Biological Monitoring
Lower Cedar River Side Channel
1999 Spawning Survey
Data Report

-FINAL-

Prepared for:

U.S. Army Corps of Engineers, Seattle District
4735 E. Marginal Way
Seattle, Washington 98124-2255

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HDR Engineering
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Bellevue, Washington 98004-5538

17 February 2000

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1. INTRODUCTION

The Cedar River is the largest tributary to Lake Washington, and drains approximately 188 mi^2 of forested, industrial, and urban lands, from the peak of the Cascade Mountains to the mouth near Renton, Washington (Chrzastowski 1983; City of Seattle 1998). The Cedar River, one of the most productive salmon streams in the Puget Sound region, is home to the largest wild sockeye (*Oncorhynchus nerka*) run south of British Columbia. The Cedar River also supports anadromous populations of chinook (*O. tshawytscha*) and coho (*O. kisutch*) salmon, and rainbow trout (*O. mykiss*).

As in other basins throughout the Pacific Northwest, the hydrology of the Cedar River watershed has undergone significant changes since European settlement. Before 1916, the Cedar River flowed into the Black River, the original outlet of Lake Washington. The Black River then drained into the Green River, forming the Duwamish River, which emptied to Puget Sound. Near the same time as the construction of the Lake Washington Ship Canal, the Cedar River was diverted away from the Green River and into Lake Washington (Chrzastowski 1983; City of Seattle 1998). The Landsburg Diversion, constructed at RM 21.8 by the City of Seattle, has been used to divert water for municipal use since 1901 (Miller 1976). Since construction of the Landsburg Diversion, approximately 27 percent of the mean annual flow at Landsburg is diverted out of the basin for municipal use (Fresh and Lucchetti 2000). Regulation of flood flows in the Cedar River occurs through a series of flood control facilities (i.e., levees and revetments). The control of flood flows along with floodplain development has combined to reduce the floodplain surface area and lateral habitat available to juvenile salmonids below Landsburg Diversion by more than 50 percent (Lucchetti 1998).

The Elliot Levee represents one of the flood control measures constructed on the Cedar River that disrupts the natural connectivity of floodplain habitats available to salmonids in the lower river. Constructed near RM 6 in the mid-1970s, the original design has failed at least twice in the past twenty years, including during the 1990 flood of record (Lucchetti 1998). Following the 1990 flood, one option was to abandon the levee; however, due to concerns over continued future flood damage to Maplewood Golf Course, the City of Renton and King County agreed upon a levee setback project. Construction of the levee setback project occurred in 1995. The project created a “floodplain” between the face of the set-back levee and the mainstem Cedar River channel. A notch was constructed to allow the Cedar River to overtop the levee and dissipate energy during high flow events. A groundwater-fed side channel (Elliot Groundwater Channel) near the downstream end of the Elliot Levee near RM 4 was also constructed in 1995. The Elliot Groundwater Channel (approximately 700-ft-long and 15-ft-wide) was designed to provide additional rearing and spawning habitat to anadromous salmonids inhabiting the lower Cedar River (Lucchetti 1998).

The lower Cedar River near RM 1 has been periodically dredged to increase channel capacity and reduce the deleterious effects of flood events in the City of Renton. Due to difficulties encountered in obtaining regulatory permits, dredging of the lower Cedar River was reduced in the 1970s and discontinued during the 1980s (West Consultants 1999). During the flood of 1990, the Cedar River inundated portions of the City of Renton. Subsequently, the City of Renton requested the U.S. Army Corps of Engineers, Seattle District (USACE) evaluate flood control alternatives. The USACE developed a flood control program that included dredging the Cedar River downstream from Williams Avenue to the mouth, and construction of levees and/or floodwalls in 1994-1997 (M. Martz, USACE, *pers. comm*). The program called for the Cedar River to be dredged to a depth of four (4) ft below the 1995 bed profile from the mouth of the Cedar River upstream to RM 1 (West Consultants 1999). From that point (near Logan Avenue Bridge) dredging would gradually taper at a slope of 0.0056 ft per ft to meet the existing channel gradient near Williams Avenue (RM 1.25). The gradual change in channel slope was considered necessary to reduce the risk of significant channel change caused by mobilization of bed particles during flood events. Additional floodwalls and levees were also constructed in the City of Renton to provide protection during a 100-year flood.

