADE	67	5	52	10	1		1		5	5
4	10.0	328	RUN/POOL	44	4	33	7					1	1
5	10.2	328	ROCK GARDEN	113	9	87	17						
6	10.4	328	RIFFLE/ROCK GARDEN	57	5	43	9						
7	10.5	328	RUN/POOL	59	5	45	9					1	1
8	10.5	328	ROCK GARDEN	74	6	57	11						
9	10.6	328	POOL	49	4	38	7	8	3	5			
10	10.7	328	ROCK GARDEN	74	6	57	11	2		2			
11	10.7	328	ROCK GARDEN	45	4	34	7	1		1			
12	10.8	328	RUN/POOL	14	1	11	2						
13	10.8	328	POOL	0	0	0	0						
14	10.9	328	ROCK GARDEN/CASCADE	40	3	31	6						
15	11.7	328	CASCADE	49	4	38	7	4		4			
16	11.9	328	POOL	22	2	17	3	3		3			
17	12.0	328	RUN/POOL	47	4	36	7	12		7	5		
18	12.1	328	POOL	44	4	33	7	25		19	6		
19	12.4	328	POOL/RUN/CASCADE	0									
20	12.4	328	POOL/RUN/CASCADE	16		10	6	3			3		
21	12.7	328	POOL/RUN/CASCADE	8		5	3						
22	12.8	328	POOL/RUN/CASCADE	3		2	1						
23	12.8	328	POOL/RUN/CASCADE	5		4	1						
24	13.4	328	POOL/RUN/CASCADE	9		8	1						
25	13.7	328	POOL/RUN/CASCADE	7		6	1	14					
26	13.8	328	POOL/RUN/CASCADE	9		8	1	4					
27	14.1	328	POOL	3		3							
28	14.3	328	RUN/POOL	5		5							
29	14.4	328	RUN/CASCADE	9		7	2						
30	14.4	328	RUN/ROCK GARDEN	7		6	1						
31	14.5	328	RUN/POOL	7		6	1						
32	14.6	328	RUN/POOL	3		3		5					
33	14.9	328	RUN	0				0					
34	15.1	328	RUN/POOL	0				0					
35	15.1	328	RUN/CASCADE	0				0					
36	15.2	328	POOL/CASCADE	0				0					
37	15.5	328	RUN/CASCADE	0				0					
Totals	5.8	12136		932				84				7	

Species codes: Rainbow trout (RBT), Mountain Whitefish (MWF), Sculpin (SCP)

Figure 5: Distribution of Rainbow Trout in Bypass Reach, Sultan River, Summer 2004

