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2.4 SWIFT BYPASS REACH SYNTHESIS (WTS 4)

2.4.1 Study Objectives

The objective of the study was to compile information on the current condition of the Swift bypass reach, and to use this information to evaluate the effects of potential flow-related enhancement measures.

2.4.2 Study Area

The study area was the Swift bypass reach of the North Fork Lewis River, extending from Swift No. 1 Dam to Swift No. 2 powerhouse.

2.4.3 Methods

Existing information on the Swift bypass reach from water quality, watershed processes, terrestrial resource, aquatic resource, recreation resource and engineering studies was compiled for inclusion in the present study. In addition, the following analyses were performed specifically for the current study.

2.4.3.1 Hydrology

The existing hydrology of the Swift bypass reach was compiled from U.S. Geological Survey (USGS) data and records from PacifiCorp. The USGS operated the Lewis River near Cougar, WA stream gage (14218000) from 1917 through 1977. The gage is located at River Mile (RM) 46.8, approximately 1 mile downstream of Swift Dam. Daily flow records from 1924 through closure of Swift Reservoir in 1958 were published by the USGS. Unpublished daily flows were obtained from the USGS for the period 1959-1977. Peak flow records are available from 1917 through 1977. The drainage area represented by this gage is 481 square miles (308,000 acres).

Peak flow frequency analyses were performed using the HECEXE program. This program computes peak flow frequency from annual instantaneous peak flows using the accepted U.S. Water Resources method (U.S. Water Resources Council 1981). Peak flow frequency was computed for pre-project conditions and with-project conditions.

An additional analysis was performed on the pre-project hydrological data using the Indicators of Hydrologic Alteration (IHA) (The Nature Conservancy 2001). This is a statistical program that compiles daily flows for a period of record, and calculates 32 parameters. Examples of the parameters calculated are 1,3, 7, 30 and 90-day minima and maxima, as well as high and low pulse flows. Daily flow data for the water years 1925-1958 were used as input for the model.

Rain and Ole Creek Inflows

Ole Creek flows into the Lewis River at the lower end of the Swift bypass reach and is the only major tributary in the reach. Rain Creek is a tributary to Ole Creek. There are no permanent stream gaging facilities on Rain or Ole creeks. Temporary staff gages have been established at various times as part of the Yale relicensing studies and the Bull

Trout Habitat Enhancement in Rain and Ole Creeks study (AQU 12: PacifiCorp and Cowlitz PUD 2001). The purpose of the staff gage readings was to determine how quickly flows dropped during the spring and to determine when the creeks became intermittent or dry in their lower reaches. Occasional staff gage readings and measurement of flows using a tape and flow meter have been made over the past 2 years, primarily during April, May, and June of 2000 and 2001. Flows during these periods were close to, or slightly lower than the long-term average flows.

In order to estimate inflows from Ole Creek, flows in the creek were predicted using the flow record from the Speelyai Creek near Cougar, WA gage (USGS 14219800). The Speelyai Creek gage was chosen because it had a long period of record (1959-present), and had a similar watershed area and configuration (Table 2.4-1).

Table 2.4-1. Comparison of the Speelyai Creek (at gage) and Ole Creek watersheds.

Watershed	Area (sq mi)	Elevation Range (ft)	Precipitation Range (inches)
Ole Creek	7.4	540-2,800	100
Speelyai Creek (at USGS gage)	12.6	600-2,800	75-110 (most of watershed in 95-110 range)

Initially, Ole Creek flows were predicted from Speelyai Creek flows based on a simple ratio of their drainage areas (i.e., Ole Creek flow = (7.4/12.6) x Speelyai Creek flow). However, when the predicted flows were compared to those measured at the mouth of Ole Creek during the spring of 2000 and 2001, the predicted flows were approximately 10 cfs higher than those measured in Ole Creek (Figure 2.4-1). This is likely a result of the loss of water into the groundwater table in the long alluvial reach at the lower end of Rain and Ole creeks.

A regression line was developed for the flows measured in Ole Creek and those measured in Speelyai to obtain a predictive relationship. This relationship is shown on Figure 2.4-1 and was used to predict mean daily flows at the mouth of Ole Creek based on the mean daily flows measured in Speelyai for the period of record:

$$\text{Flow in Ole Creek (cfs)} = 0.0303 \times \text{Flow in Speelyai Creek}^{1.6171} \qquad (R^2 = 0.9482)$$

A significance test for the regression coefficient was carried out and the power associated with the significance test was estimated. The data set was exported to a statistical analysis program (SPSS) and the regression analysis was performed using the Curve Estimation algorithm provided with SPSS. With a coefficient of determination of R2 = 0.945, test-statistics $F = 138.4$, test significance $p < 0.001$, and power $1 > 0.95$, the correlation was determined to be significant.

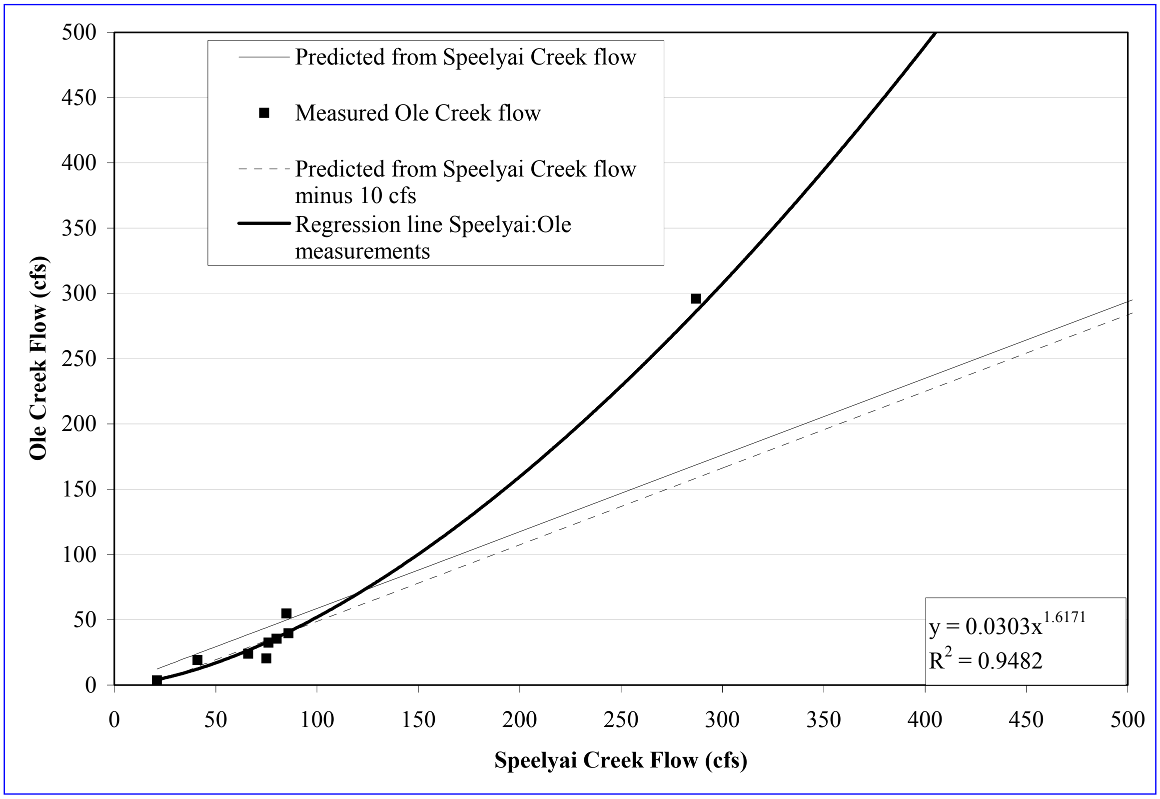


Figure 2.4-1. Comparison of measured and predicted Ole Creek flows.

2.4.3.2 Water Quality/Water Temperature

Water quality and water temperature data used in this study were compiled from previous monitoring conducted by PacifiCorp during 3 separate studies: preliminary sampling prior to Yale relicensing in 1994 (PacifiCorp 1995); Yale relicensing from 1996-1998 (PacifiCorp 1999), and more recently for the combined Lewis River relicensing in 1999 (PacifiCorp and Cowlitz PUD 2001). Field and laboratory methods were reported previously in these documents.

Water Quality

Water quality samples were not collected for laboratory analysis during the 1994 study by PacifiCorp. Monitoring at the Swift bypass reach during Yale relicensing involved monthly field measurement of dissolved oxygen, pH, and specific conductance from March 1996 through February 1998. In conjunction with the field measurements, samples were collected for laboratory analysis of the following parameters:

- turbidity;
- total phosphorus (TP);
- ortho-phosphorus (OP);
- total persulfate nitrogen;
- nitrate + nitrite nitrogen;
- ammonia nitrogen;
- fecal coliform; and
- alkalinity.

In addition to the monthly sampling, a week-long period of continuous (hourly) monitoring of temperature, pH, dissolved oxygen, and specific conductance was conducted in August 1997. The latter study was conducted to augment the monthly program and provide an indication of diel variation during "worst-case" conditions of flow and temperature. The Swift bypass reach was one of 4 sites included in this study; along with the Yale tailrace, Siouxon Creek, and Cougar Creek. All of the water quality monitoring in the bypass reach was conducted in flowing water immediately upstream of Yale Lake, at site SW2BL.

Water quality monitoring in connection with Lewis River relicensing was conducted on a monthly basis from May 1999 through April 2000. Monitoring in the Swift bypass reach during this study was conducted at the same location used during the Yale relicensing studies. Field and analytical methods, as well as sampled parameters, were also the same as those used during the previous study. In total, 36 months of data were collected at site SW2BL, 24 months during Yale and 12 months during the Lewis River monitoring program.

Water Temperature – Modeled Data

To augment empirical data, PacifiCorp and Cowlitz PUD applied SSTEMP (Bartholow 1999), a simple, planning-level temperature model, to predict Swift bypass reach temperatures under a range of flow regimes. This model is best suited to a single stream reach with no major tributaries. SSTEMP simulates average daily temperatures at the bottom of a reach, given the discharge and temperature at the upper end. Other important model inputs are air temperature and humidity, segment length and width, and time of year.

The model was run for each month of the year based on the following input data:

- Beginning discharge: Simulations were done with discharges of 50, 100, 200 and 400 cfs.
- Accretion: Estimated from field observations to be about 10 cfs between Swift Dam and Yale Reservoir. Input from tributaries (Ole Creek) was not included since the model is not capable of modeling tributary flow.
- Accretion-flow temperature: 11°C, the mean annual air temperature at the Cougar weather station.
- Air temperatures: These were taken from average daily values at Cougar, Washington, for the period 1992-2001. From the average daily values, the 10, 50, and 90 percent exceedence values were selected to represent warm, average, and cool monthly conditions, respectively (Table 2.4-2).
- Beginning water temperature: Daily water temperatures in the Swift No. 1 tailrace, measured in 1999-2000, were used to estimate this parameter. The 25, 50, and 75 percent exceedence values were used to represent warm, average, and cool conditions (Table 2.4-2).

Table 2.4-2. Air and water temperatures used in SSTEMP model.

Month	Air Temperature at Cougar (C)			Water Temperature in Swift No. 1 Tailrace (C)		
	cool	average	warm	cool	average	warm
Oct	8.1	11.9	16.4	11.3	12.1	12.7
Nov	3.3	7.2	10.8	9.3	9.8	10.4
Dec	0.8	3.9	6.7	5.3	5.5	5.7
Jan	0.8	4.4	7.5	4.3	4.4	4.9
Feb	1.8	5.3	7.8	4.1	4.3	4.3
Mar	1.8	5.3	7.8	4.3	4.7	5.3
Apr	6	9.2	15.3	6.2	6.5	6.9
May	8.4	13.1	19.4	6.9	7.4	7.9
Jun	11.7	15.6	20.6	8.4	8.8	9.3
Jul	14.4	19.2	24.7	8.8	9.1	10.1
Aug	15.2	19.7	23.9	9.3	9.8	10.6
Sep	12.8	17.5	22.5	9.6	10.7	11.4

For each month, 3 different air temperature and 3 different starting water temperature regimes were simulated for flows from 50 to 400 cfs. This resulted in 9 different scenarios for each month for each of the flow conditions:

- Cool release: temperature with cool, average, and warm air temperature
- Average release: temperature with cool, average and warm air temperature
- Warm release: temperature with cool, average and warm air temperature

2.4.3.3 Aquatic Habitat

An analysis of the stream channel changes in the Swift bypass reach and an inventory of the aquatic habitat were completed as part of the Stream Channel and Aquatic Habitat Study (WTS 3: PacifiCorp and Cowlitz PUD 2001). Stream channel maps of the Lewis River between Swift Dam and Yale Lake were prepared from 1958, 1963, 1974, 1988, 1995, and 1998 aerial photographs.

Available stream gage rating tables/curves for the Lewis River at Cougar gage (14218000) were obtained from the USGS. The river stage at a flow of 1,000 cfs, 4,000 cfs, and 10,000 cfs was determined from each rating table, along with the period that rating table was in effect. This information was plotted to determine if any systematic changes in river stage at a given flow are occurring that could be the result of channel aggradation or degradation.

A field survey of aquatic habitat in the Lewis River between Swift Dam and Yale Lake was made in 1999. The survey included mapping and measuring aquatic habitat units, counting large woody debris in each habitat unit, mapping substrate and spawning gravel, and gravel sampling to determine the size of sediment.

Painted gravel/cobble-sized particles were placed at 4 transects just prior to the instream flow study measurements in May 2000. The particles were monitored for movement following each instream flow release (60, 140, 300 cfs).

2.4.3.4 Riparian Habitat

The study area for riparian habitat in the Swift bypass reach extended from the base of Swift Dam downstream to the Swift No. 2 powerhouse, and bordered by the Lewis River Road and Swift Canal to the north. The southern boundary included an area that ranges from 500 to 2,640 feet from the river. About 523 acres of vegetation were mapped in this area.

Effects of increased flows on riparian habitat in the Swift bypass reach were estimated by using the IFIM data (study AQU 2: PacifiCorp and Cowlitz PUD 2001) and aquatic habitat mapping for this area. For each of the IFIM transects, the wetted width under current conditions (no release) from Swift Dam was subtracted from the wetted width at 50, 100, 200, and 400 cfs to estimate the width of riparian habitat inundated by each of these flows. Each IFIM transect represented a length of aquatic habitat, ranging from about 500 feet to slightly over 2,000 feet in length. A weighted average was then used to estimate the amount of riparian habitat affected by each flow along the entire reach. This method produces a gross estimate of riparian habitat inundated but cannot distinguish effects on the different cover types that make up riparian habitat, nor can it predict changes in cover types due to higher water tables and increased moisture. However, because the majority of the current channel is bordered by either riverine unconsolidated shoreline (unvegetated cobble bars or shorelines) or riparian vegetation, increased flows would be expected to affect these cover types the most. Effects of higher flows on riparian condition and function were based on information from the literature and professional judgment.

2.4.4 Key Questions

The study plan for WTS 4 did not include any “key” watershed questions from the Lewis River Project Watershed Studies.

2.4.5 Results

2.4.5.1 Hydrology

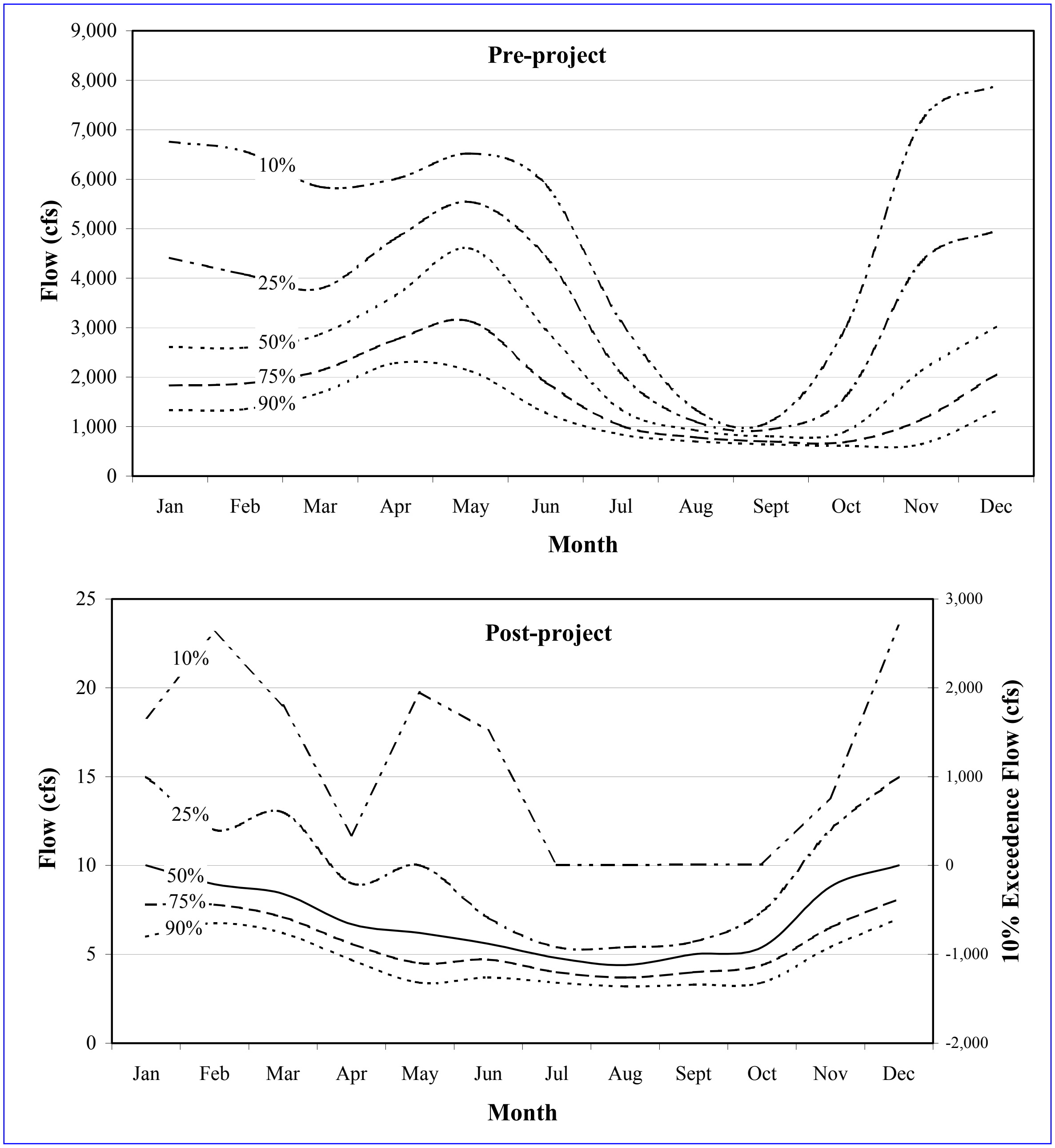
Drainage areas of sub-basins in the Swift bypass reach are shown in Table 2.4-3.

Table 2.4-3 Sub-basin areas for selected stream reaches.

Sub-basin	Sub-basin Area (acres)	Sub-basin Area (sq miles)
Swift bypass reach (total reach)	6,128	9.5
Lewis River Swift Dam – Rain Creek	649	1.0
Rain Creek	1,529	2.4
Ole Creek	3,221	5.0
Lewis River from Rain Creek to Yale Lake	729	1.1

Daily Flow Exceedence

Flow exceedence values by month (based on the daily flows) are shown in Figure 2.4-2. Prior to closure of Swift Reservoir, the 50 percent exceedence flow peaked at approximately 4,500 cfs in May during spring runoff, fell to a low of 900-1,000 cfs during the dry late summer months (July-October), and then rose with fall and winter rains to between 2,000-3,000 cfs though March.



Note: On the with-project graph, the 10% exceedence flow curve is plotted on the scale shown on the right.

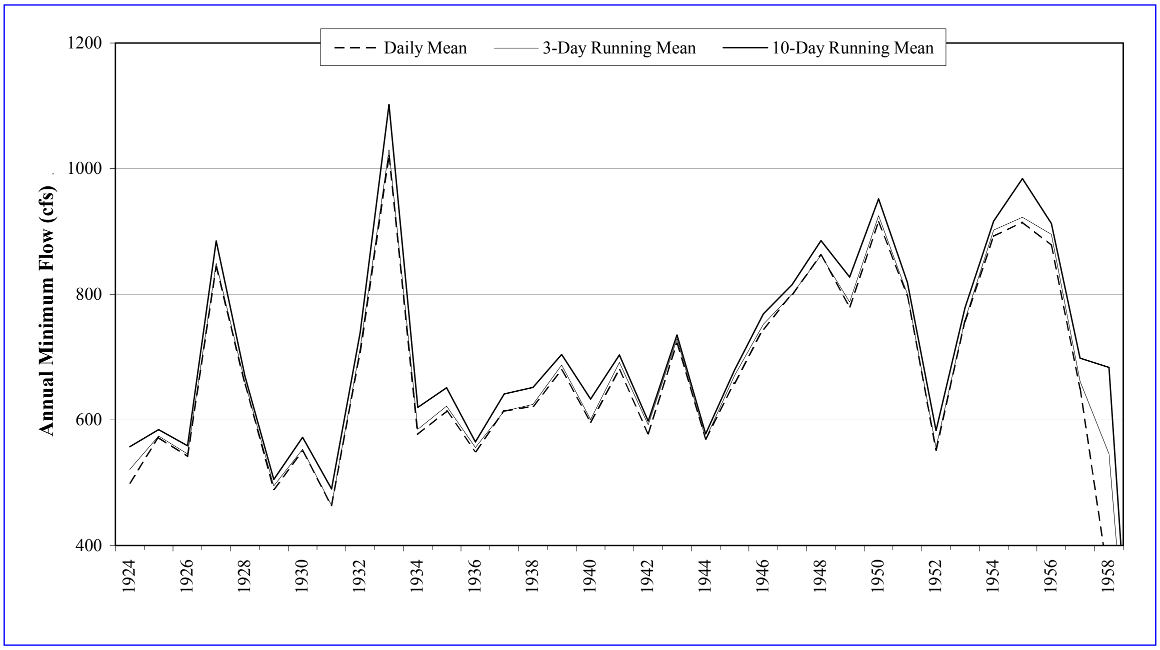
Figure 2.4-2. Daily flow exceedence curve for Lewis River near Cougar (Swift bypass reach, USGS Gage 14218000: pre-project 7/1/1924 to 9/31/1957; post-project 10/1/1958 to 12/31/77).

Under current conditions, flows to the Swift bypass reach come from canal seepage, accretion, spill over Swift Dam, and inflow from Rain and Ole creeks near the bottom of the reach (downstream of the gage location). Flows at the gage site are currently between 5-10 cfs most of the year.

The 10 percent flow reflects the infrequent spill into the reach, either from the Swift Dam spillway, or the canal spillway. Most of the big spills occur during the winter and spring months in response to high inflows. The dip in the 10 percent exceedence flow in April is due to the fact that Swift Reservoir is filling during April, so spills are very infrequent. In May and June, the reservoir is at or near full conditions in anticipation of the summer recreation season, so spills may occur if there are large peak flows from rapid snowmelt.

Base Flows

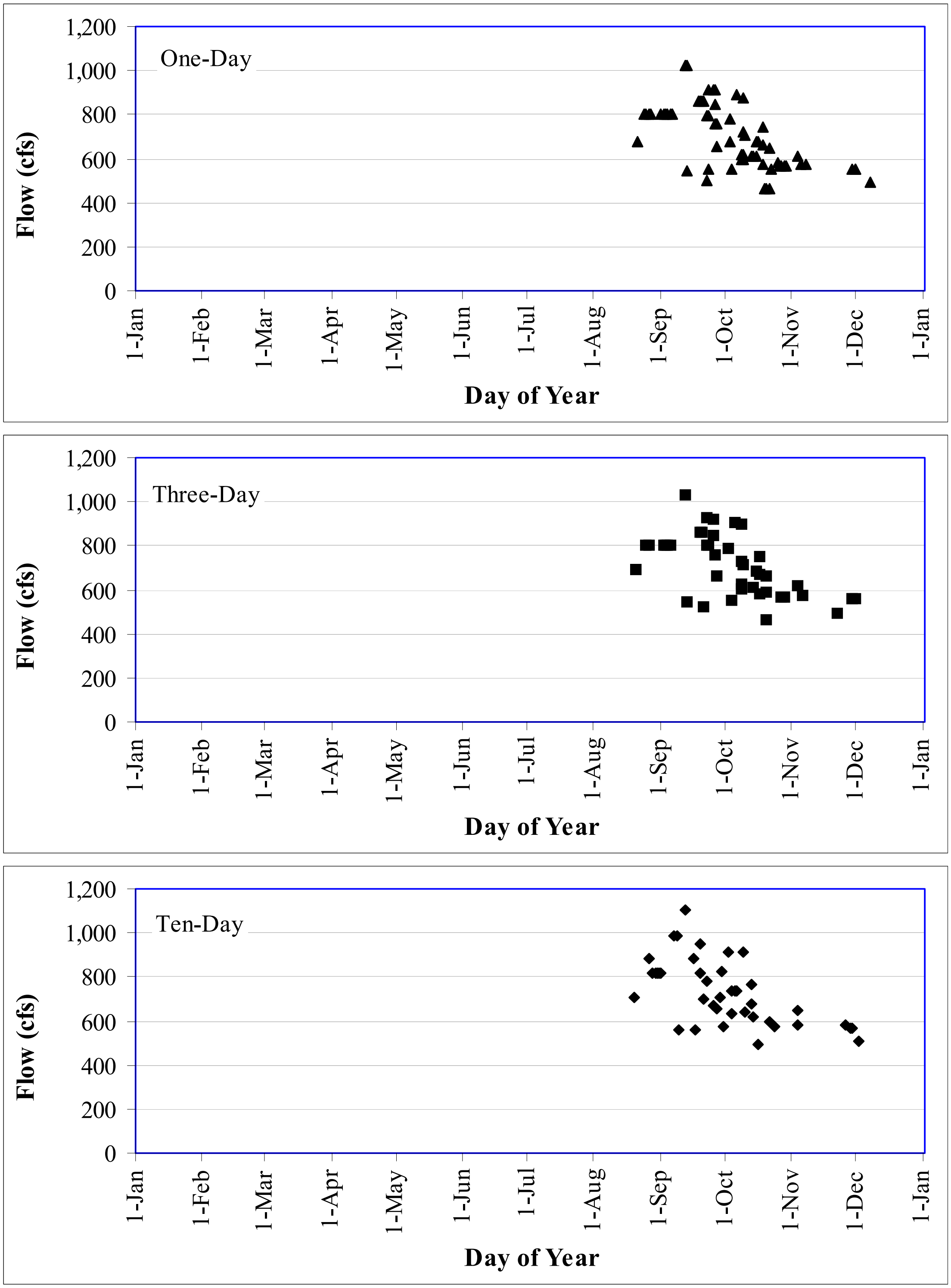
Baseflows were also computed for the gage near Cougar (Figure 2.4-3). Daily base flows refer to the lowest daily mean flow value that occurs during each year. The 3-day and 10-day running mean base flows refers to the lowest 3-day or 10-day running mean of daily flows. Base flows were only computed for pre-project conditions because low flows were not consistently recorded after Swift Reservoir was closed.



