Section 4.4 Contents

4.4 Instream Flow Management

4.4.1 Introduction

BACKGROUND AND PLANNING CONTEXT

The City of Seattle is a regional municipal water supplier providing drinking water to over 1.2 million customers in the Seattle metropolitan area. Approximately two-thirds of this water supply is provided from the Cedar River, with most of the remainder provided from the South Fork Tolt River in the Snoqualmie River basin. Protecting public health and safety by providing an adequate and reliable supply of safe, high-quality water is the City's core mission in managing its facilities and operations in the Cedar River basin. In fulfilling its water supply mission, environmental stewardship will remain a top priority for the City. The City recognizes and acknowledges the benefit of both instream and out-of-stream uses of water, as well as the relationship of land use to water quality and instream habitat (SWD 1993).

Stream flow volume, rate of change, and timing of delivery are important features of aquatic ecosystems that have been subject to significant influence from anthropogenic activities during the twentieth century in the Pacific Northwest (National Research Council 1996). Through its water storage and supply activities in the Cedar River basin, the City can exert considerable influence over stream flows in the lower 35.6 miles of the river downstream of Masonry Dam. Chester Morse Lake and the associated Masonry Pool, the City's water storage reservoir that was formed from ancient Cedar Lake with the construction of a crib dam on Cedar Lake in 1901 and the Masonry Dam in 1914, captures run-off from the upper 43 percent of the Cedar River basin. In addition, the City currently diverts approximately one-fifth of the total annual flow from the river for municipal water supply at river mile 21.8, 13.8 miles downstream from Masonry Dam (Map 2). Although inflows to the river from the lower 57 percent of the basin are unregulated, the City's releases from Chester Morse Lake and diversions at the Landsburg Dam have a significant influence on stream flows and the condition of aquatic habitat throughout the river below Masonry Dam.

Conservation of anadromous salmonids calls for broad-based, ecosystem approaches to the management of these species and their habitats (see National Research Council 1996; Gregory and Bisson 1997; Williams and Williams 1997). Because of their unique life history patterns and freshwater habitat requirements, anadromous salmonids force one to look broadly across the landscape to the many factors that influence the condition of the fish and their environment. The HCP treats salmon and steelhead as keystone species in the aquatic habitat that is formed by the Cedar River, and as such, these species form one of the central considerations for the City's HCP. As Gauvin (1997) illustrates, water management and its effects on instream flows must be a key consideration in effective, ecosystem-based approaches to salmonid conservation in the Pacific Northwest. Instream flow management is one of several central components that form the basis of the City's efforts to contribute to the conservation of anadromous salmonids in the Lake Washington basin through the implementation of the Cedar River HCP. The HCP should in turn be viewed as one component in a larger, multi-jurisdictional effort to implement a basin-wide anadromous fish conservation program (Table 4.3-1).

Prior to the construction of the Landsburg Dam early in the twentieth century, anadromous salmonids were present throughout the Cedar River from its confluence with the Black River, near the present-day site of the City of Renton, upstream to the natural barrier formed by Lower Cedar Falls, located 1.4 miles downstream from Masonry Dam (Section 3.2.5; Map 2). Today, sockeye, coho, and chinook salmon and steelhead trout are present in the 21.8 river miles between the Landsburg Diversion Dam and Lake Washington (Map 8). As part of the City's HCP, fish passage facilities will be installed at the Landsburg Diversion Dam to enable coho, chinook, and steelhead populations to reestablish themselves in their former habitat upstream (Section 4.3.2).

The majority of the steelhead and sockeye in the Lake Washington basin currently originate from the mainstem of the Cedar River. Substantial numbers of naturally reproducing chinook and coho are also present in the Cedar, although they compose a smaller fraction of the total Lake Washington population. Like many fish populations throughout the northwest, Cedar River salmon and steelhead have been experiencing a general trend of decline and are presently considered to be in a depressed condition (WDF et al. 1993). While there are many factors beyond the City's control that can affect the status of Cedar River anadromous fish populations, the City's reservoir management and water diversion activities can have a significant effect on the condition of freshwater habitat for these species. During any given season, at least two species of anadromous salmonids are present in the river. For much of the year, all four species are present simultaneously in more than one life history stage. Protective instream flow management practices can provide substantial benefits to anadromous fish in the Cedar River.

The relationship between fish habitat and instream flows on the Cedar River has been studied extensively for nearly 30 years. Most recently, a collaborative study program was initiated in 1986 with Tribal, state, and federal resource managers. The study program consisted of a comprehensive Instream Flow Incremental Methodology (IFIM) study and several ancillary investigations that addressed key biological factors not considered in standard IFIM studies (Section 3.3.2). The results of these investigations were published in 1991 and used as the basis for further analyses and negotiations with the study collaborators between 1993 and 1997. These further efforts culminated in the development of the instream flow management regime described in the March 17, 1997, Agreement in Principle for the Cedar River Habitat Conservation Plan (SPU 1997), signed by five cooperating state and federal agencies. The instream flow regime characterized in the Agreement in Principle is the basis for the instream flow management strategy presented in the City's HCP.

A formal Instream Flow Agreement (IFA), based on the Agreement in Principle, is part of this HCP (Appendix 27). The five signatories to the IFA are referred to in this section as Parties to the IFA (or "Parties"), and include NMFS, USFWS, WDFW, WDOE, and the City. The IFA establishes a Cedar River Instream Flow Oversight Commission, referred to below as "the Commission," which includes all the Parties, as well as the Muckleshoot Indian Tribe.

OBJECTIVES

The operation of water storage and diversion facilities on the Cedar River can be both beneficial and detrimental to downstream aquatic resources. The HCP attempts to fully express potential benefits while limiting detrimental impacts. The objectives established for this element of the HCP treat unlisted species as if they were listed and support the goal of avoiding, minimizing, and mitigating the incidental take of species listed as threatened or endangered. However, the objectives go beyond this goal and call for a program that: (1) provides a net benefit to the species covered in the plan; and (2) substantially contributes to the recovery of species that are currently listed or that might be listed in the future. The specific objectives listed below were developed to help guide the City's efforts to manage instream flows in a manner that protects anadromous fish and their habitat while preserving and protecting the municipal water supply.

(1) Implement a beneficial instream flow regime, based on the best current scientific information, that will help provide high quality fish habitat throughout the potential range of anadromous fish in the Cedar River from Lake Washington to the natural migration barrier formed by lower Cedar Falls;

(2) Reduce the risks of stranding juvenile salmonids and dewatering salmonid redds to levels that will help promote the full recovery and persistence of anadromous salmonid populations in the Cedar River;

(3) Provide an instream flow regime that significantly improves existing habitat conditions for all four species of anadromous salmonids in the Cedar River over existing conditions;

(4) Maintain the supply capacity from the municipal water system, including the Cedar River, as measured by average annual firm yield, protect drinking water quality and public health, and preserve the operational flexibility necessary to water supply operations;

(5) Help support measures that will contribute to improving downstream migration conditions for juvenile salmonids at the Hiram Chittenden (Ballard) Locks; and

(6) Preserve flexibility to meet water needs for people and fish that may be identified in the future.

OVERVIEW OF INSTREAM FLOW MANAGEMENT STRATEGY

To meet these objectives, the City has employed five broad categories of conservation measures.

(1) The HCP will provide a guaranteed flow regime consisting of minimum and supplemental flow commitments. The HCP minimum flow schedule is based upon the best available science and is designed to better mimic the natural hydrograph and provide beneficial conditions for fish while maintaining the City's ability to meet its municipal water supply obligations. For example,

recent investigations have revealed that, in years when spring flow levels are elevated, some steelhead spawn in areas near the stream margin that may become dewatered later in the incubation season as flows drop to normal summer base levels in July; eggs deposited in these areas can experience significant mortality. To address this problem, the HCP provides higher minimum flows during the period when steelhead eggs and alevins are most vulnerable to dewatering in July and early August.

(2) The HCP flow regime will provide supplemental flows above minimum commitments as allowed by specific hydrologic conditions in the watershed and as warranted by the biological requirements of fish. For example, when hydrologic conditions are favorable in the fall, the HCP provides higher flows to recruit additional habitat along the margins of the stream, which is believed to increase potential sockeye production by placing more eggs in areas that are less vulnerable to scour during flood events (Section 3.2.2).

(3) Through the HCP, the City will commit to additional operational constraints to improve fish habitat and which may result in additional costs and organizational changes but will not have a direct effect on water supply. For example, the rate of stream flow reduction will be significantly constrained to reduce the risk of stranding juvenile fish.

(4) The HCP recognizes that a significant volume of water is often available above the guaranteed flow commitments and water supply needs of the City, and that future studies and developments may reveal beneficial instream or out-of-stream uses for some of this water. The HCP will provide for an interagency Commission that will serve as a forum for sharing of information and discussion concerning potential use of this water. In addition to the guaranteed flow regime, the City will reserve 100 mgd of its 300 mgd water claim for instream resources and is dedicated to managing water diversions from the Cedar for the next 5 to 10 years in the same range that water diversions have been for the last five years (98-105 mgd on an annual average basis).

(5) To compliment its commitments to instream flows, the City will make specific financial commitments to protect habitat conditions in the basin downstream of the municipal watershed. For example, as part of the instream flow management conservation strategies, the City will provide $3 million for habitat protection and restoration in the lower Cedar River basin downstream of Landsburg.

The specific instream flow management provisions presented in Section 4.4.2 may be grouped into one of the four categories described above. Section 4.4.2 first describes the specific instream flow conservation measures that collectively form the instream flow management regime. The descriptions are followed by a discussion of the underlying rationale used in the development of the respective conservation measures. Next, Section 4.4.3 briefly summarizes the major components of the research and monitoring program, which is more fully described in Section 4.5.2. Finally, Section 4.4.4 summarizes the anticipated effects of the conservation strategies. (See also Section 4.6 for a more detailed analysis of effects on particular species)

The instream flow management regime is one component of a more comprehensive anadromous fish conservation strategy embodied in the HCP as a whole. The provisions described here are linked to two additional central components of the HCP: (1) the City's commitments to protect, restore, and reconnect upland, riparian, and aquatic habitat in the upper two-thirds of the basin as described in Section 4.2; and (2) the commitments set forth in section 4.3 to minimize and mitigate the effects of the anadromous fish migration barrier at the Landsburg Diversion Dam.

The HCP can provide a cornerstone for a comprehensive and integrated anadromous fish conservation program in the Lake Washington basin. However, other factors - land management, ground water withdrawals, channel hardening, habitat protection, restoration in the Cedar River basin downstream of the City's ownership boundary, ocean conditions, fish harvest management practices, and other factors - will also play an important role in the effectiveness of the anadromous fish conservation measures provided by the HCP.

4.4.2 Conservation Strategies for Instream Flow Management

Stream flow regulation through the operation of the City's water storage and diversion facilities and hydroelectric generating plant can have very direct effects on the quantity and quality of fish habitat. Stream flow regulation can affect many environmental factors important to fish including: the amount and distribution of spawning and rearing habitat in the river at any given time; the risk of damaging incubating eggs or larval fish by scour or desiccation; the risk of stranding fish during reductions in flow; conditions for upstream and downstream migration; and the biophysical factors that form and maintain stream channels. The strategies described below have been developed in an effort to address all of these issues, while attempting to encourage measures that preserve the general features and patterns of the natural hydrograph in the Cedar River basin in a manner that is consistent with the City's responsibilities as a regional municipal water supplier (Section 2.2).

The HCP Instream Flow Management program includes a guaranteed flow regime that prescribes minimum instream flow requirements, and also includes adaptive provisions for the allocation of supplemental flows, when hydrologically available and biologically beneficial, through operation of a multi-agency Cedar River Instream Flow Oversight Commission (detailed in the IFA, Appendix 27 to the HCP). To provide further flexibility to adapt instream flow management as conditions change and new information becomes available, the City will commit, over and above the guaranteed flow regime, an additional 100 MGD of its 300 MGD water claim to the river for instream resources. In addition, the City will provide a number of additional financial and operating commitments (described later in this section) that will help protect aquatic habitat throughout the basin downstream of its water management facilities. Implementation of the instream flow management regime, including the adaptive features discussed above, will be guided by research and monitoring commitments and overseen by the interagency Cedar River Instream Flow Commission (Commission).

RELOCATED AND ENHANCED FLOW MEASUREMENT POINTS

The stream flow measurement point for the present non-binding IRPP instream flow regime is located at the existing United States Geological Survey (USGS) stream gage

#12119000 in Renton, 1.6 miles upstream from Lake Washington (Map 2). The City will replace this single measurement point with several new instream flow measurement points in order to more closely align the City's accountability with its actual operations, to improve operating precision, and to provide better protection for fish habitat.

First, the measurement point for minimum and supplemental stream flows will be located at the existing USGS stream gage #12117600 at river mile 20.4, 1.4 miles downstream of the Landsburg Diversion Dam. This gage will also be used to monitor the compliance of all upstream City facility water management operations with downramping prescriptions (the rate at which stream flows may be reduced as a result of project operations) as provided below in this section.

To further reduce fish stranding risks associated with reductions in stream flow, the City will commit to a second measurement point for downramping prescriptions at the existing USGS stream gage #12116500 located at river mile 33.2, 0.5 miles downstream of the Cedar Falls hydroelectric project tailrace. This measurement point will become effective immediately after fish passage facilities are completed at the Landsburg Diversion Dam and anadromous fish are allowed to pass upstream into the reach between Lower Cedar Falls and Landsburg (Section 4.3.2).

And finally, a new USGS stream gage will be established near river mile 33.7 just upstream of the Cedar Falls hydroelectric facility tailrace. This gage will be installed to monitor compliance with the City's commitment to provide rearing flows for anadromous fish in the bypass reach between Lower Cedar Falls and the hydroelectric project once fish passage facilities are completed at the Landsburg Diversion Dam.

For the purpose of the accretion flow monitoring study discussed in Section 4.4.3, the City will monitor flows at the existing USGS stream gage # 12119000 at river mile 1.6 in Renton, or at a new USGS stream gage station located in the vicinity of this existing USGS stream gage. If a more suitable physical location is found near the site of the existing USGS stream gage # 12119000, the City will fund the installation and temporary operation of a new USGS stream gage. The existing stream gaging site at river mile 1.6 in Renton is located in a deposition zone that is subject to frequent scour and deposition events that result in a relatively unstable lateral streambed profile. The primary purpose for locating and installing a new stream gage would be to provide a more accurate and reliable data source for use in analyzing rates of natural inflow to the Cedar River between the Landsburg Diversion Dam and Lake Washington. In addition, the City will monitor flows at up to two additional locations between Renton and Landsburg. This would be for only a temporary period as part of the accretion flow study to help monitor accretion flows between Landsburg and Renton. Monitoring at these locations will begin when the accretion flow study is initiated and will terminate when the accretion flow study is completed by or before HCP year 13.

INSTREAM FLOW COMMITMENTS

The instream flow management regime provides a variety of protective elements including commitments to *minimum flows* and *supplemental flows*. The minimum instream flows described in this section represent *requirements* of the City and are referred to as "firm" flows or volumes, subject to the specific conditions and procedures set forth below for minimum flows. The term "minimum instream flow commitments" is not used here to indicate the lowest stream flow levels required to marginally protect fish habitat. Rather, the term is used here to indicate the levels below which the City will not allow stream flows to drop in the Cedar River. *The minimum instream flow commitments presented here have been collaboratively developed with the benefit of an extensive biological information base, and represent beneficial flows that will help ensure the continuous provision of high quality fish habitat throughout the Cedar River between Lower Cedar Falls and Lake Washington.*

Additional flows or volumes provided to supplement minimum flows, as described later in this section under the title, "Supplemental Flows", represent *goals* of the City and are referred to as "non-firm" flows or volumes, subject to the specific conditions and procedures described below for supplemental flows. For both requirements and goals, the City's commitments are to the *occurrence* of the specific flows under the conditions stated and not to a particular method of water management that causes those flows to occur. At times, the City will need to release water from storage in order to meet its requirements or goals downstream; at other times other flow management actions or natural hydrologic events may provide the necessary flows. The sum of the minimum flow commitments and the supplement flow commitments is referred to below as the *guaranteed flow*. As described in section 3.2, and Technical Appendix #36, actual stream flows experienced in the river during given periods of they year are often greater than the guaranteed flow commitments. These additional flows are referred to as *stream flows above the guaranteed levels,* or *expected flows*.

Minimum Flows

The City will operate its facilities on the Cedar River to ensure that stream flows remain above certain specified levels to protect fish habitat, as summarized in Table 4.4-1 and Figure 4.4-1, and as described below. The measurement point for these stream flow commitments will be the existing USGS stream gage #12117600 located at river mile 20.4, 1.4 miles downstream from the Landsburg Diversion Dam. Selections of the key species and life stages for which minimum flows were established during different periods of the year are summarized in Table 4.4.5. Detailed explanations of other elements of the flow regime are presented in the following sections.

The City will subscribe to a binding set of minimum instream flow commitments that will replace the current non-binding flow targets. The general shape of the curve for HCP minimum flow commitments over the year will follow the general shape of the natural annual hydrograph. Flows begin to trend upward in the early fall as rainfall and runoff typically increase. Flows reach relatively high levels by early to mid-October and continue at elevated levels until late spring when they begin to trend lower, reaching summer base flow levels in late July and early August. Flows remain at base levels until the start of the early fall ramp-up (Figure 4.4-1).

As with the existing IRPP regime, the HCP minimum instream flow commitments consist of normal flows and critical flows. However, the HCP minimum flows also include a number of additional features. Between October 8 and December 30, the minimum flow regime provides for either high normal or low normal flows depending upon actual hydrologic conditions. The HCP minimum flow commitments also provide a flexible block of 2500 acre feet of water which will be available in all normal years to provide added instream flow protection during the early summer. In addition, normal minimum flows include flow augmentations from September 16 through September 30, when the flashboards are in place on the overflow dike at the outlet of Chester Morse Lake. Similar provisions for augmentation also apply to critical minimum flows between September 2 and September 15. As described below under the section titled "Supplemental Flows," minimum flows are further augmented under specified conditions from February 11 to April 14 and from June 17 to August 2.

As described in the next section, critical flows would apply under adverse conditions in which specified hydrologic criteria have been met and public notification and water conservation measures specified in the City's water shortage contingency plan have been implemented (Appendix 10). Switches to critical flows would be expected at a frequency of approximately once in 10 years on the average and would be implemented according to very specific criteria and procedures described later in this section.

Table 4.4-1 summarizes the guaranteed flow regime and the frequency of occurrence of the various provisions at the stream gage below the Landsburg Diversion Dam. Low and high normal flows are included in the column titled "Normal Minimum." Normal minimums plus applicable supplements are listed in the column titled "Normal with Supplement." Critical flows are listed with and without the critical flow supplement.