Dredging occurred within the allowed fisheries migration window during the summer of 1998. To mitigate for the effects of the Cedar River Flood Control Project on salmonids in the Cedar River, the USACE, along with local sponsors, constructed a rearing and spawning side channel, approximately 2,000 ft upstream from King County's Elliot Groundwater Channel (Figures 1 through 3). Construction of the channel was completed in August 1998. In September 1999, the USACE contracted with R2 Resource Consultants (R2), as a subconsultant to HDR Engineering, to conduct biological monitoring in the USACE Groundwater Side Channel. Specifically, the scope of work identified five tasks:

- Attend a site reconnaissance;
- Conduct adult spawner surveys;
- Prepare a spawning summary report;
- Conduct fry emergence timing and production surveys; and
- Prepare a fry production summary report.

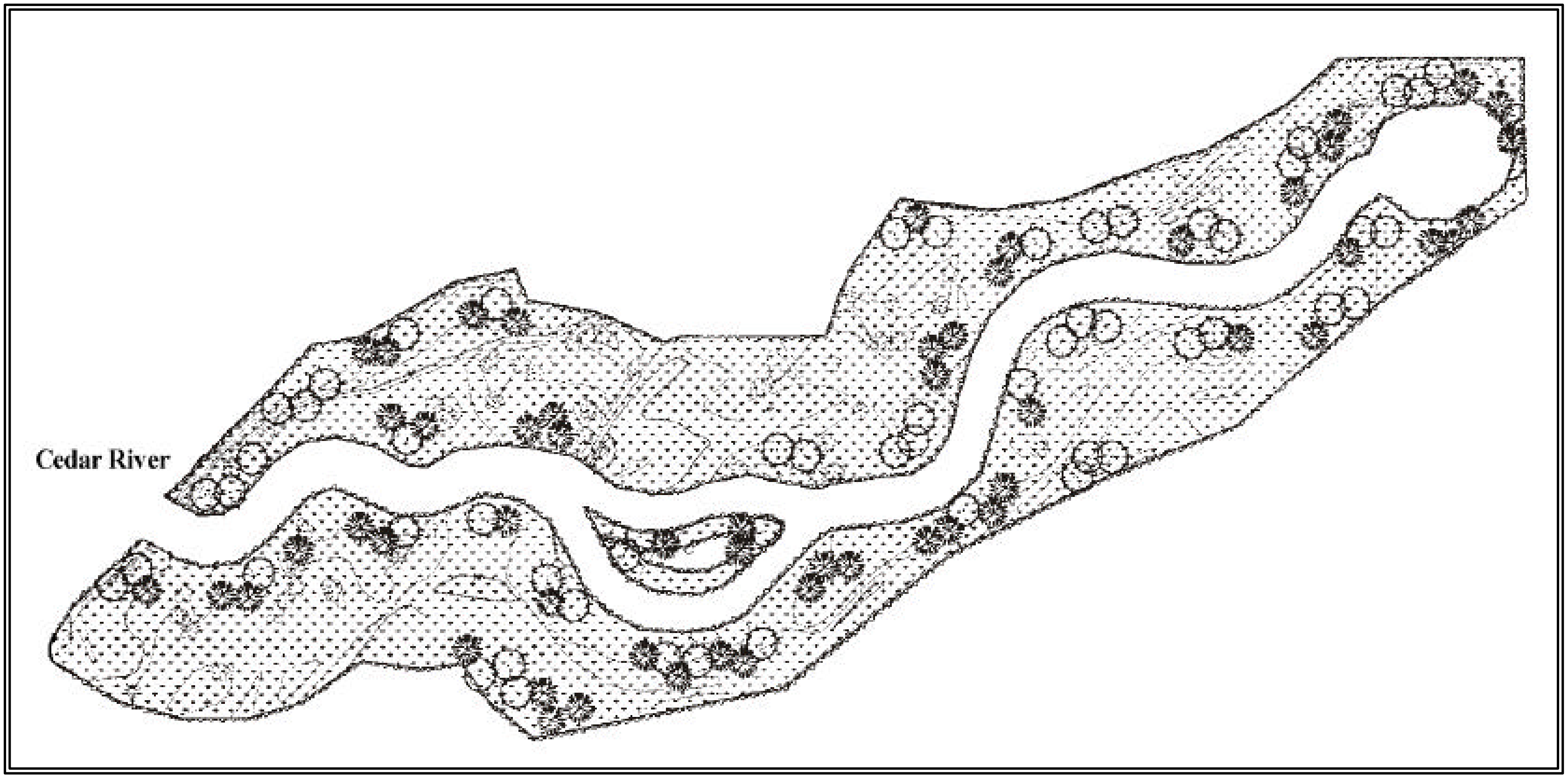

Figure 1. Side channel created by USACE as mitigation for dredging impacts in lower Cedar River, King County, Washington, 1999 (base map adapted from USACE by R2 Resource Consultants).