Note: only the pre-project flow record was used to compute baseflows due to the inconsistent recording of low flows after Swift Reservoir was constructed.

Figure 2.4-3. Base flow for Lewis River near Cougar (RM 46.8, USGS Gage 14218000).

Base flows prior to construction of Swift Reservoir ranged from 500 to 1,100 cfs. The majority of base flows occurred in the late summer/early fall period (Figure 2.4-4) prior to the start of fall rains. A few base flows occurred as late as early December.



Base flows were estimated annual minimum of daily average flow, 3-day running average flow, and 10-day running average flow.

Figure 2.4-4. Base flow timing for Lewis River near Cougar (USGS Gage 14218000).

Peak Flows

Peak flow frequency was computed for pre-project conditions and with-project conditions (Table 2.4-4). Peak flow analyses are particularly sensitive to the length of record analyzed; a short record can result in large over- or under-estimates of longer recurrence interval flows. The with-project analysis for this site is a good example. The analysis period for the with-project conditions includes only 15 years of data, and the largest flow of the entire record. As a result, the projections for the longer recurrence intervals (over about 10 years) have a large potential error, are skewed to the high side, and should not be regarded as realistic estimates of peak flows under current conditions. The results of the analysis are included here for completeness, but should be used with extreme caution.

Table 2.4-4. Peak flow frequencies, Lewis River near Cougar (14218000).

Chance of flow occurring in any given year	Recurrence interval (years)	Pre-project (flows in cfs)	With-project (flows in cfs)
		1917, 1925-1957	1958-1975
		33 years	15 years
1%	100	62,600	155,000
2%	50	53,700	115,000
5%	20	43,000	74,900
10%	10	35,600	52,300
20%	5	28,500	34,400
50%	2	19,100	15,800
80%	1.25	12,900	7,090
90%	1.11	10,500	4,510
95%	1.05	8,850	3,030
99%	1.01	6,380	1,300

Note: Shaded fields are skewed as a result of short period of analysis. Use results with extreme caution.

The timing of peak flows is shown in Figure 2.4-5. The majority of high flows occur between November and March in response to rainfall and rain-on-snow events. Some peak flows also occur in the spring during snowmelt.

Spills Events

Spill events into the Swift bypass reach since construction of Swift Dam are shown in Figure 2.4-6. Spill into the bypass reach can occur from either the Swift Dam spillway at the upstream end of the reach, or though the canal spillway, located approximately 1 mile downstream of Swift Dam. Spill events are not predictable, and are the result of either high flow events, equipment malfunction, or maintenance activities.

In general, spills over 5,000 cfs occur every few years. Spills as high as 45,000 cfs have occurred during extreme high flow events.

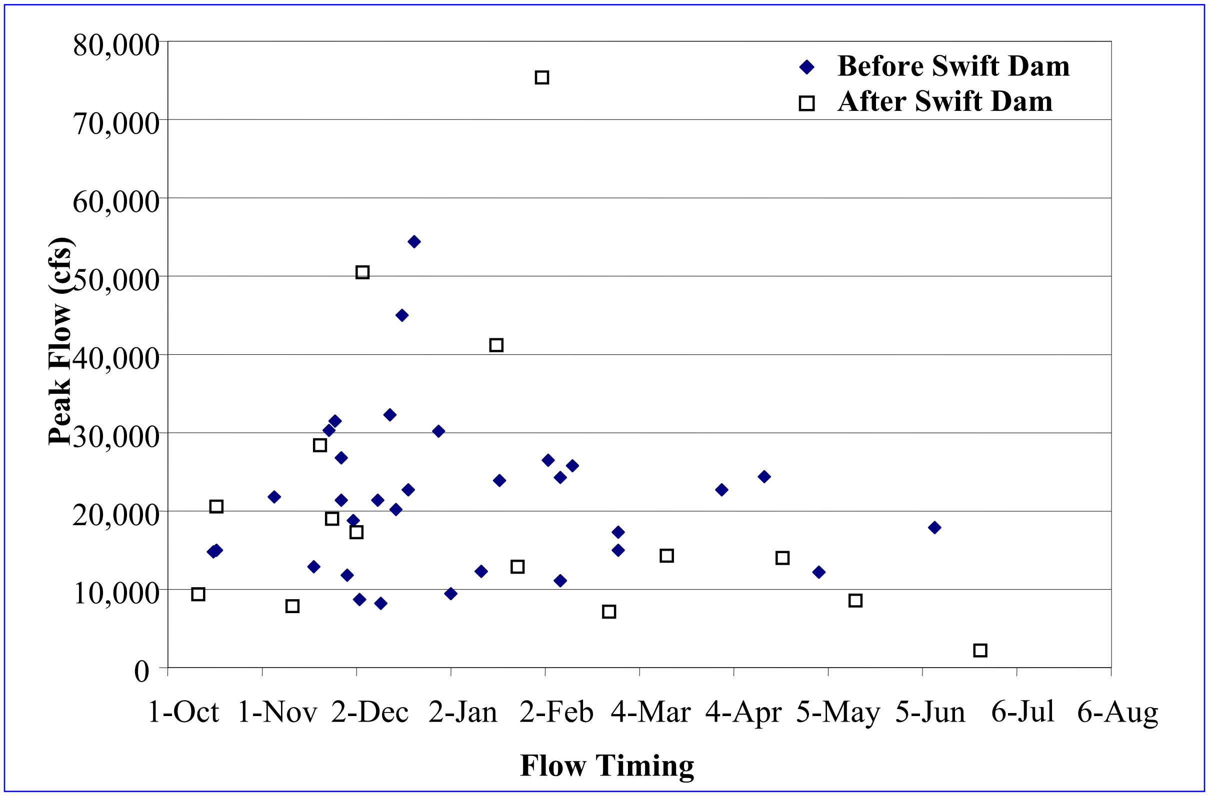


Figure 2.4-5. Timing of peak flows in the Swift bypass reach.

Indicators of Hydraulic Alteration (IHA) Results

The results of the IHA analysis on pre-project conditions are displayed in WTS 4 Appendix 1. Mean monthly flows are given for each water year in Table WTS 4 A-1. In Table WTS 4 A-2, 1, 3, 7, 30, and 90-day minima and maxima are tabulated for each water year. Table WTS A-3 provides information on dates of minimum and maximum flows, pulses in the flow conditions, and reversals in the rising and falling limbs of the hydrograph.

Inflow from Rain and Ole Creeks

Ole Creek is a small tributary that drains northward into the Lewis River at the downstream end of the Swift bypass reach, approximately 0.25 mile upstream of Yale Lake. The Ole Creek watershed consists of 2 smaller sub-basins, Rain and Ole creeks. The drainage area of the 2 creeks is 7.4 square miles. The upper watersheds are steep and forested and underlain by volcanic rocks. The creeks flow across a wide, alluvial terrace before joining the Lewis River. As they flow across the alluvium, they lose a portion of their flow to the ground water table. During low flow periods, the lower 2,000 to 3,000-foot reach of each stream is dry.

The flow exceedence curves for Ole Creek based on the predicted mean daily flows are shown in Figure 2.4-7.

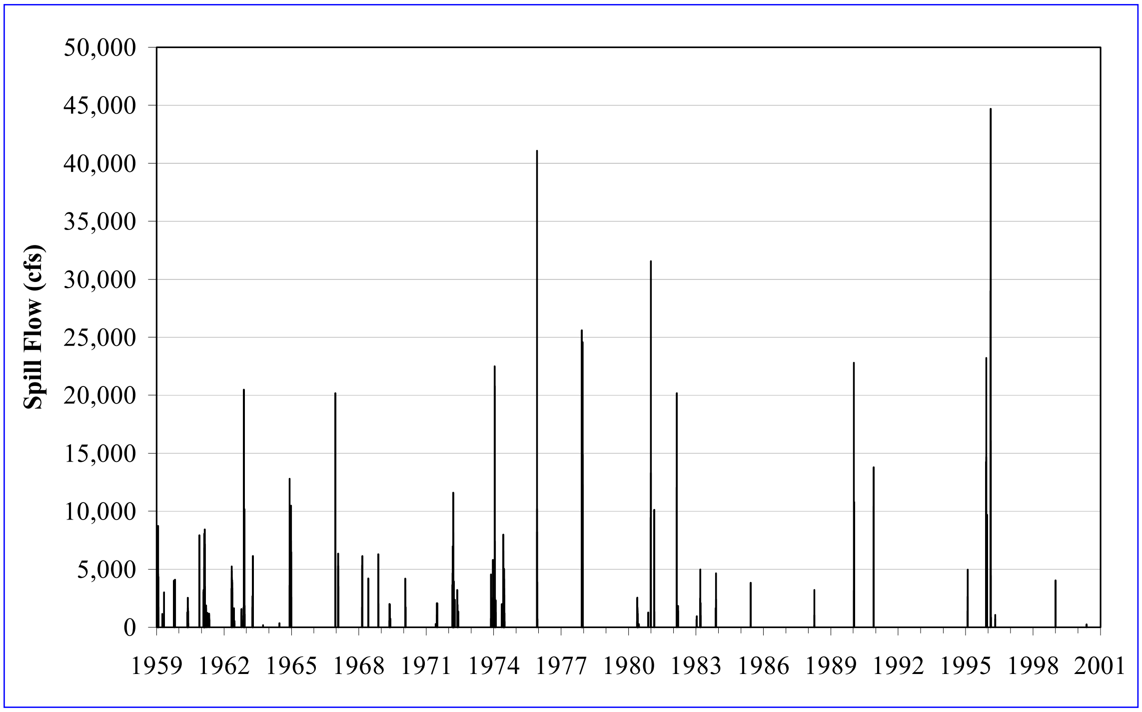
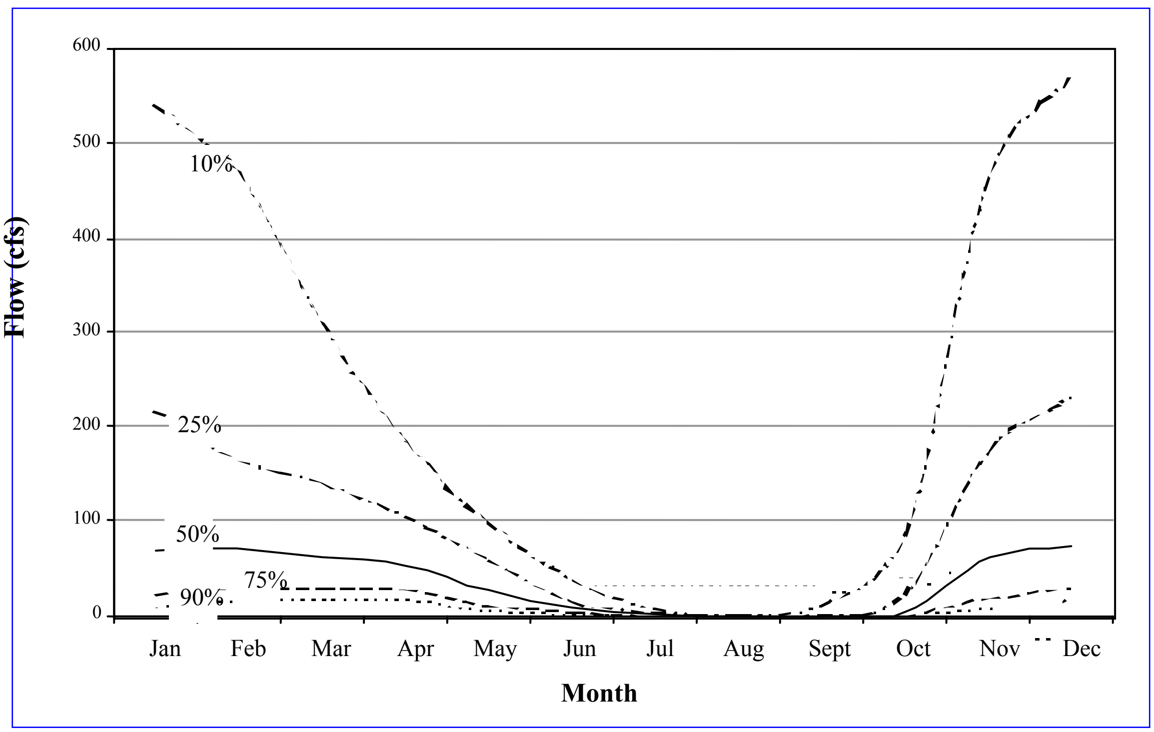


Figure 2.4-6. Spill events in the Swift bypass reach.



Ole Creek flow was estimated from Speelyai Creek flow using regression method.
Q(Ole) = 0.0303 × Q(Speelyai)^1.6171 (R^2 = 0.9482).

Figure 2.4-7. Daily flow exceedence curves for discharge from Ole Creek, from 6/1/1959 to 5/30/2001.

2.4.5.2 Water Quality/Water Temperature

Existing water quality and temperature are summarized below, as are results of the temperature modeling study.

1997 Diel Studies

A summary of the results of the 1997 diel study is shown below (Table 2.4-5). Daily fluctuations in temperature (daily maximum minus daily minimum) averaged 4.5°C at the Swift bypass reach, higher than the 2 other stream sites, but substantially less than the Lake Merwin-influenced Yale tailrace (Figure 2.4-8).

Table 2.4-5. Summary of results of 1997 diel study at Swift bypass reach, Cougar Creek, Siouxon Creek, and Yale powerhouse tailrace; August 16-21, 1997.

	Temp (C)	pH	Specific Conductance (uS/cm)	Dissolved Oxygen Saturation (%)	Dissolved Oxygen (mg/l)
Swift Bypass					
Max	17.6/63.7 (F)	7.2	56.3	104.1	10.4
Min	12.0	7.0	54.8	79.3	8.2
Median	13.8/56.8 (F)	7.0	55.5	86.5	9.0
N	163	163	163	163	163
Yale Tailrace					
Max	24.2	7.7	38.0	107.4	11.1
Min	12.2	6.8	35.0	92.4	8.5
Median	17.0	7.1	36.0	100.7	9.4
N	162	162	162	162	162
Siouxon Creek					
Max	18.8	7.8	47.6	99.0	9.5
Min	13.9	7.3	45.6	86.0	8.2
Median	15.7	7.4	46.5	88.8	8.9
N	163	163	163	163	163
Cougar Creek					
Max	7.8	7.5	36.4	101.5	12.4
Min	6.5	7.2	35.4	97.6	11.8
Median	6.7	7.3	35.8	99.4	12.2
N	163	163	163	163	163

N= Number of hourly observations.

Night-time minimums in dissolved oxygen (DO) concentration and percent saturation were lower, and the magnitude of diel changes in percent saturation were higher in the Swift bypass reach than at the other 3 sites (Figure 2.4-9). Values increased in late afternoon to between 100 percent and 104 percent, and fell to near 80 percent between midnight and 0600 (6 AM). A similar pattern was seen at Siouxon Creek, but with lower maximum and higher minimum values. In contrast to the other 3 sites in the 1997 study, afternoon increases in temperature did not reduce dissolved oxygen concentrations at the Swift bypass reach, but instead there was a positive (albeit weak) relationship. This suggests that primary production was at least a partial determinant of dissolved oxygen levels at the Swift site.

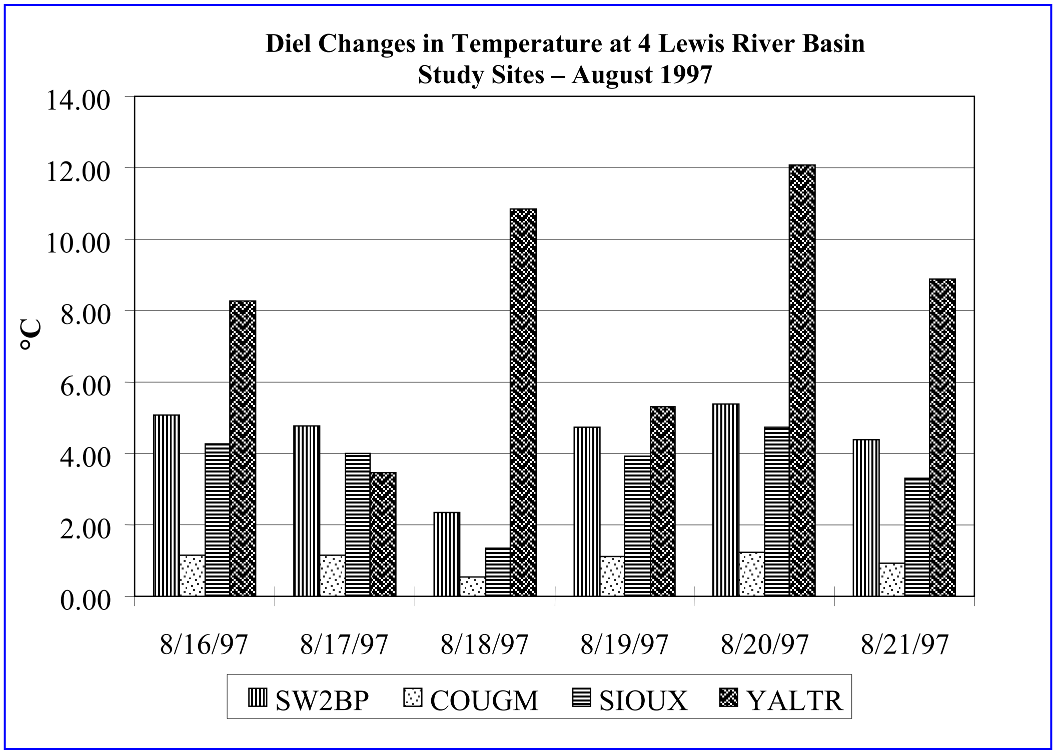


Figure 2.4-8. Diel changes in temperature at Swift bypass reach, Cougar Creek, Siouxon Cr., and Yale powerhouse tailrace; August 16-21, 1997.

<u>Lewis River Relicensing Studies</u> – Data presented below characterize the probable water source (i.e., Swift Reservoir near the current intake [SWRED]; and the Swift tailrace [SW1TR]). Following a brief discussion of the ecological importance of the various water quality constituents monitored, data collected previously at these locations are compared to data at the downstream end of the bypass reach (SW2BL).

<u>Turbidity</u>

A large number of studies have documented turbidity as a key factor influencing rates of prey consumption and energy required for predation by salmonids, and for piscivorous fish in general. For brook trout (*Salvelinus fontinalis*) held in an artificial stream at low turbidity (less than 3 Nephelometric Turbidity Units [NTUs]), and high turbidity (>40 NTUs), fish at high turbidity became more active and switched foraging strategies from drift feeding to active searching, resulting in significantly lower growth rates (Sweka and Hartman 2001). Vogel and Beauchamp (1999) studied factors influencing reaction distances of lake trout and found reduced detectability of prey (shorter reaction distance) with increasing turbidity (from 0.09 NTUs to 7.4 NTUs). Reduced ability to consume prey and slower growth rates appear clearly linked to high turbidity in salmonids, and are a likely factor in avoidance of particular stream reaches (Guensch et al. 2001). However, warmwater species may be more tolerant. A study involving largemouth bass (*Micropterus salmoides*) found no significant differences in the capture success of northern redbelly dace (*Phoxinus eos*) during *in situ* feeding trials in 2 Lake Ontario coastal wetlands differing in turbidity levels (2.3 and 20 NTUs) (Reid et al. 1999). In laboratory feeding trials, this same study found the number of fathead minnows

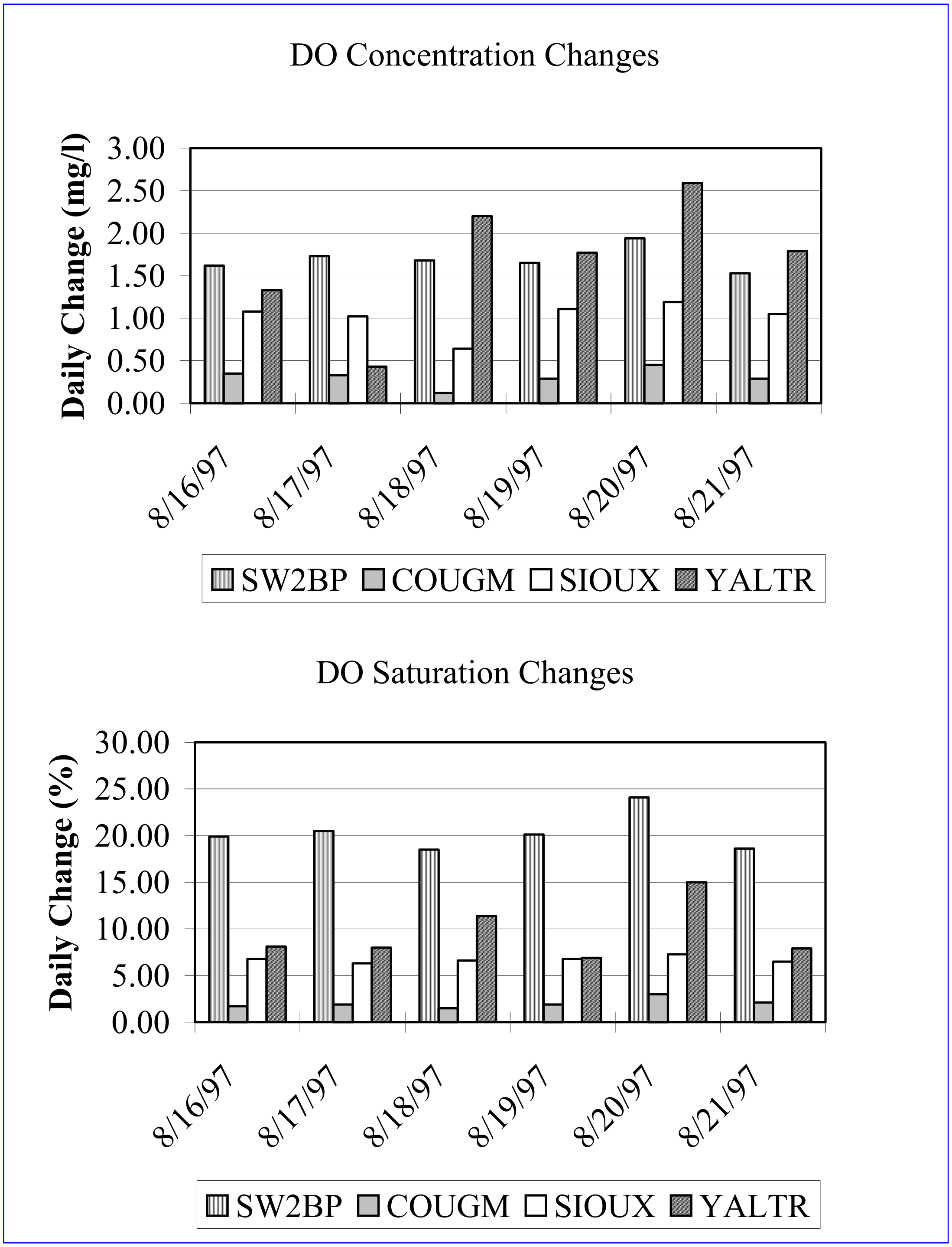


Figure 2.4-9. Diel changes in DO concentration (top) and percent saturation (bottom) at Swift bypass reach, Cougar Cr., Siouxon Cr., and Yale powerhouse tailrace; August 16-22, 1997.

(*Pimephales promelas*) captured was not significantly different among 1-, 18- and 37-NTU treatments, although the capture rate at 70 NTUs was significantly lower than at 1 NTU (Reid et al. 1999).

In addition to effects on forage success and growth rates, seasonal changes in turbidity may be an important environmental cue stimulating smoltification in anadromous fish. A turbidity-induced transition from upstream to downstream swimming occurred in mid- to late-April for Atlantic salmon parr (*Salmo salar*), followed by an increase in liver thyroxin levels (T_4, an indicator of onset of parr-smolt transformation) within 4 hours of increased turbidity (Specker et al. 2000).

A compilation of all turbidity data previously collected at the downstream end of the bypass reach shows typical values under 2 NTUs, with excursions to over 16 NTUs in January 1997 (Figure 2.4-10).

Comparison of data collected near the Swift No. 1 intake and at the tailrace with bypass reach data indicated that turbidity during the summer months is low and very similar among all 3 sites. However, while bypass reach turbidity remains low (1-2 NTUs) during the winter months, levels at depth in the reservoir and in the Swift tailrace are considerably higher (greater than 6 NTUs November through January, Figure 2.4-11). This suggests that winter turbidity in the bypass reach may increase substantially with flow additions taken near the intake of Swift.