Restoring access for chinook, coho, and steelhead into the habitat upstream of the Landsburg Diversion Dam is a central component of the HCP's conservation strategy for anadromous fish (Section 4.3). The provision of beneficial flows in the 12.4 stream miles of mainstem habitat between Lower Cedar Falls and the Landsburg Diversion Dam is key to the success of this strategy. Because of the need to deliver water via this stream reach for diversion into the municipal water supply intake at Landsburg, flows immediately upstream of Landsburg will always be higher than flows immediately downstream of Landsburg, except when diversion facilities are taken out of service. Interruptions in service at the diversion facilities are infrequent. Interruptions usually only occur when raw water turbidity thresholds are exceeded (typically during the ascending leg of freshet flow events in excess of 1000 cfs) or during infrequent maintenance and repair activities. Table 4.4-2 summarizes the expected minimum flow levels under the HCP normal minimum flow regime as measured near the center point of the upper Cedar River Study Area, *upstream* of the Landsburg Diversion Dam. The HCP minimum instream flow commitments as measured at the existing USGS stream gage #122117600 *downstream* of Landsburg, combined with the additional flows required for the City's municipal water supply diversion, ensure that flow levels in the river *upstream* of the Landsburg Dam will typically be near or above the levels required to provide maximum habitat availability for chinook, coho, and steelhead spawning and rearing.

Table 4.4-1. Minimum and Supplemental Flow Commitments.

Water Week	Calendar Week	Minimum and Supplemental Flows at Landsburg: Normal Minimum (cfs)	Normal with Supplement (cfs)	Critical Minimum (cfs)	Critical with Supplement (cfs)
49	Sep 2 - Sep 8	80		70	80[5]
50	Sep 9 - Sep 15	80		70	80[5]
51	Sep 16 - Sep 22	95	133[2]	80	
52	Sep 23 - Sep 30	95	210[2]	80	
1	Oct 1 - Oct 7	210		100	
2	Oct 8 - Oct 14	330/275[1]		130	
3	Oct 15 - Oct 21	330/275[1]		160	
4	Oct 22 - Oct 28	330/275[1]		180	
5	Oct 29 - Nov 4	330/275[1]		200	
6	Nov 5 - Nov 11	330/275[1]		200	
7	Nov 12 - Nov 18	330/275[1]		200	
8	Nov 19 - Nov 25	330/275[1]		200	
9	Nov 26 - Dec 2	330/275[1]		200	
10	Dec 3 - Dec 9	330/275[1]		200	
11	Dec 10 - Dec 16	330/275[1]		200	
12	Dec 17 - Dec 23	330/275[1]		200	
13	Dec 24 - Dec 30	330/275[1]		200	
14	Dec 31 - Jan 6	260		180	
15	Jan 7 - Jan 13	260		180	
16	Jan 14 - Jan 20	260		180	
17	Jan 21 - Jan 27	260		180	
18	Jan 28 - Feb 3	260		180	
19	Feb 4 - Feb 10	260		180	
20	Feb 11 - Feb 17	260	365[3]	180	
21	Feb 18 - Feb 24	260	365[3]	180	
22	Feb 25 - Mar 3	260	365[3]	180	
23	Mar 4 - Mar 10	260	365[3]	180	
24	Mar 11 - Mar 17	260	365[3]	180	
25	Mar 18 - Mar 24	260	365[3]	180	
26	Mar 25 - Mar 31	260	365[3]	180	
27	Apr 1 - Apr 7	260	365[3]	180	
28	Apr 8 - Apr 14	260	365[3]	180	
29	Apr 15 - Apr 21	260		180	
30	Apr 22 - Apr 28	260		190	
31	Apr 29 - May 5	260		190	
32	May 6 - May 12	260		195	
33	May 13 - May 19	260		200	
34	May 20 - May 26	250		210	
35	May 27 - Jun 2	250		210	
36	Jun 3 - Jun 9	250		200	
37	Jun 10 - Jun 16	225		200	
38	Jun 17 - Jun 23	225	[4]	160	
39	Jun 24 - Jun 30	225	[4]	100	
40	Jul 1 - Jul 7	170	[4]	80	
41	Jul 8 - Jul 14	105	[4]	80	
42	Jul 15 - Jul 21	80	[4]	80	
43	Jul 22 - Jul 28	80	[4]	80	
44	Jul 29 - Aug 4	80	[4]	70	
45	Aug 5 - Aug 11	80		70	
46	Aug 12 - Aug 18	80		70	
47	Aug 19 - Aug 25	80		70	
48	Aug 26 - Sep 1	80		70	

[1]Values shown represent High- and Low-Normal minimum flows weeks 2 - 13
[2]Guaranteed flow during normal years if flashboards in place
[3]Guaranteed flow provided approximately 70 percent of time in normal years
[4]Additional 2,500 acre-feet (for minimums) in all normal years 6/17 - 8/4; plus additional 3,500 acre-feet (supplemental) in 70 percent of normal years 6/17 - 8/4 as directed by Commission
[5]Guaranteed flow during critical years if flashboards in place

Figure 4.4-1. Minimum and Supplemental Flow Commitments.

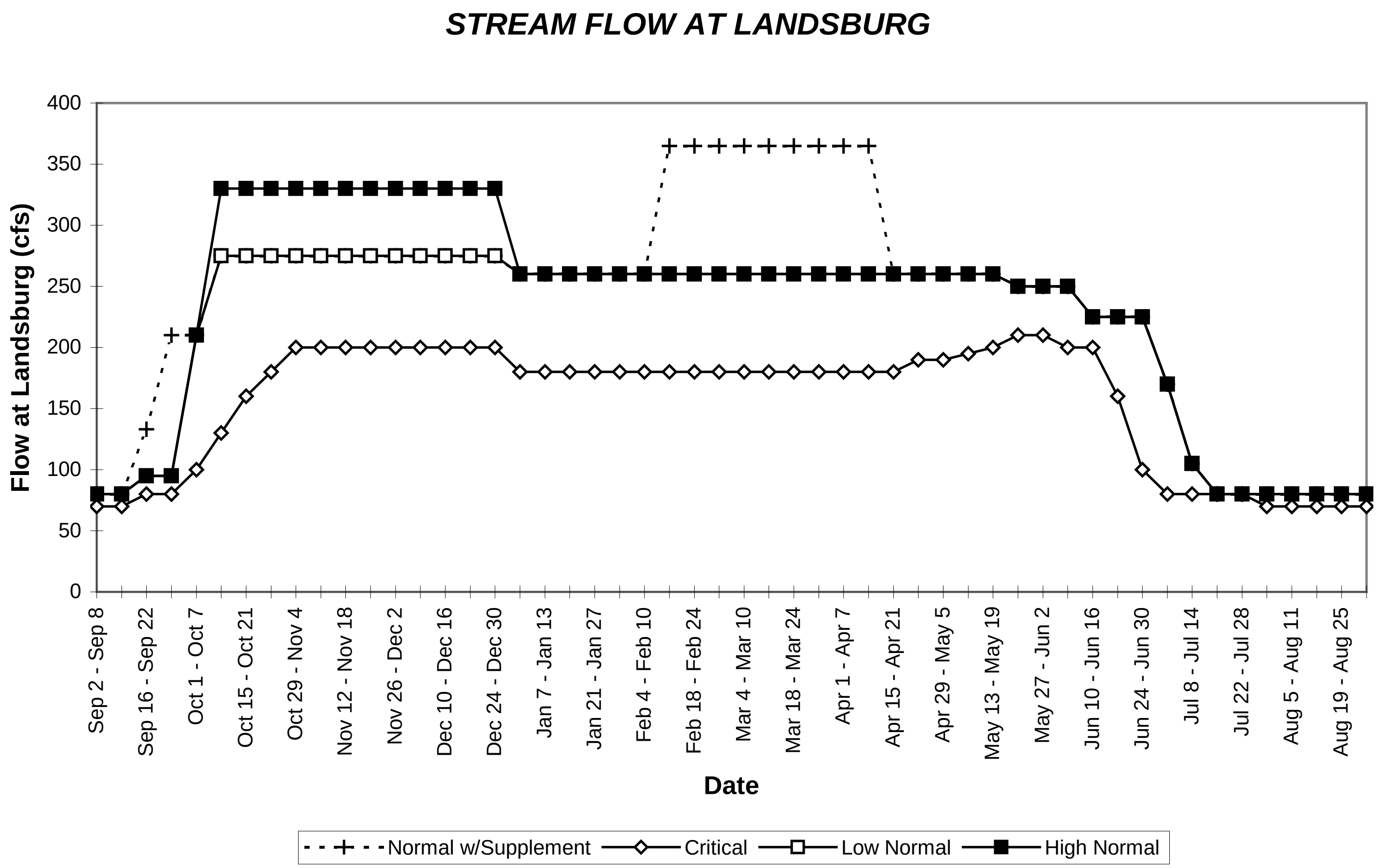


Table 4.4-2. Summary of expected minimum flows in the Upper Cedar River Study Area (upstream of Landsburg Diversion Dam).

Time period	Required HCP Minimum Plus Supplemental Flow at Landsburg (cfs)	Average Diversions Minus Inflow Flow Between Mid-Point of Upper Cedar Study Area and Landsburg (cfs)	Resultant Flow Adjusted to Mid-Point of Upper Cedar Study Area (cfs)	Key Species/Life History Stage	Percent of Maximum Weighted Usable Area Provided in the Upper Cedar Study Reach
Sept. 2 - Sept. 15	80	152	232	steelhead rearing	100
Sept. 16 - Sept. 22	133	131	264	chinook spawning	82
Sept. 23- Sept. 30	210	132	342	chinook spawning	93
Oct. 1- Oct. 7	210	118	328	chinook spawning	92
Oct. 8 - Oct. 14	330	118	448	chinook spawning	99
Oct. 15 - Oct 28	330	116	446	chinook spawning	99
Oct. 29 - Nov. 4	330	102	432	chinook spawning	99
Nov. 5 - Nov. 18	330	105	435	chinook spawning	99
Nov. 19 - Dec. 2	330	117	447*	coho spawning	85
Dec. 3 - Dec. 30	330	147	477*	coho spawning	81
Dec. 31 - Feb. 3	260	134	394*	coho spawning	92
Feb. 4 - Feb. 10	260	142	402*	coho spawning	91
Feb. 11 - Mar. 3	365	142	507*	coho spawning	78
Mar. 4 - Mar. 31	365	142	507*	steelhead spawning	100
April 1- April 14	365	143	508*	steelhead spawning	100
April 15 - May 5	260	160	420	steelhead spawning	97
May 6 - May 19	260	155	415	steelhead spawning	97
May 20 - June 2	250	155	405	steelhead spawning	97
June 3 - June 9	250	148	398	steelhead spawning	96
June 10 - June 16	225	151	376*	steelhead rearing	96
June 17 - June 30	225	186	411*	steelhead rearing	96
July 1- July 7	197	204	401*	steelhead rearing	96
July 8- July 14	186	205	391*	steelhead rearing	96
July 15 - Aug. 4	188	219	407*	steelhead rearing	96
Aug. 5 - Sept. 1	80	211	291*	steelhead rearing	99

*Flows exceed the level required to provide maximum weighted usable area.

Augmented Normal Flows in Late September for Spawning Chinook Salmon

The City's Overflow Dike located at the outlet of Chester Morse Lake has the capability to be fitted with temporary flashboards that increase the City's capability to control the flow of water from Chester Morse Lake into Masonry Pool. By retaining water in Chester Morse Lake during the dry season, seepage losses through the glacial moraine that forms the northeast bank of Masonry Pool can be reduced. This reduction in seepage loss results in a small but significant increase in water available for delivery to the Cedar River. These water savings will be entirely allocated to augmenting stream flows to provide increased spawning habitat for early arriving chinook salmon in the Cedar River. In any year in which the temporary flashboards, as they presently exist in the City's Overflow Dike or may hereafter be reconstructed (provided that such reconstruction does not result in greater impacts to Covered Species), are in place throughout the period of June 1 through September 30, the normal minimum flows will be increased by the amount of 38 cfs between September 15 and 22, and by the amount of 115 cfs between September 23 and 30.

Increased flow during this time will provide increased habitat availability for early spawning chinook. Available sockeye spawning habitat is reduced during this period as flows exceed the level required to provide maximum WUA for sockeye. However, the reduction in static sockeye spawning habitat will be somewhat offset by the potential increase in cumulative sockeye spawning habitat and by recruitment of new edge habitat that may be to some extent less vulnerable to subsequent scour during flood events.

Augmented Critical Flows in Early September

In dry years, inflows to the river between the Landsburg Dam and Renton typically remain at very low levels in early September. Additional flow during early September in drought years will improve conditions for early returning adult chinook and sockeye and improve rearing conditions for juvenile steelhead and coho. In any year in which the temporary flashboards, as they presently exist in the City's Overflow Dike or may hereafter be reconstructed (provided that such reconstruction does not result in greater impacts to Covered Species), are in place throughout the period of June 1 through September 30, the critical minimum flows will be increased by the amount of 10 cfs throughout the period between September 1 and 15.

High-Normal Flows for Sockeye Salmon Spawning

As described previously, flows in excess of those required to provide maximum WUA for spawning are thought to provide additional benefits for sockeye by recruiting spawning and incubation habitat in less scour-prone areas nearer the margins of the stream. In order to provide the potential benefits of higher spawning flows for sockeye, the City will provide a high-normal flow regime when hydrologic conditions are favorable in the fall. Note that low-normal flows are equal to the flow level that creates maximum WUA for chinook spawning and are well above the level that creates maximum WUA for sockeye spawning.

Between October 8 and December 31, the City will provide either high-normal flows of 330 cfs or low-normal flows of 275 cfs, except when flows are reduced to critical flows according to the procedures described below. More specifically, the City, beginning on October 8, will meet the high-normal and low-normal flow regimes with the following long-term average frequencies assuming that the critical minimum flow regime will be in effect at a long-term average frequency of 1 in 10 years:

- The City will follow the high-normal flow regime in 6 of 10 years, provided that it may switch down to low-normal in one of those years when and if actual or forecasted water availability conditions worsen significantly from those projected and understood at the time of the decision to provide high-normal flows; and

- The City may follow the low-normal flows in 3 of 10 years, provided that it will switch up to high-normal at such time after October 8 if the City determines that improving conditions allow, or when criteria for high-normal levels are met, whichever comes first.

Between October 1 and October 7, the City will convene a meeting of the Commission by phone or in person. The City will present information on water supply conditions and forecasts, water conservation measures taken during the spring and summer, and such other information as may be useful in assessing the situation. The WDFW and/or other Parties to the IFA will present information on the chinook and sockeye salmon run size and timing and such other information as may be useful in assessing the situation. Following discussion and consideration of the information exchanged, the City will follow either the high-normal or low-normal flow regime, provided, however, that in order to implement the high-normal flow regime, the following minimum criteria must be met:

- On October 8 the elevation of Chester Morse Lake is, or is reasonably forecasted to be, greater than elevation 1541.5 ft;

- The average inflow to Chester Morse Lake for the antecedent 30-day period is greater than 31 cfs; and

- The average inflow for the antecedent 15-day period is greater than 32 cfs.

If the City elects to implement the low-normal flow regime, the City must show that during the peak water consumption season it has provided to its water customers, through paid or unpaid advertising or general news coverage, at least two water conservation messages that emphasize the importance of stream flows to fish habitat.

Table 4.4-3 shows expected frequencies of high- and low-normal curves, on average, throughout the period following October 8, assuming off-ramping (from high to low) and up-ramping (from low to high) decisions using modeled historical hydrologic information.

Table 4.4-3. Long-term average number of years in 10 years during which high-normal and low-normal minimum flow regimes are in effect (assuming critical flows in 1 of 10 years).

Week Period	High-Normal	Low-Normal
Oct 8 - Oct 14	6.0	3.0
Oct 15 - Oct 21	6.0	3.0
Oct 22 - Oct 28	6.0	3.0
Oct 29 - Nov 4	5.0	4.0
Nov 5 - Nov 11	5.5	3.5
Nov 12 - Nov 18	6.5	2.5
Nov 19 - Nov 25	6.5	2.5
Nov 26 - Dec 2	7.0	2.0
Dec 3 - Dec 9	7.5	1.5
Dec 10 - Dec 16	7.5	1.5
Dec 17 - Dec 23	8.0	1.0
Dec 24 - Dec 31	8.0	1.0

Additional Water in Early Summer for Incubating Steelhead

Collaborative studies conducted by the City and WDFW indicate that is some years, incubating steelhead eggs and alevins can be vulnerable to dewatering from late June through early August as stream flows recede to natural base flow conditions. The timing and magnitude of vulnerability during this period varies from year to year and is partially dependent upon stream flows during the last half of the steelhead spawning season. Vulnerability to redd dewatering increases with increased spawning flow (Burton and Little 1997). To address this issue, minimum flow requirements provide a 2500 acre-foot block of water which can be applied as directed by the Commission to protect incubating steelhead between June 17 and August 4. To support decision making by the Commission, the City will fund an in-season steelhead monitoring program to provide real-time information on the degree to which redds are vulnerable to dewatering (Section 4.4.3).

Reductions to Critical Flows

During conditions of severe drought, the City will be allowed to reduce stream flows to levels described by the critical flow regime (Table 4.4-1 and Figure 4.4-1) according to the switching criteria and conditions described below. It is expected that actual reductions to critical levels would occur only under conditions that occur during a 1-in-10 year drought event. The HCP critical flow regime has been designed around the IRPP critical flow regime but differs in several ways (Figures 4.4-4 and 4.4-5). HCP critical flows will be slightly higher than IRPP flows during the fall, winter, and most of the spring and slightly lower than IRPP flows during the summer.

Switching Criteria and Procedures

The City may reduce flows to the critical minimum flow regime whenever the following conditions are met:

(1) The surface elevation in Chester Morse Lake reservoir is less than the elevations shown by date, or linearly interpolated between the dates shown in Table 4.4-4.

The measuring point for determining reservoir elevation will be the existing staff gage on the Overflow Dike.

(2) The average inflow to Chester Morse Lake for the antecedent eight -week (56-day) period is less than the flow shown by date or the flow linearly interpolated between the dates shown in Table 4.4-3. The measuring point for determining reservoir inflow will be the existing USGS stream gage #12115000, located at river mile 43.5, which serves as an index for total reservoir inflow.

(3) The City has implemented demand reduction measures, including public information programs, as described in its Water Shortage Contingency Plan adopted in 1993 by City Ordinance #116869 and has achieved water usage reductions that are significant for the season in which the shortage has occurred. The Commission shall have the opportunity to review and comment on any proposed revisions to the Water Shortage Contingency Plan in advance of any submission of such proposals for legislative action by the Seattle City Council, as well as the opportunity to comment formally during the decision-making process.

(4) The City has completed the following consultation process: Not less than five working days before it anticipates making a reduction to critical flows, the City will convene, by phone or in person, a meeting of the Commission. The City shall present information related to the switching criteria specified in Table 4.4-4, and discuss with the Commission any suggested options or alternatives to such reduction, such as alternative timing, intermediate flows, and other options. This consultation process may be repeated at the request of any member, but at a minimum, the City shall reconvene the Commission approximately 14 and 35 days after instituting reduced flows to evaluate the situation. If the City returns to normal flows before the end of the interval, the City need not reconvene the Commission, but shall simply notify it of the resumption of normal flows.