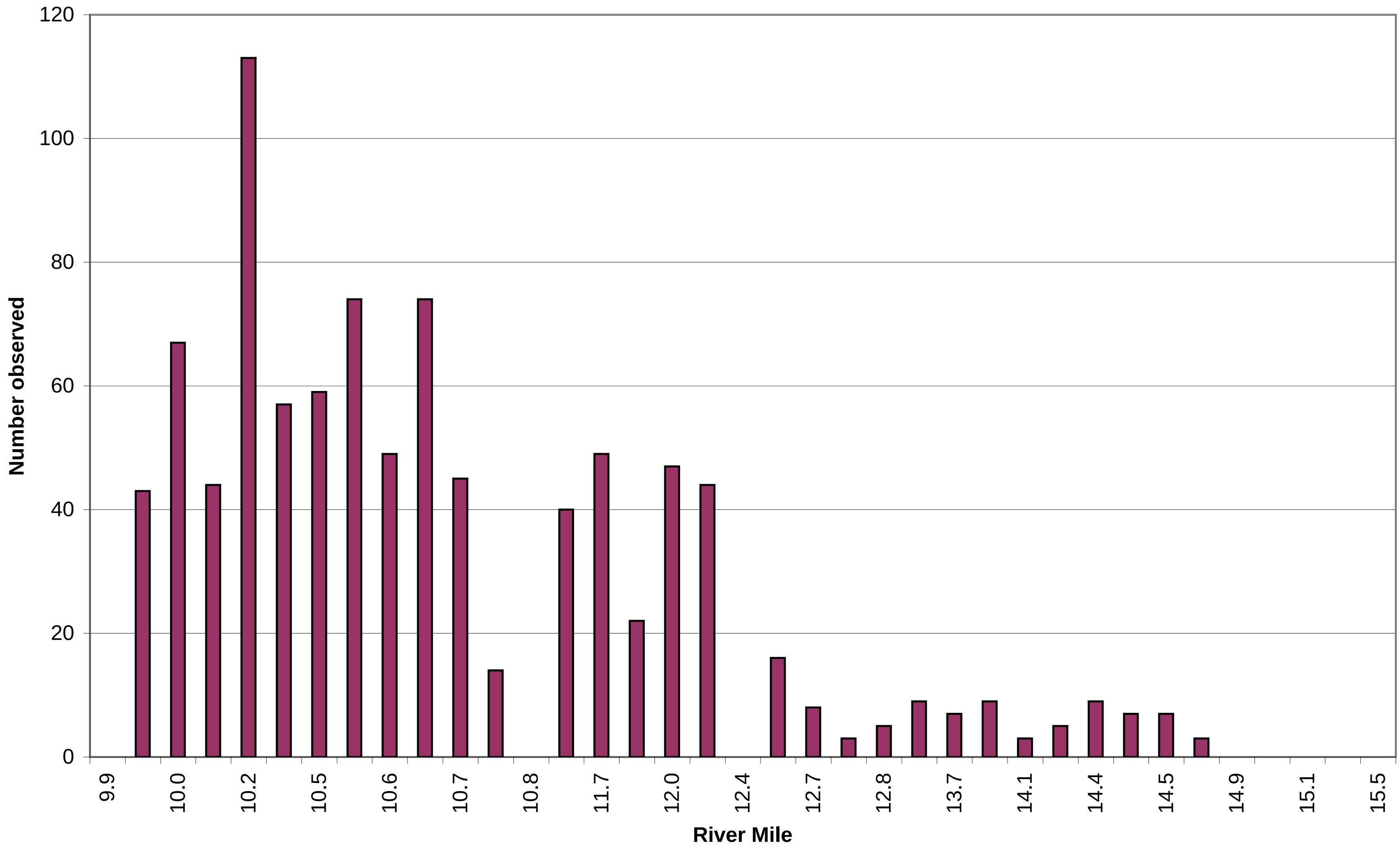
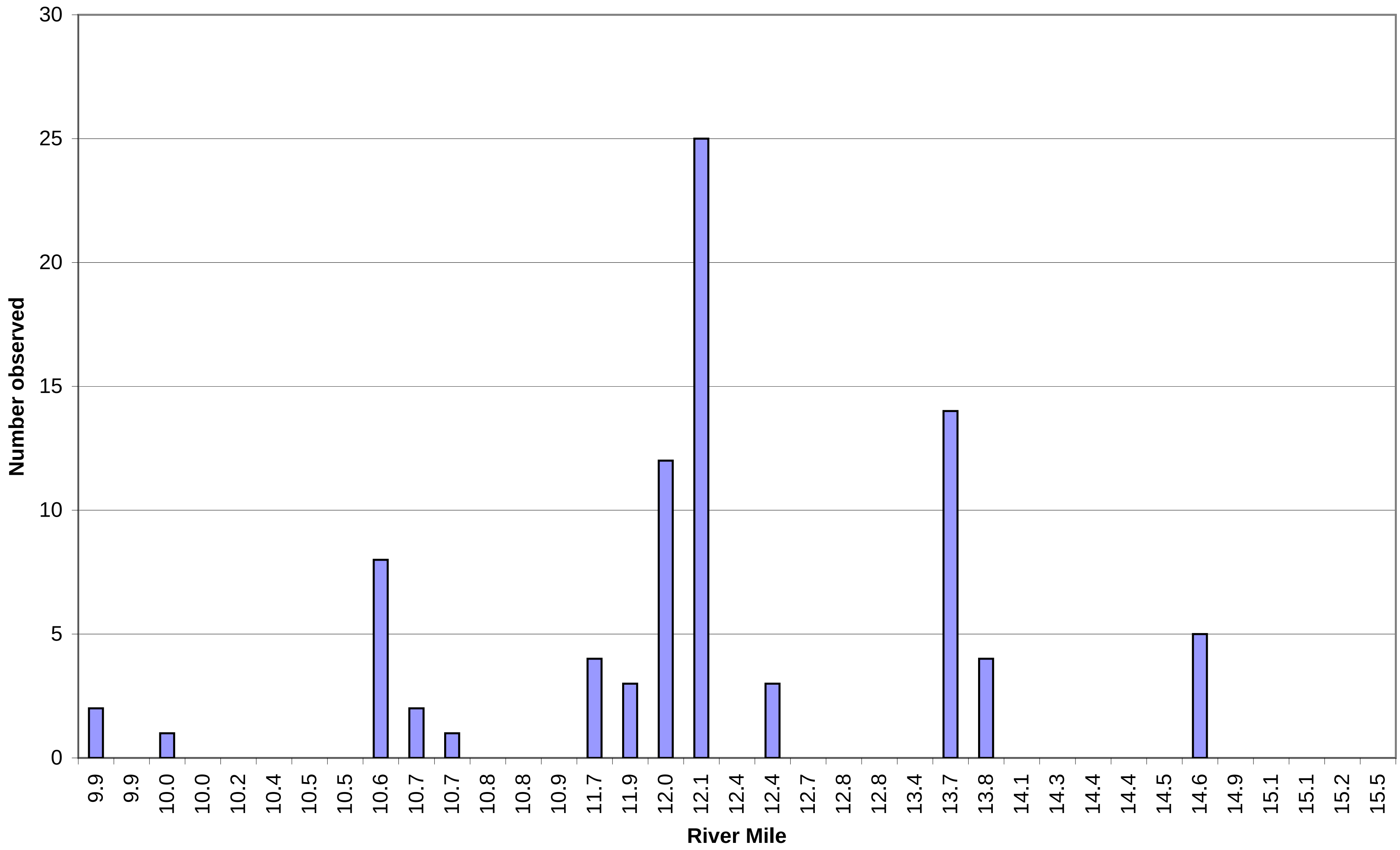


Figure 6: Distribution of Mountain Whitefish in Bypass Reach, Sultan River, Summer 2004



Discussion

In the summer of 2004, snorkel surveys were performed in the "bypass" reach of the Sultan River between the Diversion Dam and Culmback Dam. Rainbow trout, mountain whitefish, and sculpin were found but neither bull trout nor Dolly Varden were detected. Based on the AFS sampling protocol, conditions within the river and our level of sampling effort, we estimated that there was a 95% chance of detecting bull trout/Dolly Varden in the study area, if they were present. We conclude that the presence of bull trout/Dolly Varden between the two dams is unlikely. This finding is consistent with the absence of bull trout/Dolly Varden during creel surveys and fish sampling of Spada Lake, which is upstream of Culmback Dam.