The following report describes the methods and results of the adult spawner surveys. We have included descriptions of the physical conditions (discharge and water temperature) in the mainstem Cedar River during the surveys as well as conditions (stage and water temperature) in the side channel at the time of observation. We also incorporated the results of the adult spawner surveys conducted during the 1998 brood year to facilitate comparisons between brood years. Spawner survey data was also collected from the King County's Elliot Groundwater Channel. This report will help assess the success of the USACE Groundwater Side Channel relative to use by adult salmonids as spawning habitat. This information will also provide a comparison of a newly constructed feature to an established channel with documented use by spawning salmonids.

2. METHODS

2.1 SALMONID SPAWNING

Spawning surveys were conducted from 7 October 1999 through 15 January 2000 on the USACE Groundwater Side Channel as well as the Elliot Groundwater Channel. Surveys were conducted on the USACE Groundwater Side Channel and Elliot Groundwater Channel each week during the study period, except for the weeks of 10 and 24 November in the Elliot Groundwater Channel. Data for these weeks were estimated by interpolating the previous and subsequent week's data, and data on peak spawner use collected from the USACE Groundwater Side Channel.

Spawning surveys were conducted by a single observer, beginning at the confluence of the side channel with the Cedar River, moving upstream to the end of the channel. Newly constructed redds were marked with survey flagging tied to small rocks and placed adjacent to observed redds. Subsequent survey weeks utilized flagging of a different color. Total spawner counts on a survey represented all live fish observed and those dead fish not previously counted. Dead fish were marked on each survey by removing the entire caudal fin.

2.2 PHYSICAL HABITAT PARAMETERS

A staff gage was installed in the USCAE Groundwater Side Channel to record stage. An Onset Optic StowAway® shuttle recorded water temperatures to the nearest 0.05° C in both channels. Temperature recorders were installed on 29 September (USACE Groundwater Side Channel) and on 7 October (Elliot Groundwater Channel). Water temperature was also recorded in each channel and in the Cedar River using a handheld thermometer to the nearest 0.5° C on survey dates. Provisional discharge data (mean daily flows) were obtained from the U.S. Geological Survey. Representative photographs were taken of individual redds and channel habitats. All data were transcribed onto field data sheets depicting a map of the individual channel.

2.3 ESTIMATED FRY EMERGENCE

Degree days were calculated using the equation:

$$\textit{degree day} = \textit{number of days} \times {}^{\circ}C \textit{ above } 0^{\circ}C$$

Water temperature data collected from both channels were used to estimate emergence. A value of 8.5°C was used for days beyond the period of record (period of record = 7 October through 31 January). We assumed that sockeye deposited their eggs in an average of 10 days (Stober and Hamalainen 1980).

All data were entered electronically using MS Excel and cross-referenced with original field data forms for QA/QC purposes. Statistical analysis was conducted using Jandel Scientific SigmaStat. Unless otherwise specified, all data are expressed as the number of redds per 100 lineal feet of channel.

3. RESULTS AND DISCUSSION

3.1 SALMONID SPAWNING

Sockeye were the lone salmonid observed spawning in both channels during the 1999 brood year. Solitary coho salmon were occasionally observed in both channels. One chinook salmon was observed on a redd located in the Cedar River near the outlet of the USACE Groundwater Side Channel on 7 October. A total of 144 and 141 sockeye redds were observed in the USACE Groundwater Side Channel and the Elliot Levee Groundwater Channel, respectively (Table 1). Sockeye redds were first observed on 16 October (USACE Groundwater Side Channel) and on 10 November (Elliot Levee Groundwater Channel) (Figures 4 and 5). Redd density peaked on 15 November (USACE Groundwater Side Channel) and on 3 December (Elliot Levee Groundwater Channel) (Figures 4 and 5). Adult sockeye utilized the outlet of both channels as well as the mainstem Cedar River as holding habitat before moving upstream into the channels to spawn. A total of 230 adult sockeye were observed in the USACE Groundwater Side Channel and 228 in the Elliot Levee Groundwater Channel (Table 2). Observations of live sockeye spawners peaked in both channels on 3 December, while the number of carcasses present peaked on 30 December (USACE Groundwater Side Channel) and on 11 December (Elliot Groundwater Channel). Although utilizing the entire USACE Groundwater Side Channel for spawning, sockeye redd distribution was noticeably concentrated in several areas of the channel (Appendix A; Figures A-1 through A-15). These reaches were generally associated with areas of groundwater upwelling (E. Jeanes, R2, *pers. observation*). Based on a 58:42 male-to-female ratio reported in Stober and Hamalainen (1980), we would have expected to observe 266 redds in the channels. During the 1999 brood year we observed 285 redds, which is consistent with the expected value based on the total number of sockeye observed (458).