The criteria described in conditions 1 and 2 above are hydrologic and reservoir conditions that indicate a degree of drought that triggers an “alert phase” in which the City will initiate consultations with the other Parties to the IFA in order to assess overall supply and fishery conditions, demand management, and forecasts. Based on the hydrologic record, these alert phase conditions are anticipated to occur more frequently than one year in ten, but some will not result in switching to critical flows. The criteria described in conditions 3 and 4 above are other procedures and requirements that must be met before the City may reduce flows from normal to critical. It is projected and intended that actual reductions would occur approximately one year in ten over the long term.

A stabilized flow regime may be more beneficial than a flow that cycles up and down between normal and critical. Therefore the Commission may agree to extend the period of reduced flow during periods when conditions described in Table 4.4-4 are not being met, in order to protect a specific life stage.

Switching criteria will be considered interim until such time as those criteria may be modified as described later in this section under “Technical Studies and Adaptive Management.”

Table 4.4-4. Index Reservoir Inflow and reservoir condition thresholds establishing Alert Phase and potential reduction to critical flows. Flows shown in this table are based on approximately the 10th percentile of the average weekly inflow measured at the existing USGS stream gage # 12115000, for the previous eight weeks.

Water Week	Calendar Date	Average Antecedent 8-week Inflow to Chester Morse Lake (cfs)	Calendar Date	Water Elevation in Chester Morse Lake (ft)
49	September 5	40	January 1	1,539
50	September 12	37	February 1	1,539
51	September 19	36	March 1	1,540
52	September 26	31	April 1	1,548
1	October 4	37	May 1	1,552.5
2	October 11	37	June 1	1,559
3	October 18	37	July 1	1,555
4	October 25	38	August 1	1,552
5	November 1	48	September 1	1,550
6	November 8	66	October 1	1,540
7	November 15	65	November 1	1,540
8	November 22	66	December 1	1,539
9	November 29	81		
10	December 6	101		
11	December 13	114		
12	December 20	127		
13	December 27	147		
14	January 3	158		
15	January 10	156		
16	January 17	152		
17	January 24	169		
18	January 31	160		
19	February 7	139		
20	February 14	148		
21	February 21	151		
22	February 28	146		
23	March 7	133		
24	March 14	141		
25	March 21	142		
26	March 28	142		
27	April 4	149		
28	April 11	157		
29	April 18	169		
30	April 25	185		
31	May 2	203		
32	May 9	227		
33	May 16	233		
34	May 23	263		
35	May 30	289		
36	June 6	283		
37	June 13	285		
38	June 20	274		
39	June 27	249		
40	July 4	221		
41	July 11	194		
42	July 18	167		
43	July 25	133		
44	August 1	110		
45	August 8	87		
46	August 15	69		
47	August 22	55		
48	August 29	45		

Supplemental Flows

In addition to the minimum flow commitments proposed above, the City will provide supplemental flows to meet biological objectives under specific conditions that reflect actual and forecasted water availability. Although the HCP minimum flow commitments are typically well above the levels required to provide maximum WUA, ancillary investigations conducted during the collaborative study program indicate that additional biological benefits for other important aspects of salmonid life history may be obtained at still higher flows during certain times of the year. Committing to provide these additional higher flows at the same frequency as the normal minimum flows discussed would result in an unacceptable loss of firm yield from the drinking water supply. However, in many years, hydrologic conditions are such that these additional flows can be provided. Through the HCP, the City is committing to frequency goals for providing these higher supplemental flows.

The goals for these “non-firm” supplemental flows are derived from analysis and modeling of weather and hydrologic data over the 64.5-year period of record. The frequencies that are projected for achieving these goals are based on the assumption that similar hydrologic conditions will occur in the future. The goals for “non-firm” flows will be incorporated into the City’s estimates and actions regarding the water supply capacity of the Cedar River system, which are part of the City’s water supply planning process. Neither the volume of water provided to meet the non-firm flow goals, nor the frequency of the City’s achievement of those flows will be decreased throughout the term of the HCP, whether or not the City contracts to supply water from the Cedar River to customers or service territories not currently supplied.

Higher Spring Flows for Emigrating Sockeye Fry

Between February 4 and May 12, HCP normal minimum flow commitments are increased above present IRPP levels to provide improved conditions for outmigrating sockeye fry. To provide further benefits for emigrating sockeye fry between February 11 and April 14, the City will, as a goal, supplement the normal minimum instream flows listed in Table 4.4-1 by 105 cfs at least 70 percent of the time throughout said period in any year in which normal flows are in effect throughout said period.

Hydrologic conditions during this period of the year are naturally volatile. The City’s water management operations must consider flood control objectives, steelhead spawning conditions, juvenile chinook rearing conditions, water quality, reservoir refill, and facility maintenance, in addition to sockeye outmigration needs. Not later than April 30 of each year, the City will provide a report to the Commission on average daily flows during the period between February 11 and April 14. The report will explain the considerations that prevailed in any case in which the 105 cfs supplement to normal minimum flow commitments was not provided at least 70 percent of the time throughout said period.

Additional Water in Early Summer for Incubating Steelhead

In some years, high stream flows during the late spring can force steelhead to spawn in areas where their redds will subsequently experience increased risks of dewatering. To address these situations, the City will provide a block of water, in addition to minimum flows, to be allocated, as directed by the Commission, in normal years when the need exists for increased steelhead incubation protection and if specific hydrologic conditions and risk sharing mechanisms provide the flexibility to do so.

Between June 17 and August 4, in addition to the normal minimum flow commitments, (including the 2500 acre foot block of water described above), the City will, as a goal and under the conditions set forth below, expect to further supplement normal minimum flows by 3,500 acre-feet of water in 63 percent of all years. The Parties to the IFA recognize that supplementation of minimum instream flows early in the dry season increases the overall risk of shortage in meeting both water supply needs and guaranteed flow commitments as actual conditions unfold throughout the summer and fall. Therefore, the IFA prescribes a decision-making process that will be implemented to balance those risks with the benefits available from such supplementation of flows (see Appendix 27).

The options to address the increased risk of shortage that were identified by the Parties to IFA included use of the Chester Morse Lake pumping plants under modified water right permit conditions, modifications to the use of the low-normal flow curve, or such other options as may be defined by the Commission. The HCP provides that the State shall issue a new water right permit for the pumping plants, as they presently exist or may hereafter be reconstructed at substantially the same capacity. Such new permit shall reestablish the terms and conditions of the present permit, issued on October 30, 1992, except for the following three changes:

(1) The duration of the permit shall be at least as long as the term of the HCP; and

(2) The City shall be entitled to use the pumping plants to recover volumes of water released above minimum flows when authorized through the decision process described above, provided that, in such case, the permit requirement to implement the Water Shortage Contingency Plan shall not apply; and

(3) The permit shall be subject to minimum instream flow requirements as provided in the HCP

COMPARING THE HCP GUARANTEED FLOWS WITH THE EXISTING IRPP TARGET MINIMUM FLOWS

When considering the HCP flow regime, it is helpful to compare it with the existing IRPP flow management regime and various other reference points. The City has presented several comparisons in Table 4.4-5, Figures 4.4-2, 4.4-3, 4.4-4, and 4.4-5 to help clarify the basis and content of its flow regime. These comparisons are quite useful, but require further explanation and description of the manner in which they were derived.

The present flow regime for the Cedar River was adopted by the Department of Ecology in 1979, through the IRPP. The City has consistently asserted that this regime is not binding on its senior right to store and divert water on the Cedar River (Section 3.2.4). While the City uses the IRPP flow regime as an operating target and as a water supply planning assumption, it has had difficulty meeting these levels during dry periods in the past. Therefore, from the City's viewpoint, the use of the non-binding IRPP flow regime as a reference point tends to overstate current conditions and somewhat complicates comparisons with the proposed binding flow commitments. In comparing the numerical aspects of the two flow regimes, the City has presented them as if they were equal in their level of commitment and enforceability, even though the HCP regime, unlike the IRPP regime, will obligate the City to operate according to a set of binding prescriptions.

The HCP flow regime moves the flow measurement point from Renton to Landsburg for the reasons described previously. In order to compare the stream flow commitments in the HCP, as measured at river mile 20.4 near Landsburg, with the existing IRPP regime, as measured at river mile 1.6 in Renton, it is necessary to account for the effect of tributary and groundwater inputs to the river between Landsburg and Renton. These inflows vary depending upon hydrologic conditions. An extensive investigation of inflows between the two points was conducted as part of the Cedar River Instream Flow and Salmonid Habitat Utilization Study (Cascades Environmental Services 1991) and refined in subsequent discussions and analyses. The investigations resulted in the production of a model providing mean weekly inflows for the full range of hydrologic conditions experienced between water year 1929 and 1988 and later extended to mid-water year 1993 (Appendix 8). The accretion flow model developed during the instream flow study program has been used to make the appropriate adjustments to facilitate comparisons of the HCP and IRPP flow regimes.

The IRPP and HCP regimes are similar in that each provides a normal flow schedule and a critical flow schedule that is implemented during periods of severe drought. However, the IRPP normal regime is static; that is, it does not vary based upon actual or forecasted hydrologic conditions. In contrast, the HCP regime provides opportunities for increased stream flow commitments during periods of key importance to anadromous fish. The precise timing and distribution of these flows will vary from year to year depending on hydrologic conditions, biological need, and direction from the Commission. Comparisons of HCP guaranteed flows with IRPP flows, therefore, require an assumption about the pattern according to which supplemental water is distributed.

And finally, the HCP regime offers two different normal flow curves during the fall in an effort to provide additional benefits for spawning salmon. The frequency with which each of the HCP fall flow curves will be applied must be integrated into a comparison with the single normal curve provided by the IRPP regime.

Table 4.4-5. Comparison of HCP and IRPP Instream Flow Schedules

	HCP Instream Flow Schedule								*IRPP Instream Flow Schedule*			
	Requirements at Landsburg				Expected Minimum at Renton				Expected Minimum at Landsburg		Renton Target Flow	
	Minimums											
Calendar Week	High Normal (cfs)	Low Normal (cfs)	Critical (cfs)	Total With Supplemental Flow (cfs)	High Normal (+50%tile accretion) (cfs)	Low Normal (+50%tile accretion) (cfs)	Critical (+6%tile accretion) (cfs)	Total Expected With Supplemental Flow (cfs)	Normal (-50%tile accretion) (cfs)	Critical (-6%tile accretion) (cfs)	Normal (cfs)	Critical (cfs)
Sep 2 - Sep 8	80	80	70	80[1/]	137	137	97	107[1/]	73	83	130	110
Sep 9 - Sep 15	80	80	70	80[1/]	138	138	99	109[1/]	87	81	145	110
Sep 16 - Sep 22	95	95	80	133[2/]	152	152	108	190[2/]	133	82	190	110
Sep 23 - Sep 30	95	95	80	210[2/]	155	155	109	270[2/]	140	81	200	110
Oct 1 - Oct 7	210	210	100		273	273	126		205	98	268	124
Oct 8 - Oct 14	330	275	130		392	337	157		301	128	363	155
Oct 15 - Oct 21	330	275	160		402	347	186		298	161	370	187
Oct 22 - Oct 28	330	275	180		416	361	222		284	176	370	218
Oct 29 - Nov 4	330	275	200		420	365	246		280	200	370	246
Nov 5 - Nov 11	330	275	200		419	364	243		281	207	370	250
Nov 12 - Nov 18	330	275	200		459	404	253		241	197	370	250
Nov 19 - Nov 25	330	275	200		486	431	262		214	188	370	250
Nov 26 - Dec 2	330	275	200		497	442	256		203	194	370	250
Dec 3 - Dec 9	330	275	200		540	485	254		160	196	370	250
Dec 10 - Dec 16	330	275	200		513	458	271		187	179	370	250
Dec 17 - Dec 23	330	275	200		529	474	267		171	183	370	250
Dec 24 - Dec 30	330	275	200		541	486	279		159	171	370	250
Dec 31 - Jan 6	260	260	180		447	447	260		183	170	370	250
Jan 7 - Jan 13	260	260	180		450	450	263		180	167	370	250
Jan 14 - Jan 20	260	260	180		480	480	264		150	166	370	250
Jan 21 - Jan 27	260	260	180		465	465	262		165	168	370	250
Jan 28 - Feb 3	260	260	180		442	442	259		188	171	370	250
Feb 4 - Feb 10	260	260	180		468	468	256		162	174	370	250
Feb 11 - Feb 17	260	260	180	365[3/]	473	473	258	578[3/]	157	172	370	250
Feb 18 - Feb 24	260	260	180	365[3/]	473	473	277	578[3/]	157	153	370	250
Feb 25 - Mar 3	260	260	180	365[3/]	473	473	261	578[3/]	157	169	370	250
Mar 4 - Mar 10	260	260	180	365[3/]	469	469	259	574[3/]	161	171	370	250
Mar 11 - Mar 17	260	260	180	365[3/]	451	451	246	556[3/]	179	184	370	250

Table 4.4-5. Comparison of HCP and IRPP Instream Flow Schedules (continued)

	HCP Instream Flow Schedule								*IRPP Instream Flow Schedule*			
	Requirements at Landsburg				**Expected Minimum at Renton**				**Expected Minimum at Landsburg**		**Renton Target Flow**	
	Minimums											
Calendar Week	**High Normal** (cfs)	**Low Normal** (cfs)	**Critical** (cfs)	**Total With Supplemental Flow** (cfs)	**High Normal (+50%tile accretion)** (cfs)	**Low Normal (+50%tile accretion)** (cfs)	**Critical (+6%tile accretion)** (cfs)	**Total Expected With Supplemental Flow** (cfs)	**Normal (-50%tile accretion)** (cfs)	**Critical (-6%tile accretion)** (cfs)	**Normal** (cfs)	**Critical** (cfs)
Mar 18 - Mar 24	260	260	180	365[3/]	435	435	259	540[3/]	195	171	370	250
Mar 25 - Mar 31	260	260	180	365[3/]	442	442	278	547[3/]	188	152	370	250
Apr 1 - Apr 7	260	260	180	365[3/]	439	439	264	544[3/]	191	166	370	250
Apr 8 - Apr 14	260	260	180	365[3/]	426	426	248	531[3/]	204	182	370	250
Apr 15 - Apr 21	260	260	180		403	403	253		227	177	370	250
Apr 22 - Apr 28	260	260	190		393	393	249		237	191	370	250
Apr 29 - May 5	260	260	190		386	386	251		244	189	370	250
May 6 - May 12	260	260	195		375	375	249		255	196	370	250
May 13 - May 19	260	260	200		363	363	249		267	201	370	250
May 20 - May 26	250	250	210		350	350	250		270	210	370	250
May 27 - Jun 2	250	250	210		348	348	251		272	209	370	250
Jun 3 - Jun 9	250	250	200		345	345	249		275	201	370	250
Jun 10 - Jun 16	225	225	200		313	313	249		282	200	370	249
Jun 17 - Jun 23	225	225	160	[4/]	309	309	204	[4/]	278	162	362	206
Jun 24 - Jun 30	225	225	100	[4/]	298	298	143	[4/]	230	102	303	145
Jul 1 - Jul 7	170	170	80	[4/]	243	243	110	[4/]	163	80	236	110
Jul 8 - Jul 14	105	105	80	[4/]	174	174	113	[4/]	99	77	168	110
Jul 15 - Jul 21	80	80	80	[4/]	147	147	113	[4/]	63	77	130	110
Jul 22 - Jul 28	80	80	80	[4/]	142	142	107	[4/]	68	83	130	110
Jul 29 - Aug 4	80	80	70	[4/]	138	138	102	[4/]	72	78	130	110
Aug 5 - Aug 11	80	80	70		133	133	105		77	75	130	110
Aug 12 - Aug 18	80	80	70		133	133	103		77	77	130	110
Aug 19 - Aug 25	80	80	70		132	132	102		78	78	130	110
Aug 26 - Sep 1	80	80	70		131	131	101		79	79	130	110

[1/] Minimum flow during critical years if flashboards in place

[2/] Minimum flow during normal years if flashboards in place

[3/] Guaranteed flow provided approximately 70% of time in normal years

[4/] Additional 2,500 ac ft in all normal years 6/17 - 8/4 & additional 3,500 ac ft in 70% of normal years 6/17-8/4

Figure 4.4-2. Comparison at Renton of existing, non-binding IRPP flows, HCP flows, and flows required to create maximum weighted usable area (WUA) as defined by IFIM study for key species and life stages.

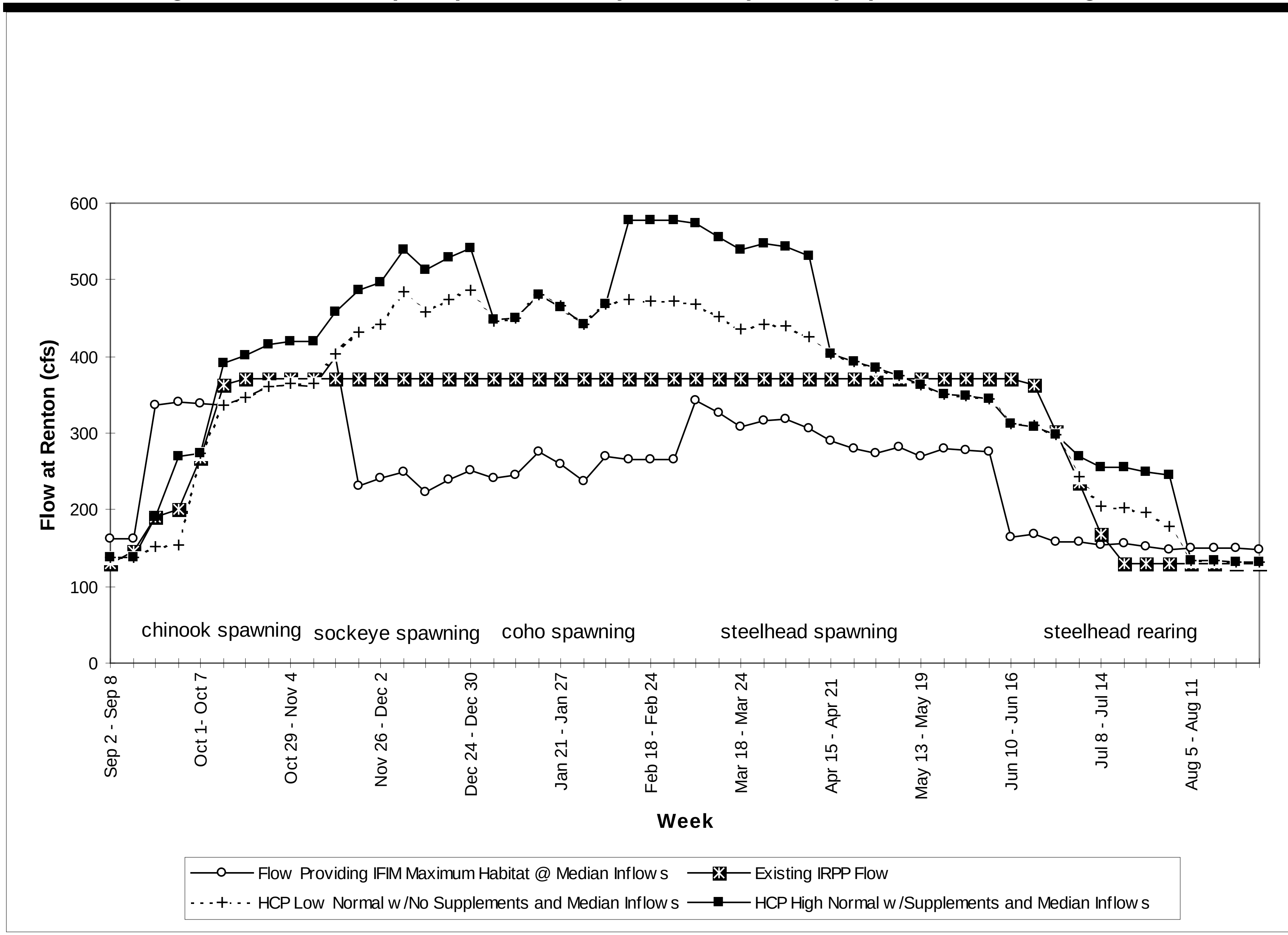


Figure 4.4-3. Comparison at Landsburg of existing, non-binding IRPP flows, HCP flows, and flows required to create maximum weighted usable area (WUA) as defined by IFIM study for key species and life stages.