Furthermore, it is doubtful that the Sultan River downstream of Culmback Dam contains suitable spawning, incubation, or early rearing habitat for bull trout on the basis of its water temperature regime. Successful spawning requires water temperatures below 46 degrees F (8 deg C) during the late summer and fall (WDFW 1999). While these temperatures were observed in the uppermost portion of the study area, the physical habitat conditions conducive to spawning are not present in this area. Where suitable spawning habitat does exist, temperatures are too warm as successful egg incubation requires temperatures below 40 deg F (4.4 deg C). Because of these requirements for cold water, most bull trout in the Puget Sound region spawn upstream of the normal winter snowline (approximately 2,500 feet)(WDFW 1999). The elevation of the reach between the two dams (655 to 1,200 ft) is below the elevation typically utilized by spawning bull trout in the Puget Sound region (i.e. above the normal winter snowline or 2,500 ft) (WDFW 1999).

Literature Cited

Mongillo, P.E. 1993. The Distribution and Status of Bull Trout and Dolly Varden in Washington State, June 1992. Report No. 93-22. Washington Department of Wildlife, Olympia, WA.

Peterson, J., J. Dunham, P. Howell, R. Thurow, and S. Bonar. 2002. Protocol for Determining Bull Trout Presence.

Rieman, B.E. and J.D. McIntyre. 1993. Demographic and Habitat Requirements for Conservation of Bull Trout. USDA-FS General Technical Report INT-302. Intermountain Research Station, Ogden, UT.

Spence, B.C., G.A. Lomnicky, R.M. Hughes, and R.P. Novitski. 1996. An Ecosystem Approach to Salmonid Conservation. TR-4501-96-6057. ManTech Environmental Research Services Corporation, Corvallis, OR.

WDFW. 1998. 1998 Washington Salmonid Stock Inventory: Bull Trout and Dolly Varden Appendix. Washington Department of Fish and Wildlife, Olympia, WA.

WDFW. 1999. Bull Trout in the Snohomish River System. Washington Department of Fish and Wildlife, Olympia, WA.

APPENDIX D

Minimum Flow and Down Ramp Incidents

Jackson Project Minimum Flow and Ramp Rate Incident Summary

	Date	Time	Location	Type (RR, MF)	Required (in/hr)	(cfs)	Recorded Flow (cfs)	Recorded Decrease (inches)	Deficient (in/hr)	(cfs)	Event Duration	Cause	FERC Finding
1	5/18-23/88	N/A	Diversion Dam	MF	175	cfs	N/A		N/A	cfs	5 Days	Gage out of calibration	Violation
2	09/22/88	23:20	Diversion Dam	MF*	155	cfs	54		101	cfs	60 minutes	Faulty circuit board	Violation
3	10/30/88	0:05	Diversion Dam	MF*	155	cfs	23		132	cfs	45 minutes	Human scheduling error	Violation
4	07/31/89	7:15	Diversion Dam	MF	95	cfs	77		18	cfs	75 minutes	Human scheduling error	Violation
5	10/27/89	14:15	Diversion Dam	MF	155	cfs	153		2	cfs	15 minutes	Low alarm setting	Violation
6	03/01/90	7:45	Diversion Dam	MF	175	cfs	166		9	cfs	15 minutes	Low alarm setting	Violation
7	04/12/90	9:30	Diversion Dam	MF	175	cfs	169		6	cfs	15 minutes	Low alarm setting	Violation
8	04/13/90	4:30	Diversion Dam	MF	175	cfs	174		1	cfs	15 minutes	Low alarm setting	Violation
9	04/20/90	11:30	Diversion Dam	MF	175	cfs	174		1	cfs	15 minutes	Low alarm setting	Violation
10	04/27/90	1:30	Diversion Dam	MF	175	cfs	169		6	cfs	15 minutes	Low alarm setting	Violation
11	05/06/90	23:45	Diversion Dam	MF	175	cfs	174		1	cfs	15 minutes	Low alarm setting	Violation
12	05/25/90	0:00	Diversion Dam	MF	175	cfs	174		1	cfs	15 minutes	Low alarm setting	Violation
	05/26/90	15:00	Diversion Dam	MF	175	cfs	174		1	cfs	15 minutes	Low alarm setting	Violation
13	05/28/90	12:45	Diversion Dam	MF	175	cfs	174		1	cfs	15 minutes	Low alarm setting	Violation
14	06/02/90	9:30	Diversion Dam	MF	175	cfs	174		1	cfs	15 minutes	Low alarm setting	Violation
15	10/04/90	6:00	Diversion Dam	MF	155	cfs	141		14	cfs	15 minutes	Low alarm setting	Violation
16	12/31/90	13:34	Powerhouse	RR	4	in/hr		*22.5			6 minutes	Accidental intake closure	Violation
17	01/03/91	15:33	Powerhouse	RR	2	in/hr		14.3			4 minutes	SCADA malfunction	Not in Violation
18	06/04/91	8:45	Diversion Dam	MF	175	cfs	171.5		3.5	cfs	15 minutes	Computer syntax error	Violation
19	06/05/91	3:35	Diversion Dam	MF	175	cfs	167		8	cfs	15 minutes	Gage out of calibration	Violation
20	10/03/91	18:00	Powerhouse	MF	200	cfs	182		18	cfs	30 minutes	Cooling system clogged	Not in Violation
	10/03/91	18:00	Powerhouse	RR	2	in/hr		3.96			15 minutes	Cooling system clogged	Not in Violation
21	11/23/92	5:36	Powerhouse	RR	4	in/hr		12.1			15 minutes	Emergency Oil Level	Not in Violation
22	03/01/93	2:00	Diversion Dam	MF	175	cfs	172		3	cfs	15 minutes	Scheduler judgement Error	Violation
23	05/01/93	12:52	Powerhouse	RR	4	in/hr		10.5			5 minutes	Cooling system clogged	Not in Violation
24	06/02/93	11:24	Powerhouse	RR	2	in/hr		6.5			7 minutes	Cooling H20 Solenoid failure	Not in Violation
25	07/18/94	15:23	Powerhouse	MF	165	cfs	154.4		10.6	cfs	6 minutes	Relay Installation Jarring	Violation
	07/18/94	15:23	Powerhouse	RR	4	in/hr		3.4			3 minutes	Relay Installation Jarring	Violation
26	11/01/94	8:23	Powerhouse	RR	4	in/hr		6.84			15 minutes	Brush Rigging Fire	Not in Violation
27	02/02/95	8:40	Powerhouse	RR	4	in/hr		18.1			5 minutes	PH isolation by BPA	Not in Violation
28	07/14/95	11:45	Powerhouse	RR	1	in/hr		3.48			3 minutes	Loss of cooling water	Not in Violation
	07/15/95	0:00	Powerhouse	MF	165	cfs	124		41	cfs	30 minutes	Loss of cooling water	Not in Violation
29	07/18/95	8:13	Powerhouse	MF	165	cfs	159		6	cfs	15 minutes	Cooling System	Not in Violation
30	09/13/95	12:00	Diversion Dam	MF	95	cfs	73		22	cfs	20 minutes	Operator Error	Not in Violation
31	12/24/95	0:04	Powerhouse	RR	4	in/hr		3.0			15 minutes	Human scheduling error	Not in Violation
32	01/09/96	6:01	Powerhouse	RR*	4	in/hr		25.6			5 hours	Battery Bank Failure	Not in Violation
33	03/20/96	13:00	Powerhouse	RR	1	in/hr		1.8			15 minutes	Needle Valve Changes	Not in Violation
	04/05/96	12:00	Diversion Dam	MF	175	cfs	159		16	cfs	20 minutes	Scheduler error	Not in Violation
34	08/24/96	7:00	Powerhouse	RR	2	in/hr		3.25			1 hour	Unit Off-line: Tunnel Inspec.	Not in Violation
35	09/14/96	10:00	Powerhouse	RR	2	in/hr		inc .31			8 hours	Generation Control Operation	Not in Violation
36	10/16/96	9:58	Powerhouse	RR	1	in/hr		2.76			15 minutes	Water Leak into Transformer bus	Not in Violation
37	10/17/96	3:00	Powerhouse	RR	0.5	in/hr		1.08			15 minutes	Needle Valve Changes	Not in Violation
	10/17/96	9:00	Powerhouse	RR	1	in/hr		1.2			15 minutes	Human scheduling error	Not in Violation