Prior spawning surveys, conducted during the 1998 spawning season, reported a total of 11 sockeye in the USACE Groundwater Side Channel from 15 October 1998 through 13 January 1999 (Table 3) (Martz 1999). Data collected every two weeks during the 1998 brood year suggested that 1998 peak spawning was two weeks earlier than 1999; however data are incomplete for the 1998 brood year. A total of 244 live sockeye were observed during the 1998 brood year in the Elliot Groundwater Channel. This compares favorably to the number observed during the 1999 brood year (228). The number of redds was not recorded during the 1998 survey of the Elliot Levee Groundwater Channel. Construction of the USACE Groundwater Side Channel was completed two months prior to the 1998 spawning season, undoubtedly the reason for low use by sockeye in 1998. The level of sedimentation appears to be greater in the USACE Groundwater Side Channel compared to the Elliot Levee Groundwater Channel (E. Jeanes, R2, *pers. observation*). Three weeks after the last redd was deposited, redds in the USACE Groundwater Side Channel were covered with a thin layer of fine sediment, while surficial sedimentation was not apparent in the Elliot Levee Overflow Channel.

3.2 PHYSICAL HABITAT PARAMETERS

Physical habitat parameters (stage and water temperature) recorded in the USACE Groundwater Side Channel and Elliot Levee during spawning surveys are presented in Table 4. Mean daily discharge in the Cedar River at Renton, Washington ranged from 144 cfs (7 October) to 2,516 cfs (18-19 December) during the study period (Figure 6). Data from January through February, 2000, are not yet available. Discharge in the Cedar River was approximately 1,800 cfs during the peak of redd deposition in both channels (3 December) (Table 4; Figure 6). Water temperatures measured in the USACE Groundwater Side Channel were slightly cooler than those measured in the Elliot Levee Groundwater Channel (Figures 7 and 8). Maximum, mean, and minimum daily water temperatures were not significantly different, however (Man-Whitney Rank Sum Test; p = 0.604, 0.398, and 0.321).

3.3 ESTIMATED FRY EMERGENCE

Estimating the number of sockeye fry produced in the USACE Groundwater Side Channel requires a prediction of the start of fry emergence based on the length of incubation. Foerster (1968) noted that a wide variation in the length of incubation occurs among sockeye populations. This should be expected considering the geographical locales of different sockeye populations. The mean (n=17) period to first emergence of 594 degree days was primarily from hatchery-reared sockeye (Foerster 1968). Burgner (1991) found length of incubation to peak emergence to average 993 degree days (n=4) based on studies conducted in the Fraser River. The latter value (993 degree days) is believed to be a more accurate reflection of peak emergence timing in the Cedar River.

Peak spawning occurred between 15-24 November in the USACE Groundwater Side Channel and from 24 November through 3 December in the Elliot Levee Groundwater Channel. Assuming 993 degree days, peak emergence is calculated to occur from 18-28 March (USACE Groundwater Side Channel) and 17-27 March (Elliot Levee Groundwater Channel). Assuming 594 degree days, sockeye should begin to emerge in both channels around 31 January. No sockeye fry have been observed in either channel during surveys conducted in early February, suggesting that 993 degree days is more appropriate for Cedar River sockeye incubation.

Figure 2. Upstream (inlet) end of USACE Groundwater Side Channel, lower Cedar River, Washington, 1999.

Figure 3. Downstream (outlet) end of USACE Groundwater Side Channel, lower Cedar River, Washington, 1999.

Table 1. Date, number of sockeye redds, and sockeye redd density recorded in the USACE Groundwater Side Channel and Elliot Levee Groundwater Channel, lower Cedar River, Washington, 1999.

Date	USACE Groundwater Side Channel		Elliot Levee Groundwater Channel	
	No. Redds	Redd Density (No. Per 100 ft)	No. Redds	Redd Density (No. Per 100 ft)
7-Oct	0	0.0	0	0.0
16-Oct	1	0.1	0	0.0
24-Oct	3	0.3	0	0.0
2-Nov	2	0.2	0	0.0
10-Nov*	12	1.3	10	1.4
15-Nov	28	3.1	24	3.4
24-Nov*	21	2.3	30	4.3
3-Dec	23	2.6	40	5.7
11-Dec	23	2.6	14	2.0
16-Dec	11	1.2	6	0.9
22-Dec	11	1.2	9	1.3
30-Dec	6	0.7	6	0.9
7-Jan	3	0.3	2	0.3
15-Jan	0	0.0	0	0.0
Total	***144***		***141***	

* missing data estimated by interpolation

Table 2. Date, number of live sockeye, and sockeye carcasses recorded in the USACE Groundwater Side Channel and Elliot Levee Groundwater Channel, lower Cedar River, Washington, 1999.