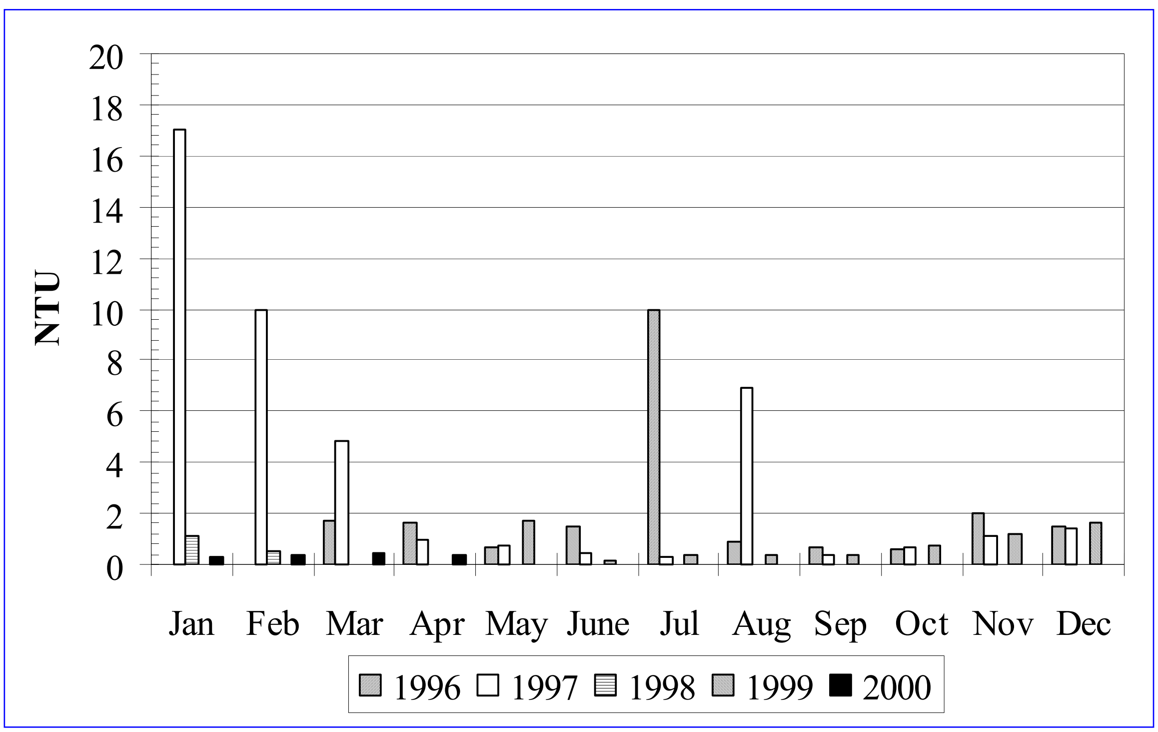


Figure 2.4-10. Turbidity at the Swift bypass reach, 1996–2000.

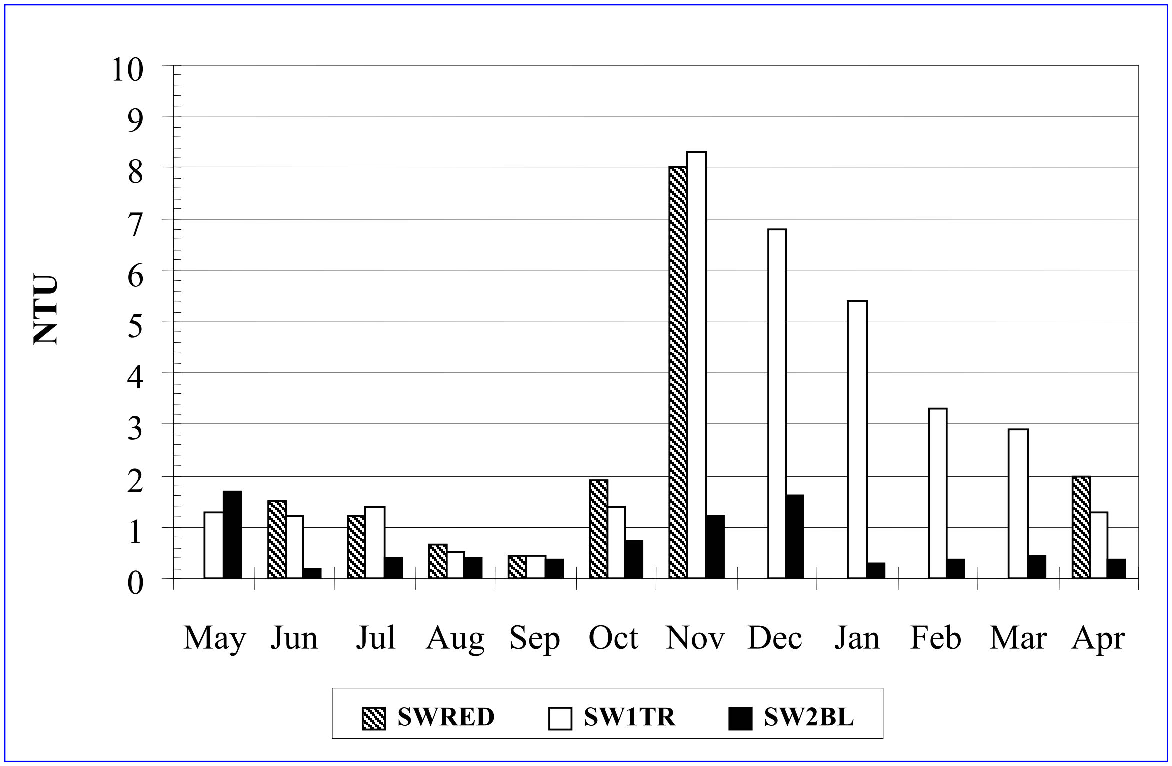


Figure 2.4-11. Comparison of turbidity measurements in 1999-2000 at Swift Reservoir near the intake, at the Swift No. 1 tailrace, and at the Swift bypass reach.

Nutrients – The nutrient regime in an aquatic environment (primarily nitrogen and phosphorus) largely dictates the type and complexity of primary producers, such as periphytic algae and phytoplankton, as well as the diversity of secondary producers such as macroinvertebrates and zooplankton. Nutrient levels in streams also have a significant effect on the ecology of the riparian zone, as seen in comparisons of growth rates in trees and other riparian species among spawning and non-spawning areas (Helfield and Naiman 2001). Nutrient concentrations reflect geochemical influences as well as anthropogenic disturbances and land use impacts. Criteria and thresholds have been developed that predict the trophic status and overall health of aquatic systems based on nutrient concentrations (Carlson 1977). In addition to increasing trophic status, excessive nutrient loading may increase bioavailability of mercury and organic pollutants in stream biota (Greenfield et al. 2001; Berglund et al. 1997). Nutrients monitored in the Lewis River are an important ecological indicator for current conditions, as well as benchmark parameters for assessment of management actions or future changes in land use. A summary of nutrient data collected at Swift Reservoir sites (SWRED, SW1TR, and SW2BL) is discussed below.

Winter nitrogen concentrations in the bypass reach are currently higher than levels measured near the intake depth in Swift Reservoir and the Swift No. 1 tailrace (Figure 2.4-12). Allochthonous nitrogen inputs (leaf fall) from riparian sources are the likely reason for higher N concentrations in the bypass reach from November through April.

Higher flows from Swift Reservoir would likely reduce (dilute) nitrogen concentrations during this period. While the same dilution effect would occur with other nutrients, for example ammonia and phosphorus, these parameters are more variable and no changes can be predicted due to increased flow. However, nutrient loading in the bypass reach, i.e., the total quantity or mass of nutrients, would be higher due solely to the increased flow.

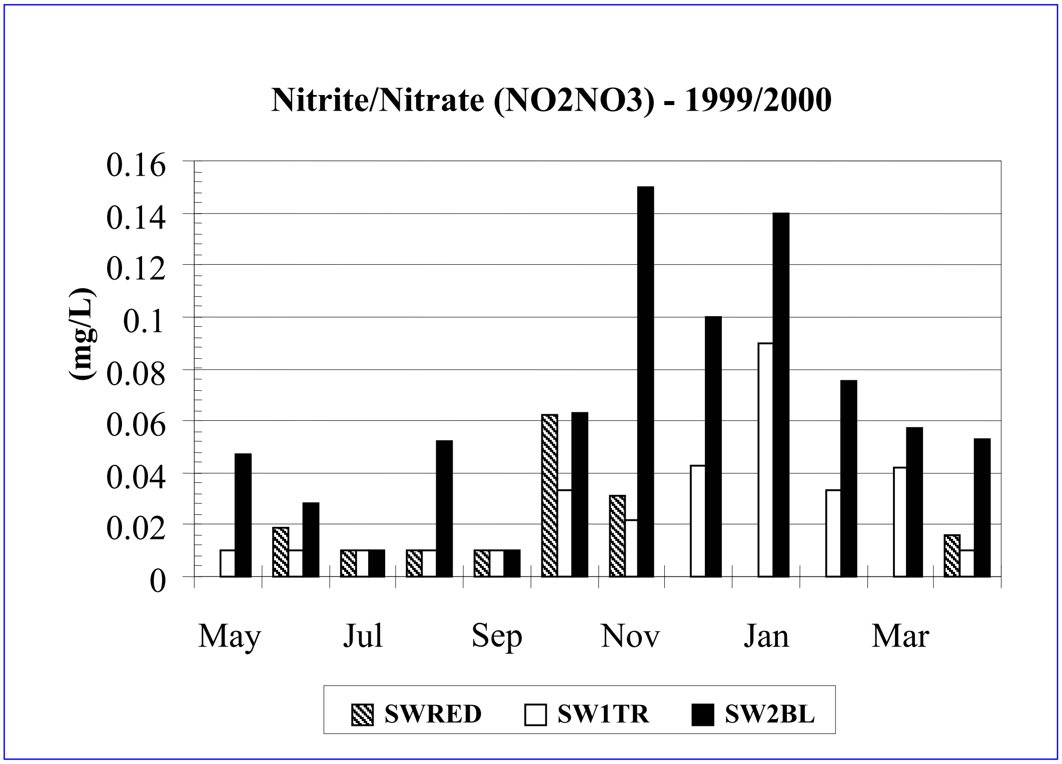


Figure 2.4-12. Nitrogen (nitrate+nitrite) at Swift Reservoir near the intake, the Swift 1 tailrace (SW1TR), and at the Swift bypass reach (SW2BL).

Alkalinity – Alkalinity is a measure of a stream or water body's acid neutralizing capacity; its ability to buffer reductions in pH utilizing carbonate and bicarbonate. Alkalinity is an integrative measurement largely determined by watershed geochemistry, and interactions between groundwater and surface water. In general, oligotrophic lakes and nutrient poor streams, such as those in high elevation granitic watersheds with shallow soils, have low alkalinity. Streams draining lower elevation watersheds, with deeper soils and sedimentary geology have generally high alkalinity. Ecologically, alkalinity imparts protection from low pH, which is particularly important from the standpoint of metals bioavailability, e.g., mercury (Greenfield et al. 2001), ensuring a chemical environment suitable to a broader range of plant and animal species (Vestergaard and Sand-Jensen 2000).

Comparison of alkalinity data collected near the Swift No. 1 intake tailrace with bypass reach data indicate that levels are fairly similar among the 3 sites throughout the year (Figure 2.4-13). No major changes in alkalinity (major cation concentrations) would be expected with addition of hypolimnetic flows to the bypass reach.

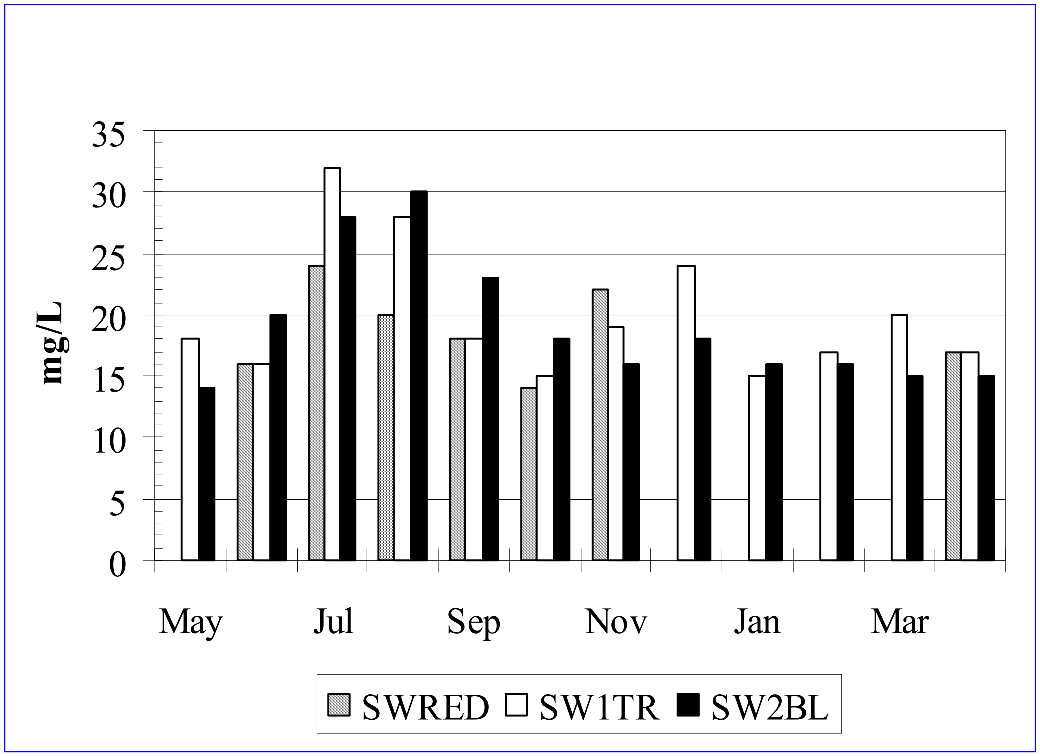


Figure 2.4-13. Alkalinity at Swift Reservoir near the intake (SWRED), the Swift 1 tailrace (SW1TR), and at the Swift bypass reach (SW2BL).

Water Temperature – Empirical Data – Changes in water temperature are likely to be the most measurable effect of increased flow to the Swift bypass reach. Currently, temperature at the downstream end of the bypass reach is several degrees warmer than the Swift No. 1 tailrace (Figure 2.4-14).

A site at the upper end of the Swift bypass reach (SW2BU) was monitored during 1996 in connection with Yale relicensing. This site was approximately 2 miles upstream of the lower bypass reach site (SW2BL), in an area of large boulders with little riparian shading. July and August median and maximum temperatures were warmer at the upper site, most likely due to the influence of accretion flows from Ole Creek, and increased shading in the lower section of the bypass reach which reduced the downstream temperatures (Table 2.4-6).

A pattern observed in comparing temperature data collected near the intake at Swift Reservoir with tailrace data is that the reservoir temperatures are consistently cooler than tailrace temperatures, even during summer full-pool conditions (Figure 2.4-15). Reservoir data in this case are at a depth of 45 meters (148 feet), the intake depth at full pool. Potential reasons for this difference include: 1) water quality measurement depths are lower than the intake due to lower reservoir elevation in summer, hence deeper, colder water was measured; 2) physical warming due to friction within the turbine itself, leading to warmer tailrace temperatures; or 3) mixing of water pulled from higher in the water column into the turbine penstock, resulting in slightly higher tailrace temperatures.

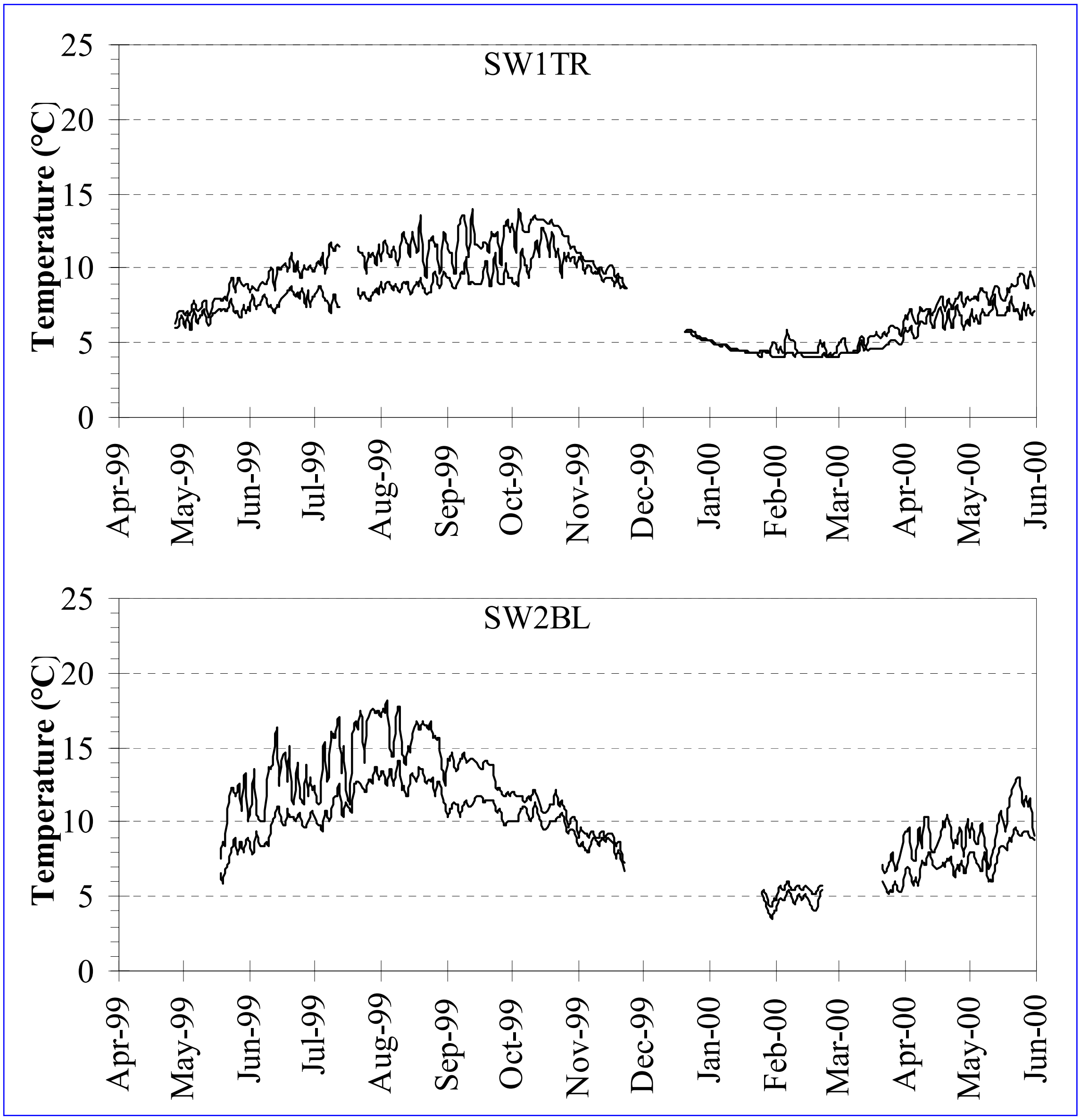
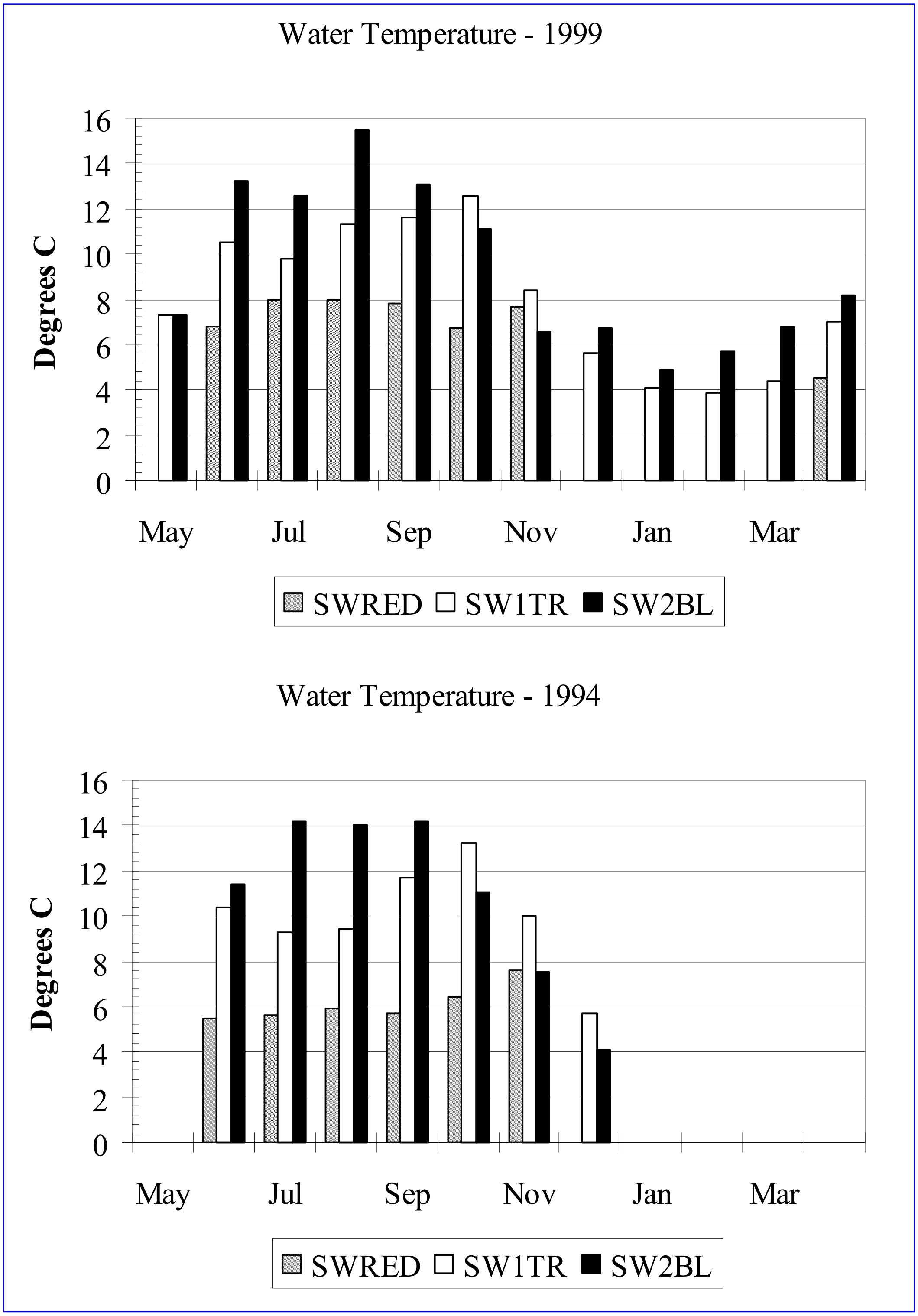


Figure 2.4-14. Daily maximum and minimum temperatures at Swift No. 1 tailrace (top), and the Swift bypass reach (bottom); April 1999 through June 2000.

Table 2.4-6. Comparison of water temperatures at upstream and downstream locations within the Swift bypass reach, July and August, 1996.

	July 1996		August 1996	
Site	**Median**	**Maximum**	**Median**	**Maximum**
SW2BU	14.7	19.7	13.6	18.3
SW2BL	13.8	18.5	13.3	17.8



Note: All data are instantaneous measurements made during monthly *in situ* sampling.

Figure 2.4-15. Water temperature at depth in Swift Reservoir near the intake (35 m, SWRED), at Swift No. 1 tailrace (SW1TR), and at the downstream end of the Swift bypass reach (SW2BL).

Figure 2.4-16 shows late-summer (August and September) profiles of Swift Reservoir. Pronounced stratification is evident at this time of year. During August, the epilimnion occupied depths from the surface to 10 meters (33 feet), the metalimnion from 10 to 45 meters (33-148 feet), and hypolimnion from 45 meters to 100 meters (148-328 feet). Epilimnetic temperatures were between 19 and 20 °C, metalimnetic temperatures between 6 and 19 °C, and hypolimnetic temperatures between 5 and 6 °C. At a depth of 45 meters (148 feet), the intake to Swift No. 1 is in the uppermost hypolimnion, although little change in temperature occurs between 45 meters and the reservoir bottom.

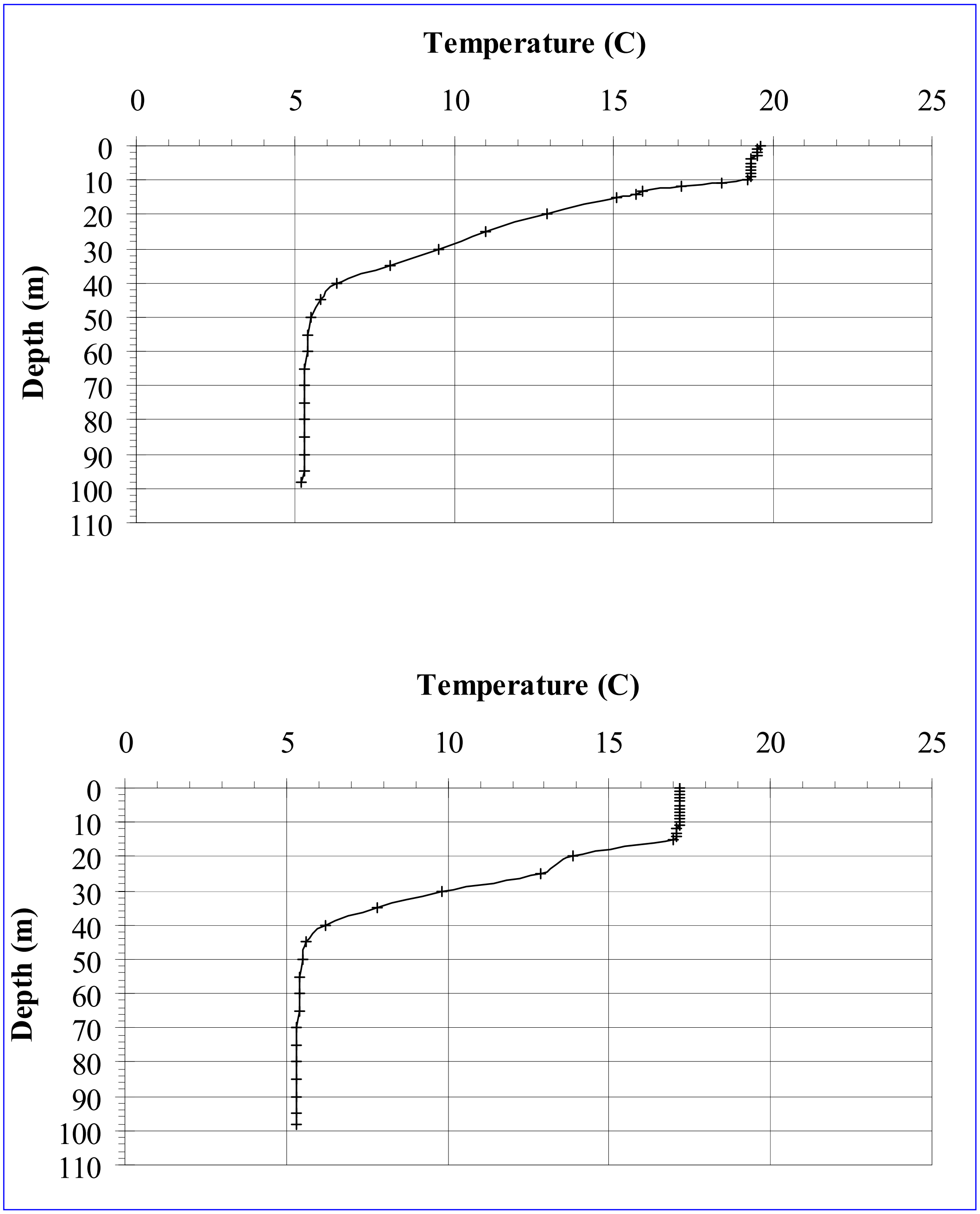


Figure 2.4-16. Vertical profile of temperature measurements at Swift Reservoir near the dam (SWRED) in August (top) and September (bottom), 1999.