Jackson Project Minimum Flow and Ramp Rate Incident Summary

	Date	Time	Location	Type (RR, MF)	Required (in/hr)	(cfs)	Recorded Flow (cfs)	Recorded Decrease (inches)	Deficient (in/hr)	(cfs)	Event Duration	Cause	FERC Finding
38	03/25/97	9:58	Diversion Dam	MF	175	cfs	146.1		28.9	cfs	8 minutes	SCADA: human error	Not in Violation
39	06/04/97	13:56	Powerhouse	RR	2	in/hr		6.7			13 minutes	Auto Voltage Reg. Relay Open	Not in Violation
40	06/10/97	2:27	Powerhouse	RR	2	in/hr		16.2			7 minutes	2 powerhouse lines de-energized	Not in Violation
	06/10/97	2:27	Diversion Dam	MF	175	cfs	171		4	cfs	7 minutes	3 powerhouse lines de-energized	Not in Violation
41	06/11/97	11:31	Diversion Dam	MF	175	cfs	118		57	cfs	21 minutes	Unit Watthour meter tests	Not in Violation
42	08/25/97	9:06	Powerhouse	RR	0.5	in/hr		1.68			30 minutes	Unit 2 off-line: cooling water loss	Not in Violation
	08/25/97	9:06	Powerhouse	MF	165	cfs	152		13	cfs	30 minutes	Unit 2 off-line: cooling water loss	Not in Violation
43	09/05/97	9:30	Powerhouse	RR	0.5	in/hr		1.56			15 minutes	Unit 2 off-line: cooling water loss	Not in Violation
	09/05/97	9:30	Powerhouse	MF	165	cfs	154		11	cfs	15 minutes	Unit 2 off-line: cooling water loss	Not in Violation
44	04/14/98	15:00	Powerhouse	RR	2	in/hr		2.32			15 minutes	Human scheduling error	Not in Violation
45	07/28/98	3:22	Powerhouse	MF/RR	165	cfs	141.1	6.48	23.9	cfs	10 minutes	Powerhouse lines de-energized	Not in Violation
46	06/22/99	10:56	Diversion Dam	MF	95	cfs	90		5	cfs	4 minutes	Unit 4 tripped off line	Not in Violation
47	08/03/99	21:15	Powerhouse	MF/RR*	165	cfs	114.7	19.92	50.3	cfs	50 minutes	Lightening Surge, BPA main breakers opened - Plant Isolated	Not in Violation
48	09/14/99	11:03	Diversion Dam	MF	95	cfs	80.5		14.5	cfs	20 minutes	Scheduler error in Monitoring	
49	05/26/00	13:56	Powerhouse	RR	2	in/hr		28.8			50 minutes	Intake Gate Closure on false	
	05/26/00	13:56	Diversion Dam	MF	175	cfs	74		101	cfs	50 minutes	over velocity signal	Not in Violation
50	07/22/00	16:16	Powerhouse	MF/RR	165	cfs	132	7.56	33	cfs	50 minutes	Lightening Surge, BPA main breakers opened - Plant Isolated	Not in Violation
51	09/13/01	11:00	Powerhouse	RR	2	in/hr		3.6			15 minutes	Needle Valve Changes	Not in Violation
52	05/05/01	12:33	Powerhouse	RR	2	in/hr		13.8			57 minutes	Tree Limb - Plant Isolated	Not in Violation
53	06/13/02	14:24	Powerhouse	RR	4	in/hr		6.84			6 minutes	Unit tripped off line - temperature sensor	Not in Violation
54	07/01/02	8:06	Diversion Dam	MF			91.6		3.4	cfs	4 minutes	Automation software	Not in Violation
55	07/11/02	10:45	Powerhouse	RR	2	in/hr		1.92			15 minutes	Unit tripped off line - erratic needle valve change	Not in Violation
56	07/27/02	4:00	Powerhouse	RR	1	in/hr		1.32			2 hours	Problem with restoring flows after plant shutdown	Not in Violation
57	11/01/02	3:45	Powerhouse	MF	200	cfs	170		30	cfs	2 hours	Scheduler error in flow reduction	Not in Violation
58	06/19/03	11:15	Diversion Dam	MF	95	cfs	92		3	cfs	3 minutes	Unit tripped off line - short	Not in Violation
59	06/27/03	12:00	Diversion Dam	MF	95	cfs	88		7	cfs	30 minutes	Human error - weir modification	Not in Violation
60	7/2/2003	7:08	Powerhouse	RR	2	in/hr			1.32		15 minutes	Human error - opened TSV man door	Not in Violation
	* = Major Aquatic Impact												