Date	USACE Groundwater Side Channel		Elliot Levee Groundwater Channel	
	No. Live Sockeye	No. Sockeye Carcasses	No. Live Sockeye	No. Sockeye Carcasses
7-Oct	0	0	0	0
16-Oct	0	0	0	0
24-Oct	7	1	0	0
2-Nov	5	2	0	0
10-Nov*	8	6	17	0
15-Nov	30	3	34	3
24-Nov*	24	9	38	4
3-Dec	39	5	43	5
11-Dec	34	8	27	11
16-Dec	30	4	28	2
22-Dec	29	6	25	4
30-Dec	15	10	8	8
7-Jan	6	5	6	2
15-Jan	3	3	2	0
Total	230	62	228	39

Table 3. Date, number of live sockeye, number of sockeye carcasses, and number of redds recorded in the USACE Groundwater Side Channel and Elliot Levee Groundwater Channel, lower Cedar River, Washington, 1998.

Date	USACE Groundwater Side Channel			Elliot Levee Groundwater Channel	
	No. Live Sockeye	**No. Sockeye Carcasses**	**No. Redds**	**No. Live Sockeye**	**No. Sockeye Carcasses**
30-Oct-98	0	1	0	1	0
5-Nov-98	0	2	0	1	0
13-Nov-98	2	2	0	7	0
29-Nov-98	2	0	0	109	10
9-Dec-98	0	1	0	91	30
28-Dec-98	1	0	17	35	39
13-Jan-99	0	0	4	0	27
Totals	***5***	***6***	***21***	***244***	***106***

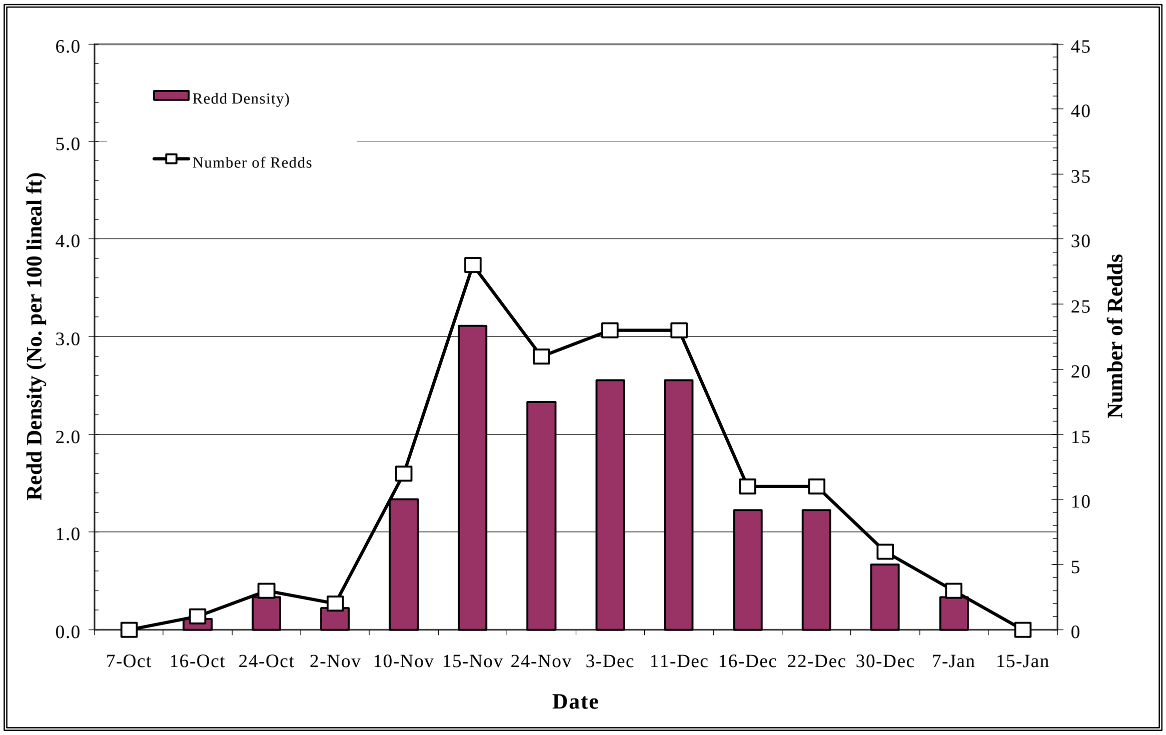

Figure 4. Sockeye redd density (no. per 100 lineal ft) and number of redds constructed in the USACE Groundwater Side Channel, lower Cedar River, Washington, 1999.