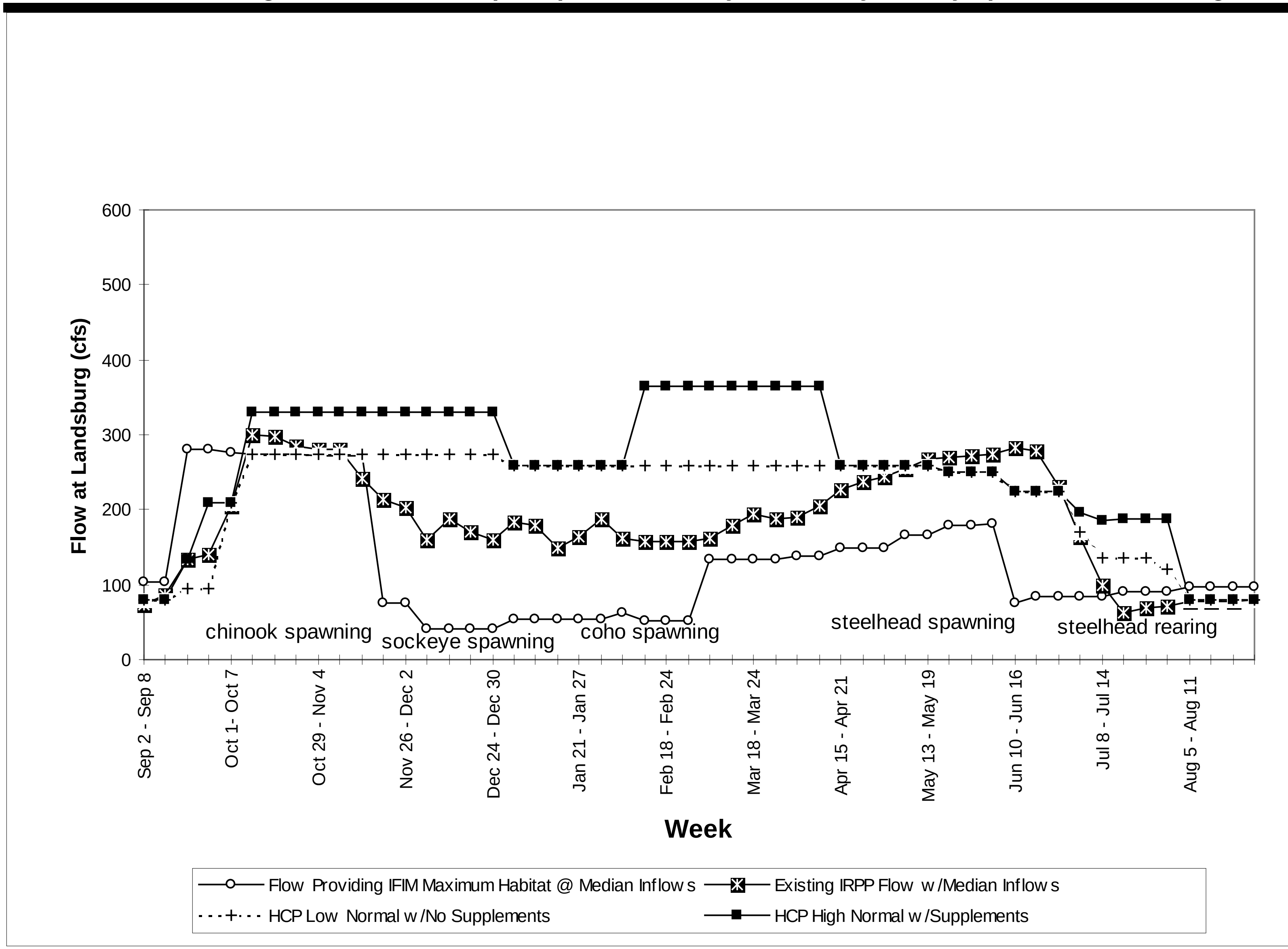


Figure 4.4-4. Comparison at Renton of existing, non-binding IRPP critical flows, HCP critical flows, and flows required to create maximum WUA as defined by IFIM study for key species and life stages.

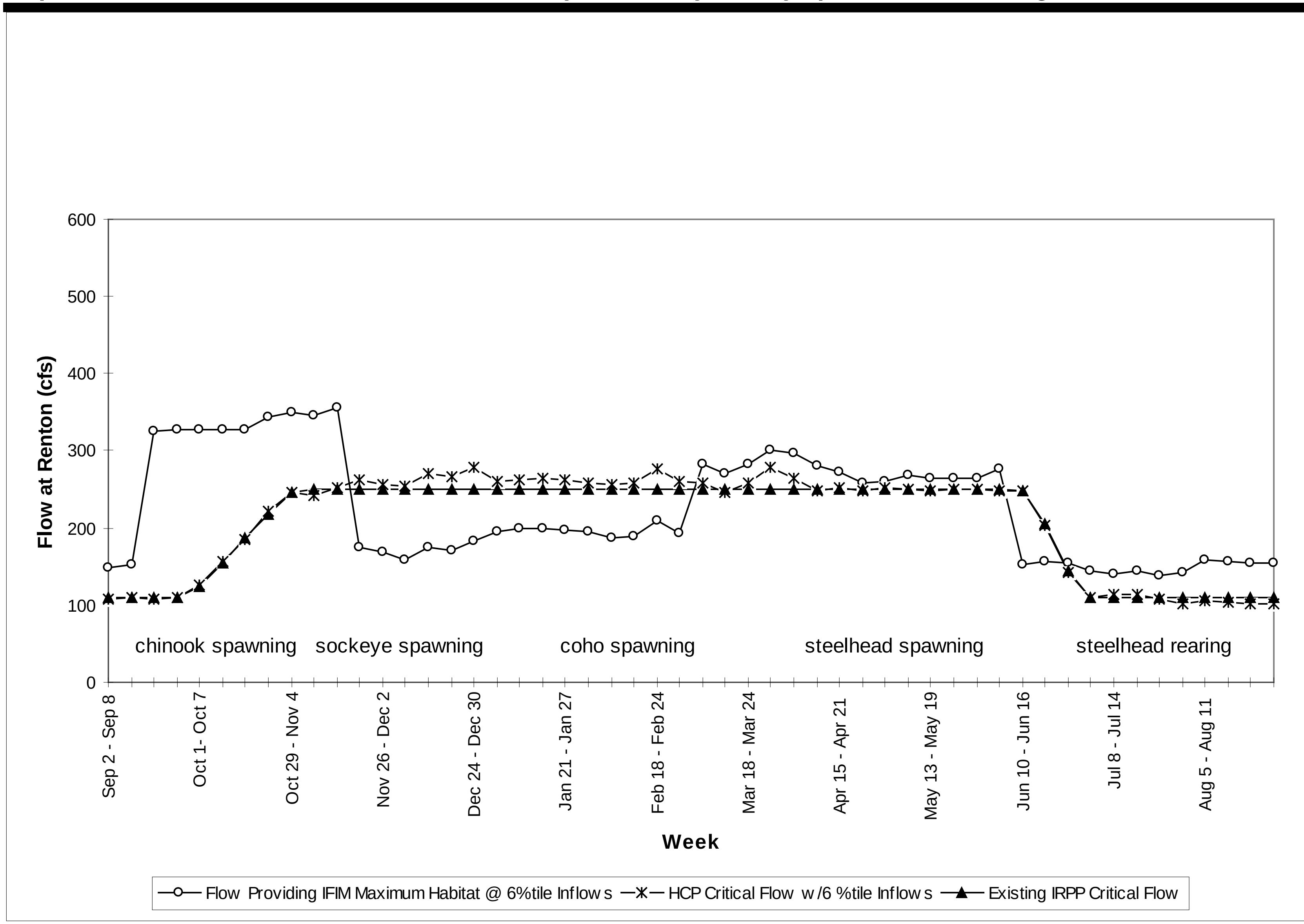
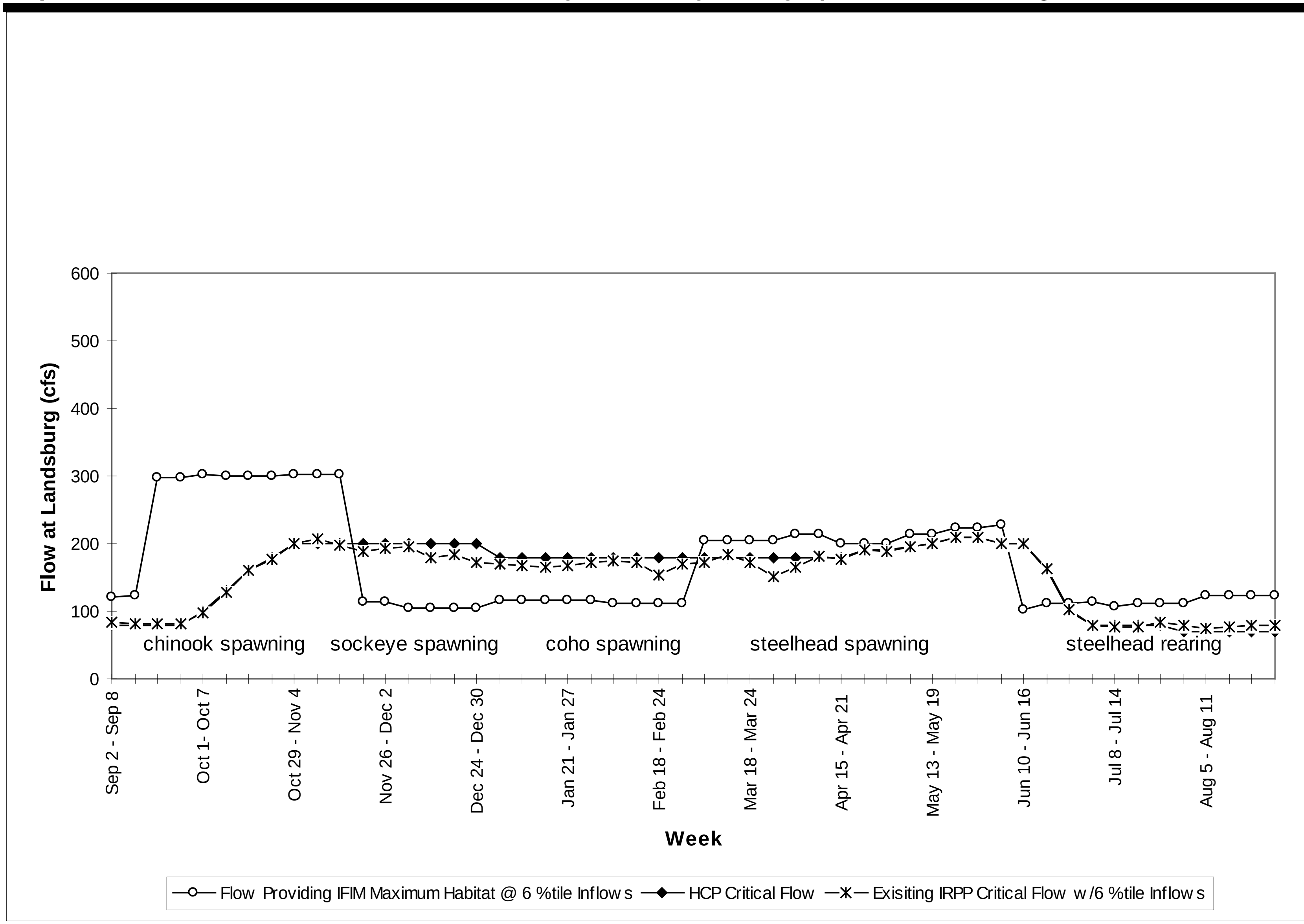


Figure 4.4-5. Comparison at Landsburg of existing, non-binding IRPP critical flows, HCP critical flows, and flows required to create maximum WUA as defined by IFIM study for key species and life stages.



BIOLOGICAL BASIS FOR THE GUARANTEED FLOWS

Biotic communities in freshwater ecosystems of the Pacific Northwest have evolved and developed over an approximate 10,000-year period since the recession of the continental glaciers at the end of the last ice age. A key feature to which these communities have adapted during this period is the general hydrologic pattern in the watershed they inhabit. Therefore, it seems prudent to consider general natural hydrologic patterns when developing an instream flow management regime for regulated rivers.

Several features of the instream flow management regime help reflect the natural hydrologic patterns in the basin. In particular, the minimum instream flow requirements follow the general shape of the natural annual hydrograph. The provision of supplemental flows linked to actual hydrologic conditions will help link instream flow management to naturally changing hydrologic conditions. In addition, by relocating the instream flow measurement point to Landsburg, the guaranteed flow regime will promote more natural short-term hydrologic patterns of variation throughout the river.

While the instream flow conservation strategy considers natural hydrologic patterns, simply attempting to mimic general natural hydrologic patterns is perhaps overly simplistic and insufficient to provide high quality salmonid habitat in a highly altered environment. This rather broad, high-level approach is important and informative, but can miss much of the complexity inherent in the relationships between stream flow and habitat quality. This added complexity can be partitioned into three general categories, as described below.

First, as an example, salmon and steelhead display a tendency to adapt to specific and unique conditions in particular watersheds, but they also display considerable plasticity. For example, robust anadromous salmonid populations are found in systems with a rather broad range of hydrologic conditions, from systems that exhibit quite sudden and dramatic flow fluctuations in response to phenomena such as rain-on-snow events, to very stable, spring fed systems in which flow variations are quite limited. Secondly, the specific micro-habitat preferences of various species and life stages of anadromous fish are complex, somewhat variable, and can be found in a relatively broad range of geomorphic conditions and stream channel types. Third, as discussed in section 3.2.5 and 4.3, the aquatic habitat for anadromous fish in the Cedar River Basin has been rather dramatically altered by anthropogenic activities during the twentieth century. The relationships between aquatic habitat characteristics and stream flow in the present channel, which is highly constrained, much narrower, shorter, and higher gradient than the original channel, are far different than the relationships that existed when the channel was in a natural condition. To further complicate matters, the changes in the drainage patterns of the Lake Washington basin that occurred with the construction of the Ballard Locks and re-routing of the Cedar River into Lake Washington resulted in rather dramatic ecological changes in the system and a shift in fish species composition (Section 4.3.2). In the Cedar River, these alterations likely resulted in the extinction of pink and chum salmon and have created challenging conditions for ocean-type chinook salmon (Section 3.5.10), but have provided conditions under which sockeye salmon were able to flourish (Section 3.5.8).

Therefore, in addition to considering natural hydrologic patterns, the instream flow conservation strategy also makes use of an extensive body of scientific information developed during 10 years of collaborative study and analysis (Sections 3.3.2 and 4.4.1). This body of knowledge provides detailed information on the habitat preferences of the anadromous fish species in the Cedar River and on many of the complex relationships between the quantity and quality of fish habitat and stream flow.

Supporting Studies and Analyses

The effects of stream flow on fish and fish habitat in the Cedar River have been the subjects of substantial study for the past 30 years. Early work conducted by the United States Geological Survey and Washington Department of Fisheries (Collings et al. 1970; Collings 1974) was used by the Washington Department of Ecology to establish minimum instream flow recommendations for the Cedar River in 1971 (WWRA 1971). Using this early work, coupled with additional studies conducted by the University of Washington (Stober and Greybill 1974; Stober et al. 1976; Stober et al. 1978; Stober and Hamalainen 1979; Stober and Hamalainen 1980; Miller 1976), the Washington Department of Ecology established a new set of minimum instream flows recommendations for the Cedar River in 1979 (Washington Department of Ecology 1979).

In 1986, the Cedar River Instream Flow Committee (CRIFC) was formed with the goal of using the best available science to conduct additional, collaborative investigations of the instream flow needs of aquatic resources in the Cedar River. The CRIFC was composed of representatives from the Washington Department of Fisheries, the Washington Department of Wildlife, the Washington Department of Ecology, the Muckleshoot Indian Tribe, the National Marine Fisheries Service, the United States Fish and Wildlife Service, the United States Army Corps of Engineers and the City of Seattle. The CRIFC called for and directed all aspects of a new set of studies conducted around a core approach provided by the Instream Flow Incremental Methodology (IFIM). IFIM "…is a decision- support system designed to help natural resource managers and their constituencies determine the benefits or consequences of different water management alternatives" (Bovee et al. 1998). The methodology is a broad-based approach that includes a library of linked analytical procedures that is grounded in ecological principles and is continuing to evolve. It provides a framework within which a number of different analytical tools can be developed to investigate the effects of stream flow on aquatic resources. IFIM can be used to help integrate the effects of natural and managed hydrology, instream and out-of-stream uses, and conflicting institutional interests with the biological requirements of aquatic species.

The CRIFC selected a contractor to perform selected studies and oversaw all aspects of the study planning, design, implementation, interpretation, and reporting of results. These studies were completed between 1986 and 1991 and published as the Cedar River Instream Flow and Habitat Utilization Studies in late 1991 (Cascades Environmental Services 1991) (see Section 3.3.2 of the proposed HCP). The studies included extensive Physical Habitat Simulation (PHABSIM) analyses (Bovee 1982, 1986) and a number of additional biological investigations. The CRIFC used this information, coupled with a number of additional hydrologic and biological analyses conducted jointly and independently by members of the committee as a primary information base during discussion and development of the HCP instream flow management regime from 1993 through 1997.