Jackson Project Minimum Flow and Ramp Rate Incident Summary

	Date	Time	Location	Type (RR, MF)	Required (in/hr)	(cfs)	Recorded Flow (cfs)	Recorded Decrease (inches)	Deficient (in/hr)	(cfs)	Event Duration	Cause	FERC Finding
1	5/18-23/88	N/A	Diversion Dam	MF	175	cfs	N/A		N/A	cfs	5 Days	Gage out of calibration	Violation
4	07/31/89	7:15	Diversion Dam	MF	95	cfs	77		18	cfs	75 minutes	Human scheduling error	Violation
5	10/27/89	14:15	Diversion Dam	MF	155	cfs	153		2	cfs	15 minutes	Low alarm setting	Violation
6	03/01/90	7:45	Diversion Dam	MF	175	cfs	166		9	cfs	15 minutes	Low alarm setting	Violation
7	04/12/90	9:30	Diversion Dam	MF	175	cfs	169		6	cfs	15 minutes	Low alarm setting	Violation
8	04/13/90	4:30	Diversion Dam	MF	175	cfs	174		1	cfs	15 minutes	Low alarm setting	Violation
9	04/20/90	11:30	Diversion Dam	MF	175	cfs	174		1	cfs	15 minutes	Low alarm setting	Violation
10	04/27/90	1:30	Diversion Dam	MF	175	cfs	169		6	cfs	15 minutes	Low alarm setting	Violation
11	05/06/90	23:45	Diversion Dam	MF	175	cfs	174		1	cfs	15 minutes	Low alarm setting	Violation
12	05/25/90	0:00	Diversion Dam	MF	175	cfs	174		1	cfs	15 minutes	Low alarm setting	Violation
	05/26/90	15:00	Diversion Dam	MF	175	cfs	174		1	cfs	15 minutes	Low alarm setting	Violation
13	05/28/90	12:45	Diversion Dam	MF	175	cfs	174		1	cfs	15 minutes	Low alarm setting	Violation
14	06/02/90	9:30	Diversion Dam	MF	175	cfs	174		1	cfs	15 minutes	Low alarm setting	Violation
15	10/04/90	6:00	Diversion Dam	MF	155	cfs	141		14	cfs	15 minutes	Low alarm setting	Violation
18	06/04/91	8:45	Diversion Dam	MF	175	cfs	171.5		3.5	cfs	15 minutes	Computer syntax error	Violation
19	06/05/91	3:35	Diversion Dam	MF	175	cfs	167		8	cfs	15 minutes	Gage out of calibration	Violation
20	10/03/91	18:00	Powerhouse	MF	200	cfs	182		18	cfs	30 minutes	Cooling system clogged	Not in Violation
22	03/01/93	2:00	Diversion Dam	MF	175	cfs	172		3	cfs	15 minutes	Scheduler judgement Error	Violation
25	07/18/94	15:23	Powerhouse	MF	165	cfs	154.4		10.6	cfs	6 minutes	Relay Installation Jarring	Violation
	07/15/95	0:00	Powerhouse	MF	165	cfs	124		41	cfs	30 minutes	Loss of cooling water	Not in Violation
29	07/18/95	8:13	Powerhouse	MF	165	cfs	159		6	cfs	15 minutes	Cooling System	Not in Violation
30	09/13/95	12:00	Diversion Dam	MF	95	cfs	73		22	cfs	20 minutes	Operator Error	Not in Violation
	04/05/96	12:00	Diversion Dam	MF	175	cfs	159		16	cfs	20 minutes	Scheduler error	Not in Violation
38	03/25/97	9:58	Diversion Dam	MF	175	cfs	146.1		28.9	cfs	8 minutes	SCADA: human error	Not in Violation
	06/10/97	2:27	Diversion Dam	MF	175	cfs	171		4	cfs	7 minutes	3 powerhouse lines de-energized	Not in Violation
41	06/11/97	11:31	Diversion Dam	MF	175	cfs	118		57	cfs	21 minutes	Unit Watthour meter tests	Not in Violation
	08/25/97	9:06	Powerhouse	MF	165	cfs	152		13	cfs	30 minutes	Unit 2 off-line: cooling water loss	Not in Violation
	09/05/97	9:30	Powerhouse	MF	165	cfs	154		11	cfs	15 minutes	Unit 2 off-line: cooling water loss	Not in Violation
46	06/22/99	10:56	Diversion Dam	MF	95	cfs	90		5	cfs	4 minutes	Unit 4 tripped off line	Not in Violation
48	09/14/99	11:03	Diversion Dam	MF	95	cfs	80.5		14.5	cfs	20 minutes	Scheduler error in Monitoring	
	05/26/00	13:56	Diversion Dam	MF	175	cfs	74		101	cfs	50 minutes	over velocity signal	Not in Violation
54	07/01/02	8:06	Diversion Dam	MF			91.6		3.4	cfs	4 minutes	Automation software	Not in Violation
57	11/01/02	3:45	Powerhouse	MF	200	cfs	170		30	cfs	2 hours	Scheduler error in flow reduction	Not in Violation
58	06/19/03	11:15	Diversion Dam	MF	95	cfs	92		3	cfs	3 minutes	Unit tripped off line - short	Not in Violation
59	06/27/03	12:00	Diversion Dam	MF	95	cfs	88		7	cfs	30 minutes	Human error - weir modification	Not in Violation
2	09/22/88	23:20	Diversion Dam	MF*	155	cfs	54		101	cfs	60 minutes	Faulty circuit board	Violation
3	10/30/88	0:05	Diversion Dam	MF*	155	cfs	23		132	cfs	45 minutes	Human scheduling error	Violation
45	07/28/98	3:22	Powerhouse	MF/RR	165	cfs	141.1	6.48	23.9	cfs	10 minutes	Powerhouse lines de-energized	Not in Violation
50	07/22/00	16:16	Powerhouse	MF/RR	165	cfs	132	7.56	33	cfs	50 minutes	Lightening Surge, BPA main breakers opened - Plant Isolated	Not in Violation