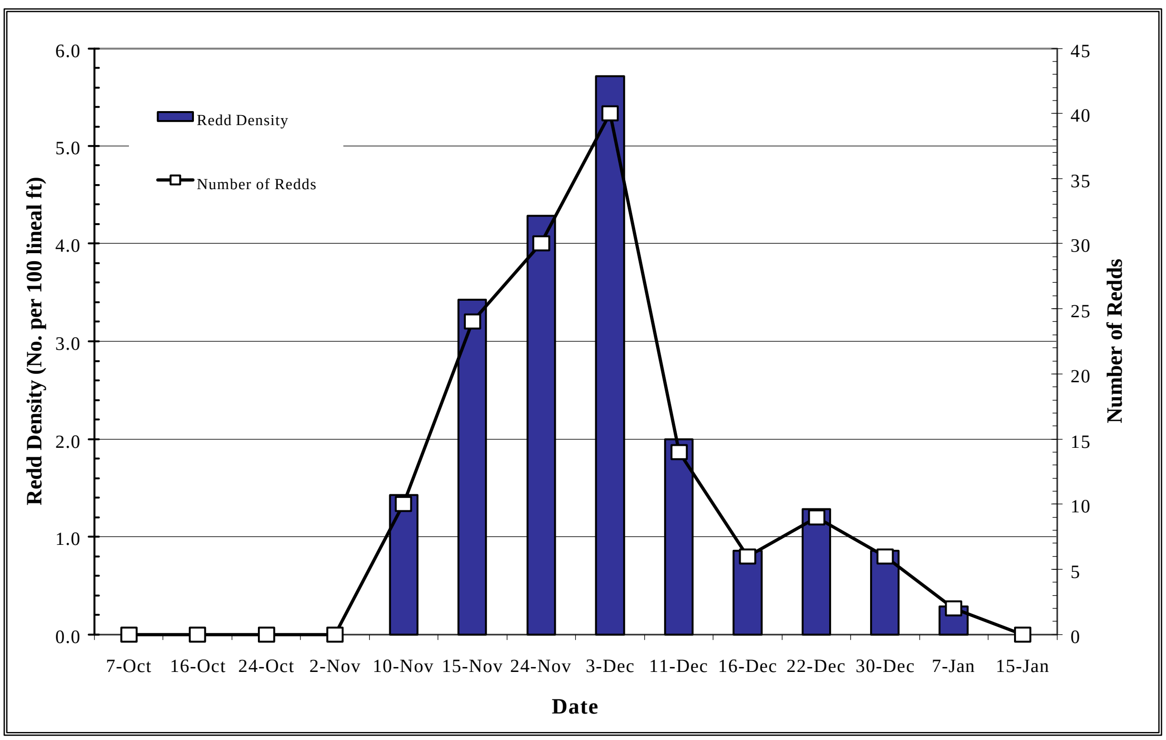

Figure 5. Sockeye redd density (no. per 100 lineal ft) and number of redds constructed in the Elliot Levee Groundwater Channel, lower Cedar River, Washington, 1999.

Table 4. Date, stage (mm), water temperature (°C), and mean daily discharge (cfs) during the USACE Groundwater Side Channel and Elliot Levee Groundwater Channel spawner surveys, lower Cedar River, Washington, 1999.

	USACE Groundwater Side Channel		Elliot Levee Groundwater Channel	Mainstem Cedar River	
Date	**Stage (mm)**	**Water Temp (C)**	**Water Temp (C)**	**Water Temp (C)**	**Mean Daily Discharge (cfs)**
7-Oct-99	N.A.	12.8	13.3	9.4	321
16-Oct-99	N.A.	12.2	12.2	8.3	386
24-Oct-99	N.A.	12.2	12.2	11.7	381
2-Nov-99	N.A.	11.1	10.6	9.4	366
10-Nov-99	235	10.6	10.0	8.9	587
15-Nov-99	210	10.6	10.0	8.3	606
24-Nov-99	365	10.0	10.0	8.3	948
3-Dec-99	785	9.4	9.4	8.9	1768
11-Dec-99	706	9.4	9.4	7.8	1366
16-Dec-99	1152	7.8	8.9	6.1	2306
22-Dec-99	780	8.9	8.3	6.7	1692
30-Dec-99	427	7.8	7.8	6.7	1346
7-Jan-00	483	7.8	6.7	6.7	N.A.
15-Jan-00	355	8.9	6.7	5.6	N.A.