During the collaborative instream flow studies and development of the HCP instream flow management regime, the interagency CRIFC viewed the extensive PHABSIM analyses conducted on the Cedar River as a foundation for an instream flow management regime rather than as a prescriptive tool for determining preferred flows at any give time during the year. While the CRIFC agreed that PHABSIM analyses are an important tool in developing effective instream flow management practices, the members of the committee recognized that anadromous salmonid biology is complex and habitat requirements for these species are not completely described by standard PHABSIM analyses. Additional information is helpful in prioritizing species and life stages during particular times of the year; addressing aspects of their biology not typically analyzed in standard PHABSIM investigations; and understanding the complex relationships between hydrologic variation and natural ecological processes in the aquatic environment. During the course of collaborative studies and subsequent development of the HCP instream flow regime, a broad array of information was used in an effort to establish management provisions that would provide comprehensive protection for all life stages of anadromous fish and the habitat upon which they depend. These management provisions address key biological considerations determined to be of particular importance to Cedar River anadromous fish by the CRIFC and include:

- Limits on the rate at which stream flows can be reduced as a result of City's water management activities, established to reduce the risk of fish stranding and better reflect natural rates of stream flow recession;
- Increased guaranteed flows during the fall for increased cumulative sockeye spawning habitat and to recruit additional sockeye spawning habitat along the margins of the stream, which may potentially reduce the vulnerability of sockeye redds to scour during subsequent winter peak flow events;
- Increased guaranteed flows during the chinook and sockeye incubation season in the fall, winter, and spring to reduce the risk of redd dewatering;
- Increased guaranteed flows during the late winter and early spring to provide improved emigration conditions for sockeye fry;
- Steelhead redd monitoring program and flexible blocks of guaranteed and supplemental water during the summer for increased flows to reduce the risk of steelhead redd dewatering;
- Higher guaranteed flows into Lake Washington for more flexibility to provide beneficial fish passage conditions at the Ballard Locks; and
- A number of commitments that will result in stream flows that better reflect natural hydrologic patterns including: 1) relocation of the flow compliance point from Renton 20 miles upstream to Landsburg; 2) supplemental flows linked to real time hydrologic conditions; and 3) flexibility to collaborative manage flows above the guaranteed levels to support important natural ecological processes and provide benefits to fish

Species and Life History Considerations

The CRIFC identified all life stages of chinook, coho, sockeye and steelhead as the primary focus of the studies. Theses species were considered keystone species in subsequent discussion and negotiations. Life history periodicity information for the four species is provided in Figure 4.4-6. A summary of key considerations for the various species and life stages throughout the year is presented in Table 4.4-6.

A basic understanding of the life history of the salmon and steelhead is important for recognizing and understanding the likely impacts associated with different flow regimes. Differences in the timing of life stages mean that flows most advantageous for a particular life stage of one species may not be effective for another. Because each species and life stage has different habitat preferences, it is not possible to optimize habitat conditions for all species and life stages at a single river discharge level when multiple species and life stages are simultaneously present in the river. When habitat preferences for particular species and life stages do not overlap, prioritization decisions must be made. One approach is essentially an "averaging" approach that attempts to establish a combined aggregate measure of habitat condition for all species and life stages present. The other solution is to prioritize key species and life stages and to attempt to optimize conditions accordingly while minimizing potential detrimental impacts on other species and life stages. The CRIFC selected the latter approach.

Coastal cutthroat trout were not included in the studies because their smaller size and preference for small size streams and tributaries indicated they are much less influenced by Cedar River instream flows than other salmonids. Instream flows that meet the needs for the four studied species are expected to also provide adequately for cutthroat.

During the development of the HCP, the Services agreed that the Cedar River downstream of Cedar Falls does not presently support a viable population of bull trout, nor was such a population present in this area historically. If future information suggests that this is not the case and a viable population of bull trout is present in the Cedar River downstream of Cedar Falls, the City believes that the HCP instream flow management regime, which is designed to provide for the protection and recovery of chinook, coho, sockeye and steelhead, will protect and preserve bull trout also.

Stream flow commitments have been patterned to meet the habitat requirements of the various life stages for the four anadromous fish species in the Cedar River as summarized in Figure 4.4-6. A significant amount of information has been compiled on the run timing of adult chinook, sockeye, and steelhead and on the incubation and emergence timing of sockeye and steelhead in the Cedar River. Less information is available on adult coho run timing, coho and chinook emergence, and juvenile migration. Therefore life history periodicity descriptions for these life stages should be considered tentative.

Physical Habitat Simulation (PHABSIM) Analyses

Within the IFIM approach, Physical Habitat Simulation (PHABSIM) analyses provide an important tool for investigating the effects of stream flow on the physical components of fluvial fish habitat. PHABSIM analyses are based on the premise that habitat conditions preferred by different species and life stages of stream-dwelling fish vary within the channel as a function of flow. Or, stated more precisely, stream-dwelling fishes prefer specified ranges of depth, velocity, substrate, and cover type, and the availability of these preferred habitat conditions varies with stream flow. PHABSIM analyses use a set of computer models developed by the USFWS to integrate the life stage habitat preferences of individual species with measured, river-specific stream depth, velocity, substrate, and cover type to generate an index of habitat availability for particular species and life stages over a range of stream flow levels. This index of habitat availability is termed Weighted Usable Area (WUA) and is measured in square feet of habitat for a defined species and life stage per linear length of stream (Bovee 1982, 1986). The available habitat is weighted by its suitability in calculating WUA.

For example, chinook salmon have a preference for a certain range of water depths, velocities and substrate size for spawning. For the Cedar River, the CRIFC determined that preferred spawning depth for chinook ranged from 0.75 feet to 3.4 feet, preferred spawning velocity ranged from 1.0 feet per second to 3.5 feet per second and preferred substrate particle size ranged from 0.5 inches to 6.0 inches. The river discharge that provides the greatest area of these combined habitat preferences is commonly referred to as the flow that provides maximum WUA for chinook spawning and would be represented by the peak of the chinook spawning WUA curve (Figure 4.4-7). WUA is generally curvilinear. WUA typically increases as river discharge increases up to a certain level, and then WUA decreases as river discharge reaches a level that produces depths and velocities that are beyond the fish's habitat preference. The fact that WUA decreases to the right of the peak (as discharge increases) is an important aspect of the WUA function and is integral to discussions throughout this section.

By integrating the output from PHABSIM analyses for a particular species and life stage (such as spawning chinook salmon) with expected stream flows over a specified season (such as the fall chinook spawning season), habitat duration analyses may be generated to compare aggregate habitat availability for different potential flow regimes over a long period of time (in this case, the term of the HCP). In Appendix 36, the City presents analyses that describe and compare historic Cedar River stream flows, flows expected to occur over the next 50 years under the HCP flow regime, and flows that would be expected to occur under future conditions without the HCP flow regime, both based on the assumption that hydrologic conditions over the next 50 years will be similar to conditions over the 64.5-year period of record (Appendix 27, Exhibit A). This information on expected flows, coupled with modeled unregulated flows for the same period, was then used to generate the series of habitat duration analyses provided in Appendix 37 for various life stages of chinook, coho, sockeye and steelhead.

Habitat duration analyses allow investigators to compare total WUA and WUA distribution for given species and life stages for different stream flow regimes over specified time periods. For example, these analyses compare total aggregate chinook spawning WUA during the fall chinook spawning season as whole for three different stream flow regimes: flows expected under the HCP regime; flows that occurred historically under the IRPP regime; and predicted flows that would occur under natural conditions without regulation by the City's water management facilities. The results presented in Appendix 37 demonstrate that under nearly all hydrologic conditions that might occur, the HCP instream flow regime will provide more WUA for chinook spawning during the fall spawning season than either historical flows or predicted natural unregulated flows.

Because each species and life stage has different habitat preferences, it is not possible to achieve maximum WUA for all species and life stages at a single river discharge when timing of species and life stage in the river overlap. For example, Figure 4.4-7 illustrates that maximum WUA in Study Reach #1 for spawning sockeye is achieved at 125 cfs whereas maximum WUA for spawning chinook is achieved at 350 cfs. When the WUA/discharge function of two different species or life stages do not overlap but timing does, species prioritization decisions must be made.

Figure 4.4-6. Cedar River salmon and steelhead freshwater life stages.

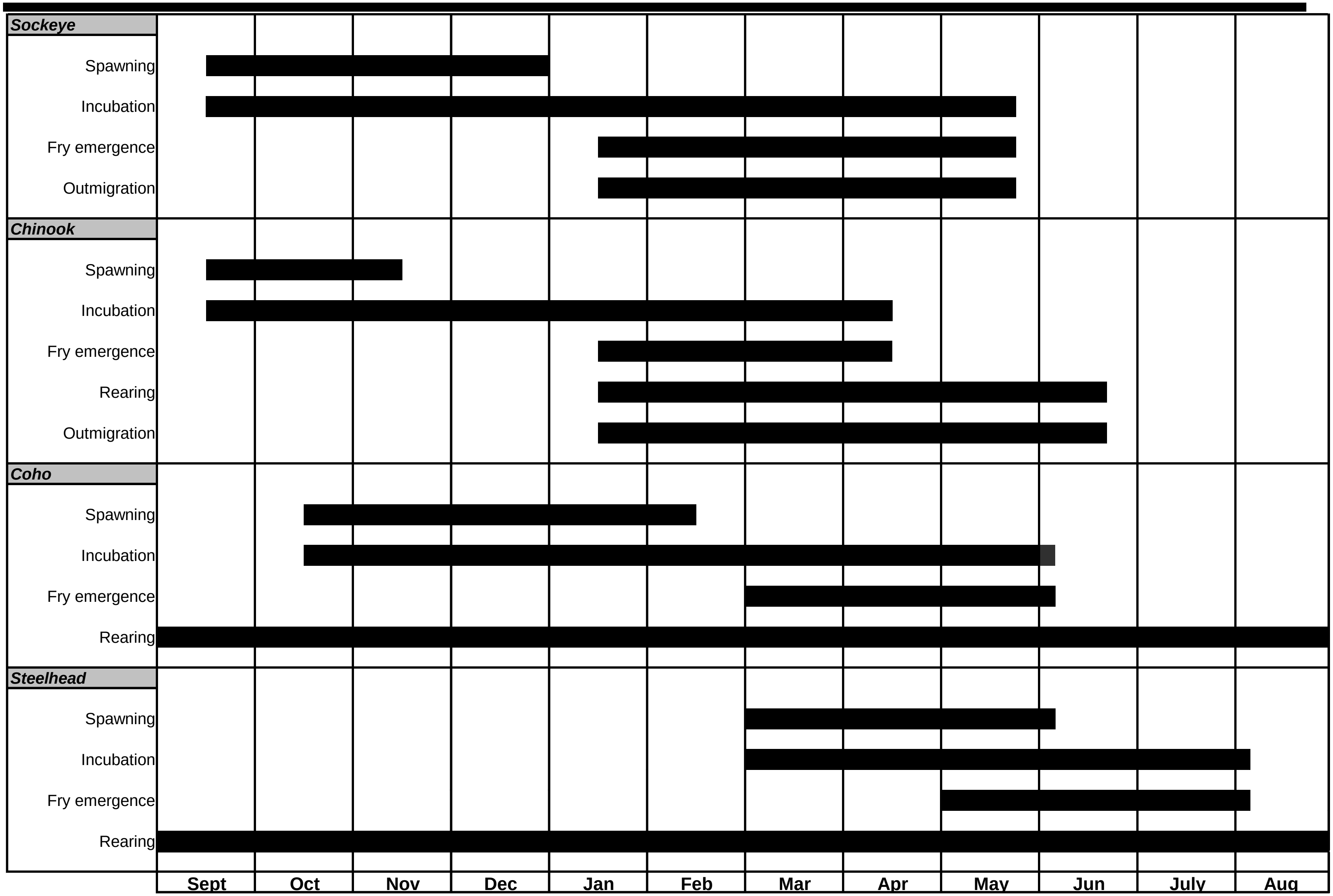
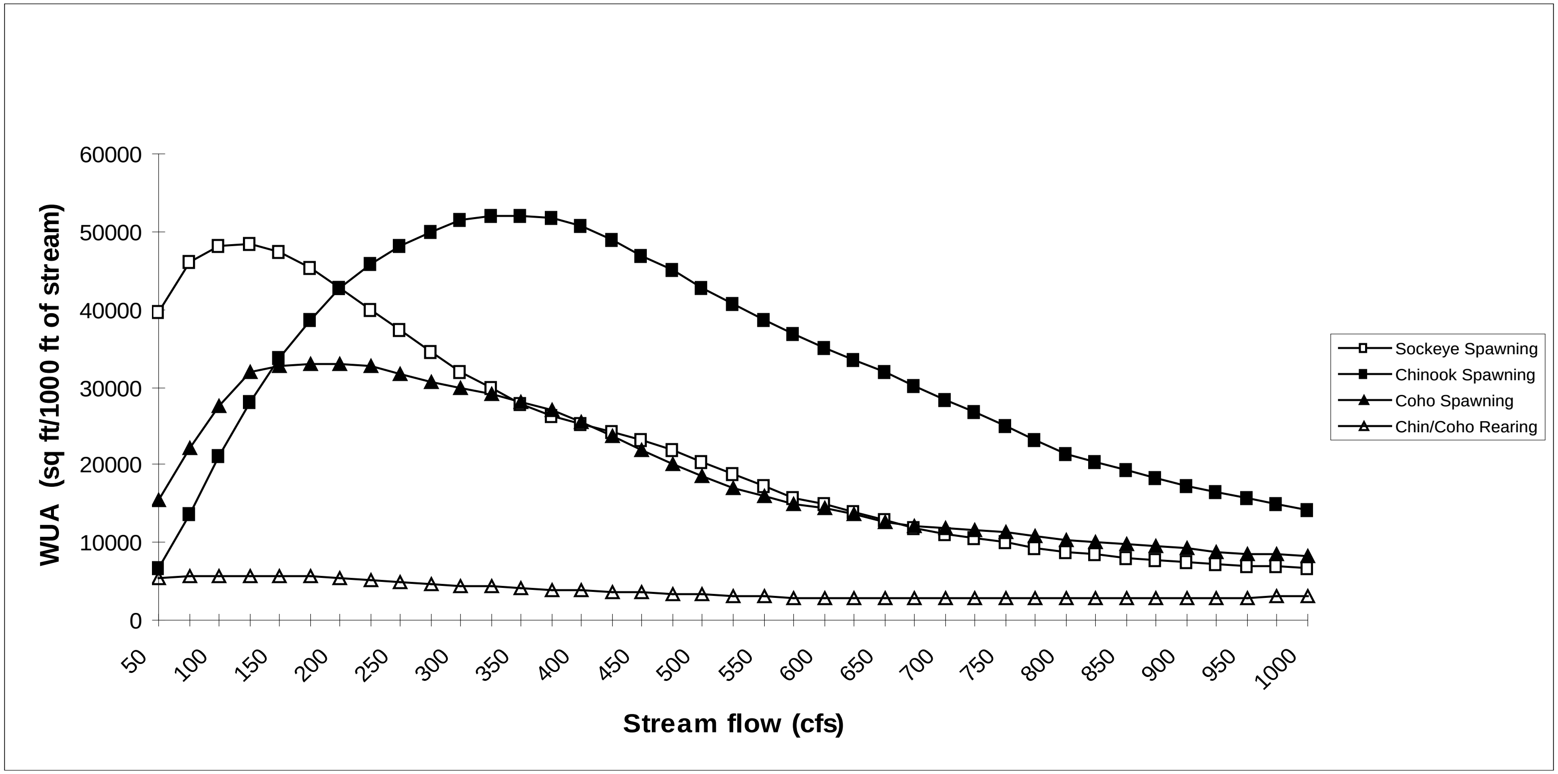


Table 4.4-6. Key instream flow considerations for anadromous fish in the lower Cedar River.

Time Period	Primary Species and Life History Stage Considerations	Additional Important Considerations
Mid-Sept. to Mid-Nov.	Quantity of chinook spawning habitat	• Cumulative habitat and edge habitat for spawning sockeye • Protecting incubating salmon • Quantity of juvenile rearing habitat
Mid-Nov. to End Dec.	Edge habitat for spawning sockeye	• Protecting incubating salmon • Quantity of coho spawning habitat
End Dec. to Early Feb.	Salmon incubation protection	• Quantity of coho spawning habitat • Protecting incubating salmon?
Early Feb. to mid-April	Outmigrating sockeye fry	• Protecting incubating salmon • Quantity of steelhead spawning habitat • Avoiding excessively high sustained flows that force steelhead to spawn in areas where redds will be vulnerable to later dewatering
Mid-April to early June	Avoid excessively high sustained flows that force steelhead to spawn in areas where redds will be vulnerable to dewatering	• Outmigrating sockeye fry • Quantity of steelhead spawning habitat • Quantity of juvenile rearing habitat • Protecting incubating salmon
Early June to early Aug.	Protecting incubating steelhead	• Quantity of juvenile rearing habitat
Early Aug. to Mid-Sept.	Quantity of juvenile rearing habitat	

Figure 4.4-7. Example of the relationship between stream flow and habitat, or Weighted Usable Area (WUA), for salmon spawning and rearing in Lower Cedar River Study Reach number 1.



The first consideration in designing the HCP flow regime has been to attempt to provide flows that meet or exceed the flows required to provide maximum WUA as defined by the PHABSIM analyses for key species and life stages throughout the year. PHABSIM is a powerful tool that is helpful in describing the relationship between stream flow and fish habitat and is a generally accepted methodology used to establish instream flow requirements for fish. However, the methodology entails some uncertainty and does not address all aspects of the biological requirements of fish (Castleberry et al. 1996). Recognizing that the PHABSIM analyses would not provide all the necessary information for establishing the appropriate instream flow regime, the CRIFC requested many additional studies be conducted to complement the PHABSIM information base (see Section 3.3.2). The flows required to provide maximum WUA have been used here as a foundation upon which additional flow is added to better address uncertainty and help meet ancillary biological requirements of anadromous fish as described by the companion investigations conducted during the collaborative study program.

Figures 4.4-2 and 4.4-3 are presented as the basis for discussing the needs of the fish and how they are addressed by the HCP normal minimum flow regime. To adjust the respective flow regimes to alternative measurement points, we have assumed median levels (50^{th} percentile) of inflow between Landsburg and Renton. For most of the year, the expected median HCP flows are not only greater than the existing IRPP flows, but are also greater than flows required to provide maximum WUA for key species and life stages as determined by the PHABSIM analyses. Although these increases in flow can result in significant decreases in the availability of spawning and rearing habitat, they provide additional overriding benefits that result in a net gain for target species and life stages.