As seen in Figure 3.1-6(a) in WAQ 1 (PacifiCorp and Cowlitz PUD 2001), fall turnover in Swift Reservoir begins in September in the epilimnion, and surface temperatures cool to approximately 8 °C by December (approximately 3 degrees warmer than bottom temperatures at that time). However, while epilimnetic temperatures drop by 12 °C, the water column below 40 meters (131 feet) varies little throughout the year, remaining between 5 and 6 °C.

The maximum temperature measured at the Swift No. 1 tailrace (13.9ºC) occurred during September and October of 1999. Maximum temperature (18.2ºC) at the downstream end of the bypass reach occurred in August 1999. Timing of maximum tailrace and reservoir temperatures reflects turnover of Swift Reservoir, which occurs in late summer/ early fall. In contrast, the Swift bypass reach thermal regime reflects seasonal changes in air temperatures, and maximums are reached earlier in the year. Assuming flow additions to the bypass reach originate at depth in Swift Reservoir, maximum temperatures in the bypass reach would be expected to occur approximately one month later than they currently do. In addition, the bypass thermal regime would be expected to be more stable, i.e., there would be less diel fluctuation than currently exists. Median diel fluctuation (maximum temperature minus minimum temperature) in July at the lower bypass reach (SW2BL) was 4.1ºC, and was 2.6ºC at the Swift No. 1 tailrace.

<u>Adequacy of Bypass Reach Temperatures for Salmonids</u>

As depicted in Table 2.4-7, median summer temperatures in the Swift bypass reach under existing conditions are at the upper end of preferred ranges for salmonids based on 1999 data and life history requirements for species that historically spawned in the Lewis River (PacifiCorp and Cowlitz PUD 2001: Study AQU 1). Existing maximum summer temperatures exceed the optimal ranges for all salmonid species, particularly bull trout. A summary of preferred ranges for Lewis River salmonids is presented below.

In general, favorable water temperatures for incubating salmonid eggs range between 4 and 14°C (Bjornn and Reiser 1991). The upper lethal temperature for Chinook fry is 25.1°C; the preferred temperature is 12 to 14 °C (Scott and Crossman 1973). The optimum temperature for growth depends on food availability, and salmonids will not grow until their metabolic requirements are met (Murphy 1995).

The length of time required for coho salmon eggs to incubate in the gravel is largely a function of temperature. In the Lewis River, at 10°C, fertilization to eyed-egg stage takes about 3.5 weeks, eyed-egg to hatching takes about 2.5 weeks, and hatching to emergence about 8 weeks (Hymer et al. 1993). Preferred water temperatures for coho range from 9 to 13°C (WDFW 1994).

The peak of chum salmon migration generally usually occurs when water temperatures range between 7° and 11°C. Preferred water temperatures for spawning range from 7.2 to 12.8°C (45 to 55°F) (Bell 1986). Favorable water temperatures for incubation and emergence range between 4 and 14°C (39 and 57°F) (Bjornn and Reiser 1991).

Table 2.4-7. Summer (June through September) and winter temperatures at the downstream end of the Swift bypass reach, and generalized optimal temperatures for salmonids.

Swift Bypass Reach Temperatures (°C)						Generalized Optimal Temperatures (°C) for Lewis River Salmonids and Life Stages (as available)											
Date	N	Min	Mean	Median	Max	Chinook			Coho	Chum		Steelhead		Cut-throat	Bull Trout		
					life stage→	spn	egg	fry	all	spn	egg	spn	fry	all	spn	egg	fry
Jan	nm	nm	nm	nm	nm											2-4	
Feb-00	516	4.1	5.1	5.2	6.0		4-14				4-14						
Mar	nm	nm	nm	nm	nm												
Apr	nm	nm	nm	nm	nm							7 (3.8-12.6)					
May	nm	nm	nm	nm	nm												
Jun-99	719	7.8	10.9	10.7	16.2			12-14	9-13				10-13	10			2-10
Jul-99	744	9.3	13.2	13.0	17.6												
Aug-99	742	11.2	14.2	14.1	18.2												
Sep	nm	nm	nm	nm	nm	5.6-13.9									5-9		
Oct	nm	nm	nm	nm	nm		4-14									2-4	
Nov	nm	nm	nm	nm	nm					7.2-12.8	4-14						
Dec	nm	nm	nm	nm	nm												

N= number of hourly observations.
Spn = spawning
Source: PacifiCorp and Cowlitz PUD 2001: WTS 1 and AQU 1.

The optimum spawning temperature for steelhead is about 7°C (45°F), but they have been reported spawning at temperatures of 3.8° to 12.6°C (39 to 55°F) (Bell 1986, Barnhart 1991). The preferred water temperature for rearing steelhead ranges from 10 °C to 13°C (Bjornn and Reiser 1991). Rearing cutthroat trout require temperatures of about 10°C; the upper lethal temperature for rearing cutthroat trout is 22.8°C (Bjornn and Reiser 1991).

All life forms of bull trout generally spawn in low gradient stream reaches with water temperatures between 5 and 9°C. Optimum water temperatures for bull trout have been estimated at 2 to 10°C, while temperatures above 15°C are thought to provide a thermal barrier for most bull trout (Federal Register, Vol. 63, No. 111, June 10, 1998). A narrow range from 10 to 12°C represents the preferred water temperatures for spawning migrations. Optimum water temperatures for incubation are between about 2° and 4°C (McPhail and Murray 1979; Brown 1985; and Carl 1985 *in* Brown 1992). Existing temperatures in the Swift bypass reach at the time of emergence for bull trout (primarily the month of February), are between 4 and 6 °C, slightly above the preferred range of 2-4°C.

2.4.5.3 Aquatic Habitat

An analysis of the stream channel changes in the Swift bypass reach and an inventory of the aquatic habitat were completed as part of the Stream Channel and Aquatic Habitat Study (WTS 3). The sections below are compiled from Section 2.3 of the 2000 Technical Report (PacifiCorp and Cowlitz PUD 2001).

Stream Channel Mapping

Stream channel maps of the Lewis River between Swift Dam and Yale Lake were prepared from 1958, 1963, 1974, 1988, 1995, and 1998 aerial photographs. The maps show the extent of the wetted channel, side channels, and active bars (Figure 2.3-12).

The maps show that the active river channel has decreased in width following closure of Swift Dam. Vegetation has encroached on the former active channel. However, during extremely large spill events that occur every decade or so (Figure 2.4-5), the vegetation is uprooted, widening the active channel. Vegetation encroaches again following the spill, and the cycle repeats.

Channel Aggradation

An analysis of Lewis River at Cougar gage data indicate that no systematic aggradation or degradation of the river bed took place at the gage location between the 1920s and late 1950s (Figure 2.4-17). However, following construction of Swift Dam in 1958, the gage data indicate that the river began to aggrade at the gage location. The aggradation appears to be episodic, and corresponds with high flows (spills) in the reach. It is likely that during the spills, gravel from upstream of the gage was flushed down and accumulated in the large pool at the gage site or on the bar just downstream. The gage height record stops in 1975; it is not known if the aggradation trend continued or not. It is known that large spills in the Swift bypass reach transport wood and sediment through the reach and disrupt the riparian vegetation. These effects will continue during the period of the new license if large spill events continue to occur as part of flood management procedures.

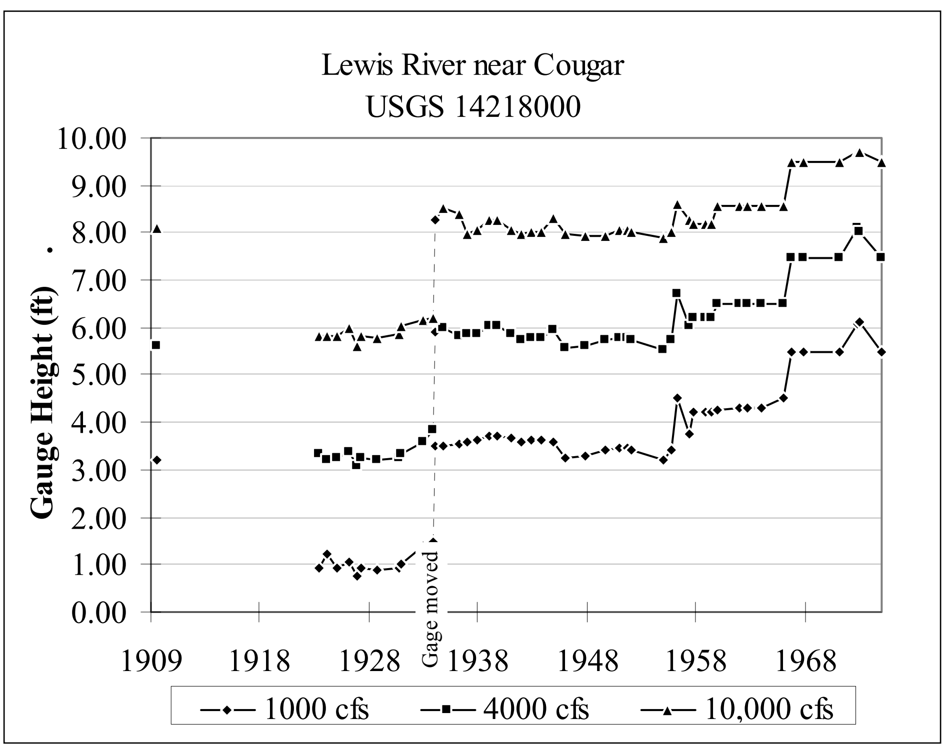


Figure 2.4-17. Gage height versus given flow for the Lewis River at Cougar gage.

Sediment Input

Under current conditions, there is little input of sediment into the Swift bypass reach upstream of Ole Creek. No major upslope sediment sources exist in the reach. The only sediment comes from gravel and cobble stored in the bars along the reach. During large spill events, some of the stored sediment is moved into the active channel. This occurred during the 1996 spill event (peak flow was approximately 40,000 cfs) and resulted in some small gravel deposits on the downstream side of boulders in the reach. These gravel deposits were absent during the 1994 river survey conducted as part of the Yale relicensing studies. It is likely that the gravel deposits will slowly be flushed downstream and out of the reach during future moderate spill events.

The Rain/Ole creek watersheds supply sediment, including gravel and cobble-sized particles to the Lewis River downstream of their confluence. This is evident from the field survey of substrate and the substrate samples (see following section).

Sediment input from soil creep, landslides, and road surface erosion were estimated for the Rain/Ole creek watersheds. Soil creep and road surface erosion were estimated using the SEDMODL GIS program. Landslide input was estimated based on an inventory of aerial photographs (1963, 1974, 1980, and 1999), size and estimated depth of each landslide.

All estimates were annualized for comparison; in reality sediment input is episodic in response to large rainfall events. Sediment inputs from each source is shown in Table 2.4-8.

Table 2.4-8. Sediment input from the Ole Creek watershed (estimates in average tons/year).

Soil Creep	Landslides	Road Surface Erosion	Total	Average tons/acre/year
66	11,375	4	12,445	2

Soil creep refers to the slow downslope movement of soil in response to gravity and biogenic causes. It is the result of natural ecosystem processes and encompasses creep, tree throw, and animal burrowing. An estimated 85 tons/year is supplied to the Rain and Ole watersheds from soil creep.

Annually, an average 11,375 tons/year of sediment is added to streams in the Rain and Ole creek watershed. Much (90 percent) of this input is from naturally occurring landslides in the steep, forested basins. Approximately 10 percent of the input is related to roads or timber harvest in the watershed. Landslides represent a very episodic sediment source.

The third major source of sediment in the Rain and Ole creek basins is surface erosion from roads. There are approximately 21 miles of road in the watersheds that occasionally are used to access timber harvest units, and frequently are used by recreationists. Based on these use levels, an average of 5 tons of sediment annually is added to Rain and Ole creeks from road surface erosion.

The soils and sediment in the Rain and Ole creek watersheds are derived from volcanic rocks and have a large fraction of gravel and cobble particles. The Soil Conservation Service (currently called Natural Resource Conservation Service) has mapped and sampled soil in Skamania County, the area encompassing the Swift bypass reach (SCS 1974). They report that soils in the Rain and Ole creek watersheds are composed of an average of 55 percent gravel (20 percent >3 inches), 10 percent sand, and 25 percent silt and clay. This is the source of the large amount of cobble and gravel found in the lower reaches of the creeks, that is routed to the lower bypass reach during high flow events.

Aquatic Habitat and Substrate

Fish and aquatic organisms prefer to have a variety of habitat and substrate conditions present in their environment, including features that provide hiding cover from predators, feeding opportunities, and sites to deposit and incubate eggs. Different life stages of fish and other organisms are adapted to specific habitat and substrate conditions, with a mix of pools, riffles, and glides important for various life stages and needs. Preferred habitat for juvenile coho, steelhead, spring Chinook, and cutthroat during the winter months includes side channels and backwater channels, especially those areas with heavy groundwater influence. These areas provide protection from extreme flows, freezing temperatures, and predation (Sandercock 1991). Side channels of rivers are also important spawning habitat. Their slower water velocities protect eggs from scouring during flooding and their relatively narrow channels offer better instream and overhanging cover to hide fry after they emerge from the gravel.

The Swift bypass reach is dominated by riffle (37 percent) and glide (28 percent) habitat (Table 2.4-9). Approximately 19 percent of the reach is pool habitat; 12 percent is classified as side channels. Substrate was dominantly cobble and small boulder with gravel downstream of Ole Creek. There was very little large woody debris within the wetted or high water channel; however, boulders provided cover. Details of the aquatic habitat and substrate sampling are included in Section 2.3.5.2 and in WTS 3 Appendices 1, 2, and 3 (PacifiCorp and Cowlitz PUD 2001).

Table 2.4-9. Distribution of aquatic habitat units in the Swift bypass reach.

Habitat Type	Total Number	Total Length (ft)	Percent Length	Area (ft^2)	Percent Area
Pool	8	2,274	12%	178,924	19%
Riffle	22	5,548	28%	353,939	37%
Glide	22	5,027	26%	266,188	28%
Cascade	6	690	4%	31,465	3%
Dry Channel	1	670	3%	NA	NA
Side Channel	2	5,498	28%	115,998	12%
Total	61	19,707	100%	946,514	100%

Note: Measurements include side channel habitat units. The actual bypass reach measured 14,209 feet in length.

Four size classes of large woody debris were counted in each habitat unit. The location of the woody debris was also noted (within wetted channel or within bankfull channel). A total of 10 small wood pieces (defined as over 12 inches in diameter and over 25 feet long) and 44 pieces of brush (defined as over 6 inches in diameter and over 25 feet long), were located within the bankfull channel. Only 7 of these pieces (3 small and 4 brush) were within the wetted channel. This is an average of 42.4 pieces per mile of small and brush-sized wood. The majority of wood was in the downstream end of the reach.

The riparian zone closest to the active channel in the Swift bypass reach is dominated by alder, with some large cottonwoods. There are few large coniferous trees in the riparian zone. As a result, recruitment potential of large woody debris from the riparian forests in the bypass reach is low. The riparian areas in lower Ole Creek contain larger trees, with overstory trees estimated between 10-24 inches diameter at breast height (dbh) based on aerial photograph interpretation. The Ole Creek riparian stands are a mix of black cottonwood, Douglas-fir, and mixed hardwood/conifer stands. Observations of lower Ole Creek show more abundant large woody debris loading in the creek than in the upper Swift bypass reach, indicating Ole Creek is a source of large woody debris as well as gravel.

During the field survey, pebble counts and river bed substrate samples were made at 3 locations, approximately every mile. Results of the substrate sampling are summarized in Figure 2.4-18. The substrate samples upstream of Ole Creek were primarily large particles (over 64 mm median diameter); those downstream of Ole Creek were much finer, with a median diameter closer to 32 mm.

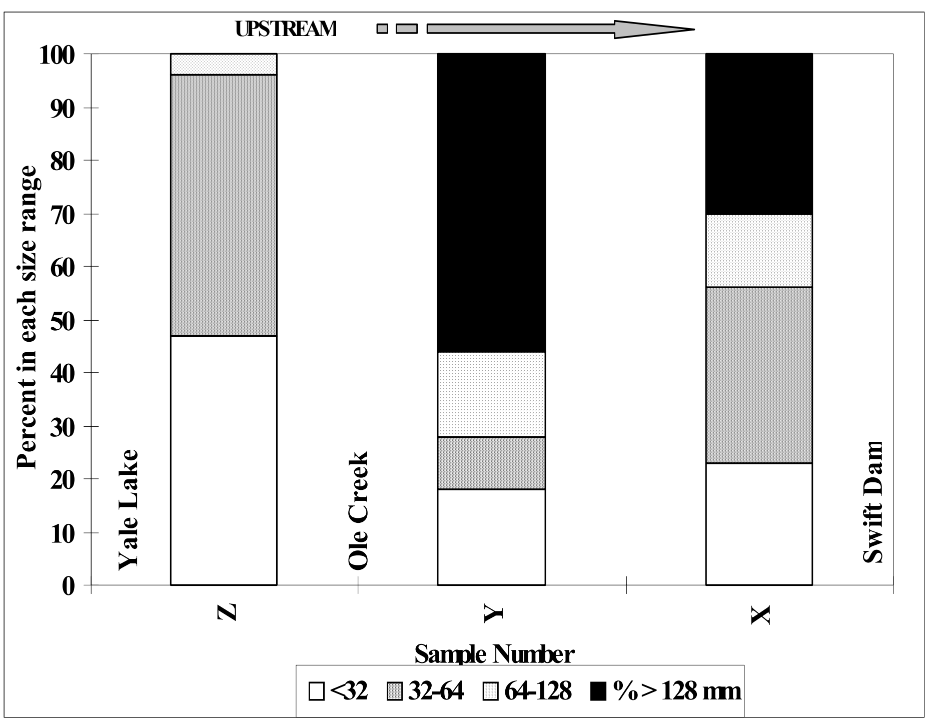


Figure 2.4-18. Change in grain size distribution of surface (armor) gravel samples in the Swift bypass reach.

Samples of spawning gravel were also collected at 2 locations in the bypass reach downstream of Ole Creek, and 1 location in Ole Creek. No substantial accumulations of spawning gravel were found upstream of the Ole Creek confluence. Results of the spawning gravel sampling are summarized in Table 2.4-10. The sampled spawning gravel had a median diameter of 13-17 mm (0.5-0.7 inches), 4-9 percent particles finer than 2 mm, and a Fredle Index of 7-10. These metrics indicate the available spawning gravel is good quality. There is a lack of suitably-sized spawning gravel for most resident salmonids and anadromous salmonid species upstream of Ole Creek.

Table 2.4-10. Summary of spawning gravel samples, Swift bypass reach and Ole Creek.

Sample	D_{84}[a] (mm)	D_{75} (mm)	D_{65} (mm)	D_{50} (mm)	D_{25} (mm)	D_{16} (mm)	Dg[b] (mm)	Sorting Coeffi-cient[c]	Fredle Index[d]	% finer than 2 mm	% finer than 1 mm
Average Swift Bypass 1	26	21	17	13	6	3	18	5	5	9%	5%
Average Swift Bypass 2	23	19	16	13	7	4	20	3	7	4%	1%
Average Ole	25	20	17	13	5	3	17	4	5	8%	5%

[a] D_{84} through D_{16} indicate the grain size (in mm) of the 84th through 16th percentile. In other words, a D_{84} of 27 mm indicates that 84% of the sample was smaller than 27 mm and 15% of the sample was coarser than 27 mm.

[b] Dg is the geometric mean of the sample and is defined as $Dg=(D_1^{W1} \times D_2^{W2} \times \ldots\ldots Dn^{Wn})$ where Dn is the midpoint diameter of particles retained on the nth sieve and Wn is the decimal fraction of particles retained on the nth sieve.

[c] The sorting coefficient is defined as D_{75} divided by D_{25} and is a dimensionless coefficient.

[d] The Fredle Index is defined as Dg (in mm) divided by the sorting coefficient.

Brightly-painted groupings of gravel/cobble sized rocks were placed at 4 locations in the Swift bypass reach just prior to the flow releases for the instream flow study. The rocks were visually inspected following each flow release (approximately 60, 140, and 300 cfs) and during a later survey in September 2000 to determine if they had been transported by any flows. No movement at either of the upstream transects was noted during the instream flow study, indicating that transport of gravel would not be expected to occur at flows up to at least 300 cfs. Minor movement (up to a few feet) was noted at the lower 2 transects following the 300 cfs release (with inflow, measured at 362 cfs at the downstream end of the bypass reach). Between May and September, substantial movement of rocks did occur at the 2 downstream-most transects (just upstream and downstream of the Ole Creek confluence). Flows in the reach during this period are not known, but a high flow event was recorded at the gage in Speelyai Creek (660 cfs on June 12, 2000). Based on this information, it is anticipated that flows of around 400-500 cfs will initiate gravel transport, at least in the lower portions of the bypass reach.

2.4.5.4 Riparian Habitat and Wetlands

The habitat mapping in the study area included 58 acres of disturbed and developed lands, and 287 acres of upland shrub and forest types, 16 acres of wetlands, 85 acres of riparian vegetation, and 78 acres of riverine cover types (Table 2.4-11). Through most of the bypass reach, the river is bordered primarily by riparian and upland deciduous forests and stands of riparian shrubs. Riparian vegetation dominates the islands, bars, and low terraces within the old channel and is maintained by the current hydrological regime. Terraces along the existing channel support upland deciduous forests at lower elevations and conifer forest types in higher locations. Most of the wetlands in the bypass reach are north of the river, outside and several feet in elevation above the main channel. Although the majority of the wetlands appear to be created and maintained by seepage from the Swift canal and beaver dams, a few may be hydrologically connected to the river.

Table 2.4-11. Vegetation cover types in the Swift bypass reach study area.

Cover Types	Area(ac)	Percent of Area (%)
Developed/Disturbed/Sparsely Vegetated	58.24	11
Uplands		
Conifer Forest	205.27	39
Mixed Deciduous/Conifer Forest	13.09	3
Deciduous Forest	67.87	13
Shrublands	0.88	<1
Upland Total	**287.11**	**55**
Wetlands		
Palustrine Unconsolidated Bottom	0.36	<1
Palustrine Emergent Wetland	0.29	<1
Palustrine Scrub-shrub Wetland	9.43	2
Palustrine Forested Wetlands	5.89	1
Wetland Total	**15.97**	**3**
Riparian		
Riparian Deciduous Forest	54.52	10
Riparian Mixed Forest	9.26	2
Riparian Shrub	20.74	4
Riparian Total	**84.52**	**16**
Riverine/Lacustrine		
Riverine Unconsolidated Bottom	19.26	4
Riverine Unconsolidated Shore	57.90	11
Lacustrine Unconsolidated Bottom	0.34	<1
Riverine/Lacustrine Total	**77.50**	**15**
Bypass Reach Total Area	**523.34**	**100**

Riparian habitat in the Swift bypass reach was characterized using the U.S. Fish and Wildlife's (USFWS) Habitat Evaluation Procedure and is depicted in Table 2.4-12. Both riparian and upland deciduous forests in the bypass reach are characterized by a dense canopy of red alder (*Alnus rubra*) trees. Riparian stands are distinguished by the presence of black cottonwood (*Populous balsamifera trichocarpa*), some of which are quite large. Shrub canopy cover in riparian deciduous stands is moderate and consists primarily of non-native blackberry species (*Rubus discolor, R. laciniatus*). Hydrophytic shrubs, such as red osier dogwood (*Cornus stolonifera*) and salmonberry (*Rubus spectabilis*), are almost completely lacking. The high flows that periodically occur in the bypass reach may create conditions favorable to non-native blackberry species, which are extremely invasive and quickly colonize disturbed areas. Shrub cover in upland deciduous forests is relatively low, and consists of vine maple (*Acer circinatum*), Oregon grape (*Mahonia nervosa*), hazelnut (*Corylus cornuta*), and trailing blackberry (*Rubus ursinus*), all native species.

The one riparian mixed forest stand that was sampled in the bypass reach appears to be somewhat less disturbed than many of the riparian deciduous stands. This stand was characterized by a mix of cottonwood, big-leaf maple (*Acer macrophyllum*), and Douglas-fir (*Pseudotsuga menziesii*). Shrub cover was moderate and consisted primarily of native shrubs, including some red osier dogwood, a hydrophytic species. The riparian shrub stands in the Swift bypass reach are typical of communities that occur on gravel bars and islands along rivers and streams in western Washington (Pojar and MacKinnon 1994). These areas are dominated by Sitka willow (*Salix sitchensis*), a native hydrophytic shrub that can quickly colonize moist sites and withstand periods of high, swift water.