Jackson Project Minimum Flow and Ramp Rate Incident Summary

	Date	Time	Location	Type (RR, MF)	Required (in/hr)	(cfs)	Recorded Flow (cfs)	Recorded Decrease (inches)	Deficient (in/hr)	(cfs)	Event Duration	Cause	FERC Finding
47	08/03/99	21:15	Powerhouse	MF/RR*	165	cfs	114.7	19.92	50.3	cfs	50 minutes	Lightening Surge, BPA main breakers opened - Plant Isolated	Not in Violation
	* = Major Aquatic Impact												

Jackson Project Minimum Flow and Ramp Rate Incident Summary

	Date	Time	Location	Type (RR, MF)	Required (in/hr)	(cfs)	Recorded Flow (cfs)	Recorded Decrease (inches)	Deficient (in/hr)	(cfs)	Event Duration	Cause	FERC Finding
34	08/24/96	7:00	Powerhouse	RR	2	in/hr		3.25			1 hour	Unit Off-line: Tunnel Inspec.	Not in Violation
45	07/28/98	3:22	Powerhouse	MF/RR	165	cfs	141.1	6.48	23.9	cfs	10 minutes	Powerhouse lines de-energized	Not in Violation
39	06/04/97	13:56	Powerhouse	RR	2	in/hr		6.7			13 minutes	Auto Voltage Reg. Relay Open	Not in Violation
	10/03/91	18:00	Powerhouse	RR	2	in/hr		3.96			15 minutes	Cooling system clogged	Not in Violation
21	11/23/92	5:36	Powerhouse	RR	4	in/hr		12.1			15 minutes	Emergency Oil Level	Not in Violation
26	11/01/94	8:23	Powerhouse	RR	4	in/hr		6.84			15 minutes	Brush Rigging Fire	Not in Violation
31	12/24/95	0:04	Powerhouse	RR	4	in/hr		3.0			15 minutes	Human scheduling error	Not in Violation
33	03/20/96	13:00	Powerhouse	RR	1	in/hr		1.8			15 minutes	Needle Valve Changes	Not in Violation
36	10/16/96	9:58	Powerhouse	RR	1	in/hr		2.76			15 minutes	Water Leak into Transformer bus	Not in Violation
37	10/17/96	3:00	Powerhouse	RR	0.5	in/hr		1.08			15 minutes	Needle Valve Changes	Not in Violation
	10/17/96	9:00	Powerhouse	RR	1	in/hr		1.2			15 minutes	Human scheduling error	Not in Violation
43	09/05/97	9:30	Powerhouse	RR	0.5	in/hr		1.56			15 minutes	Unit 2 off-line: cooling water loss	Not in Violation
44	04/14/98	15:00	Powerhouse	RR	2	in/hr		2.32			15 minutes	Human scheduling error	Not in Violation
51	09/13/01	11:00	Powerhouse	RR	2	in/hr		3.6			15 minutes	Needle Valve Changes	Not in Violation
55	07/11/02	10:45	Powerhouse	RR	2	in/hr		1.92			15 minutes	Unit tripped off line - erratic needle valve change	Not in Violation