Flows in the river between the Landsburg Dam and Renton are significantly influenced by natural local inflows. Under the provisions of the HCP, the flow measurement point will be moved upstream to Landsburg. As a result, stream flows throughout the river will exhibit a more natural pattern than under the existing regime. Because of this natural variation in inflows, HCP minimum flow commitments, as measured at Renton, may at times be somewhat higher or lower than the median flows displayed in Figure 4.4-2. Figure 4.4-3 compares the two flow regimes at Landsburg and demonstrates another important distinction between the two flow regimes. Under the present IRPP regime, the City can reduce flows in the upper river significantly during much of the year while still meeting the IRPP stream flow targets at Renton. Even relatively short-term reductions in flow to levels allowed by the IRPP regime as measured at Renton could pose a significant risk to incubating salmon and steelhead in the upper portions of the river.

Application of PHABSIM Analyses and Additional Studies

The HCP guaranteed flow regime is summarized in Table 4.4-1. The relationships between guaranteed flows, the existing non-binding IRPP minimum flows and the flows that provide maximum WUA for key species and life stages as determined by collaborative PHABSIM analyses are summarized in Figures 4.4-2 through 4.4-5. Expected flows will often exceed guaranteed flows during the fall, winter and spring because: (1) inflows to the basin often exceed amounts required to meet the guaranteed flows and municipal water supply demands; (2) surface runoff in the lower 57% of the basin enters the Cedar River naturally and is not influenced by the water storage reservoir; and (3) flood storage capacity in the reservoir is relatively limited. Expected flows under the HCP instream flow management regime, under the existing IRPP regime, and under natural unregulated conditions are summarized in HCP Appendix 36. Appendix 37 provides habitat duration analyses for expected flows under the HCP, IRPP and natural flow regimes using PHABSIM output for target species and life stages.

As described in the previous section, the HCP guaranteed flows are designed to be substantially greater than the flows required to provide maximum WUA for key species and life stages for the majority of the year. As flows increase above the levels required to provide maximum weighted usable area, water depths and velocities increase and the total amount of suitable habitat in the river generally decreases. Within this general pattern, spawning and rearing habitat availability vary independently and in different ways as flows change. For example, WUA for steelhead spawning increases as flows increase to a level of approximately 150 cfs as measured at Landsburg. When flows increase above this level, the amount of spawning habitat decreases rather markedly as depths and velocities in much of the channel increase beyond suitable ranges. In contrast, juvenile steelhead rearing habitat continues to increase as flows increase to a level of approximately 75 cfs, then decreases only slightly as flows increase further, because new low velocity habitat along the edges of the channel is recruited nearly as rapidly as low velocity habitat is lost in the rest of the channel.

For the three studied anadromous species that rear in the river (i.e., chinook, coho and steelhead), PHABSIM analyses demonstrate that WUA for juvenile rearing is less sensitive to changes in flows than is WUA for spawning. That is, for a given incremental flow change, the change in WUA for juvenile rearing is typically much smaller than the change in WUA for spawning. The analyses also demonstrate that the flows required to provide maximum WUA for spawning are much higher than the flows required to provide maximum WUA for juvenile rearing. For these reasons, and because WUA for juvenile rearing during the fall, winter and spring base flow conditions is not believed to be a major concern, spawning habitat and other considerations have generally been given higher priority in the Cedar River than rearing habitat availability.

There is one period during the year when there are no other overriding concerns and juvenile rearing is the primary focus of instream flow management. After the completion of steelhead incubation in early August and prior to the beginning of substantial chinook and sockeye spawning in mid-September, steelhead juvenile rearing is the key life history stage of concern. Juvenile coho salmon are also present at this time. However, the flows required to maximize WUA for juvenile steelhead are slightly greater than flows required to provide maximum WUA for either juvenile coho or juvenile chinook. Therefore, steelhead was selected as the key species of concern. During this time of year, instream flow considerations are typically important in determining the amount and quality of habitat available when juvenile fish are well dispersed and actively feeding and growing. Insufficient habitat availability at this time of year can potentially create a bottleneck for salmonids that rear in the river as juveniles. From August 4 through September 15, the HCP guaranteed flows are slightly below the levels required to provide maximum WUA for juvenile steelhead rearing, but still provide 98 to 99 percent of maximum WUA for this species and life stage. Habitat duration analyses summarized in Appendix 37 of the proposed HCP demonstrate that, for this period as a whole, expected flows under the HCP regime provide more WUA for juvenile steelhead rearing than expected flows under the existing IRPP regime or expected flows that would occur under natural conditions without the presence of water storage and diversion facilities.

For the remainder of the year, from late September through the end of July, HCP guaranteed flows remain well above the levels required to provide maximum WUA for juvenile steelhead rearing. During this period, HCP normal flows provide between 65 and 93 percent of maximum WUA for juvenile steelhead rearing.

In the fall, spawning conditions for salmon become a key biological consideration. By mid-September, substantial numbers of adult chinook salmon begin entering the river and maximizing chinook spawning habitat becomes a primary concern. With approximately 6 percent of the chinook salmon run typically in the river by September 16, the HCP guaranteed normal flows provide 77 percent of maximum WUA for chinook spawning. By September 23 with approximately 16 percent of the chinook run typically in the river, the HCP guaranteed flows provide 95 percent of maximum WUA. By October 8, with 50% of the run typically in the river, the HCP guaranteed low-normal flow provides 100 percent of maximum WUA, and the high-normal flow is greater than required to provide maximum WUA for chinook spawning. HCP low-normal and high-normal flows both remain equal to or greater than the flows that provide maximum WUA through the end of the chinook spawning season. Habitat duration analyses summarized in Appendix 37 demonstrate that, for the chinook spawning period as a whole, expected flows under the HCP regime will provide more WUA for chinook spawning than expected flows under either the existing IRPP regime or the natural flow regime.

By mid-October, the HCP low normal flows have increased to a level that is approximately three and one half times the level required to provide maximum WUA for juvenile steelhead rearing. However, because of the relative insensitivity of WUA for juvenile rearing to flow in the Cedar River, these elevated flows still provide approximately 83 percent of maximum WUA for steelhead rearing.

The provision of cumulative spawning habitat is incrementally adding spawning habitat at the river margins, based on the assumptions that fish will fully occupy mid-channel habitat at lower flows and that increasing flows will recruit more unoccupied habitat at the river edge. A potential additional benefit of such edge habitat for fish that spawn there is a decreased risk of scour from high flows relative to redds nearer the thalweg. Efforts to provide additional cumulative spawning habitat and potential added protection from subsequent redd scour for sockeye take precedence over WUA for sockeye spawning in the fall. With approximately 11 percent of the sockeye run typically in the river by September 16, the HCP low-normal flows already exceed the flows required to provide maximum WUA for sockeye spawning. By the approximate mid-point of the run in mid-October, the HCP low-normal flows are more than two and one-half times the level required to provide maximum WUA for sockeye spawning. Water depth and velocity increase throughout much of the channel at these elevated flows, and the amount of total sockeye spawning habitat decreases. From October 8 through December 30, low-normal flows provide between 56% and 71 % of maximum WUA for sockeye spawning. High-normal flows provide between 51% and 61% of maximum WUA during this same period. Habitat duration analyses summarized in Appendix 37 demonstrate that, for the sockeye spawning period as a whole, expected flows under the HCP regime will provide less WUA for sockeye spawning than expected flows under the existing IRPP regime, but more WUA than expected flows under the natural flow regime. Although significant amounts of sockeye spawning habitat become unavailable at these higher flows, the losses in static habitat are partially offset by cumulative increases in potential sockeye spawning habitat. That is, if we assume that significant numbers of sockeye have spawned during the earlier part of September, then flow increases in

October will tend to force newly entering fish away from already seeded habitat and towards new, previously unsuitable habitat nearer the stream margins. This newly recruited sockeye spawning habitat nearer the stream margins is believed to provide further benefits to sockeye because this new habitat is believed to be somewhat less vulnerable to scour during subsequent flood events.

To reduce the risks associated with subsequent redd dewatering, minimum flows remain well above the levels required to provide maximum WUA for coho spawning throughout the winter. Because coho tend to spawn primarily in tributaries, reductions in available mainstem spawning habitat at this time are believed to be of less concern than providing added incubation protection for chinook and sockeye.

Preliminary analyses by WDFW suggest that emigrating sockeye fry can benefit from elevated flows during the late winter and spring (Seiler and Kishimoto 1997b). Therefore, HCP minimum flows remain elevated at elevated levels throughout the period of juvenile sockeye emigration from early February through the middle of May. Steelhead spawn in the mainstem from early March through early June and are also a consideration during this period. Higher flows for emigrating sockeye fry result in a moderate reduction in available spawning habitat for steelhead. Between mid-March and the end of May, the HCP guaranteed normal flows provide between 78 and 98 percent of maximum WUA for steelhead spawning. Habitat duration analyses demonstrate that, for the steelhead spawning period as a whole, expected flows under the HCP regime provide more WUA for steelhead spawning than expected flows under natural flow conditions or expected flows under the IRPP regime.

Higher flows during the period of steelhead spawning may also encourage fish to spawn in areas where their redds will be at greater risk of dewatering as flows drop naturally to base flow levels during the summer (Burton and Little 1997). The redds of late-spawning steelhead are most susceptible to this risk, because alevins may remain in these redds until early August. The risks associated with elevated spawning flows are offset in two ways. First, as sockeye emigration approaches completion in May, minimum flows decline to levels that are still above, but nearer the levels that create maximum WUA for steelhead spawning and thus provide more available spawning habitat. More moderate flows also reduce the risk that redds will be constructed in areas that will subsequently be dewatered. Second, the City will commit in the HCP to a real-time steelhead redd monitoring program and will provide a flexible block of water to be used by the Commission to provide added protection for any potentially vulnerable redds.

Upstream Fish Passage

Shallow depths across a riffle or gravel bar can create a low-flow blockage that limits a fish's ability to swim upstream. The shallowest and widest riffle in the Cedar River downstream of Landsburg was identified during the collaborative instream flow studies. Using the field data from the cross section measurements and hydraulic information developed for the PHABSIM analyses, the studies investigated the flow required to allow adult chinook to pass over the low-flow passage barrier. Although the absolute lowest minimum flow that would allow passage was not determined, the study demonstrated that passage of adult chinook would not be impeded at flows of 94 cfs or more as measured at the low flow blockage located approximately 0.5 miles upstream of the confluence with Rock Creek. HCP minimum flows are substantially greater than 94 cfs at this location from September 15 throughout the entire salmon and steelhead spawning seasons.

Delivery of Water to Lake Washington

On an annual basis, the Cedar River provides approximately one-half the total inflow to Lake Washington. The total volume of inflow to Lake Washington during the dry season is especially important for protecting water quality, for managing water levels in Lake Washington, and for providing suitable conditions for fish passage and vessel traffic at the Ballard Locks. Therefore, it is helpful to include consideration of factors beyond the river itself when developing a comprehensive approach to managing Cedar River instream flows. As a result of all the provisions listed above, the HCP guaranteed instream flow regime provides higher flows into Lake Washington than the existing IRPP minimum flow regime. Guaranteed flow volumes into Lake Washington (minimums plus supplemental flows) are summarized in Table 4.4-6 for different flow exceedance levels during the typically dry period of the year between June 17 and September 16. As can be seen from Table 4.4-7, the HCP guaranteed flow regime provides from 5 to 39 percent more flow volume into Lake Washington, than the existing IRPP minimum flow regime.

Table 4.4-7. Compared total Cedar River flow volume at Renton for the period June 17 through September 30.

City of Seattle HCP Minimum Normal Flow Exceedance Level at Renton	*Total Flow Volume Passing Renton with HCP Minimum Normal Flows Plus Supplemental Flows at Specified Accretion Flow Exceedance Levels (acre-feet)*	*Total Flow Volume Passing Renton with IRPP Minimum Normal Flows (acre-feet)*	*Difference Between IRPP and HCP Flow Regimes Minimums at Specified Exceedance Levels (acre-feet)*	*% Difference Between IRPP and HCP Flow Regimes at Specified Exceedance Levels*
10%	50,850	36,628	14,222	39%
30%	45,614	36,628	8,986	25%
50%	43,592	36,628	6,964	19%
70%	41,541	36,628	4,913	13%
90%	38,493	36,628	1,865	5%

MANAGEMENT OF STREAM FLOWS ABOVE THE GUARANTEED LEVELS

As described previously, stream flows in the Cedar River can often exceed the levels required to meet HCP guaranteed flow commitments and municipal water supply demands; especially during the wet periods of the year. These higher flows can be both beneficial and detrimental to aquatic resources. For example, high flow in the early spring may improve emigration conditions for sockeye fry. High flows also support many features and processes that help create and maintain favorable habitat characteristics in the stream channel and in riparian areas. However, higher flows can also have negative effects, such as displacing rearing juvenile fish into less favorable habitat and inducing bedload movement, which can cause mortality to incubating salmonids.

Scientists' understanding of the ecological benefits of natural patterns of river flows has increased in the last decade, and we can expect it to change more in the future (Poff et al. 1997; Richter et al. 1996). It is the City's intent not to over-exploit the Cedar River and to preserve ample flexibility to manage instream flows in the manner most beneficial to fish and the ecosystems upon which they depend. The City will use information gained in the many studies to be performed under the HCP, and by others, to attempt to manage instream flows in a manner that, where biologically appropriate, more closely mimics natural hydrologic patterns and that encourages natural ecological and regenerative processes throughout the lower river. These efforts must necessarily also consider the altered conditions of the lower river, flood control needs, and water customer needs.

Biotic communities in freshwater ecosystems of the Pacific Northwest have evolved and developed over an approximate 10,000-year period since the recession of the continental glaciers at the end of the last ice age. A key feature to which these communities have adapted during this period is the general hydrologic pattern in the watershed they inhabit. Therefore, it seems prudent to consider general natural hydrologic patterns when developing an instream flow management regime for regulated rivers.

The relationships between hydrology and aquatic habitat in fluvial systems are very complex. Attempting to precisely mimic general natural hydrologic patterns can result in both beneficial and detrimental effects to aquatic resources, especially in altered stream channels. A broad, high-level approach that is informed by natural hydrologic patterns can be helpful and informative. However, such an approach but can potentially miss much of the complexity inherent in the relationships between stream flow and specific habitat conditions. This added complexity can be partitioned into three general categories.

First, as an example, salmon and steelhead display a tendency to adapt to specific and unique conditions in particular watersheds, but they also display considerable plasticity. For example, robust anadromous salmonid populations are found in systems with a rather broad range of hydrologic conditions, from systems that exhibit quite sudden and dramatic flow fluctuations in response to phenomena such as rain-on-snow events to very stable, spring-fed systems in which flow variations are quite limited. Secondly, the specific micro-habitat preferences of various species and life stages of anadromous fish are complex, somewhat variable, and can be found in a relatively broad range of geomorphic conditions and stream channel types. Third, as discussed in sections 3.2.5 and 4.3, the anadromous aquatic habitat in the Cedar River Basin has been rather dramatically altered by anthropogenic activities during the twentieth century. The relationships between aquatic habitat characteristics and stream flow in the present channel, which is highly constrained and much narrower than the original channel, are far different than the relationships that existed when the channel was in a natural condition. To further complicate matters, the changes in the drainage patterns of the Lake Washington basin that occurred with the construction of the Ballard Locks and re-routing of the Cedar River into Lake Washington resulted in rather dramatic ecological changes in the system and a shift in fish species composition (Section 4.3.2).

Therefore, in addition to considering natural hydrologic patterns, the City has also committed to fund additional studies associated with the effects of stream flow on the early life history of chinook salmon and other salmonids and to further explore the effects of stream flow in altered fluvial environments. This information will be developed in consultation with the Instream Flow Commission and will be used by the Commission and the City in managing stream flows above the guaranteed levels provided by the HCP.

Adaptive Features of the Instream Flow Management Regime

Although a substantial amount of information was assembled over the last 10 years to guide the development of the HCP instream flow regime, the City anticipates that additional information will become available as the science of fluvial systems and strategies for managing stream flows in altered channels continue to evolve. In addition to well defined, guaranteed instream flow management commitments, the City acknowledges the need to provide sufficient flexibility to adapt and improve instream flow management strategies, as new information becomes available. Therefore, the HCP provides substantial commitments to manage the City's future diversions from the Cedar River with sufficient flexibility to meet additional needs for instream resources should such needs arise. In addition, the HCP provides over $ 3.4 million for further studies to: 1) monitor natural and regulated stream flows throughout the basin; 2) better quantify the effects of natural local inflows on stream flow in the Cedar river downstream of municipal watershed; 3) improve the ability of stream flow switching criteria to accurately reflect natural hydrologic conditions; 4) to improve our understanding of key aspects of the biology of chinook salmon and other salmonids in the Cedar River; and 5) better understand the effects of natural hydrologic patterns and stream flow management on fish habitat in altered fluvial systems (see Section 4.5.2). Finally, the HCP establishes an Instream Flow Commission (below and Appendix 27) that will make use of the information gathered during future studies to help guide the management of stream flows over and above the guaranteed levels to provide additional benefits for instream resources.

The use of this adaptive approach is particularly important in addressing the early life history of Cedar River chinook. Ocean-type juvenile chinook, such as those found in the Cedar River, typically express a tendency toward two early life history patterns. In one pattern, newly emerged juvenile chinook migrate directly downstream to the estuary where they rear for up to several months before moving into continental shelf waters. In the second pattern, juvenile chinook emerge from their redds and rear for up to three months in their natal stream before moving downstream to the estuary where they rear for shorter periods of time before moving into continental shelf waters (Healey 1991).

Preliminary investigations conducted by WDFW suggest that substantial portions of the juvenile chinook population in the Cedar River display both of these early life history patterns (WDFW 1999, unpublished data). However, in the case of the Cedar River fish, young chinook no longer have ready access to an estuary. Because the Cedar River was rerouted into Lake Washington during the early 1900s, all juvenile chinook that migrate from the Cedar River to the marine environment must now swim through approximately 19 miles of lacustrine habitat that supports a wide variety of native and introduced predators. As they enter the marine environment, juvenile chinook must pass through the Ballard locks and cope with a highly modified marine/freshwater interface that has relatively little resemblance to a natural estuary. This hydrologic configuration is very atypical for ocean-type chinook in general. There are few, if any, examples of newly emerged, ocean-type chinook fry rearing and migrating through a large natural lake system en route to the marine environment. In particular, this configuration is foreign to native Cedar River chinook that historically migrated only a very short distance in the Duwamish River between the Cedar River and the Duwamish Estuary. The degree to which Cedar River chinook have been able to adapt to this rather dramatic alteration of their environment is unclear.

The degree to which either of the two chinook early life history patterns contributes to the production of returning adults and overall survival of the population is also unclear. If, for example, juvenile chinook that migrate immediately out of the Cedar River contribute to the majority of the smolt production in the system, then spring juvenile rearing conditions in the river are less of a concern, and spring in-river emigration conditions become a greater concern. Alternatively, if young chinook that rear in the river for three months before migrating through the lake survive better than fish that enter the lake as newly emerged fry, then juvenile rearing conditions in the river during the spring are a very important consideration.