Palustrine forest wetlands in the Swift bypass reach are generally dominated by red alder, although a few western red cedar (*Thuja plicata*) occur as well. Shrub cover is low and the understory consists primarily of grasses, sedges (*Carex* spp.), rushes (*Juncus* spp.) and forbs. Pockets of water appear to persist year round. In contrast, the palustrine scrub-shrub wetlands in the bypass reach support dense stands of hydrophytic shrubs, primarily willow and red-osier dogwood, and have a relatively sparse cover of herbaceous species.

Table 2.4-12. Structural characteristics of riparian and wetland habitats in the Swift bypass reach[1].

Habitat Parameter	Upland Deciduous Forest[2] (n=3)	Riparian Deciduous Forest (n=5)	Riparian Mixed Forest (n=1)	Riparian Shrub (n=2)	Palustrine Scrub-shrub (n=2)	Palustrine Forest (n=2)
Mean tree canopy cover (%)	99 (98-100)	88 (77-98)	80	0	0	75 (53-98)
Mean deciduous shrub canopy cover (%)	11 (0-20)	29 (12-52)	55	66 (53-79)	85 (70-100)	14 (5-22)
Mean hydrophytic shrub canopy cover (%)	0	1 (0-3)	7	63 (47-79)	85 (70-100)	2 (0-5)
Mean combined tree/shrub cover (%)	99 (98-100)	95 (81-100)	97	66	85 (70-100)	80 (64-98)
Mean overstory tree height (ft)	75 (62-95)	72 (33-115)	105	--	--	66 (59-22)
Mean shrub height (ft)	--	5.9 (3.3-9.5)	5.9	8.2 (6.9-9.8)	7.5 (3.9-10.8)	2.3 (1.6-2.9)
Mean no. trees >20 in. dbh/ac	11 (4-24)	12 (0-32)	49	0	0	12 (0-24)
Mean no. of snags/ac	5 (0-16)	17 (0-44)	16	0	0	0
Mean no. snags >20 in. dbh/ac	1 (0-4)	0	8	0	0	0
Mean no. logs > 7 in. large-end diameter/ac	40 (16-73)	43 (20-69)	73	8 (0-16)	2 (0-4)	34 (8-61)

[1] The range of each habitat parameter is shown in parentheses.
[2] Upland deciduous forests were included because they represent riparian habitat in higher areas along the existing channel and are often intermixed with riparian deciduous forests.

2.4.5.5 Recreation Resources and Use

Recreation resources in the Swift bypass reach include undeveloped dispersed use opportunities—tent camping, bank fishing, swimming/wading, tubing, hunting, and wildlife observation. There were 5 undeveloped dispersed campsites, primarily located to the west near the IP Road bridge near the shallow pools and sandy beaches. Based on 1996 user counts, an occasional inflatable boat was observed in the river near the bridge. An average of 2 bank anglers were also seen fishing along the shoreline in this area during each survey. A few camping parties were typically observed here, averaging 9 people (2 to 3 parties) during holiday weekends and 6 people (1 to 2 parties) during non-holiday weekends. An average of 4 vehicles were parked at this location during holiday and non-holiday weekends. One or more swimmers/sunbathers and 3 to 5 people relaxing were also observed on a continuous basis. As many as 5 tents at one time were observed here during a peak use weekend. Several small user-defined trails exist in and around these dispersed campsites.

Another area that receives repeat visitation is a dispersed campsite below the Swift canal and south of the highway. An average of 6 people during holiday weekends and 2 people during non-holiday weekends were observed here. During hunting season, hunters were also dispersed throughout the bypass reach and surrounding lands. Many hunters camp at the old log sorting area in the southern bypass reach area where concrete foundations exist. Several large groups of RV campers who were hunting were observed here in the fall of 1999. The rest of the bypass reach received no significant recreation use. Large teenager parties were once held in the bypass reach; however, access roads have been barricaded in recent years, which has reduced this type of activity.

2.4.5.6 Generating Resources and Uses

<u>Swift No. 1 and Swift No. 2 Benefits to the Regional Power Grid</u>

The regional power grid benefits from the inherent generation flexibility of Swift No. 1 (240 MW) and Swift No. 2 (70 MW). As such, PacifiCorp, as operator of the 2 projects, is able to provide more benefits to the grid from these projects than from any other generation facility in its portfolio. These projects provide the ability to: 1) meet moment-to-moment changes in load demand within 2 control areas of the North American Electric Reliability Council; 2) provide generating reserve capacity to maintain electric grid voltage and frequency in the event of the loss of a major generating unit elsewhere on the grid; 3) minimize inadvertent generation interchange with other grid operators; 4) provide firm energy, thereby making the best use of uncontrolled generating resources such as wind turbines; 5) maximize the efficiency and economy of fossil fuel plants; and 6) minimize the exposure of ratepayers to the financial impacts of power price volatility.

Swift No. 2 is Cowlitz PUD's only generating resource and meets up to 30 percent of its peaking needs and a smaller but substantial portion of the energy needs of Cowlitz PUD's 44,000 residential, commercial and light industrial customer/owners. In order to preserve the above benefits provided by Swift No. 1 and Swift No. 2, Cowlitz PUD pre-schedules its generation needs within guidelines that allow PacifiCorp almost full control of the 2 projects—after meeting the PUD's pre-schedule.

2.4.5.7 Potential Options to Release Water into Swift Bypass Reach

There are 3 primary options to deliver water to the bypass reach. These are described in general terms below, followed by a more detailed evaluation of the effects of 2 of those options.

Option 1. Swift No. 1-No Bypass Turbine: Water could be provided to the bypass reach directly through the Swift No. 1 spill gates or from the Swift No. 1 surge tank.

Option 2. Swift No. 1-With Bypass Turbine: Water could be provided to the bypass reach by tapping the Swift No. 1 penstock and installing a small turbine (bypass unit).

Option 3. Swift No. 2 Canal: Water could be provided to the bypass reach from the Swift No. 2 canal. This option would require drafting the canal when Swift No. 1 and Swift No. 2 are not operating. According to CH2M Hill (2002) (WTS 4 Appendix 2), to protect the integrity of the canal embankments, the maximum drawdown rate in the canal is 2 feet per day. That drawdown rate limits the discharge from the canal into the bypass reach to a maximum of 50-70 cfs. In theory, to eliminate drafting the canal, Swift No. 1 could operate continuously and provide 50 to 400 cfs to the bypass reach; however, Swift No.1 can not physically operate at those flow levels. For these reasons, this option has been eliminated and is not considered further in this report.

Effects of Releasing Water into Swift Bypass Reach – Decreased Generation and Reduced Reservoir Elevation

Providing flow to the bypass reach decreases the flexibility of both Swift No. 1 and Swift No. 2 relative to the timing of generation to meet changing load demands. These losses could not be offset by constructing a bypass turbine. Losses are unquantifiable so are not included in this analysis, but must be considered in addition to the following quantitative analysis of generation energy losses.

Generation would be adversely affected by any flow provided to the Swift bypass reach, and the magnitude of impact would be directly proportional to the amount of flow provided. To quantify generation losses, the options for releasing water into the bypass reach were analyzed using an operations model that predicts annual generation for each option in a median water year (e.g., WY 1965). A base case scenario was also run to which each option was compared. The base case represented a scenario that assessed generation under the current operational conditions.

WDFW and the Cowlitz Tribe provided written comments and alternative viewpoints (included in WTS 4 Appendix 3) on the operational analysis included in this report. PacifiCorp and Cowlitz PUD reviewed these comments and revised this report to address them to the extent possible.

The operations model used in this analysis determines the impacts of flow in the bypass reach on generation. It does not however, quantify impacts to reservoir elevation or to the electric system-wide impacts described above. Reservoir impacts cannot be determined using this model because it optimizes (maintains) head (reservoir elevation) in order to maximize generation, and stores water in the reservoirs until such time in the future when power prices are assumed to be higher. Hence, by using the operations model, all impacts resulting from the options presented manifest themselves as losses to generation and not losses to the "water budget" of the reservoir (see Effects on Generation-The Generation Only Impact Case).

A formula and a table of relationships between flows and reservoir levels was specifically developed over 20 years ago and is used daily to convert generation at Swift No.1 and Swift No. 2 into water used and to determine the resulting change in reservoir level. Therefore, there is a reasonable means to convert the model-predicted lost generation associated with flows diverted into the bypass reach into decreases in Swift Reservoir levels (see Effects on Reservoir Elevation –The Swift Reservoir Level Only Impact Case, page 38).

In reality, we would expect to see impacts to both generation and reservoir elevations in some unquantifiable combination. This is because the operations/generation schedule for the Lewis River is driven by a combination of system load demands, forecasted power demand, and recreational/hydrological constraints.

It is difficult to quantify the magnitude of the impacts because, in practice, negative impacts would occur to both generation and reservoir elevation concurrently in a variable and unpredictable ratio. The extent to which generation and/or reservoir elevation are affected depends upon load requirements at the time. Further, generation would be negatively impacted in order to accommodate diverted bypass flows and to maintain reservoir elevations necessary for potential generation.

The following 2 sections discuss the 2 ends of the spectrum of the impacts of diverting the various bypass reach flows: 1) all impacts quantified as lost generation, and 2) all impacts quantified as loss to Swift Reservoir levels.

<u>Effects on Generation – The Generation Only Impact Case</u>

Impacts to generation are presented in 2 ways; as those associated with foregone generation and those associated with the shift in timing of generation from on-peak load hours to off-peak load hours. (On-peak hours were assumed to occur Monday through Saturday from 7 am through 11 pm. The remainder of time during the week was assumed to be off-peak.) A shift in generation would occur since flow would have to be diverted to the bypass reach at all times of the day and not just during on-peak loads periods (i.e., flow would be provided to the bypass reach in the off-peak load periods whereas under current operations, generation at Swift No. 1 and Swift No. 2 is often biased towards generation during on-peak load periods).

<u>Option 1: Swift No. 1 Source – No Bypass Turbine</u> – Under this scenario, bypass flows could come from 2 sources; the spill gates or the surge tank. The overall effects are the same for either source. If the 50-foot tainter spill gates are used, water would come from a depth of 50 feet (15.2 m) at full pool conditions, and shallower depths at lower reservoir levels. If the surge tank is used, a flowline would be installed from the penstock surge tank to pipe water to the upstream end of the bypass reach.

Issues associated with this option include:

- Water from spill would be unavailable during most winters because the reservoir is drawn down below the 50-foot depth of the spill gates to provide downstream flood protection. It would be difficult, using the spill gates, to provide accurate target flows given that existing equipment (i.e., 50-foot tainter gates) is sized to pass large flows.

- Generation potential would be lost from Swift No. 1 and Swift No. 2 plants. Approximately 17,000–134,000 mWh of electricity production would be foregone annually at bypass flows of 50–400 cfs (Table 2.4-13).

- Approximately 12,000–93,000 mWh of this generation would be lost from on-peak load hours and 5,000–41,000 mWh from off-peak load hours (Table 2.4-14). Figure 2.4-19 depicts the information from Tables 2.4-13 and 2.4-14 in a graphic form.

Table 2.4-13. Annual generation lost (mWh/yr) from Swift No. 1 and Swift No. 2 associated with 2 options and 4 bypass flows.

	Option 1 – No Turbine Flow from dam spill gates or surge tank			**Option 2 – With Turbine** Up to 250 cfs flow through a small bypass turbine, up to 150 cfs from dam spill gates or surge tank.		
Flow cfs	**Total Loss mWh**	**Swift No. 1 mWh**	**Swift No. 2 mWh**	**Total Loss mWh**	**Swift No. 1 mWh**	**Swift No. 2 mWh**
50	16,729	13,138	3,591	3,474	2,744	730
100	33,458	26,275	7,183	6,948	5,489	1,459
200	66,917	52,580	14,337	13,896	10,977	2,919
400	133,833	105,101	28,732	48,110	37,946	10,164

Lost generation as estimated by PacifiCorp

Table 2.4-14. Annual generation lost (mWh/yr) for 2 options and 4 flows for on-peak and off-peak load hours.

		On-Peak (positive values represent generation lost)			**Off-Peak** (negative values represent generation gained)			**NET Totals**		
Flows cfs	**Option**	**Total Loss mWh**	**Swift No.1 mWh**	**Swift No.2 mWh**	**Total Loss mWh**	**Swift No.1 mWh**	**Swift No.2 mWh**	**Total Loss mWh**	**Swift No.1 mWh**	**Swift No.2 mWh**
50	1	11,621	9,151	2,470	5,108	3,986	1,122	16,729	13,138	3,591
	2	4,687	3,691	996	-1,213	-947	-266	3,474	2,744	730
100	1	23,243	18,303	4,940	10,215	7,973	2,242	33,458	26,275	7,183
	2	9,374	7,382	1,992	-2,426	-1,893	-532	6,948	5,489	1,459
200	1	46,486	36,605	9,881	20,431	15,975	4,456	66,917	52,580	14,337
	2	18,748	14,764	3,984	-4,852	-3,787	-1,065	13,896	10,977	2,919
400	1	92,972	73,210	19,762	40,861	31,890	8,971	133,833	105,100	28,733
	2	56,639	44,603	12,036	-8,529	-6,657	-1,872	48,110	37,946	10,164

Lost generation as estimated by PacifiCorp

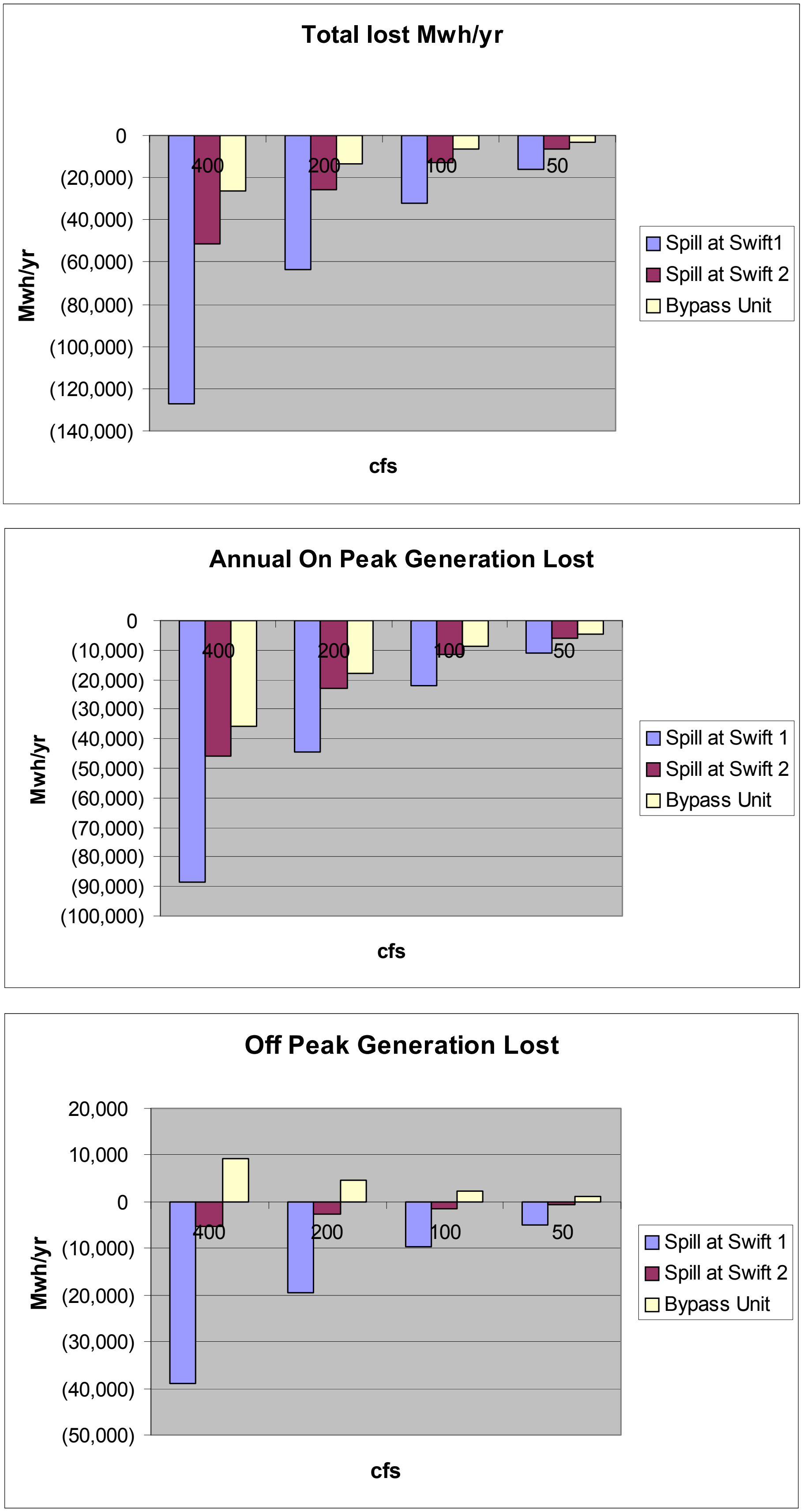


Figure 2.4-19. Graphic representation of data from Tables 2.4-13 and 2.4-14.

Option 2: Bypass Unit to Supplement Flow Using Spill or Surge Tank – The existing No. 3 penstock at Swift No. 1 would be tapped with a smaller penstock that would send water to a small high-head turbine at the upstream end of the bypass reach. It was assumed that the maximum capacity of this small turbine would be 250 cfs (the maximum amount of water that could be tapped from the No. 3 penstock). In this scenario, at bypass flows up to 400 cfs, flows in excess of the 250 cfs maximum turbine capacity (up to 150 cfs) would be added to the bypass reach from either the spillway or the surge tanks. Hence flow in excess of that passed through the small turbine would be lost from generation at Swift No. 1, Swift No. 2, and the new small turbine. Issues associated with this option include:

- The maximum capacity of a pipe that could be tapped from the No. 3 penstock is 250 cfs. Bypass flows in excess of 250 cfs would require a combination of release options such as those discussed in Option 1; therefore, at a bypass flow greater than 250 cfs, issues associated with Option 1 may apply here as well.
- At releases in excess of 250 cfs, up to 150 cfs of generation potential would be lost from Swift No. 1 and Swift No. 2. Approximately 3,500–48,000 mWh would be lost from generation annually in this scenario (Table 2.4-13).
- Losses associated with generation timing shifts from on-peak load hours to off-peak load hours vary. At 50 cfs, approximately 4,600 mWh of on-peak generation would be lost, while 1,213 mWh would be gained back during off-peak load hours. At 400 cfs, approximately 56,600 mWh would be lost from on-peak load hours, and approximately 8,500 mWh would be gained back during off-peak periods (Table 2.4-14).

Characteristics and Assumptions Associated with the Bypass Unit – The new bypass turbine used in the operation model runs had the following characteristics. It was sized for a flow of 400 cfs (meaning a maximum efficiency would occur at this flow and the rated head). The results for other bypass flows under consideration in this study were calculated simply by taking the relative proportion of the bypass flow compared to 400 cfs. The overall energy conversion efficiency of the bypass unit when compared to the existing Swift No. 1 units was both positively and negatively impacted by a number of issues:

- The bypass unit would likely have a higher gross operating head available to it compared to Swift No.1 units.
- Generation losses in the form of spill would occur during outages/maintenance on this unit since water would have to be diverted to the bypass reach at all times regardless of whether the unit was operating or not. It was assumed that water would be spilled from the reservoir to meet minimum flow requirements in the bypass reach when the turbine was not operating. Since these outage losses could not be adequately represented in the operations model, it was decided to adjust the efficiency of the unit to a degree similar to the unit availability of other Lewis River projects (92%).
- Although the bypass unit would be sized to accommodate the bypass flow, the unit would not operate at peak efficiency at all times. This is because the efficiency of a

unit is a function of head and flow. And although flow would remain relatively constant, the reservoir elevation (head) would fluctuate.

For simplicity, these impacts were considered to be equal and offsetting in the operations model analysis. However, it is likely that spilled energy during planned and forced outages would be the predominant issue and energy losses are understated.

Effects on Reservoir Elevation – The Swift Reservoir Level Impact Only Case

The previous section used an operations model to predict the impacts on generation of diverting flow into the bypass reach, assuming that the projects can be operated without such flows affecting reservoir levels. As indicated above, flows into the bypass reach would, in reality, impact both Swift No. 1 and No. 2 generation and Swift Reservoir levels.

The flow exceedence curves and base flows presented in Figures 2.4-2 and 2.4-3 respectively, show that the negative impacts to Swift Reservoir elevation caused by diverting 50 to 400 cfs flow to the bypass reach would be particularly severe during the summer recreation months when PacifiCorp's electricity demand is highest and inflows to the reservoir are lowest. In the summer, flow diverted to the bypass reach plus generation requirements to meet customer electricity demand would exceed inflow to the reservoir. Hence, water would be drawn from storage and the reservoir elevation would drop.

As indicated above, there is a known and calculable relationship between energy generated, water used for that generation, head levels at the hydro generators, and Swift Reservoir level. This same relationship is used on an almost daily basis by PacifiCorp and Cowlitz PUD to determine the impacts of Cowlitz PUD's scheduled generation on its share of the Swift No. 1 and Swift No. 2 projects. It can also be used to reasonably estimate what the lost generation amounts predicted by the operations model would equate to in Swift Reservoir elevation impacts.

The basic formula used to calculate the quantity of water used to generate electricity at Swift No. 1 and Swift No. 2 in a 24-hour period is:

$$\frac{\text{kWh}}{\text{kW/cfs} \times 24 \text{ hours/day}} = \text{cfs-days}$$

where:

kWh is kilowatt-hours generated (or lost in this case of bypass flows);

kW/cfs is an efficiency factor (sometimes referred to as H/K) which is dependent on the energy output of Swift No. 1 and Swift No. 2, the number of generators being used, and the amount of head at each project; and

cfs-days is the amount of water required to produce the energy generated (or lost in this case of bypass flows).

When choosing how to run Swift No. 1 and Swift No. 2, the operating criteria attempt to maximize the kW/cfs efficiency factor, as this minimizes the amount of water needed to generate the energy in a given period of time. The efficiency factor can be maximized for a given amount of generation by choosing how many units to run and by the maximum head at each project. Of course, head (determined by the reservoir levels at Swift and at Yale) depends solely on natural inflow to the reservoirs and the output for generation and diverted bypass flows. Swift No. 1 and Swift No. 2 are operated to maintain as narrow an efficiency band as possible throughout the year.

The approximate amount of cfs-days, a measure of water volume, is known for the Swift Reservoir at elevations to the 1/100 of a foot. Therefore, given the lost generation amounts predicted by the operations model for flows diverted into the bypass reach, the decrease in Swift Reservoir elevation that would be associated with a decision to maintain historical generation levels can be estimated.

As shown in Table 2.4-15, providing flows from 50 cfs to 400 cfs causes an annual loss of Swift Reservoir elevation of 8.5 to 76.2 feet if historical generation levels at Swift No. 1 and Swift No. 2 are maintained. This is based on a finite water supply and no spill. Under Option 1, at 50 cfs, there is no opportunity to recoup any generation, so the reservoir elevation drops 8.5 feet over a one-year period. The water used in Option 1 is in "addition to" not "in lieu of" the water used to maintain historic generation. Under Option 2, historic generation is "maintained" and generation does not increase because water is passed through the bypass turbine. Instead, some of the generation and water is shifted from Swift No. 1 and Swift No. 2 to the bypass turbine. Under Option 2, it effectively takes more water to generate the same amount of electricity because the bypass turbine cannot make up for losses at both Swift No. 1 and Swift No. 2.

Table 2.4-15. Loss in Swift Reservoir if no generation loss is used to offset flows diverted to the bypass reach.

Flows cfs	Option	Annual Lost mWh	Associated Loss in Swift Elevation (feet)
50	1	16,729	8.5
	2	3,474	1.8
100	1	33,458	17.2
	2	6,948	3.5
200	1	66,917	35.5
	2	13,896	7.0
400	1	133,833	76.2
	2	48,110	25.1

Given that all water currently is used for generation, there is a finite water supply, and assuming no spill, if the utilities did not decrease generation from historical levels to offset the loss of water to the bypass reach, the above data show that, even under the 50 cfs flow option with the bypass turbine providing some recovery of lost generation, the accumulated reservoir elevation loss would negatively affect all uses of the reservoir in just a few years (1.8 feet per year).

2.4.5.7 Summary of Instream Flow Study Results

A Physical Habitat Simulation Model (PHABSIM) was run for the Swift bypass reach to estimate the relative amount of available habitat for a variety of different fish species that have or could have access to the reach. This model has been in use for over 20 years as a tool to assess the relationship between streamflow and fish habitat. In PHABSIM, the different habitat types in a stream reach are represented by measurements of depth, velocity, substrate, and cover conditions. Measurements are made at many points across a number of transects (cross sections). The physical conditions that are measured at one or more flows can be simulated for a whole range of flows of interest. The usability of various combinations of depth, velocity, substrate, and cover varies among fish species and life stages. Habitat suitability curves (HSC) exist for many fish species, including salmon and trout. They are usually based on direct underwater observations of the fish. Measurements and simulations of depth, velocity, substrate and cover are combined with HSC to produce an overall index of habitat quality for each fish species, for any given discharge. This index is called Weighted Usable Area (WUA). The relationship between WUA and discharge is the fundamental output of PHABSIM.

PHABSIM results for the Swift bypass reach have been distributed to ARG members and are compiled in Table 2.4-15. Data are expressed as weighted usable area (WUA), in square feet per 1000 linear feet of stream. The transects that describe rearing habitat were placed in pools, riffles, glides, and split channels, in proportion to the actual occurrence of these habitat types in the entire reach. Therefore, when all of the rearing transects are combined into WUA for the whole reach, the WUA is indeed per 1000 linear feet of stream.

Table 2.4-15. WUA of fish/lifestages for 4 release scenarios in square feet per 1,000 linear feet of stream.