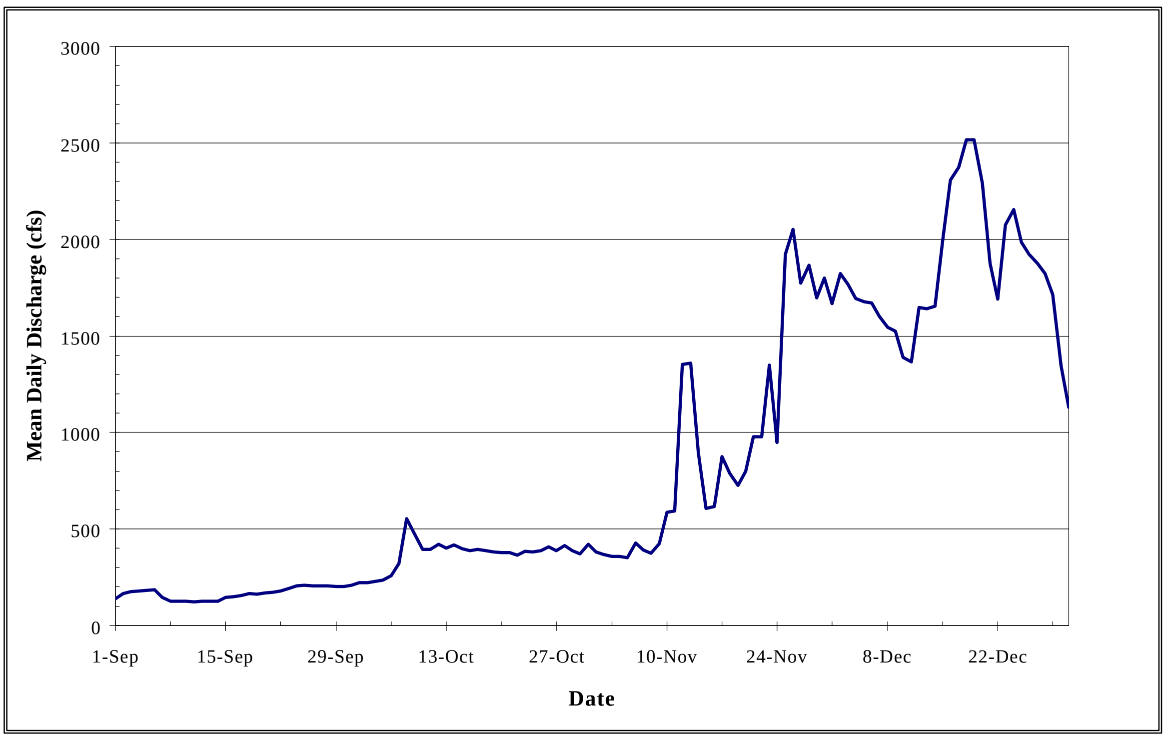

Figure 6. Mean daily discharge (cfs) at Renton, Washington (USGS Gage 12119000), 1999.