Much of the Cedar River downstream of the Landsburg Dam is confined by levees, with approximately 64 percent of the length of the river hardened on at least one bank (King County 1993). The average width of the active channel is now estimated to be approximately one half the width of the active channel in the mid-1800s prior to the impacts of development (King County 1998). During periods of high stream flow, the availability of suitable fry rearing and refuge habitat in this confined and narrowed channel can be substantially reduced. Preliminary studies conducted by WDFW indicate that large numbers of chinook fry emigrate from the river during high flow events in the spring. If high spring flows induce chinook fry to migrate to the lake, and these fish survive at a significantly lower rate than fish that rear in the river, then high spring flows could reduce overall smolt production. However, if fry that rear in the lake survive at a greater rate than fry in the river, then high spring flows may increase overall smolt production. The Cedar River constitutes one of the best opportunities in the region to protect and rehabilitate juvenile rearing habitat for chinook. Given that Lake Washington is completely surrounded by urban development, caution is advisable regarding changes to river flows during the chinook spring emigration period, particularly when other species are also considered.

Water management decisions on the Cedar River are very complex during the spring. Managers must consider the needs of (1) incubating salmon and steelhead, (2) spawning steelhead, (3) rearing juvenile steelhead, coho, and chinook, (4) emigrating sockeye and chinook fry, and (5) emigrating chinook, coho and steelhead smolts. In addition to protection of anadromous fish, decision-makers must also consider (1) flood management, (2) refilling Chester Morse Lake in a manner that protects nesting loons and incubating bull trout, and (3) continuing to provide a safe and reliable municipal water supply.

To make good instream flow management decisions, managers must be supplied with accurate and reliable information. As mentioned above, such information on the early life history of chinook salmon is presently limited. To address this information gap and support instream flow management decisions, the HCP provides $1 million specifically earmarked for studies that address the early life history of chinook salmon and other key life stages of anadromous salmonids in the Cedar River (Section 4.5.2). The City expects that these study results, along with results from other key studies, will be used by the Cedar River Instream Flow Commission to help make well informed and balanced instream flow management decisions during the spring and other key periods of the year.

In summary, the adaptive approach to instream flow management provided by the HCP is expected to improve our understanding of the complex biological requirements of anadromous salmonids in altered fluvial systems. This improved understanding, combined with the flexibility provided by the HCP, will support a more robust management framework that is expected to improve conditions for aquatic resources and help protect and restore ecological processes that shape and maintain aquatic habitat in the lower Cedar River.

Future Uses of the Cedar River

The City of Seattle influences river flows in the Cedar River through its water supply and hydroelectric operations within the municipal watershed. Water from the Cedar River is used by two-thirds of the City's 1.3 million customers in King and Snohomish Counties. While the daily and average river flows in the Cedar River vary substantially, the river has an average annual total flow of about 550 million gallons per day (mgd). The City has a water right claim for annual average water withdrawals, or diversions, of 300 mgd from the Cedar River, where an annual average diversion for a given year is the average of the daily diversions over that year. Over the past 50 years, the City has withdrawn an average of about 118 mgd annually from the river, with a peak annual diversion of 144 mgd during 1991. In recent years, aggressive conservation has reduced annual withdrawals to between 98 and 105 mgd, even though the region's population has grown substantially. Annual withdrawals and the total volume of river flow vary year to year, but an average annual withdrawal of 118 mgd constitutes about 22 percent of the average annual total river flow. This withdrawal also represents about 12 percent of the water that the entire Lake Washington basin produces.

The technical basis of the instream flow regime in this HCP is the habitat needs of anadromous fish, however, not the pattern of water withdrawals. The HCP's instream flow regime is based on the best available science. It was developed collaboratively with experts in many agencies, the methods used have been standard throughout the U.S. for decades, and these standard methods were extended in significant ways to address issues specific to the Cedar River. Potential future river flows are expected to be substantially better for fish than past river flows due to improved and higher guaranteed flows coupled with the wide range of additional instream flow protection measures described elsewhere in Section 4.4. For additional information on expected flows in the Cedar River under the HCP, please refer to Technical Appendix 36.

The IFA includes the following statement of intent: "All Parties recognize that the Cedar River provides stream flows which are essential to the needs of people as well as to the survival and recovery of fish. It is the intent of the Parties to protect instream flows for fish and navigation and to minimize use of the Cedar River to serve future regional growth, while recognizing that conjunctive use of the Cedar may be important to achieving regional water supply efficiencies. All Parties recognize that there are innovative opportunities for use of the Cedar River, which may benefit both fish and people. The City will continue to actively pursue other water sources, innovative projects (such as the Cedar Dead Storage Project described herein), and water reuse options to address future growth. WDOE is not, by signing this agreement, approving or permitting any intertie project, water transfer, and/or future permits."

Through the HCP, the City is making a 50-year commitment to a binding set of minimum instream flow requirements, to replace the current non-binding flow targets, in order to contribute to the protection of aquatic resources above and below the Landsburg Diversion Dam. In addition, the City will provide "non-firm" water to supplement minimum instream flows under specified conditions. The goals for "non-firm" flows will be incorporated into the City's estimates and actions regarding the water supply capacity of the Cedar River system, which are part of the City's water supply planning process. Neither the volume of water provided to meet the non-firm flow goals nor the frequency of the City's achievement of those flows will be decreased throughout the term of the IFA.

The City also recognizes that a significant volume of water is often available above the instream commitments and current water supply needs of the City, and that in the future beneficial instream, downstream, or out-of-stream uses may be proposed for some of this water. The HCP allows the flexibility for future decisions regarding uses for this water. The HCP provides for a Commission that will serve as a forum for sharing of information and discussion of such issues.

An example of "innovative opportunities for use of the Cedar River which may benefit both fish and people" (from intent statement, above) is the Cedar Permanent Dead Storage Project described in this HCP. This project, if implemented, could provide greater water supply reliability and yield, while also making more water available for higher flows to provide additional biological benefits for some important aspects of salmonid life history during certain times of the year. The planned Tacoma-Seattle Intertie and Tolt Treatment Facility are examples of new projects that have been designed to work in conjunction with the City's existing Cedar and Tolt sources to meet future demand. As these two projects approach full utilization, they will use small additional increments of Cedar River water. When these projects are first brought online, use of Cedar River water will be decreased.

The City is dedicated to managing water diversions from the Cedar River for the next 5-10 years, except under emergency or very unusual situations (e.g., natural disasters, pipeline failures, water quality events, extreme drought, and system failures), in the same range that water diversions have been for the last five years (98-105 mgd on an annual average basis). The City is confident that this can be achieved because of significant capital investments in 1) current conservation programs; 2) the Tolt Treatment Facility (projected to come online in late year 2000), which will increase the capability and reliability of the Tolt system; 3) the Regional 1% Water Conservation Initiative (see subsection below for further description), which will be expanded to include participation by the City's wholesale customers in addition to current participation by the City's direct service area; and 4) potentially, the Tacoma-Seattle Intertie (project in planning) which, when developed, would enable the City to import Green River source water. The effect of the conservation programs will be to keep year-round and summer demand peaks lower. Availability of additional water through the Tolt Treatment Facility and, later, through the Tacoma-Seattle Intertie will, in that they will add water supplies from outside the Cedar River, also defer the overall need for Cedar River diversions, particularly during the peak demand season. Because increases in regional water demand over the next 5-10 years are expected to be offset through the mechanisms identified above, the within-year diversion patterns will be largely a function of hydrology and demand response to variable weather conditions. Therefore, within-year diversion patterns are expected to continue to vary and fluctuate as they have over past years.

Over the 50-year term of the HCP, the City currently projects that future annual water withdrawals from the Cedar River will continue to vary within a wide range, and as referenced in Technical Appendix 36 of the HCP, the City expects that annual diversions will average approximately 118 mgd over the next 50 years. Past experience makes it clear that swings in weather and the realities of operating a complex water supply system require that the City retain the ability to use more water in some years than in others. The public has access to the City's Cedar River water diversion data by making a request for such data from the City of Seattle Public Utilities. The City's annual average diversions are also reported to and published by the U. S. Geological Survey in their public annual reports that document hydrologic data for the State of Washington. Additionally, in the future, the City may develop the capability to provide public access to near real-time Cedar River water diversion data via the Internet and the World Wide Web.

While the purpose and function of the HCP is not to authorize or establish limits on the City's water diversions or to address the City's water supply planning process, there has nevertheless been citizen comment seeking to have the City allow some of the water which it may be entitled to withdraw under its water right to be left in the river for the benefit of fish over the term of the HCP, and that the City continue to develop and implement long-term water conservation measures for the region. Therefore, it is the City's intent to develop and implement a legal mechanism, such as a trust or other arrangement, by which it can reserve, for the length of the HCP, one-third or 100 mgd of its water right claim (on an annual average basis) for the benefit of fish, subject to the following conditions: 1) that the water so reserved is available to the City for emergency situations (natural disasters, pipeline failures, water quality events, extreme drought, and system failures); and 2) that the reserved water is protected from appropriation by third parties. It is also the City's intent to reserve an additional one-sixth or 50 mgd of its water right claim (on an annual average basis) through the same mechanism and subject to the same conditions described above, and subject to the additional condition that the City resolves some outstanding issues with the Muckleshoot Indian Tribe.

Near-term Demand Management

One method that will assist the City in managing diversions from the Cedar River within the specified range over the next five to ten years is demand management, or conservation. Towards that end the City has conducted a Conservation Potential Assessment (Appendix 31), which profiles the range of water conservation opportunities available to the City's retail and wholesale customers at differing levels of investments and over differing time periods. As a result of that Assessment, the City has created a long-term water conservation program that it will implement in both its direct retail and wholesale service areas. The goal of the program is to reduce average per capita consumption by 10% within a 10-year time frame. From an administrative standpoint, the program will consist of expansion of current conservation programs and development of new conservation programs to achieve the desired savings.

FLOW DOWNRAMPING PRESCRIPTIONS

Background

Resident and anadromous salmonids, particularly juvenile life stages, are vulnerable to sudden flow reductions in regulated rivers. Fish can be killed by stranding on open gravel bars or by isolation in potholes or side channels that subsequently dry up. Juvenile fish, especially newly emerged fry in their first growing season, are vulnerable to sudden flow reductions. Downramping guidelines prescribe the rates at which flows can be reduced in regulated rivers without causing significant detrimental impacts on aquatic resources.

Through its operations on the Cedar River, the City of Seattle can alter instream flows at three locations on the river that can create significant downramping events. The three locations and mechanisms are:

(1) Masonry Dam: low level outlet valve.

(2) Cedar Falls powerhouse: two turbines.

(3) Landsburg Diversion Dam: municipal water supply intake valve and/or diversion dam radial gates.

A recent analysis of the frequency and magnitude of instream flow changes on the Cedar River suggests that significant downramping events can occur quite frequently due to the need to make flow changes for many different reasons during normal operations. Presently, no formal downramping criteria are used to guide flow control operations at any of the three flow control points on the river.

Implementation of formal downramping rates that limit impacts on juvenile salmonids will provide a significant benefit to fisheries resources in the Cedar River basin below Masonry Dam. The City will commit to the implementation of downramping prescriptions for each of the three locations within the constraints posed by the biological needs of the resource and reasonable considerations for facility operations.

Points of Measurement

The City proposes that stream flow gages positioned downstream of flow control points be used to monitor and regulate ramping rates. Ramping rates below the Masonry Dam will be measured at a new gage immediately upstream of Seattle City Light's Cedar Falls Hydroelectric Project at RM 33.7. Ramping of discharge from the Cedar Falls Hydroelectric Project will be measured at the existing USGS station at Cedar Falls (gage #12116500) located downstream from the powerhouse at RM 33.2. The downramping measurement point for operation of the diversion facilities and radial gates at the

Landsburg Dam will be the existing USGS station below Landsburg (gage #12117600) at RM 20.4.

Definition of Critical Flow Ranges

The critical flow range may be defined as the range of flows within which significant exposure of streambed can occur. Information from the collaborative IFIM study was used to define the critical flow ranges for various locations on the river. In each case, transects exhibiting the greatest degree of stage sensitivity over the broadest range of flows were used to establish the flows above which the effects of flow reductions have relatively minor impact on potential fish stranding. Table 4.4-8 describes the critical flow ranges within which downramping prescriptions will apply at various locations on the river.

Table 4.4-8. Critical flow ranges for Seattle City Light and Seattle Public Utilities ramping operations at three locations on the Cedar River.

Measurement Location	Flow Range (cfs)	Downramping Prescription Classification
New USGS gage immediately above the Cedar Falls Powerhouse to be located near river mile 33.7	0-80	Critical
	>80	No ramping restrictions
Existing USGS Gage # 12116500 immediately below the Cedar Falls Powerhouse, located at river mile 33.2	0 - 300	Critical
	>300	No ramping restrictions
Existing USGS Gage # 12117600 immediately below the Landsburg Diversion Dam, located at river mile 20.4	0 - 850	Critical
	>850	No ramping restrictions

Downramping Prescriptions for Operations at the Landsburg Dam

Downramping at each of the three flow control locations poses a unique set of operational challenges. Because of these challenges and the need to better understand operational fine points, the City will phase in downramping prescriptions gradually over a 2-year trial period. Downramping prescriptions for the Landsburg Diversion Dam facilities are summarized in Table 4.4-9.

Table 4.4-9. Landsburg Diversion downramping prescriptions.

Operation Mode	Approximate Frequency of Occurrence	Period	Flow Range (cfs)	Maximum Downramping Rate
Normal Operation	Normal operations are considered to be in effect at all times except as noted below	February 1 to October 31	0 - 850	1 inch /hour
			>850	no ramping restrictions
		November 1 to January 31	0 - 850	2 inches /hour
			>850	no ramping restrictions
Full System Start-up	approx. 1 - 3 times per year for maint. and repair--approx. 2 hours per event	January 1 to December 31	0 - 850	60 cfs /hour
	approx. 5 - 10 times per year, depending upon the frequency of turbidity events--approx. 3 hours per event	January 1 to December 31	> 850	no ramping restrictions
Radial Gate Operations	One day per year for forebay cleaning	January 1 to December 31	0 - 850	Develop collaboratively with WDOE and WDFW as part of Forebay Cleaning Improvement Project
	As required to pass high flows during freshets and floods	January 1 to December 31	> 850	no ramping restrictions

Downramping rates and procedures will become effective not later than the end of HCP year 2. Not later than the end of HCP year 2, the City will install equipment to monitor the USGS compliance gage #12117600 at RM 20.4 on a real-time basis. Ramping rates will be calculated from provisional real time data measured at USGS gage #12117600. For compliance purposes, gage error, as determined by the USGS, shall be factored into the actual ramping rate calculation.

Normal Operations at Landsburg

Flow control capabilities at the Landsburg diversion facilities are quite refined and are capable of meeting quite conservative ramping rate prescriptions. However, at high flows, existing facilities are inundated if the radial gates are not opened to maintain a forebay elevation below 540 feet msl. The radial gates and their controls are not designed to operate in a manner required to meet the prescribed ramping rates.

Substantial modification of the gates and their controls would be required to meter the small increments of flow necessary to meet a ramping rate of 1 inch per hour. To avoid ramping with the radial gates, the City will maintain the radial gates in a closed position during normal operations at flows equal to or less than 850 cfs as measured at the existing USGS stream gage #112117600 below Landsburg at river mile 20.4. Below 850 cfs, ramping will be controlled by the water supply valve in combination with Cedar Falls Hydroelectric Facility operations. Between February 1 and October 31, the maximum downramping rate will be 1 inch per hour as a result of normal operations of the water supply intake valves. Between November 1 and January 31, the maximum downramping rate will be 2 inches per hour. The radial gates will be down and closed during normal operations

Full System Start-up at Landsburg

Full shutdown and subsequent start-up of the water diversion system occurs relatively infrequently. The system is shut down at least once per year during forebay cleaning in early March and normally once or twice per year for both scheduled and unscheduled maintenance. In addition, the diversion is shut down when influent turbidity approaches Washington State Department of Health specifications for raw drinking water supplies. Shutdowns due to high turbidity occur approximately 5 - 10 times per year, and these events almost always coincide with periods when stream flows exceed 1000 cfs.

When reinstating diversion operations (start-up) following a system shut-down, initial water supply valve adjustments are constrained by structural integrity concerns that in turn will limit the minimum extent of incremental flow control for short periods of time. In order to avoid cavitation and resulting mechanical damage to the two primary supply valves and pipelines, the supply valves on each of the supply lines at the Landsburg Dam must initially be opened to at least 25 percent of the fully open position during the first hour of reopening. This results in a flow increase in the water delivery system (decrease in stream flow) during the first 2 hours of the operation of approximately 60 cfs per hour. Cavitation and mechanical damage concerns do not constrain subsequent incremental openings. Therefore, during the first 2 hours following full system start-up, downramping will occur at a maximum rate of 60 cfs per hour when flows at Landsburg are 850 cfs or less. Continued increases in diversions after the first 2 hours are not constrained by mechanical concerns and will therefore proceed at the rates prescribed in Table 4.4-9.

Forebay-cleaning Procedures at Landsburg

In order to protect the quality of the municipal water supply, the forebay immediately upstream of the intake at the Landsburg Dam must be cleaned annually. To facilitate cleaning, the forebay is drained for 1 or 2 days each spring. Forebay draining requires opening the five radial gates on the dam. Opening and closing the radial gates can cause sudden reductions in stream flow below the diversion dam. For the past 2 years the City, in collaboration with WDFW, has been developing and implementing improved operating procedures to reduce the magnitude of downramping events when opening and closing the radial gates during the annual forebay-cleaning project. Significant operational improvements are being implemented and will continue to be refined.

By no later than the end of HCP year 2 and as part of the collaborative effort by the City and WDFW to improve forebay-cleaning procedures, the City will propose downramping rates and procedures for operation of the radial gates. After consideration of the City's proposal, the Commission will adopt final ramping prescriptions. Such prescriptions must be capable of implementation with existing equipment.

Downramping Provisions for Facilities Upstream of Landsburg

Downramping Below Masonry Dam

Water is periodically released directly into the Cedar River from Masonry Pool by way of the lower level outlet valve, the emergency spill gates, or the service spillway on Masonry Dam. Not later than the end of HCP year 1, the City will propose ramping rates, criteria, and procedures for operation of equipment at Masonry Dam at flows below 80 cfs. The Commission will adopt, with or without modification, the City's proposal, provided that the adopted ramping rates, criteria, and procedures will be limited to operations that can be accomplished with existing equipment. Ramping rates that are part of the final ramping requirements will be calculated from provisional real time data measured at a new USGS stream gage to be installed near RM 33.7, just upstream of the Cedar Falls Hydroelectric Facility. For compliance purposes, gage error, as determined by the USGS, shall be factored into the actual ramping rate calculation. Adopted ramping rates, criteria, and procedures will become effective only after construction of a fish ladder at Landsburg Dam and upstream passage of anadromous fish.