Resident Rearing WUA						
Flow (cfs)	**Cutthroat**	**Bull Trout**	**Whitefish Adults**	**Whitefish Juveniles**	**Rainbow Trout Adults**	**Rainbow Trout Juveniles**
50	11,884	20,996	2,457	6,520	13,241	21,773
100	17,748	33,325	5,296	12,613	20,703	28,946
200	22,840	44,763	13,277	24,026	28,472	32,284
400	24,155	42,936	23,826	32,673	32,149	30,754

Resident Spawning WUA		
Flow (cfs)	**Bull Trout**	**Rainbow Trout**
50	13,793	1,809
100	18,335	5,928
200	22,437	14,908
400	21,008	23,540

Table 2.4-15. WUA of fish/lifestages for 4 release scenarios in square feet per 1,000 linear feet of stream (cont.).

Anadromous Rearing WUA			
Flow (cfs)	**Chinook**	**Coho**	**Steelhead**
50	23,664	23,128	26,698
100	28,179	20,927	37,419
200	28,974	18,808	45,652
400	26,697	18,809	46,132
Anadromous Spawning WUA			
Flow (cfs)	**Chinook**	**Coho**	**Steelhead**
50	2,092	11,364	722
100	8,416	17,975	2,437
200	20,982	28,963	8,558
400	35,837	29,245	23,115

The spawning transect, in contrast, was placed in one discrete habitat type: a gravel-rich riffle near Ole Creek. The WUA calculated here is actually "per 1000 linear feet of this particular habitat type." Since the habitat unit where the transect is located was mapped at 497 feet in length (Harza data), the WUA for spawning would be roughly half the number in the table.

2.4.5.8 Summary of SSTEMP Model Results

The SSTEMP model was run for 4 different flow conditions (50, 100, 200, and 400 cfs) for each month of the year using warm, average, and cool local air temperatures (based on measurements at Cougar), and warm, average, and cool water temperatures (based on Swift No. 1 tailrace temperatures).

The average monthly water temperatures in the reach are plotted as a function of discharge in Figure 2.4-20, along with the beginning water temperature. In most months, water warms as it travels down the reach. In October and November, water cools slightly in the reach, and in December it remains nearly constant. The amount of warming or cooling is inversely related to discharge. In July, water warms by nearly 4.5^{o}C at 50 cfs, vs. 1^{o}C at 400 cfs. In November, water cools by about 1^{o}C at 50 cfs, but only by a fraction of a degree at 400 cfs.

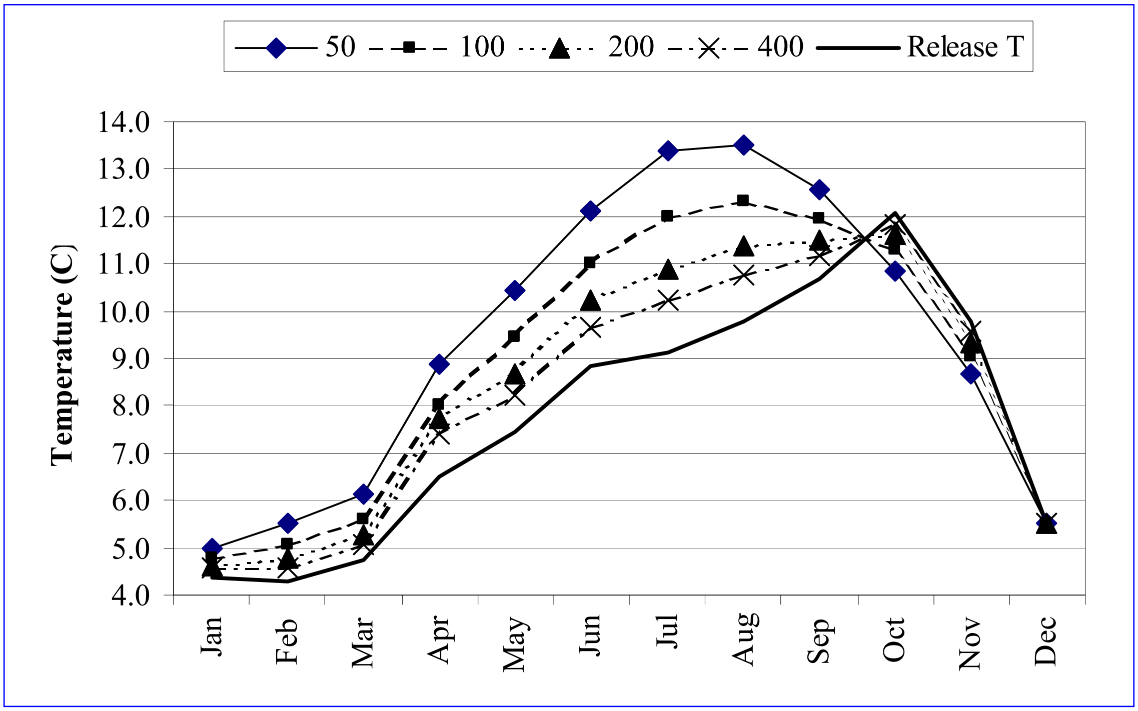


Figure 2.4-20. Swift Dam release temperature and water temperature at downstream end of Swift bypass reach for 4 release flows under average temperature conditions.

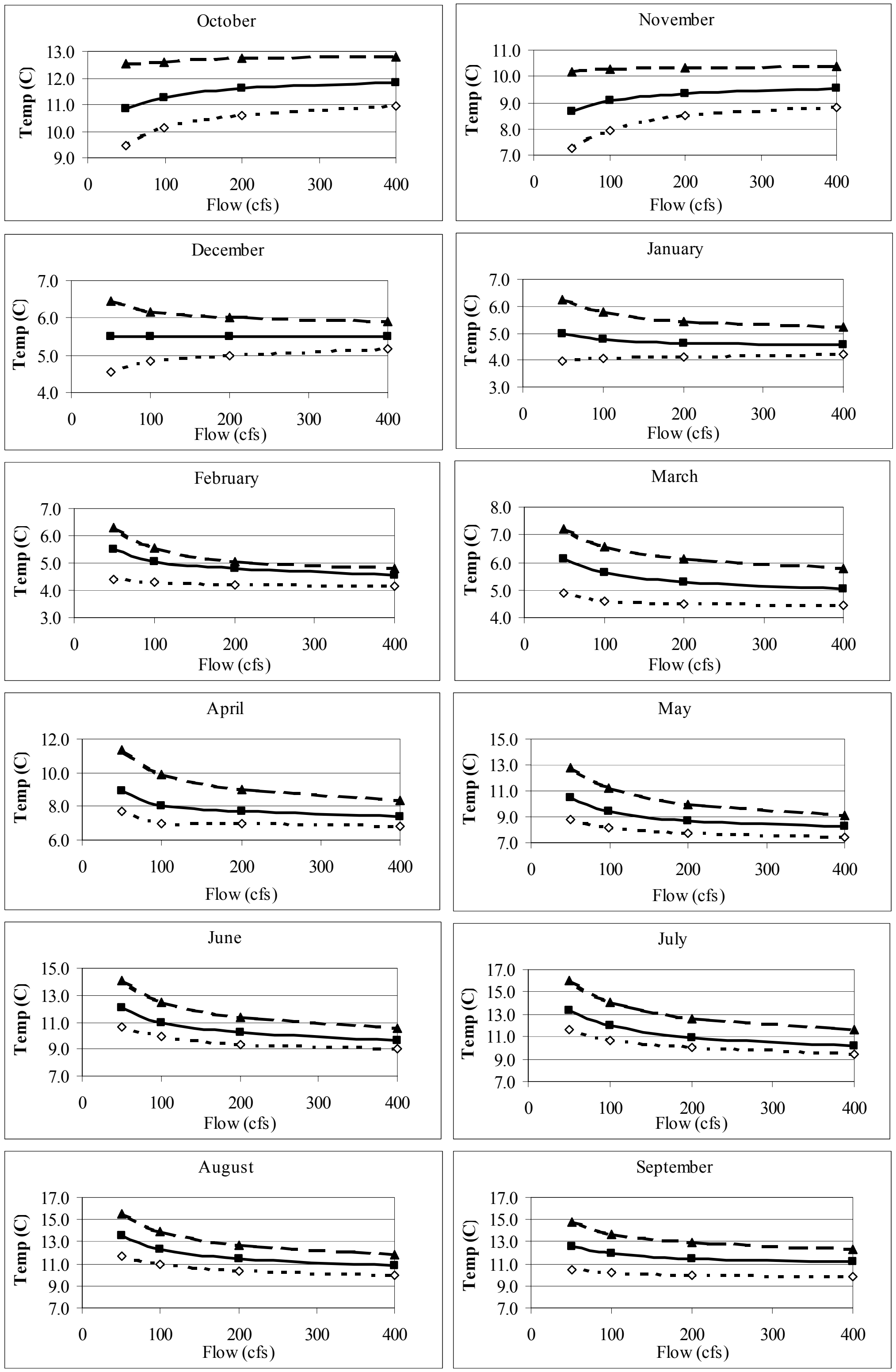
Figure 2.4-21 illustrates the predicted temperatures in the reach as a function of discharge under 3 different starting conditions: high air and inflow water temperatures, average air and water temperatures, and low air and water temperatures.

In October and November, water cools slightly under all scenarios, and the cooling is inversely proportional to the flow. In December and January, water can either warm or cool in the reach, depending on the air temperature.

In the remaining months (February through September), water warms under all 3 scenarios, and the warming is an inverse function of the discharge. With cool air temperatures, considerably less warming takes place. The highest predicted water temperatures occur in July and August. With high air and inflow water temperatures, water at the downstream end of the bypass reach is predicted to reach 16^{o}C at 50 cfs.

The range of expected monthly water temperature is displayed in Table 2.4-16. The low end of the temperature range would occur with low starting water temperatures, low air temperatures, and (for most months) high discharge. Conversely, the high end of the range would occur at high starting water temperatures, high air temperatures, and (for most months) low discharges.

The SSTEMP model can be used to back-calculate input water temperature requirements for different life stages of fish during different months of the year.



Key: Dashed line (triangles) is high air and water temperatures; solid line (squares) is average air and water temperatures; dotted line (open triangles) is low air and water temperatures.

Figure 2.4-21. Modeled temperatures at downstream end of Swift bypass reach.

Table 2.4-16. Range of predicted water temperatures in the Swift bypass reach.

Month	Low (°C)	High (°C)
Oct	9.4	12.8
Nov	7.2	10.6
Dec	4.4	6.7
Jan	3.9	6.1
Feb	3.9	6.1
Mar	4.4	7.2
Apr	6.7	11.1
May	7.2	12.8
Jun	8.9	13.9
Jul	9.4	16.1
Aug	10.0	15.6
Sep	10.0	15.0

2.4.6 Discussion

Several different management actions are being discussed for the Swift bypass reach, including: changing the flow regime by adding water; changing the mix of fish species that have access to the reach; encouraging or discouraging recreational use of the reach; and other potential actions. Table 2.4-17 and the following sections summarize the effects of 4 different flow levels on the different resources in the bypass reach. This information is provided to decision makers as a tool to illustrate the effects of various flows on the bypass reach, not to recommend any flow or flow regime.

Table 2.4-17. Summary of effects of flow augmentation in the Swift bypass reach.

Flow Release	Project Operations	Water Quality	WUA	LWD/ Sediment	Riparian Habitat	Wetlands/ Side Channels	Recreation
50 cfs	▪ 3,474 to 16,729 mwh/yr lost generation ▪ 4,687 to11,621 mwh/yr on-peak load generation lost ▪ 5,108 mwh/yr off-peak load generation lost to 1,213 mwh/yr off-peak load generation gained -OR- ▪ 1.8 to 8.5 feet annual loss Swift Reservoir elevation	▪ temperature range 4-16C ▪ meets Class A and AA standard ▪ other parameters not expected to change much ▪ turbidity may increase in winter	▪ rearing BT-21,000 RB/CT- 12-22,000 WF 2-7,000 Anad: 23-27,000 ▪ spawning BT: 14,000 RB: 2,000 Anad: 2-11,000	▪ no increase in LWD or sediment transport	▪ inundate 5 acres (6%) ▪ a few upland acres may become riparian habitat ▪ small benefit to habitat function and condition	▪ no effect on existing wetlands	▪ no effect on 5 dispersed camping sites
100 cfs	▪ 6,948 to 33,458 mwh/yr generation lost ▪ 9,374 to 23,243 mwh/yr on-peak load generation lost ▪ 10,215 mwh/yr off-peak load generation lost to 2,426 mwh/yr off-peak load generation gained -OR- ▪ 3.5 to 17.2 feet annual loss Swift Reservoir elevation	▪ temperature range 4-14C ▪ turbidity expected to increase in winter to between 5 and 10 NTUs	▪ rearing BT-33,000 RB/CT- 18-29,000 WF 5-13,000 Anad: 21-37,000 ▪ spawning BT: 18,000 RB: 6,000 Anad: 2-18,000	▪ no increase in LWD or sediment transport ▪ slight increase in transport of gravel/ smaller particles provided by Ole Creek	▪ inundate 8 acres (9%) ▪ a few upland acres may become riparian habitat, net loss may be low ▪ some benefit to habitat function and condition	▪ no effect on existing wetlands ▪ some new wetlands may develop	▪ no effect on 5 dispersed camping sites

Table 2.4-17. Summary of effects of flow augmentation in the Swift bypass reach (cont.)

Flow Release	Project Operations	Water Quality	WUA	LWD/ Sediment	Riparian Habitat	Wetlands/ Side Channels	Recreation
200 cfs	▪ 13,896 to 66,917 mwh/yr generation lost ▪ 18,749 to 46,486 mwh/yr on-peak load generation lost 20,431 mwh/yr off-peak load generation lost to 4,852 mwh/yr off-peak load generation gained -OR- ▪ 7.0 to 35.5 feet annual loss Swift Reservoir elevation	▪ temperature range 4-13C ▪ turbidity expected to increase in winter to between 5 and 10 NTUs	▪ rearing BT-45,000 RB/CT-23-33,000 WF 13-24,000 Anad: 19-46,000 ▪ spawning BT: 22,000 RB: 15,000 Anad: 9-29,000	▪ no increase in LWD or sediment transport ▪ slight increase in transport of gravel/ smaller particles provided by Ole Creek	▪ inundate 11 acres (13%) ▪ upland acres may become riparian habitat, net loss may be low ▪ greater benefit to habitat function and condition	▪ no effect on existing wetlands ▪ some new wetlands may develop	▪ partially inundated beaches at 4 dispersed campsites
400 cfs	▪ 48,110 to133,833 mwh/yr generation lost ▪ 56,639 to 92,972 mwh/yr on-peak load generation lost ▪ 8,529 mwh/yr gained to 40,861 mwh/yr off-peak load generation lost -OR- ▪ 25.1 to 76.2 feet annual loss Swift Reservoir elevation	▪ temperature range 4-13C ▪ turbidity expected to increase in winter to between 5 and 10 NTUs	▪ rearing BT-43,000 RB/CT-24-32,000 WF 24-33,000 Anad: 19-46,000 ▪ spawning BT: 21,000 RB: 24,000 Anad: 23-36,000	▪ threshold for initiating gravel transport ▪ no increase in amount of gravel in upper bypass reach ▪ increase in transport of gravel/smaller particles provided by Ole Creek – coarser substrate in lower bypass reach	▪ inundate 16 acres (19%) ▪ upland acres may become riparian habitat, net loss may be low ▪ greatest benefit to habitat function and condition	▪ no effect on existing wetlands ▪ some new wetlands may develop	▪ partially inundated beaches at 4 dispersed campsites

2.4.6.1 Effects of Releasing 50 cfs into Swift Bypass Reach

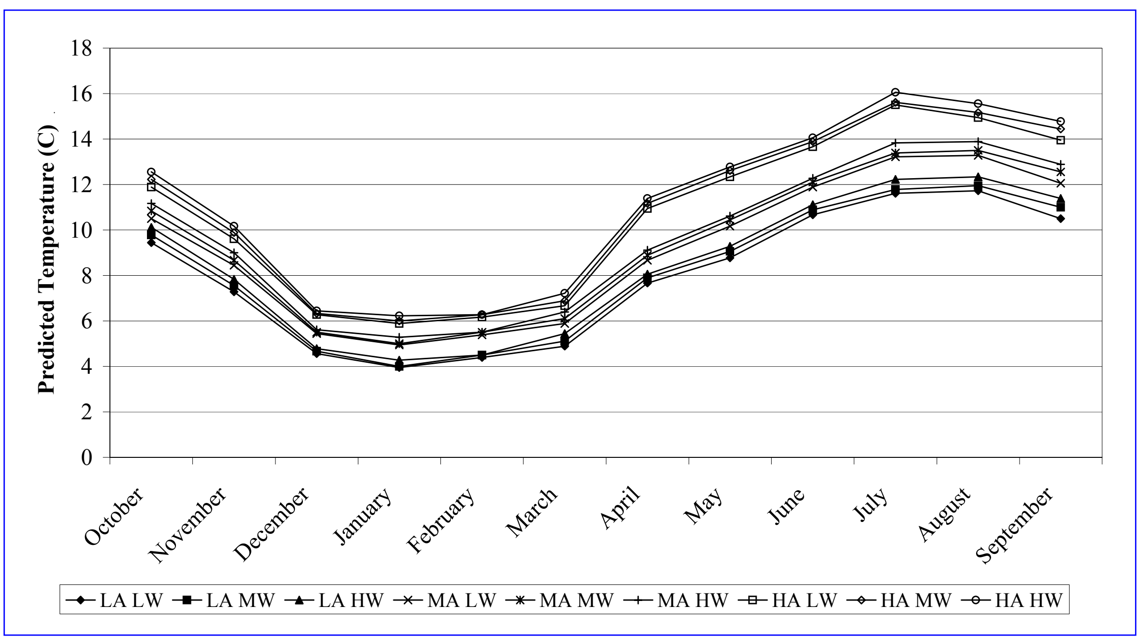
Under this scenario, 50 cfs would be released into the bypass reach. The following sections describe the effects on project operations and bypass reach resources from such a release.

Project Operations

Fifty cfs could be provided to the bypass reach through 2 options (Section 2.4.5.6). If 50 cfs was provided year-round, lost generation from Swift No. 1 and Swift No. 2 would range from approximately 3,500 mWh/year (Option 2) to approximately 17,000 mWh/ year (Option 1). If historic generation were maintained, the annual loss in Swift Reservoir elevation would range from approximately 1.8 feet under Option 2 to approximately 8.5 feet under Option 1.

Water Quality

SSTEMP model runs for 50 cfs predicted temperatures ranging between 4°C and 16°C, depending upon time of year and starting water and air temperature (Figure 2.4-22). However, flows of 50 cfs or more under all input temperature regimes reduced water temperatures at the downstream end of the bypass reach to well under the existing state Class A standard of 18°C, or the Class AA standard of 16°C. Other water quality parameters were not modeled with SSTEMP, but would not be expected to change significantly at flows of 50 cfs, although turbidity may increase during the winter months.



Key: LA LW: low air, low water temperatures; LA MW: low air, mean water temperatures; LA HW: low high water temperatures, etc.

Figure 2.4-22. Modeled temperatures under 50 cfs flow regime.

Aquatic Habitat

The input of 50 cfs into the Swift bypass reach would increase the area of aquatic habitat in the reach. The PHABSIM results indicate that 50 cfs would provide about 21,000 units of rearing WUA for bull trout, 12,000 for cutthroat, and 13,000-22,000 for rainbow trout (Table 2.4-15). For whitefish, rearing WUA would be 2,500-6,500 units. Spawning WUA would be 14,000 units for bull trout, and 1,800 units for rainbow trout. Anadromous rearing habitat for Chinook, coho, and steelhead would range from 23,000 to 27,000 units. Spawning habitat WUA numbers for Chinook, coho, and steelhead are 2,100; 11,000; and 700; respectively.

WUA is expressed as square feet of habitat per 1,000 linear feet of stream, and the bypass reach is 14,000 feet long. The rearing WUA is based on a representative sample of all the habitats in the bypass reach. Thus, in order to calculate the amount of usable habitat in the entire reach, the rearing numbers would be multiplied by 14. The spawning WUA would not be multiplied, since it is based on one specific habitat type that is comparatively rare in the reach.

The 50 cfs releases would be augmented by inflows downstream of Ole Creek, resulting in higher flows in the lower part of the reach, notably the spawning transect. The predicted 50 percent exceedence flows in Ole Creek are between 50 and 75 cfs from November through April.

Flows of 50 cfs would not increase sediment or large woody debris transport or recruitment in the reach.

Riparian Habitat

Riparian deciduous trees and shrubs grow to the edge of the current water level throughout most of the existing channel. Releases of 50 cfs into the Swift bypass reach would inundate about 5 acres of riparian habitat. The loss of 5 acres of riparian vegetation represents about 6 percent of the amount currently present in the bypass reach. However, it is possible that the increased flows and/or higher ground water levels would convert a few adjacent upland acres to areas that support riparian vegetation. Greater flows would also benefit riparian habitat condition and function (see Section 2.4.6.4 for more detail).

Wetland and Side Channel Habitat

Most of the wetlands in the Swift bypass reach occur away from the existing channel and are maintained by beaver dams and seepage from Swift canal. Consequently, it is unlikely that an additional 50 cfs of flow into the bypass reach would affect existing wetlands.

Recreation Use

In 1999, flow releases from Swift Dam were photographed and documented. The main channel in the northern portion of the bypass reach contained most of the flow with a much smaller volume of water elsewhere in the bypass reach. No significant impacts to the 5 dispersed campsites were observed at releases of 50 cfs.

2.4.6.2 Effects of Releasing of 100 cfs into Swift Bypass Reach

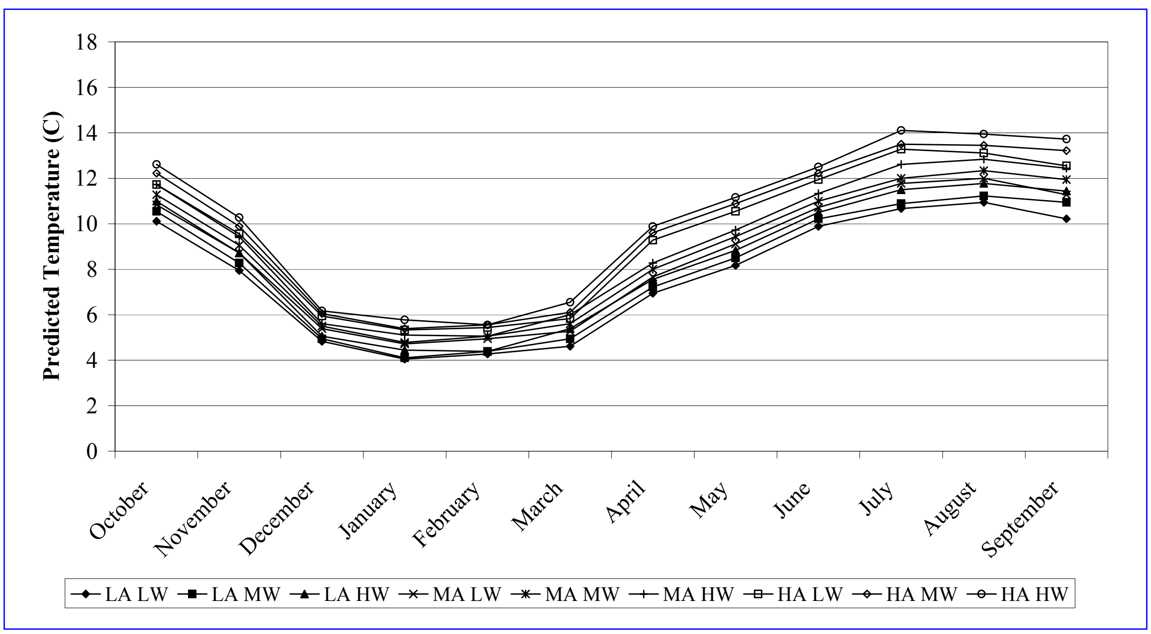
Under this scenario, 100 cfs of water would be released into the bypass reach. The following sections describe the effects of 100 cfs on the resources in the bypass reach.

Project Operations

One hundred cfs could be provided to the bypass reach through 2 options (Section 2.4.5.6). If 100 cfs was provided year-round, lost generation from Swift No. 1 and Swift No. 2 would range from approximately 7,000 mWh/year (Option 2) to 33,500 mWh/year (Option 1). If historic generation were maintained, the annual loss in Swift Reservoir elevation would range from approximately 3.5 feet under Option 2 to approximately 17.2 feet under Option 1.

Water Quality

SSTEMP model runs for 100 cfs predicted temperatures ranging between 4°C and 14°C, depending upon time of year and starting water and air temperature (Figure 2.4-23). Under all input temperature regimes, flows of 100 cfs reduced water temperatures at the downstream end of the bypass reach to well under the existing Class A standard of 18°C, or the Class AA standard of 16°C. Turbidity at 100 cfs would be expected to increase during the winter months to levels observed at the Swift tailrace and at Swift Reservoir near the intake, i.e., between 5 and 10 NTUs. Nutrient concentrations may decrease due to dilution, although the quantity (loading) of nutrients may increase over existing conditions.



Key: LA LW: low air, low water temperatures; LA MW: low air, mean water temperatures; LA HW: low air, high water temperatures, etc.

Figure 2.4-23. Modeled temperatures at 100 cfs flow regime.

Aquatic Habitat

The input of 100 cfs into the Swift bypass reach would increase the area of aquatic habitat in the reach. The PHABSIM results indicate that 100 cfs would provide about 33,000 units of rearing WUA for bull trout, 18,000 units for cutthroat, and 21,000-29,000 units for rainbow trout. For whitefish, rearing WUA would be 5,300-13,000 units (Table 2.4-15). Spawning WUA would be 18,000 for bull trout, and 5,900 for rainbow trout. Anadromous rearing habitat for Chinook, coho, and steelhead would range from 21,000 to 37,000 units. Anadromous spawning habitat WUA numbers for Chinook, coho, and steelhead are 8,400; 18,000; and 2,400, respectively. The 100 cfs releases would be augmented by inflows downstream of Ole Creek, resulting in higher flows in the lower part of the reach. The predicted 50 percent exceedence flows in Ole Creek are between 50 and 75 cfs from November through April.