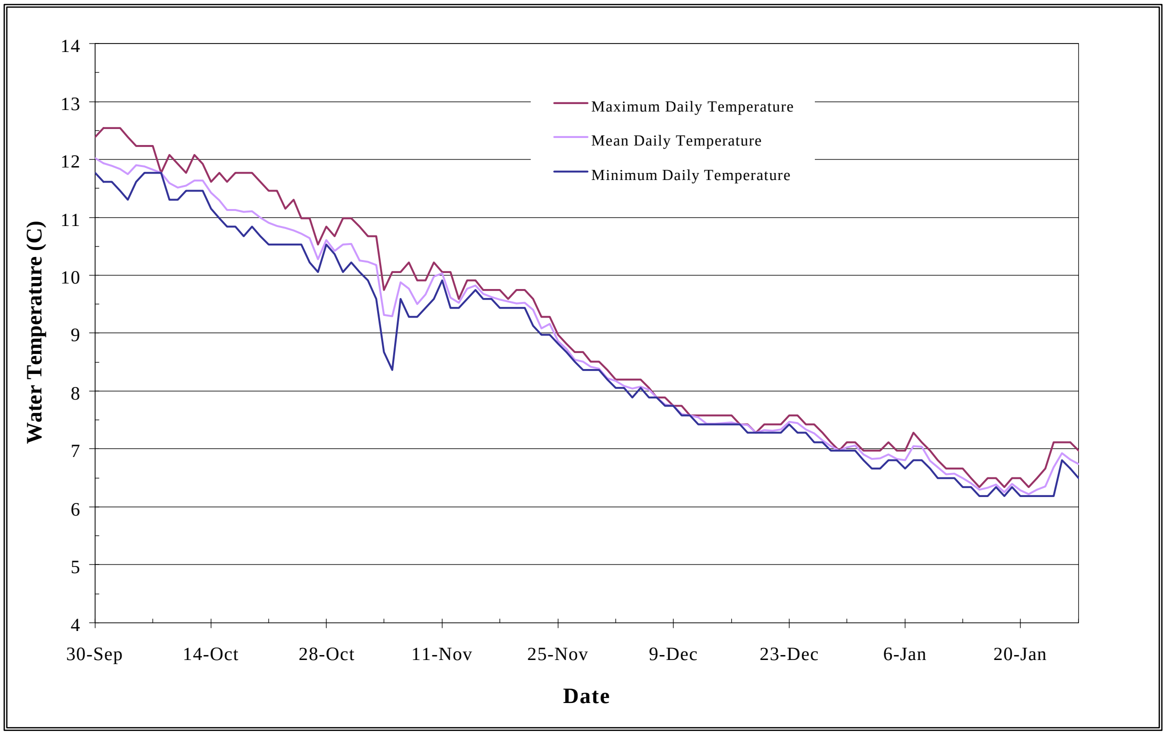

Figure 7. Daily maximum, mean, and minimum water temperatures (°C) recorded in the USACE Groundwater Side Channel, lower Cedar River, Washington, 1999.

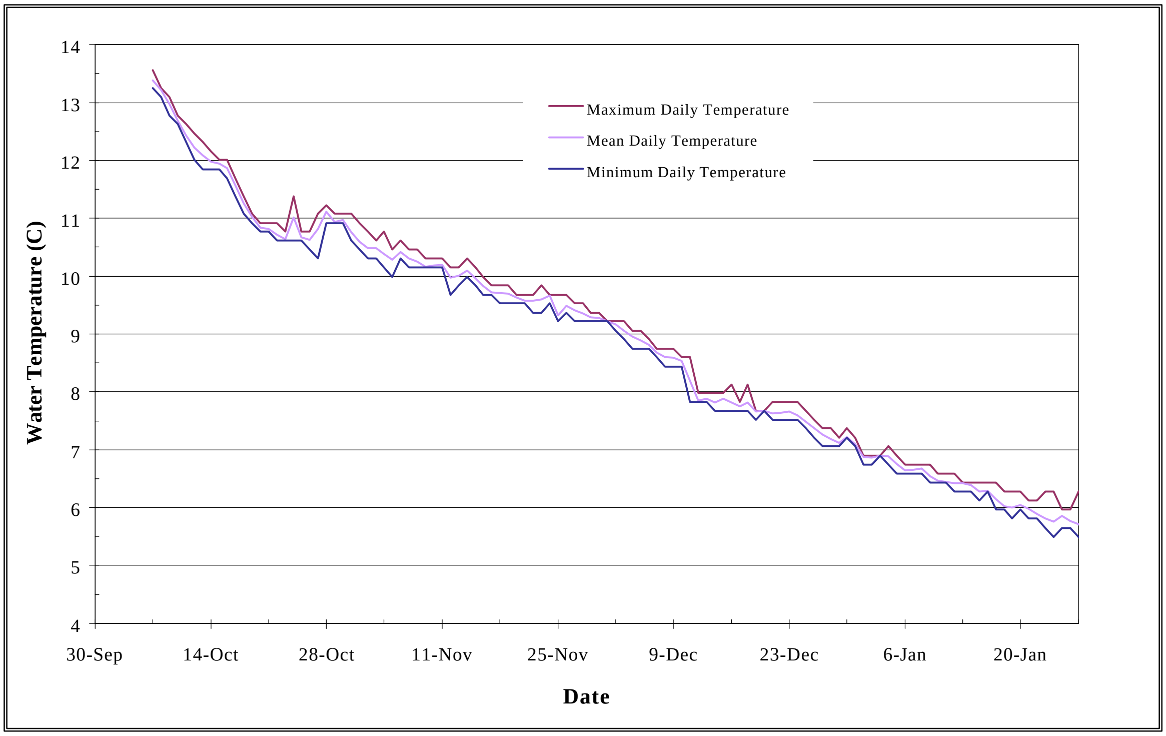

Figure 8. Daily maximum, mean, and minimum water temperatures (°C) recorded in the Elliot Levee Groundwater Channel, lower Cedar River, Washington, 1999.

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Appendix A

Redd Distribution Summary Data