60	7/2/2003	7:08	Powerhouse	RR	2	in/hr			1.32		15 minutes	Human error - opened TSV man door	Not in Violation
56	07/27/02	4:00	Powerhouse	RR	1	in/hr		1.32			2 hours	Problem with restoring flows after plant shutdown	Not in Violation
	07/18/94	15:23	Powerhouse	RR	4	in/hr		3.4			3 minutes	Relay Installation Jarring	Violation
28	07/14/95	11:45	Powerhouse	RR	1	in/hr		3.48			3 minutes	Loss of cooling water	Not in Violation
42	08/25/97	9:06	Powerhouse	RR	0.5	in/hr		1.68			30 minutes	Unit 2 off-line: cooling water loss	Not in Violation
17	01/03/91	15:33	Powerhouse	RR	2	in/hr		14.3			4 minutes	SCADA malfunction	Not in Violation
32	01/09/96	6:01	Powerhouse	RR*	4	in/hr		25.6			5 hours	Battery Bank Failure	Not in Violation
23	05/01/93	12:52	Powerhouse	RR	4	in/hr		10.5			5 minutes	Cooling system clogged	Not in Violation
27	02/02/95	8:40	Powerhouse	RR	4	in/hr		18.1			5 minutes	PH isolation by BPA	Not in Violation
50	07/22/00	16:16	Powerhouse	MF/RR	165	cfs	132	7.56	33	cfs	50 minutes	Lightening Surge, BPA main breakers opened - Plant Isolated	Not in Violation
47	08/03/99	21:15	Powerhouse	MF/RR*	165	cfs	114.7	19.92	50.3	cfs	50 minutes	Lightening Surge, BPA main breakers opened - Plant Isolated	Not in Violation
49	05/26/00	13:56	Powerhouse	RR	2	in/hr		28.8			50 minutes	Intake Gate Closure on false	
52	05/05/01	12:33	Powerhouse	RR	2	in/hr		13.8			57 minutes	Tree Limb - Plant Isolated	Not in Violation
16	12/31/90	13:34	Powerhouse	RR	4	in/hr		*22.5			6 minutes	Accidental intake closure	Violation
53	06/13/02	14:24	Powerhouse	RR	4	in/hr		6.84			6 minutes	Unit tripped off line - temperature sensor	Not in Violation
24	06/02/93	11:24	Powerhouse	RR	2	in/hr		6.5			7 minutes	Cooling H20 Solenoid failure	Not in Violation
40	06/10/97	2:27	Powerhouse	RR	2	in/hr		16.2			7 minutes	2 powerhouse lines de-energized	Not in Violation
35	09/14/96	10:00	Powerhouse	RR	2	in/hr		inc .31			8 hours	Generation Control Operation	Not in Violation
	* = Major Aquatic Impact												

APPENDIX E

Frequency and Magnitude of Down Ramping Events

APPENDIX E

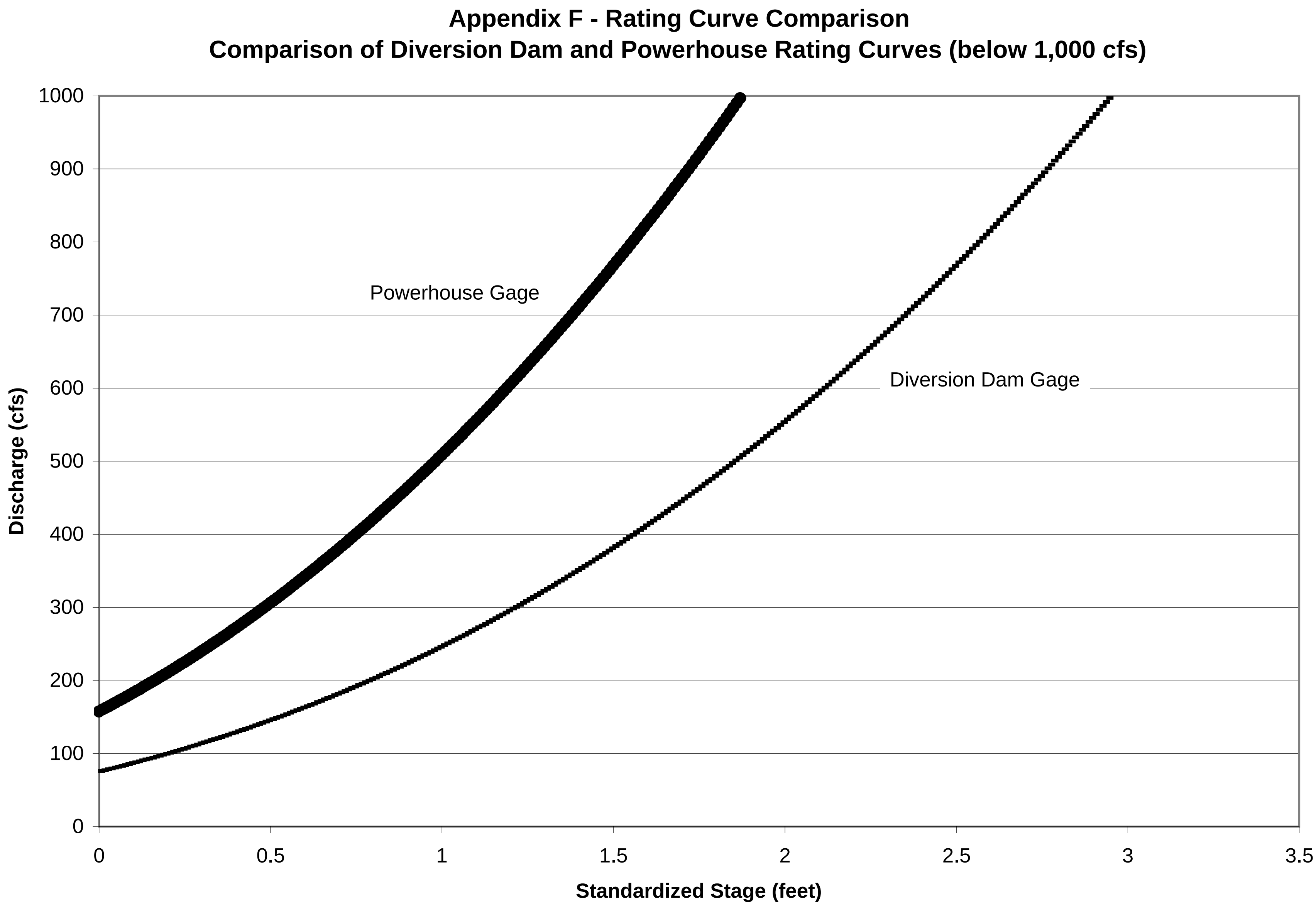
Frequency and Magnitude of Hourly Down Ramping Events During January through May 1985-2003