Flows of 100 cfs would not increase existing sediment or large woody debris transport or recruitment in the reach, but may slightly increase transport of gravel and smaller particles that are provided by Ole Creek. This would occur by augmenting peak Ole Creek flows in the lower Swift bypass reach.

Riparian Habitat

The addition of 100 cfs into the bypass reach would inundate about 8 acres of riparian habitat. Assuming that the majority of the inundated area now supports riparian vegetation and that none of this type would develop in other areas, 9 percent of the riparian vegetation in the bypass reach would be lost. However, it is likely that some adjacent uplands would be affected by higher surface or ground water levels, resulting in changes that make these areas conducive to species tolerant of wetter conditions. Consequently, the net effect on the acreage of riparian vegetation in the bypass reach may be relatively low. Greater flows would benefit riparian habitat condition and function (see Section 2.4.6.4 for more detail).

Wetland and Side Channel Habitat

The majority of the wetlands in the Swift bypass reach are not adjacent to the existing channel and are unlikely to be affected by an additional 100 cfs of flow in the bypass reach. It is possible that some additional wetlands may develop over time with increased ground water levels in flat, low-lying areas.

Recreation Use

In 1999, flow releases from Swift Dam were photographed and documented. The main channel in the northern portion of the bypass reach contained most of the flow with a much smaller volume of water elsewhere in the bypass reach. No significant impacts to the 5 dispersed campsites were observed at releases of 100 cfs.

2.4.6.3 Effects of Releasing 200 cfs into Swift Bypass Reach

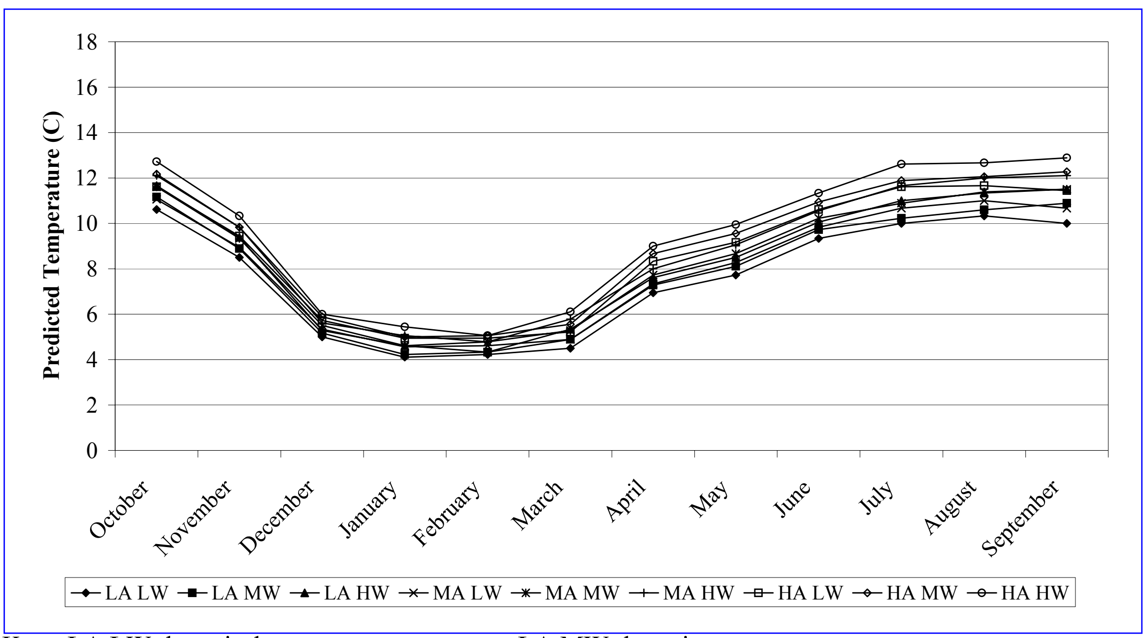
Under this scenario, 200 cfs would be released into the bypass reach. The following sections describe the effects of these releases on the bypass reach.

Project Operations

Two hundred cfs could be provided to the bypass reach through 2 options (Section 2.4.5.6). If 200 cfs was provided year-round, lost generation from Swift No. 1 and Swift No. 2 would range from approximately 14,000 mWh/year (Option 2) to 67,000 mWh/year (Option 1). If historic generation were maintained, the annual loss in Swift Reservoir elevation would range from approximately 7.0 feet under Option 2 to approximately 35.5 feet under Option 1.

Water Quality

SSTEMP model runs for 200 cfs predicted temperatures ranging between 4C and 13C, depending upon time of year and starting water and air temperature (Figure 2.4-24). Under all input temperature regimes, flows of 200 cfs reduced water temperatures at the downstream end of the bypass reach to well under the existing state Class A standard of 18°C, or the Class AA standard of 16°C. Increases in turbidity would be expected to occur during the winter months, as discussed above. Changes in nutrient concentrations would be similar to those mentioned above, i.e., decreased concentrations but greater nutrient loading with increased flows.



Key: LA LW: low air, low water temperatures; LA MW: low air, mean water temperatures; LA HW: low air, high water temperatures, etc.

Figure 2.4-24. Modeled temperatures at 200 cfs flow regime.

Aquatic Habitat

The input of 200 cfs into the Swift bypass reach would increase the area of aquatic habitat in the reach. The PHABSIM results indicate that 200 cfs would provide about 45,000 units of rearing WUA for bull trout, 23,000 units for cutthroat, and 28,000-32,000 units for rainbow trout (Table 2.4-15). For whitefish, rearing WUA would be 13,000-24,000 units. Spawning WUA would be 22,000 for bull trout, and 15,000 for rainbow trout. Anadromous rearing habitat, for Chinook, coho, and steelhead, would range from 19,000 for coho to 46,000 for steelhead. Anadromous spawning habitat WUA numbers for Chinook, coho, and steelhead are 21,000; 29,000; and 8,600 units, respectively. The 200 cfs releases would be augmented by inflows downstream of Ole Creek, resulting in higher flows in the lower part of the reach. The predicted 50 percent exceedence flows in Ole Creek are between 50 and 75 cfs from November through April.

Flows of 200 cfs would not increase existing sediment or large woody debris transport or recruitment in the reach, but may increase transport of gravel and smaller particles that are provided by Ole Creek. This would occur by augmenting peak Ole Creek flows in the lower Swift bypass reach.

Riparian Habitat

Releases of 200 cfs into the Swift bypass reach would inundate about 11 acres of riparian habitat, which represents about 13 percent of the existing riparian vegetation. It is, however, likely that higher moisture levels in adjacent vegetation types may change the composition of these areas to species more tolerant of wetter conditions. Consequently, there may be relatively little effect on the amount of riparian vegetation in the bypass reach. Greater flows would benefit riparian habitat condition and function (see Section 2.4.6.4 for more detail).

Wetland and Side Channel Habitat

Most of the wetlands in the Swift bypass reach are not adjacent to the existing channel and are unlikely to be affected by an additional 200 cfs of flow into the bypass reach. It is possible that some increased ground water levels in flat, low-laying areas may result in the development of additional wetlands in riparian habitats.

Recreation Use

In 1999, water releases from Swift Dam were photographed and documented. During releases of 200 cfs, the main channel in the northern portion of the bypass reach contained most of the flow, with a much smaller volume of water elsewhere in the bypass reach. At the 4 dispersed campsites near the IP Road bridge, some of the sandy beaches used by visitors became partially inundated. Other areas were unaffected.

2.4.6.4 Effects of Releasing 400 cfs into Swift Bypass Reach

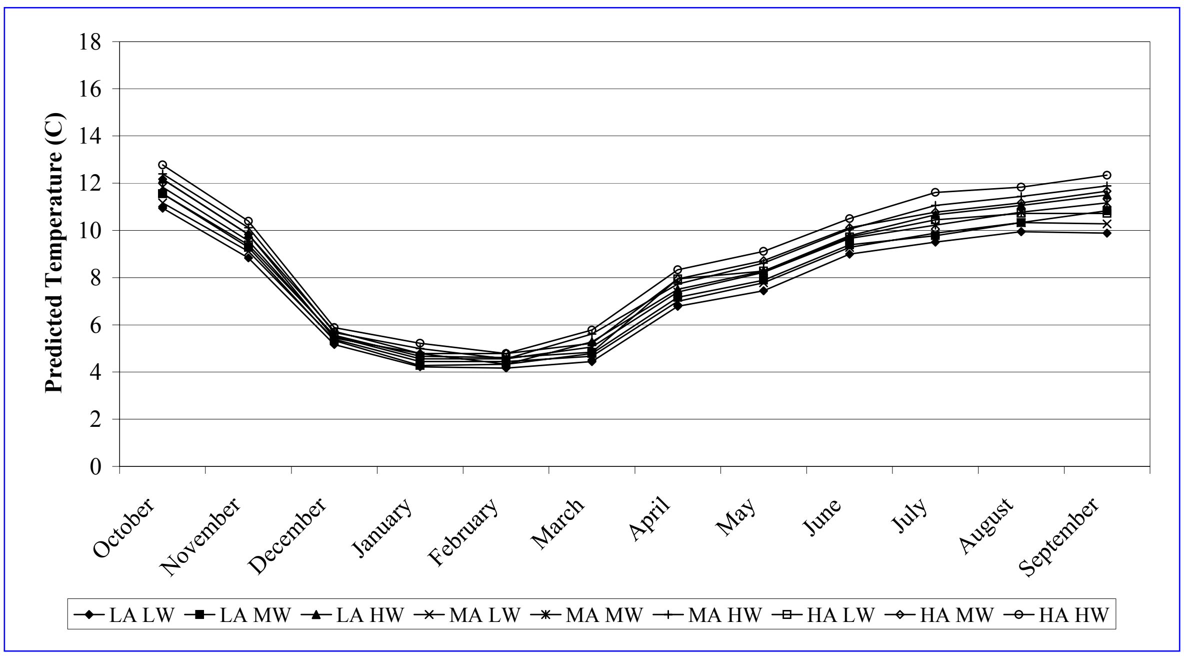
Under this scenario, 400 cfs would be released into the bypass reach. The effects of this regime are described below.

Project Operations

Four hundred cfs could be provided to the bypass reach through 2 options (Section 2.4.5.6). If 400 cfs was provided year-round, lost generation from Swift No. 1 and Swift No. 2 would range from 65,168 mWh/year (Option 2) to 133,833 mWh/year (Option 1). If historic generation were maintained, the annual loss in Swift Reservoir elevation would range from approximately 25.1 feet under Option 2 to approximately 76.2 feet under Option 1.

Water Quality

SSTEMP model runs at 400 cfs predicted temperatures ranging between 4°C and 13°C, depending upon time of year and starting water and air temperature (Figure 2.4-25). Under all input temperature regimes, flows of 400 cfs reduced water temperatures at the downstream end of the bypass reach to well under the existing state Class A standard of 18°C, or the Class AA standard of 16°C. Increases in turbidity would be expected to occur during the winter months, as discussed above. Decreased nutrient concentrations but greater nutrient loading (in contrast to existing conditions) would be expected at flows of 400 cfs.



LA LW: low air, low water temperatures; LA MW: low air, mean water temperatures; LA HW: low air, high water temperatures, etc.

Figure 2.4-25. Modeled temperatures at 400 cfs flow regime.

Aquatic Habitat

The input of 400 cfs into the Swift bypass reach would increase the area of aquatic habitat in the reach. The PHABSIM results indicate that 400 cfs would provide about 43,000 units of rearing WUA for bull trout, 24,000 units for cutthroat, and 31,000–32,000 units for rainbow trout (Table 2.4-15). For whitefish, rearing WUA would be 24,000–

33,000 units. Spawning WUA would be 21,000 units for bull trout, and 24,000 units for rainbow trout. Anadromous rearing habitat, for Chinook, coho, and steelhead, would range from 19,000 units for coho to 46,000 units for steelhead. Anadromous spawning habitat WUA numbers for Chinook, coho, and steelhead are 36,000; 29,000; and 23,000 units, respectively. The 400 cfs releases would be augmented by inflows downstream of Ole Creek, resulting in higher flows in the lower part of the reach. The predicted 50 percent exceedence flows in Ole Creek are between 50 and 75 cfs from November through April.

Flows of 400 cfs are predicted to be at the threshold for initiating gravel transport in the riffle transects modeled. Releasing 400 cfs into the reach would not substantially increase gravel movement in the upper bypass reach because there is very little gravel in the active channel at present. However, it would likely increase transport of gravel and smaller particles that are provided by Ole Creek by augmenting flows in the lower Swift bypass reach. This would result in a river bed with somewhat larger particles than currently exists downstream of Ole Creek.

Riparian Habitat

The addition of 400 cfs into the bypass reach would inundate about 16 acres of riparian habitat. Assuming that the majority of this area currently supports riparian vegetation and that none would develop in other areas, 19 percent of the riparian vegetation in the bypass reach would be affected. However, it is likely that some adjacent uplands would be affected by higher moisture conditions, and eventually support species tolerant of wetter conditions and typical of riparian areas. Consequently, the net effect on the amount of riparian vegetation in the bypass reach would probably be relatively low.

The potential benefits on riparian habitat condition and function from increased flows would be the greatest with the addition of 400 cfs to the bypass reach, particularly if a variable flow regime were implemented. Higher flows would be expected to increase the extent of the wetted channel and floodplain hyporheic zone and raise associated soil moisture. Thus, floodplain terraces that currently support primarily upland species may provide habitat for facultative species, which are generally more tolerant of higher soil moisture. The result may be an overall increase in plant species diversity in some areas, provided that Himalayan blackberry and other invasive non-native species do not dominate. Higher flows, particularly under a variable regime, would also be expected to increase the annual exchange of nutrients and organic matter between aquatic and terrestrial habitats.

Currently, one of the greatest effects of Swift Dam on vegetation in the bypass reach is periodic high spill, which can scour vegetation along the channel. Although large flows passed through the bypass reach prior to the project, the current active channel through this area is narrower and encroached by vegetation. Thus, when large spill events occur, they inundate and/or scour the vegetation that has become established within the old bankfull channel. Even with flows of 400 cfs, the periodic extreme spill events through the bypass reach will still occur and scour substantial amounts of riparian vegetation.

Wetland and Side Channel Habitat

Existing wetlands in the Swift bypass reach are not likely to be affected by an additional 400 cfs of flow into the bypass reach. It is possible, however, that some increased ground water levels in flat, low-lying areas may result in the development of additional wetlands in riparian habitats near the new channel.

Recreation Use

During 400 cfs test flow releases, the main channel in the northern portion of the bypass reach contained most of the flow, with a much smaller volume of water elsewhere in the bypass reach. Some of the sandy beaches and campfire rings at the 4 dispersed campsites near the IP Road bridge were partially inundated. Other areas were unaffected.

2.4.7 Methods Used in Other Rivers to Determine Instream Flows

Instream flows have been set for numerous managed river systems throughout the United States. The methods used to set flows in each case have been different, depending upon the goals developed for that particular reach of river. Some flow regimes have been aimed at optimal flows for specific aquatic/fish species, while in other reaches recreation, riparian vegetation, or channel maintenance objectives have been the goal. In order to determine the best method or combination of methods to use for determining appropriate flows for the Swift bypass reach, the management objectives for the reach should be determined.

The following papers list a number of different methods used in other river systems for setting instream flows.

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Knight, J.G., M.B. Bain, and K.J. Scheidegger. 1991. A habitat framework for assessing the effects of streamflow regulation on fish. Alabama Cooperative Fish and Wildlife Research Unit, Auburn University, Auburn, Alabama. 161pp.

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Locke, A.G.H. 1994. The Highwood River: Instream flow needs for fish and flow scenario evaluations. Alberta Environmental Protection, Fish and Wildlife Service. Edmonton, AB. 154+pp.

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2.4.7.1 Categories of Instream Flow Analysis

The 2 major categories of instream flow analysis used in other systems are hydrologic and hydraulic methods. Hydrologic methods use long-term flow records as a basis for annual or seasonal recommendations. Hydraulic methods relate flow volume to site-specific data in the channel, such as width, depth, or velocity.

<u>Simple Hydrologic Methods</u> – These include the 7Q10, the Tennant, Tessman, and others. Basically, from the hydrologic record, a single flow is set as a minimum. For

example, in the Tennant method, 30 percent of the mean annual flow is designated as "excellent" for aquatic health.

Complex Hydrologic Methods – The Indicators of Hydrologic Alteration (IHA) is a flow-setting method that incorporates 33 different streamflow parameters. Based on 20 or more years of the hydrologic record, the range for each statistic (e.g., mean flow, 7-day low flow, 1-day high flow) is determined. This naturally-occurring range is set as the baseline against which alternatives are evaluated. The goal with this method is to manage the river in such a way that the post-project flow does not deviate from the range of natural variability for each parameter.

Simple Hydraulic Methods – A simple hydraulic method is Wetted Perimeter. In this method, the change in wetted perimeter at one or more cross-sections is plotted as a function of flow. The inflection point, where the gain in perimeter per unit increase in flow begins to slow down, is set as a minimum flow.

Complex Hydraulic Methods – The Physical Habitat Simulation (PHABSIM) uses measurements along transects to divide the channel into a large number of cells. Each cell is characterized by a value of depth, velocity, substrate, and cover. This combination of characteristics is used to calculate the value of the cell as habitat for an aquatic species and life stage (usually fish, but sometimes other animals).

PHABSIM does not by itself generate flow recommendations. It generates quantitative information that helps guide interpretations and negotiations. Flow recommendations can be derived from PHABSIM data in a number of ways:

- Peak of the WUA curve: The basic PHABSIM result is a curve of WUA vs. discharge. The simplest flow recommendation is the flow corresponding to maximum WUA for one species.
- Optimal range of WUA: As an alternative, the flow corresponding to 90 percent, 80 percent, or some other percentage of the peak WUA can be selected.

Both of these methods presume that a single key life stage can be selected for each time period, and that other species will be protected by the flow that is selected for the key species. Most instream flow studies, including the Swift bypass study, involve multiple species and life stages.

Averaging Multiple Life Stages – In this method, 2 or more species/life stages are averaged. The flow that maximizes average WUA for each time period is selected.

2.4.7.2 Combining Hydrologic and Hydraulic Methods

Several investigators have combined hydrologic and hydraulic methods to determine instream flows, recognizing the fact that flow recommendations must consider the realities of the natural hydrograph.

Fish Rule Curve – This method, developed by Locke (1984) starts with a WUA vs. flow curve. This may be for one life stage, or an average of several. Then optimal, average, and minimal conditions are defined. Locke (1984) defined these conditions as 100 percent, 50 percent, and 20 percent of the peak of the WUA curve, respectively.

Superimposed on this is the hydrologic data for a given period. In a dry year, the flow is set for minimal conditions; in an average year, for average conditions; and in a wet year, for optimal conditions. Thus, during a dry year, the flow corresponding to 20 percent of the peak WUA is recommended; but in an average year, the flow corresponding to 50 percent of the peak is selected.

Habitat Exceedance Curve – This method was developed by Bovee (1982). It combines the WUA vs. flow curve with the hydrologic record to produce a habitat exceedance curve. Every flow scenario for a given project has a different flow exceedance curve. Therefore, it also has a different habitat exceedance curve. Several project alternatives can be plotted on the same figure in order to make comparisons.

The main value of this method is that it accurately represents WUA values at each point in time. For example, if the minimum flow proposed below a hydropower project is 20 cfs, a simpler analysis might compare WUA at 20 cfs vs. the optimum. But habitat exceedance would take into account all of the periods of spill or shut-down in which flow would be different from 20 cfs. This gives a more accurate picture of impacts than would a single point on a WUA vs. flow curve.

PHABSIM and IFIM

PHABSIM is a useful tool for estimating the value of microhabitat (depth, velocity, cover, and substrate) for aquatic species. PHABSIM is part of an overall system of analysis termed IFIM. An IFIM analysis should consider broader ecosystem functions, in addition to fish microhabitat. The aquatic ecosystem is also a function of other flows, such as flushing flows, flows for riparian vegetation, and flows affecting temperature and water quality. Instream flow recommendations for these other functions can easily be superimposed on the microhabitat flows. Once all the flows with quantifiable benefits to the system are identified, the sideboards of the instream flow recommendation are in place. If desired, the concept of flow variability (using IHA or some other means) can also be added.

2.4.8 Schedule

This study is complete.

2.4.9 References

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2.4.10 Comments and Responses on Draft Report

Commenter	Volume	Page/ Paragraph	Statement	Comment	Licensees' Response	Response to Responses
USDA Forest Service: John Kinney	1	WTS 04	Riparian Habitat discussions all flows	There was no discussion of cumulative effects or functional characteristics (fully, partially etc) on the riparian zone relative to streamflows that represented the modeled or historical flows.	Comment noted. The results section acknowledges that increased flows are likely to have a relatively small net effect on the amount of riparian vegetation in the reach. It is also difficult to quantify the potentially positive effects of the flow increases analyzed (50 -400 cfs) on riparian habitat in terms of nutrient exchange and other functions. The primary project effect on riparian habitat in the bypass reach is the periodic high flow, which scours vegetation and generally modifies the riparian communities.	Is there documented evidence of riparian vegetation scour? If so, was BLM (public land within the bypass reach) consulted about the deleterious effects to those public lands. They recently re-initiated participation in the Lewis River relicensing effort. Consultation with them on SBR flows may be warranted relative to their management of public lands. **Licensees' Response**: *Scouring of vegetation in the Swift bypass reach occurs during extreme high flow events, such as in 1996, when 45,000 cfs was spilled through this reach. See TER-9, Section 5.9.5.3 for maps showing the vegetation loss of about 31 acres of riparian and/or upland forest, and another 10 acres of riparian and/or palustirine shrub (see Table 5.9-8 and text in TER-9). A discussion of riparian scour has been added to Section 2.4.6.4, Riparian Habitat*.

Commenter	Volume	Page/ Paragraph	Statement	Comment	Licensees' Response	Response to Responses
USDA Forest Service: John Kinney	1	WTS 04	Side channel and wetlands	I found very little analysis, discussion of, or reference to another study on the role of side channel and wetland in terms of juvenile coho salmon habitat, amphibians, etc necessary to promote a functional condition that supports reintroduction of anadromous fish and restoration of various "habitats."	A discussion of the role of side channel and wetland habitat in a properly functioning ecosystem will be included in the final report.	To what extent, and how will it be related to flows? Will the discussion include cumulative effects in terms of my initial comment? **Licensees' Response:** *A discussion of side channels has been added to the report; however, it does not address flows*.
WDFW – CURT LEIGH	1	WTS 04 Sec. 2-4	Swift Bypass.	Eliminated the use of Swift No. 1 tailrace as an option. Did not look at 100% bypass valve or option #3 when Swift 1 & 2 operating with bypass when not operating for generation. Also there is no mention, copies of, or responses to the comment letters sent to the utilities by both WDFW and the Cowlitz Indian Tribe regarding generation and reservoir level impacts. This is again very disappointing.	A 100% bypass valve in Swift No. 1 is functionally the same as Option 1 for the purpose of evaluating lost generation. Based on the operations model, a new turbine would minimize the amount of generation loss. The Utilities explain in the report why other options have been eliminated. If the new turbine were to be constructed, an emergency bypass valve would be incorporated into the design. The issues raised in the comment letters have been addressed. Copies of the comment letters can be included in the final report.	
USDA Forest Service: John Kinney	1	WTS 04-4 – 5	Water Temperature-Modeled Data	SSTEMP was used (1999) to model/predict SBR temperatures under a range of flow regimes. Water temperature data was collected from Swift #1 tailrace (power canal)	Results of application of the SSTEMP model to the Swift Bypass Reach are presented on pages WTS 4-36 through 4-38.	Thanks!

Commenter	Volume	Page/ Paragraph	Statement	Comment	Licensees' Response	Response to Responses
				and reported in Table 2.4-2. Where is the discussion of that effort and how does it relate to the SBR?		
J. Kaje – Tech.Adv. for Cowlitz Tribe	1	WTS 04-6, section 2.4.3.4, 2nd para	"Effect of increased flows on riparian habitat in the Swift bypass reach were estimated by using the IFIM data…"	The analysis is limited to an analysis of inundated acreage, which is characterized as "loss". It seems quite reasonable that introduction of flow to the reach, while perhaps inundating some existing riparian areas, will likely have a strongly positive effect on both the health, species diversity and acreage of riparian habitat. The impact of continuous flows in the reach is not confined to the wetted area itself; the dynamics of exchange between surface and groundwater will be altered as well. Also, the analysis was performed assuming a constant flow regime at the prescribed IFIM levels, whereas a more likely solution will feature a seasonally variable regime. Variable flow regimes are one of the primary engines of riparian development. Please discuss riparian habitat effects in a more dynamic sense throughout this report.	Comment noted. The results section acknowledges that increased flows are likely to have a relatively small net effect on the amount of riparian vegetation in the reach. It is difficult to quantify the potentially positive effects of the flow increases (50-400 cfs) on riparian habitat in terms nutrient exchange and other functions. The primary project effect on riparian habitat in the bypass reach is the periodic high flows, which scour vegetation and generally reset the riparian communities.	Your response statement "The primary project effect on riparian habitat in the bypass reach…." Confuses the purpose of the study with current conditions /impacts. Currently, the only flows are periodic high flows as you suggest. My comment was clearly directed toward the inadequate assessment of beneficial riparian impacts resulting from the reintroduction of continuous flow to the reach. I agree that quantification of these changes is difficult. Giving them a professional, thorough treatment in the study is not. Please provide a more thorough discussion. **Licensees' Response**: *Additional discussion has been added to Section 2.4.6.4, Riparian Habitat.*
WDFW – JIM BYRNE	1	WTS 04-8	Base flows at Swift Res.	Why were base flow not recorded after Swift Reservoir was "closed"? No flows at all?	Base flows following the closure of Swift Reservoir would have been "0" in each year since the USGS gage is upstream of most seepage inflow.	Confusing.