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Frequency (All flows)																			
Hours in Season	3,624	3,624	3,624	3,648	3,624	3,624	3,624	3,648	3,648	3,624	3,624	3,648	3,648	3,624	3,624	3,648	3,624	3,624	3,624
Hours Operating	2,667	3,547	3,064	3,648	3,624	3,624	3,619	3,074	3,620	3,624	3,624	3,645	3,480	3,616	3,600	3,453	3,006	3,624	3,607
Hours Not Operating	957	77	560	0	0	0	5	574	28	0	0	3	168	8	24	195	618	0	17
Percent of Season - Operating	73.6	97.9	84.5	100.0	100.0	100.0	99.9	84.3	99.2	100.0	100.0	99.9	95.4	99.8	99.3	94.7	82.9	100.0	99.5
No. of Hours Up Ramping Occurred	507	426	354	439	403	397	215	140	194	247	149	236	301	278	197	1156	919	1289	1241
Percent of Operating Hours	19.0	12.0	11.6	12.0	11.1	11.0	5.9	4.6	5.4	6.8	4.1	6.5	8.6	7.7	5.5	33.5	30.6	35.6	34.4
No. of Hours with no change in MW	1,631	2,546	2,186	2,597	2,640	2,651	3,092	2,686	3,135	2,979	3,260	3,092	2,795	2,920	3,144	2,041	2,034	2,172	2,246
Percent of Operating Hours	61.2	71.8	71.3	71.2	72.8	73.2	85.4	87.4	86.6	82.2	90.0	84.8	80.3	80.8	87.3	59.1	67.7	59.9	62.3
No. of Hours Down Ramping > 1 MW Occurred	529	575	524	588	581	576	312	224	267	398	215	293	360	418	259	87	52	137	102
Percent of Operating Hours	19.8	16.2	17.1	16.1	16.0	15.9	8.6	7.3	7.4	11.0	5.9	8.0	10.3	11.6	7.2	2.5	1.7	3.8	2.8
No. of Hours Down Ramping > 2 MW Occurred	200	233	268	227	350	324	154	81	135	234	95	118	141	249	85	49	27	97	78
Percent of Operating Hours	7.5	6.6	8.7	6.2	9.7	8.9	4.3	2.6	3.7	6.5	2.6	3.2	4.1	6.9	2.4	1.4	0.9	2.7	2.2
No. of Hours Down Ramping > 3 MW Occurred	115	178	217	178	216	175	99	44	97	151	60	50	76	198	47	34	17	82	60
Percent of Operating Hours	4.3	5.0	7.1	4.9	6.0	4.8	2.7	1.4	2.7	4.2	1.7	1.4	2.2	5.5	1.3	1.0	0.6	2.3	1.7
No. of Hours Down Ramping > 4 MW Occurred	92	133	171	144	193	140	74	20	69	99	39	28	50	156	23	26	14	61	34
Percent of Operating Hours	3.4	3.7	5.6	3.9	5.3	3.9	2.0	0.7	1.9	2.7	1.1	0.8	1.4	4.3	0.6	0.8	0.5	1.7	0.9

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Frequency (Flows below 750 cfs)																			
No. of Hours Down Ramping > 2 MW Occurred	76	125	140	97	94	35	52	37	78	86	32	29	21	133	13	35	19	47	49
January	27	6	42	27	26	2	20	15	12	7	20	2	1	27	0	12	2	3	1
February	12	35	47	42	39	9	0	6	24	58	1	2	9	32	7	13	5	8	21
March	13	29	20	21	14	18	12	11	24	13	11	8	1	29	2	3	3	13	1
April	11	41	14	7	5	1	9	0	12	7	0	1	6	35	4	0	0	6	16
May	13	14	17	0	10	5	11	5	6	1	0	16	4	10	0	7	9	17	10

APPENDIX F

Rating Curve Comparison



Appendix F - Rating Curve Comparison
Comparison of Diversion Dam and Powerhouse Rating Curves (below 1,000 cfs)
Discharge (cfs)
0
100
200
300
400
500
600
700
800
900
1000
0
0.5
1
1.5
2
2.5
3
3.5
Standardized Stage (feet)
Powerhouse Gage
Diversion Dam Gage