Commenter	Volume	Page/ Paragraph	Statement	Comment	Licensees' Response	Response to Responses
WDFW – JIM BYRNE & KAREN KLOEMPKEN	1	WTS 04-10	Shading in table.	There is no shading in Table 2.4-4 as indicated.	The shading was inadvertently missing from the table; shaded rows should be 100, 50, and 20-year recurrence intervals. A corrected table will be provided.	
WDFW – KAREN KLOEMPKEN	1	WTS 04-12 Fig. 2.4-6	Spill events in Swift bypass reach.	Missing X axis title.	The x-axis is year.	
J. Kaje – Tech.Adv. for Cowlitz Tribe	1	WTS 04-13, sec 2.4.5.2	general scope of section	This section includes no discussion whatsoever about what each of the water quality parameters means for particular organisms, with the limited exception of temperature effects on salmonids. The data are not useful to most readers without the aid of some interpretation. Please provide a discussion of each WQ parameter as it relates to the biology, behavior and ecology of key organisms.	Text briefly describing ecological significance of various water quality constituents will be added to discussion of results.	Thank you.
WDFW – KAREN KLOEMPKEN	1	WTS 04-14 Fig. 2.4-8	Diel Changes in temperature at Swift Bypass Reach.	Missing X axis title.	The x-axis is the sample date.	
WDFW – KAREN KLOEMPKEN	1	WTS 04-15 Fig. 2.4-9	Diel changes in DO concentration & saturation.	Missing X axis title.	The x-axis is the sample date.	
WDFW – KAREN KLOEMPKEN	1	WTS 04-16 – 17 Figs. 2.4-10 – 12	Turbidity & Nitrogen at Swift bypass reach.	All are missing X axis titles.	The x-axes are month.	
USDA Forest	1	WTS 04-17	Nutrients	Winter N levels are higher in the SBR than at the Swift #1 intake	Increased flow in the bypass reach would increase the	Understood. We were getting at a reduction of N levels within

Commenter	Volume	Page/ Paragraph	Statement	Comment	Licensees' Response	Response to Responses
Service: John Kinney				(attributed to flow and leaf drop). However, the last sentence states, "…the total quantity…of nutrients would be higher due solely to increased flow". If N is lower in the reservoir than in SBR it would seem increased flows would lower the overall nutrient load…all others nutrients being the same. Maybe a table, with a supporting graph showing the measured nutrients from Swift reservoir and SBR, would better illustrate your interpretation. Also, a discussion of flow regime would be helpful.	loading or mass of N in the bypass reach. The statement regarding lower N in the reservoir pertained to N concentrations, not loading.	the SBR if flows from Swift were introduced. If N is lower in Swift Reservoir, then it seems likely that flows from Swift into the SBR would lower N concentrations (dilution and shorter retention time within the channel).
USDA Forest Service: John Kinney	1	WTS 04-17 – 23	General water temperature questions	Once the reservoir stratifies where are the epi, meta, and hypo limnions depths and how long do they persist, i.e., when is fall turnover? What are their respective temperature regimes? How does the stratification interact with Swift #1 intake? In other words, which stratification layer coincides with the intake depth (relative to reservoir stage)? Do you really think that water retention time through the turbines is long enough to actually warm the water? (P. 4-18, #2)	Thermal characteristics of Swift and Merwin reservoirs are shown in Figures 3.1-16(a), and a discussion of the reservoir profiles is on page WAQ 1-43, and (more pertinent to this comment) on WAQ 1-50. The intake at Swift No. 1 is well within the hypolimnion of the reservoir under stratified conditions. Text clarifying intake depths and stratification conditions will be added to this section.	Thank you!

Commenter	Volume	Page/ Paragraph	Statement	Comment	Licensees' Response	Response to Responses
				Where is the interpretation for the SBR's water temperature regime? The "Adequacy of Bypass Reach…" section does not provide an adequate interpretation of the results.	Turbine warming is not likely a reason for observation of higher temperatures in the Swift 1 intake than near the reservoir, but it deserved mention. Comment noted regarding discussion of adequacy of SBR temperature regime for salmonids (page WTS4-20).	I would suggest removing this statement. What does "comment noted…" mean? **Licensees' Response**: *The revised text includes additional information about temperatures in the Swift bypass reach.*
WDFW – KAREN KLOEMPKEN	1	WTS 04-18 – 19 Figs. 2.4-13 – 14	Alkalinity and daily min./max. temps at Swift.	All are missing X axis titles.	The x-axes are month	
WDFW – JIM BYRNE	1	WTS 04-20	Median temperatures.	Why were median not mean temperatures used? Mean may be more representative of overall temperatures. The median puts more emphasis on higher temperatures.	Median temperatures do not emphasize higher temperatures; a median is the value with an equal number of data points on either side it, regardless of the range of data. If desired, means (which are influenced by the range of data) will be reported with the medians in Table 2.4-7.	
WDFW – KAREN KLOEMPKEN	1	WTS 04-20 – 23	Adequacy of Bypass Reach Temps for Salmonids.	There is a discussion of preferred temps for salmonids, but no discussion of which months these preferences occur, except for in the	A summary of optimal temperatures for various salmonid life stages will be added to this section.	

Commenter	Volume	Page/ Paragraph	Statement	Comment	Licensees' Response	Response to Responses
				case of bull trout. A table with each species and their timing and temp preference would be helpful.		
WDFW – KAREN KLOEMPKEN	1	WTS 04-21 Fig. 2.4-15	Water Temps.	Missing X axis title.	The x-axis is the month.	
WDFW – JIM BYRNE	1	WTS 04-23	Emergence temperatures.	Emergence water temperatures 4-6 ºC. Still OK for bull trout. Adults may spawn and lay eggs in Rain and Ole Creeks where temperatures may be cooler. Juveniles will move to cooler waters.	Comment noted.	
J. Sampson, Technical Advisor to the Conservation Groups	1	WTS 04-23 para 4	"An analysis of Lewis River at Cougar gage data indicate (*sic*) that no systematic aggradation or degradation of the river bed took place at the gage location between the 1920s and the late 1950s."	The specific location of the gage (#14218000) should be included in Figures 2.3-12 a through c. This will help understand the meaning of the results in Figure 2.4-17.	The gage location will be added to the maps.	
J. Sampson, Technical Advisor to the Conservation Groups	1	WTS 04-23 para 4	"The gage height record stops in 1975; it is not known if the aggradation	The analysis is incomplete. The following paragraph should be added after this paragraph: "Comparison of the Swift bypass channel in Figure 2.3-7a (1958) with the channel in Figure 2.3-7 b (1963)	It appears this comment refers to comparing Figure 2.3-<u>12</u>a (1958) and 2.3-<u>12</u>b (1963). The paragraph the comment	

Commenter	Volume	Page/ Paragraph	Statement	Comment	Licensees' Response	Response to Responses
			trend continued or not."	clearly indicates a large volume of gravel aggradation just downstream of where the Lewis River Road crossed the power canal. In the 1963 photo, the channel is wide and braided at that location, and remains so to the present. The transport of this large sediment volume to this location appears to have resulted from a spill flow of 20,000 cfs released to the channel in the winter of 1963 (Figure 2.2-31). This indicates that spill flow in the Swift bypass reach has the potential to move large volumes of sediment, and to strongly affect the channel form in this reach."	refers to was intended to address aggradation/incision based on analysis of the gage height record. The wide, braided channel downstream of where the Lewis River Road crosses the power canal is likely the result of sediment deposition during the 20,000 cfs release, but it could also be an area where the river washed away existing vegetation and exposed the underlying gravel (it is not clear from the aerial photographs). Regardless, we agree that "spill flow in the Swift bypass reach has the potential to move large volumes of sediment, and to strongly affect the channel form in this reach." This is described in WTS 3, Section 2.3.6.2, on page WTS 3-114. Repetition of the conclusions from WTS 3 may be helpful in this section of WTS 4.	
USDA Forest Service: John Kinney	1	WTS 04-23 Table 2.4.7		The supporting narrative data and citations are from sources throughout the northwest. They do not account for local adaptations.	No local data on salmonid temperature preferences were found, so data from the Pacific Northwest were cited.	

Commenter	Volume	Page/ Paragraph	Statement	Comment	Licensees' Response	Response to Responses
WDFW – KAREN KLOEMPKEN	1	WTS 04-24 Fig. 2.4-17	Gage height vs. flow for LR at Cougar gage.	Missing X axis title.	The x-axis is the year.	
WDFW – KAREN KLOEMPKEN	1	WTS 04-31 Option 3, last sentence	Reason for eliminating this option for consideration.	This is not a fully thought out reason for not continuing to consider Option 3 for providing flow in the Swift bypass reach. It would not be a constant flow it would have seasonal variations. The other option is to put a bypass valve in the dam to supply water for the Swift bypass reach. Also there is no mention, copies of, or responses to the comment letters sent to the utilities by both WDFW and the Cowlitz Indian Tribe regarding generation and reservoir level impacts. This is very disappointing.	Option Number 3 specifically covers providing flows from the canal and, as described, does not include a bypass valve. A bypass valve in Swift No. 1 is functionally the same as Option 1 for the purpose of evaluating lost generation. The maximum drawdown rate in the canal and the physical limitations of Swift No. 1 do not change under the concept of seasonal variations in flow. The issues raised in the comment letters have been addressed. Copies of the comment letters can be included in the final report.	
WDFW – JIM BYRNE	1	WTS 04-31 para (2nd to the last)	Peak loads.	Critters do not recognize on or off peak loads. Steady flows still need to be provided in bypass reach.	The paragraph recognizes the need for continuous flows in the bypass reach.	
J. Kaje – Tech.Adv. for Cowlitz Tribe	1	WTS 04-31, sec 2.4.5.6, last para	"Providing continuous flows to the bypass reach would negatively	This statement is ONLY true if flows for the bypass reach are provided IN ADDITION TO the existing level of flows used for generation. The statement conveys an image of "draining the river" due to diversion	Your first statement is correct. Any flow in the bypass reach would be "in addition to" not "instead of" current releases. "Critically low" means that at the	Your comment reveals a serious inconsistency in the study. If water for the bypass reach is to be "in addition" to what is used for generation, then it is not at all clear how the impacts to

Commenter	Volume	Page/ Paragraph	Statement	Comment	Licensees' Response	Response to Responses
			affect the elevation of Swift Reservoir"	of 50-400 cfs into the reach, while the lowest pre-project 7-day minimum flow is over 500 cfs. The paragraph also uses the term "critically low by the end of the water year" to describe the state of the reservoir if flows are provided to the reach. What is meant by "critically low"? According to what metric? This entire section has failed to respond to the detailed comments provided repeatedly on the issue of generation and reservoir level impacts by both WDFW and the Cowlitz Indian Tribe (Letter dated October 8, 2001) (and perhaps others). The report does not fairly or accurately discuss the trade-offs between reservoir changes and power generation.	beginning of the water year, the likelihood of reservoir refill failure is quite high.	power generation have been calculated. These make no sense at all in this context. Thank you for the definition of "critically low" Please include it in the report, together with an explanation of how the "likelihood of reservoir refill failure" is defined, and what the threshold is for "quite high". **Licensees' Response** *This topic was discussed with a small group of interested stakeholders on October 23, 2002.*
J. Sampson, Techical Advisor to the Conservation Plan	1	WTS 04-31 para 4	"Water could be provided to the bypass reach from the Swift No. 2 canal…For these reasons, this option has been eliminated and is not considered further in this report."	The statement was drafted before the failure of the canal in April, and the CH2M Hill report referenced in the paragraph was drafted before the failure. The CH2M Hill report finds that because of permeability of the canal walls, extraction of waters from the canal risks "slope failures in the canal banks" (WTS 4 Appendix 2 p.3). Since the canal has failed, and since Cowlitz Public Utility District	Cowlitz PUD will repair Swift No. 2 and it will look and function much the same as it did before the embankment failure. While there may be some re-engineering in the vicinity of the breach area, the majority of the canal embankment will remain as it is currently constructed. Permeability of the canal walls is natural and expected in earthen	

Commenter	Volume	Page/ Paragraph	Statement	Comment	Licensees' Response	Response to Responses
				(CPUD) has made several public statements that they intend to repair or rebuild the canal, there is an opportunity to reconsider the use of water from the power canal for flows in the bypass reach. We would like this option (Option 3 in Section 2.4.5.6) to be re-analyzed, using the same level of detail as for the analysis of the other options. The analysis should be conducted with the assumption that the power canal will be re-constructed such that permeability of canal walls with water is not a concern. This is important because the other two options for providing water to the bypass reach suffer from limitations on the total volume of available flows, and possible interruption in flows.	embankments and it will continue for most of the canal. The canal also, as you say, "suffers from limitations on the total volume of available flows". Swift No. 1 and Swift No. 2 are peaking plants operated in tandem and are often off-line for more than 48 consecutive hours. A review of the elevation, volume and discharge calculations presented in the Attachment to CH2MHill's Consulting Engineer's Report shows that the maximum canal depth is 20 feet, and, under two of the four modeled bypass flows, the canal reaches full pool minus 20 feet (empty) in 48 hours or less.	
J. Kaje – Tech.Adv. for Cowlitz Tribe	1	WTS 04-32	"In the summer, flow requirements for the bypass reach and generation requirements to meet customer electricity demand will exceed inflow	This statement is misleading in two ways: 1. No flow requirements have been set. The range contemplated in the IFIM is 50-400 cfs. Does this mean that any flow whatsoever is too much? The statement conveys an image of a set of customers who rely	Swift No. 2 is Cowlitz PUD's only generating plant. Any flow in the bypass reach cannot be used to generate electricity at Swift No. 2 at a minimum and potentially at Swift No. 1 as well. Swift No. 2 meets up to 30% of the peaking needs for 44,000 commercial, residential and light industrial customers of	Again, without providing some clarification regarding the amount of diversion that would cause such a hardship, the reader is led to believe that 50 cfs is just as 'costly' as 400 cfs. Your statement again assumes that all water to the bypass reach are "in addition" to any

Commenter	Volume	Page/ Paragraph	Statement	Comment	Licensees' Response	Response to Responses
			to the reservoir"	exclusively on Swift for their energy needs. While it is likely true that the utilities would prefer to use all available flow for power production given high regional demand and prices, passing a small amount of flow into the reach will not cause anyone to have an electricity shortage.	Cowlitz County and is critically important to the economically depressed area. You state that flows in the bypass reach will not cause anyone to have an electricity shortage, but you do not provide supporting data or references. "Electricity shortages" can occur for two reasons: 1) the electricity is not available and/or 2) the electricity is priced beyond an entities' reach and is thus not available. Providing flow in the bypass reach would both reduce the amount of electricity available and increase the price of the electricity that is available to Cowlitz PUD's customer/owners.	flows for generation. I am not sure that this is a safe assumption. The Cowlitz Tribe recognizes that some costs may increase as a result of mitigation measures. The river ecosystem has borne the ecological costs of the hydro project since 1930. You are correct, I do not have data or references to prove that diverting 50 cfs of an annual average flow (at Cougar) of roughly 2800 cfs (<2%) will cause an electricity shortage.
WDFW – JIM BYRNE	1	WTS 04-32 para 2	Reservoir elevation.	"Summer is more severe on reservoir elevation." This is true but where does the generated electricity go? Does it stay in Cowlitz County or go to California.	Power from Swift No. 2 serves Cowlitz County's 44,000 residential, commercial and light industrial customers. PacifiCorp's system-wide electricity demand is highest in the summer.	Where electricity goes is a non issue. Sorry.

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J. Kaje – Tech.Adv. for Cowlitz Tribe	1	WTS 04-32 – 34, Tables 2.4-13,14	Table data	If the values in the tables are to be relied upon in decision making, the model used to derive them must be made transparent and available. There are several counterintuitive or erroneous values in the tables. The following points are based in part on the assumption that the smaller (up to 250 cfs) turbine should be at least as efficient in terms of generation as if the same volume were passing through existing turbines, though the assumed efficiency is not stated. It seems to me that a new turbine would enjoy greater efficiency due to both improved engineering over time and due to higher head – the small turbine would discharge into the bypass reach which is at a lower elevation than the power canal: 1. The difference in lost generation values for Option 1 and Option 2 do not make sense. If we assume (as stated above) that passing 250 cfs through a new turbine is essentially identical to passing it through existing ones, the Option 2 values must represent generation lost only at Swift 2, with the exception of the 400 cfs flow. By examining the	The net head loss on a new turbine would be less than the combined head of Swift No. 1 and Swift No. 2 since the new turbine would presumably discharge into the upper end of the bypass reach, which is higher elevation than the Swift No. 2 tailrace. The operations model used in this exercise is proprietary and contains information that, if provided, would give PacifiCorp's competitors an advantage in the power markets. Therefore the model and its assumptions cannot be shared. Your assumption about the smaller turbine and its efficiency are incorrect. The model took into account the differences and optimized the alternatives.	The responses do not provide sufficient information to determine whether the values provided in the study are realistic even to an order of magnitude. Numerous inconsistencies remain, including the fundamental question whether flow to the bypass is in excess of flows used for generation purposes (see comments above). We ask that the utilities – including the operations modeler responsible for the values– participate in a workshop that will allow these pressing issues to be adequately discussed. **Licensees' Response**: *PacifiCorp's operations modeling staff met with stakeholders on October 23, 2002.*

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				difference in the values in the two columns, this suggests that Swift 2 generates only 21% of the combined output of Swift 1 and 2, i.e., Swift 1 generates at roughly a 4:1 ratio for the same amount of flow. However, the annual generation values (Final IIP p.2-15) suggest a generation ratio of 2.4:1 between Swift 1 and 2. Since all flow through Swift 1 passes through Swift 2, please explain this discrepancy. It would be helpful to include a table that shows the % of annual generation lost under each option. For example, under Option 1, the stated values represent 0.8%, 1.6%, 3.3%, and 6.6% of total system (all projects) generation at the four flow levels, whereas Option 2 ranges from 0.2% at 50 cfs to 1.4% for 400 cfs.		
USDA Forest Service: John Kinney	1	WTS 04-35 – 48	Summary of Instream Flow Study	Why is there a section on Project Operations describing lost generation? Please provide a Lost Revenue analysis to support the Project Operations section. Was SSTEMP run for the current average flow regime?	Given the volatility of electricity markets it is too difficult to provide a lost revenue analysis. When this study was approved by the ARG it was agreed that the consultants would use lost generation as the standard.	If one were to provide an average, based upon a reasonable time frame of say 10 years worth of market data, could a reasonable range or estimate of potential revenue loss be developed and provided. Are there opportunities to offset

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						that loss?
				How does the current flow regime compare to the 50-400 cfs regimes? Model 500/600 cfs and the current flow of 1200 cfs.	The PHABSIM and SSTEMP models were both run for the range of flow regimes agreed upon and stated in the study plan. The current flow regime is a temporary flow and does not pertain to the Licensees' long-term plan for the Swift bypass reach. The current flow regime at low flow conditions is 0-10 cfs upstream of Rain and Ole Creeks, with accretion of 1-2 cfs from these streams at low flow and up to several hundred cfs during peak flows and was not run with the SSTEMP model. See pages WTS4-11 and 4-12, and Figure 2.4-7 for further information on flows in this reach.	Response noted. You may want to revisit this effort.
				400 cfs does not provide enough flow to re-water side channels and wetlands.	The studied 400 cfs flow did not re-water side channels. The wetlands in the reach that were monitored during flow releases for the PHABSIM study did not respond to flow levels in the river, indicating they were not controlled by river flows.	The wetlands were not influenced by *modeled* flows, which were below historical base flows. I would argue that under a normal flow regime, or an enhanced flow regime (500-1200 cfs), that side channels and riparian wetlands are controlled by river flows. **Licensees' Response:** *The effects of higher flows on riparian conditions were based on information from literature and professional judgment because flows in this magnitude were not modeled. In several places in the text, the following statement has been added: "Greater flows would also benefit riparian habitat condition and function (see*

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						Section 2.4.6.4). Additional discussion is added under the subheading "Riparian Habitat."
J. Kaje – Tech.Adv. for Cowlitz Tribe	1	WTS 04-35, section 2.4.5.7	entire section	The WUA values mean very little to most readers. The results need to be discussed and interpreted in a way that reflect both the advantages and limitations of the approach. These are inadequately discussed.	The Physical Habitat Simulation model (PHABSIM) has been in use for over 20 years as a tool to assess the relationship between streamflow and fish habitat. In PHABSIM, the different habitat types in a stream reach are represented by measurements of depth, velocity, substrate, and cover conditions. Measurements are made at many points across a number of transects (cross-sections). The physical conditions that are measured at one or more flows can be simulated for a whole range of flows of interest. The usability of various combinations of depth, velocity, substrate, and cover varies among fish species and life stages. Habitat suitability curves (HSC) exist for many fish species; for salmon and trout. They are usually based on direct underwater observations of	Please include the discussion provided at left in the report. This document is supposed to be a reference for the Negotiating Group. Not all participants have a technical background in fishery science, much less the IFIM method in particular. Thank you. **Licensees' Response:** *This description has been added to Section 2.4.5.7 of the final report.*

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					the fish. Measurements and simulations of depth, velocity, substrate and cover are combined with HSC to produce an overall index of habitat quality for each fish species, for any given discharge. This index is called Weighted Usable Area (WUA). The relationship between WUA and discharge is the fundamental output of PHABSIM. PHABSIM and WUA have been criticized for various reasons. The models typically deal with one species at a time, so competition and predation are not taken into account. Fish populations cannot be easily predicted from WUA results. The major advantages of the models are: (1) They are specifically designed to be incremental. That is, instead of a single answer, the models provide results for an entire range of flows. (2) They are based on a large amount of data, and the results are calculated in a	

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					step-by-step, objective manner.	
WDFW – KAREN KLOEMPKEN	1	WTS 04-36 Fig. 2.4-20	Swift Dam release temps.	Missing X axis and heading titles.	The x-axis is the month.	
J. Sampson, Technical Advisor to the Conservation Groups	1	WTS 04-38	"The SSTEMP model can be used to back-calculate input water temperature requirements for different life stages of fish during different months of the year."	On October 2, 2001, the Conservation Groups requested in a letter that such an back-calculation be performed to determine the best water source for the bypass. The analysis does not appear anywhere in this report. We again request that, at a minimum, one fish species be selected, and that the SSTEMP model be used to back calculate the source water temperatures that would be needed to support the expected life cycle of the species. The analysis could be presented as an example of this statement, and should directly address the flows and source water temperatures that would be needed for the species in question. Water directly from the canal should be included as a potential source since a new canal would likely not have the permeability problem described in the CH2M Hill report (WTS4 Appendix 2). We also suggest that bull trout and coho salmon be used as example species for this analysis.	Optimal temperatures for various life stages of coho, chum, steelhead, cutthroat, and bull trout are discussed on page WTS 4-20 through WTS 4-22, and in Table 2.4-7. Theoretically, additional model runs using different temperatures could be made to determine maximum input temperatures to ensure that downstream temperatures remain below a set value (based on a particular life stage and species). However, SSTEMP is a planning level model and is not designed to determine precise temperatures that would occur in a reach. Additionally, other model inputs would be required to run the model (air temperature, meteorology, shading). Thus changing input temperature without changing in a suite of other parameters that is reasonable (i.e. based on observable air	

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					temperatures) would not improve the analysis. The model runs presented in WTS 4 link input water and air temperatures on a monthly basis. These runs bracket expected downstream temperatures given cool, average and warm air temperatures at Cougar. The most likely source of bypass flows is a penstock (at essentially intake temperatures), thus model results in WTS 4 are an accurate reflection of what can be expected in terms of water temperature over a range of flows. Knowing species and life history requirements, existing model runs can be used to assess the adequacy of bypass reach temperatures to support bull trout, coho salmon, or other species. Cowlitz PUD will repair Swift No. 2 and it will look and function much the same as it did before the embankment failure. While there may be some re-engineering in the vicinity of the breach area, the majority	

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					of the canal embankment will remain as it is currently constructed. Permeability of the canal walls is natural and expected in earthen embankments, and it will continue for most of the canal.	
USDA Forest Service: John Kinney	1	WTS 04-38 2.4.5.8	Summary of SSTEMP model results	A table is needed to display expected water temperatures for modeled PHABSIM flows, **and possibly for historical base flows.**	The agreed-upon methods for WTS-4 were to run the SSTEMP model for the 4 flow scenarios studied (50, 100, 200, 400 cfs).	So, is it possible, based upon your collective knowledge, to predict water temperatures through the SBR at the historical base flows? **Licensees' Response**: *It is possible to model historic base flows, but this was not modeled because it wasn't part of the approved study plan.*
WDFW – KAREN KLOEMPKEN	1	WTS 04-41 Fig 2.4-22	Modeled temps under 50 cfs.	Missing X axis and heading titles. Also for acronym LA HW the word "air" is missing between the descriptions.	The x-axis is the month.	
WDFW – KAREN KLOEMPKEN	1	WTS 04-43 Fig. 2.4-23	Modeled temps at 100 cfs.	Missing X axis and heading titles.	The x-axis is the month.	
WDFW – KAREN KLOEMPKEN	1	WTS 04-45 Fig. 2.4-24	Modeled temps at 200 cfs.	Missing X axis and heading titles.	The x-axis is the month.	
WDFW – KAREN KLOEMPKEN	1	WTS 04-47 Fig. 2.4-25	Modeled temps at 400 cfs.	Missing X axis and heading titles.	The x-axis is the month.	

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WDFW – KAREN KLOEMPKEN	1	WTS 04-51 Sec. 2.4.7.1	Categories of Instream Flow Analysis.	There was no chart done to show how flow corresponded to WUA. This would be helpful information.	Such charts are presented in Figures 4.2-2 through 4.2-5, with additional information in the appendices for study AQU 2.	
WDFW – KAREN KLOEMPKEN	1	WTS 04-52 Sec. 2.4.7.2	Combining Hydrologic and Hydraulic Methods/Habitat Exceedence Curve.	There was no chart with WUA vs. flow with hydrologic records to show habitat exceedence curves. This also would be helpful information.	We assume you are requesting habitat suitability curves. These are presented in AQU 2 Appendix 1, with hydraulic simulations included in AQU 2 Appendix 2.	

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