Downramping Below Cedar Falls Powerhouse

During much of the year water is delivered from Masonry Pool to the Cedar River at Cedar Falls via the Cedar Falls Hydroelectric Facility. Reductions in flows through the Hydroelectric Facility have the potential to cause significant reductions in flow and stage in downstream reaches of the river.

Not later than the end of HCP year 1, the City will propose ramping rates, criteria, and procedures for operation of equipment and reducing powerhouse discharge at flows below 300 cfs. Based on previous tests, ramping rates can be expected to be 2 inches or less per hour. The Commission will adopt, with or without modification, the City's proposal, provided that the adopted ramping rates, criteria and procedures will be limited to operations that can be accomplished with existing equipment. Ramping rates that are part of the final ramping requirements will be calculated from provisional real-time data measured at the existing USGS stream gage located at river mile 33.2. For compliance purposes, gage error, as determined by the USGS, shall be factored into the actual ramping rate calculation. Adopted ramping rates, criteria, and procedures will become effective only after construction of a fish ladder at the Landsburg Dam and upstream passage of anadromous fish.

ADDITIONAL MEASURES

Rearing Flows in the Bypass Reach Upstream of the Cedar Falls Hydroelectric Project

Approximately 0.5 miles of potential anadromous fish habitat is present in "Canyon Reach" of the Cedar River between the tailrace of the Cedar Falls Hydroelectric Project at RM 33.7 and the natural migration barrier formed by Lower Cedar Falls at RM 34.2. This 0.5 mile bypass reach is located upstream of the influence of water delivered from Masonry Pool to the Cedar River via Cedar Falls Hydroelectric Project.

After construction of a fish ladder at Landsburg Diversion Dam and subsequent upstream passage of selected species of anadromous fish, the City will provide a minimum flow of 30 cfs on a continuous basis to protect rearing habitat in the Cedar River "Canyon Reach," measured by a new USGS stream gage to be installed near river mile 33.7 and funded by the City.

Emergency Bypass Capability at the Cedar Falls Hydroelectric Project

In its original configuration, the Cedar Falls Hydroelectric Project was not equipped with facilities to prevent an interruption in water delivery to the river during emergency shutdown of electrical generating equipment. To remedy this situation, in early 1999, the City installed, tested, and implemented operating procedures for new equipment to provide bypass flows around its hydroelectric turbines during most emergency plant shutdowns to protect against stranding fish and dewatering redds as a result of such events. The City committed up to a maximum of $350,000 for emergency bypass equipment.

Tailrace Protection at Cedar Falls Hydroelectric Project

With the present configuration of the tailrace at the Cedar Falls Hydroelectric Project, upstream migrating adult fish can enter the turbine effluent pipes where they are subject to injury or mortality. Upon construction of a fish ladder at the Landsburg Diversion Dam, and subsequent upstream passage of selected species of anadromous fish, the City will install a tailrace rack at the Cedar Falls Powerhouse to protect fish from injury or mortality. The City will commit up to a maximum of $250,000 for tailrace protection.

Downstream Habitat Protection and Restoration

Protection and restoration of aquatic and riparian habitat in the lowlands of the Lake Washington basin constitute a critical element in regional salmonid recovery efforts. The quality of fluvial habitat is strongly influenced by basin hydrology and the structure of the stream channels. Stream channel structure can in turn be strongly influenced by land management activities in floodplains and upland areas. In recognition of the value of complimenting beneficial instream flow management with beneficial land management, the City will provide up to $3 million dollars to protect and restore aquatic, riparian and floodplain habitat in the lower Cedar River downstream of the municipal watershed. Protection and restoration projects may include habitat acquisition and will be directed toward habitat for any and/or all species of naturally reproducing salmonids in the lower Cedar basin.

In its Lower Cedar River Basin and Nonpoint Pollution Action Plan, King County identified restoration of the Walsh Lake system within and just outside the municipal watershed as a high priority. The City proposes to provide up to $270,000 in funding for restoration of the Walsh Lake system and connecting areas within the municipal watershed, provided that King County agrees to contribute an equal amount for restoration of the this system. These funds will be provided in addition to the $3 million described above and the $1.6 million provided for lower river habitat as part of the mitigation program for the migration blockage at the Landsburg Dam (Section 4.3.2).

Funding for downstream habitat under the provisions of this section will be available in HCP years 2 through 4. City funding of projects that will ultimately be owned or managed by jurisdictions other than the City will be contingent upon a dollar for dollar match by the receiving jurisdiction.

Improvement of Long-term Water Use Efficiency and Smolt Passage at the Ballard Locks

The Ballard Locks form the outlet of Lake Washington. Water flow at the locks must be shared between vessel traffic and upstream and downstream migrating fish. All anadromous fish in Lake Washington must pass through the locks twice during their life. Recent investigations suggest that opportunities may exist to improve the efficiency with which freshwater is used at the locks (ACOE 1991) and provide better conditions for downstream migrating anadromous fish (Goetz et al. 1997).

The City will commit local sponsorship, up to a maximum expenditure of $1,250,000, for purposes of funding a feasibility study and implementation of long-term water efficiency improvements at the Ballard Locks provided that analyses show that the project will meet its intended purposes in a cost-effective manner. It is the City's understanding, based on information provided by the ACOE, that preliminary estimates for fresh water savings from these improvements would be about 30 cfs from June 1 through September 30. Thus, more than 6,000 acre-feet each year would be available for use in improving fish passage conditions at the Ballard Locks.

The City will also commit funding, up to a maximum expenditure of $625,000, for smolt passage improvements at the Ballard Locks in co-sponsorship with King County and the Muckleshoot Indian Tribe

Funding for Conservation Messages

Educating consumers about the linkage between water use and salmon habitat will help reduce diversions and keep more water in the river. The City will fund and publish or broadcast water conservation messages every summer that emphasize the importance of water conservation to protect fish habitat, at a cost of up to $30,000 per year.

Supplemental Stream Flows Resulting from the Cedar Permanent Dead Storage Project

Potential benefits exist for augmentation of both stream flows and water supply through the development of permanent non-emergency access to water stored below the natural gravity outlet of Chester Morse Lake (i.e., dead storage). The City will sponsor the evaluation of the Cedar Permanent Dead Storage Project, including necessary environmental, engineering, and financial studies. Engineering studies will address design options, siting, water quality, geology and hydrology, yield analysis, costs and economics, constructability, reliability, and other factors. Environmental studies will address potential effects of the project on resident fish and wildlife populations and wetlands, and will evaluate alternative mitigation measures. This feasibility study will commence not later than the end of HCP year 1 and will require not more than five years to complete. Total costs for HCP years 1 through 5 will not exceed $700,000 for the engineering, water quality, and economic studies and $745,000 for the environmental studies.

Representatives of the Commission, as well as other agencies, public groups, and individuals who are not Parties to the IFA, will participate in all stages of this analysis and will receive materials generated in support of this effort. The City will seriously consider suggestions by the Commission, as well as all other participants, throughout the analysis. The Parties are not, through the IFA, making resource commitments to this analytic effort.

Following this evaluation, the City will decide through its water supply planning processes whether and when to proceed with development of this source option, after comparing it with other source options in terms of its yield, reliability, cost, environmental impacts, timing, infrastructure and treatment requirements to deliver the water, likelihood and cost of securing necessary permits, and other factors. By agreement to this evaluation and process, WDOE is not validating in any way the City's claim or use of the dead-storage water.

If the City decides to proceed with the project, the Parties to the IFA agree to work collaboratively to evaluate whether the environmental impacts can be reasonably and cost-effectively mitigated. If environmental studies indicate that such mitigation is feasible, the Parties agree to negotiate in good faith amendments to the IFA to apportion between instream flows and municipal water supply the additional water benefits made available by the project, including consideration of additional water that may be needed to improve survival of fish at the Ballard Locks. Such amendments to the IFA shall not take effect unless and until the project is constructed and becomes operational. The Parties are not, through this IFA, addressing or resolving any questions relating to whether or not new permits or changes to water rights documentation will be required. By agreeing to negotiate any amendment regarding use of dead storage water for instream flows and water supply, WDOE is not in any way validating the City's claim or use of the water.

Gage Operation and Maintenance

The City will bear any expense not borne by the United States Geological Survey (USGS) and other cooperating agencies for flow and elevation measurements at all compliance and hydrologic monitoring locations required for implementation of the instream flow regime, including installation, real-time telemetry, relocation, rehabilitation, and maintenance of the measurement devices and related equipment. One or more of these devices may continue to be owned and operated by the USGS or other parties. If measurement instruments at one or more of the locations are not operational when the flow commitments set forth in the IFA become effective, the Commission, after consultation with the USGS, shall determine a reasonable temporary method of determining compliance with the requirements contained herein based upon available data. After consultation with the City and the USGS, the Commission will propose to USGS a reasonable schedule for installation of a permanent gage.

PROVISIONS FOR OVERSIGHT AND ADAPTIVE MANAGEMENT

Cedar River Instream Flow Oversight Commission

There will be established a Cedar River Instream Flow Oversight Commission (Commission) consisting of one member representing each of the signatories to the IFA. The purpose of the Commission will be to provide general oversight, coordination, and, where specifically authorized, direction regarding the implementation of the IFA. The Commission will serve as a forum for:

- Communication and coordination among the Parties to the IFA of technical information on hydrologic conditions, facility and system operations (water supply, hydropower, and Ballard Locks); fish biology and ecology; and such other subjects as may be beneficial in implementing the IFA;
- Allocation of the 2,500 acre-foot block of water in all normal years between June 17 and August 4;
- Allocation of an additional 3,500 acre-feet of water that is supplemental to minimum stream flow between June 17 and August 4 when available; and, if the need should arise, developing risk-sharing mechanisms to recover this additional water later in the same calendar year;
- Switching between high-normal and low-normal instream flow commitments;
- Switching between normal and critical minimum instream flow commitments;
- Review of supplemental flows provided between February 11 and April 14;
- Sharing of information and discussion concerning potential uses of unallocated non-firm Cedar River water; and
- Administering the responsibilities of the Parties to the IFA in support of technical studies and adaptive management.

In addition, the Commission will provide a forum for the Parties' exercise of rights, responsibilities, and decision-making authority, as further specified in the IFA. The Commission's authority is limited to that which is expressly granted by terms of the IFA. No action by the Commission shall abrogate WDOE's authority to manage the state's water resources, including regulation of diversion and use of the waters of the state.

Reporting

The City will provide to the Commission, on an annual basis, the record of measurements from all compliance and monitoring gage locations. Average daily flows and reservoir elevations will be provided to indicate compliance with guaranteed instream flow commitments. A table will be provided to show flows at the measuring points compared to the critical, low-normal, high-normal, and non-firm flow levels. For periods affected by downramping operations, flow data will be provided in one-hour increments to indicate compliance with downramping prescriptions.

The reports will include an explanation of circumstances involved in decisions concerning instream flows, including an analysis of cumulative progress toward achieving the goals for supplemental flows identified in Section B of the IFA. The reports will also include tables of precipitation levels, reservoir inflow, reservoir outflow, and Chester Morse Lake levels and usage. The reporting year is based on January 1 through December 31. For the first year, the City will make best efforts to submit its annual report within 90 days of the end of the annual reporting period, and advise the Commission as to whether report preparation can be accelerated in succeeding years. The Parties may then agree to a shorter report preparation period. The Commission may modify the frequency and detail of flow and reservoir elevation reports.

As soon as reasonably feasible, but in any event not later than 30 days following discovery, the City will notify the Commission of any case, including emergency conditions, in which recorded flows are significantly below those specified in the IFA. Such nonconformance as may occur as a result of gage malfunction or retroactive USGS flow corrections to the record shall not constitute noncompliance by the City.

Supporting Technical Studies

The maintenance of the instream flow regime and other commitments contained in the IFA will benefit the fishery resources of the Cedar River by protecting, improving and increasing available habitat. The Parties recognize the importance of monitoring the condition of the habitat to assure that the purposes of the IFA are met. The Parties also acknowledge that available information on certain complex ecological and hydrologic processes is not complete. Therefore, the City, in cooperation with the other Parties, will sponsor and conduct certain studies and act on the results as indicated.

Except as otherwise provided, including the established cost caps, all major aspects of study planning, implementation, and coordination with other related studies shall be subject to the approval of the Commission, which shall meet as frequently as study requirements dictate. The Commission shall have the opportunity to review and comment on drafts of any final study reports. The City shall make every effort to complete final study reports no later than 1 year after completion of the respective studies.

Accretion Flow Analyses in the Lower Cedar River

The measurement point for the City's instream flows below Landsburg is located at the existing USGS gage at river mile 20.4. Accretion flow estimates developed in jointly overseen technical studies and further refined by the Cedar River Instream Flow Committee were used to represent the local inflows between Landsburg and Renton. Since accretion flow patterns can have a significant effect on fish habitat, and since future accretion flow patterns may vary somewhat from those calculated from historical data, the City will sponsor a long-term monitoring study to develop a better understanding of inflow patterns throughout the lower river.

The accretion flow study will: (1) specify the inflow assumptions to be evaluated; (2) establish and implement a long-term monitoring protocol; (3) establish analytical objectives; (4) identify any apparent long-term differences from the assumptions; and (5) perform additional investigations and analyses, if needed, to identify causes. The study will begin not later than the end of HCP year 3 and will continue for not less than 10 years. Total costs for monitoring and analysis will not exceed $400,000.

If the conclusions of the long term monitoring study show that actual local inflow patterns (after allowance for gage error) are clearly more or less than the previously assumed patterns for causes that cannot be reasonably attributed to factors such as land development and water withdrawals downstream of Landsburg, the Commission may agree to a procedure for adjusting the agreed-upon minimum flow commitments upward or downward by limited amounts. The Commission shall act through a majority vote (at least 51 percent) of the members participating in the decision, but only if that majority includes the City.

Development of Improved Switching Criteria

The switching criteria established to guide reductions to critical flows and selection of the high- and low-normal flows in the fall shall be considered interim. The City will provide up to $200,000 to sponsor a collaborative analysis of alternatives to these criteria. Revised switching criteria will incorporate advancements in modeling and forecasting, and will be necessary to accommodate potentially significant changes to the operation of the water supply system arising from planned development of a new supply source and water treatment facilities. Improved switching criteria can have a significant effect on the water manager's ability to manage the water resource efficiently and can benefit fish by ensuring that decisions are appropriate to conditions of concern. The purpose of this study is to develop new criteria that are more comprehensive, timely, and reliable representations of key conditions.

The analyses will involve evaluation of various switching criteria, including measured stream flows and reservoir conditions, forecasted stream flows and reservoir conditions, refill success, system-wide (beyond only the Cedar River) conditions, biological conditions, and watershed conditions, such as soil moisture, snowpack, and groundwater. Adaptive management techniques will also be investigated. It will be the goal of the analyses to develop switching criteria that are measurable, independently verifiable, robust, and representative of the system's ability to meet future diversion and instream flow needs. It is the intent of the Parties to the IFA to complete the study, and develop and implement revised criteria no later than the end of HCP year 4.

Revised switching criteria will replace the interim, provided, however, that implementation of the revised criteria will still result in the same predicted average frequencies for critical flow (one in ten years) and high-normal flow (six of nine normal years on October 8, and approximately the weekly frequencies as shown in the Table 4.4-3) as the interim switching criteria. In the event that the Commission is unable to reach unanimous agreement on revised switching criteria following completion of this analysis, the matter shall be resolved following the procedure set forth in Section F.4 of the IFA. If the matter cannot be resolved through the informal dispute resolution process, the interim criteria shall be retained. Nothing precludes a result in which one or more of the existing criteria are retained.

Monitoring Steelhead Incubation

The HCP provides for a "firm" and a "non-firm" block of water to supplement base flow commitments during the steelhead incubation period. In order to support decision-making regarding the use of this water and to minimize dewatering of steelhead redds, the City will sponsor annual monitoring of redds for a period of time until prospective flow guidelines and objectives can be established.

The monitoring program will locate, characterize and monitor steelhead redds from the time of their construction through the completion of fry emergence. The City will monitor steelhead redds for up to eight spawning seasons beginning in HCP year 1. Total costs of the study will not exceed $240,000.

Supplemental Biological and Physical Studies

In addition to the monitoring research efforts mentioned elsewhere in this and other sections of the HCP, the City will provide an additional $1,000,000 to support further study of the effects of certain aspects of instream flow management on anadromous salmonids; with special emphasis on additional information about chinook salmon and other salmonids originating from the Cedar River. The City recognizes the key role of Tribal, state, and federal fisheries resource managers in the development and implementation of future studies. Therefore, all major aspects of study planning, implementation, and coordination with other related studies shall be subject to the approval of the Commission through a majority vote of it members as specified in Section F.3 of the IFA (Appendix 27). The Commission shall have the opportunity to review and comment on drafts of all final study reports.

To enhance present understanding of the biology of aquatic resources in the Cedar River and the complex relationships between stream flow and fish habitat, the City proposes the following list potential supplemental study topics:

- The effects of stream flow on the migratory response of recently emerged chinook and sockeye fry, and chinook fingerlings;
- The effects of size of juvenile chinook and timing of entry into Lake Washington on survival to smolt and/or adult;
- Distribution, abundance and habitat preferences of rearing juvenile chinook in the mainstem Cedar River, with emphasis on the interaction of these factors with stream flow;
- Behavioral response of adult chinook salmon to changes in stream flow and the operation of sockeye broodstock collection facilities;
- Modeling analysis of the potential impacts of stream flow at Landsburg on water temperature at the mouth of the river and in Lake Washington;
- Modeling analysis of the potential impacts of spring and early summer stream flows at Landsburg on water velocity vectors and water residence time in Lake Washington;
- Vulnerability of chinook salmon and sockeye salmon to redd scour;
- The potential effects of redd superimposition on the survival of sockeye and chinook eggs and alevins; and

- Further investigations of the relationship between hydrologic features and the structure and function of instream and riparian habitat in altered stream channels.

The Commission will prioritize the study topics and may add or delete topics with the consent of the City. As descried above, all major aspects of study planning, implementation and coordination with other related studies shall be subject to the approval of the Commission.

Funding for the studies will be available over a period of up to 9 years, which would be sufficient time to encompass the complete life cycle of 4 brood years of chinook salmon. A schedule for dispensation of the supplemental study funds will be developed in consultation with the Commission by the midpoint of HCP year 1, with initial funding to occur after that date.

This study effort is expected to help generally advance the scientific basis for managing altered fluvial systems. The results of the studies can potentially be used by a variety of entities involved in the management of aquatic, riparian and upland habitat. Natural hydrology in the Cedar River basin is quite variable and stream flows in the Cedar River can often exceed the levels provided by the guaranteed flow regime. The results of the supplemental biological studies will provide an enhanced biological and physical information base that the Commission may use to advise the City in its management of stream flows at levels over and above those included in the guaranteed regime described in Section 4.4.2.

The Lake Washington ecosystem is very complex. Many of the factors that can affect the proposed Cedar River supplemental study topics and the successful implementation of appropriate investigations are outside the jurisdiction of the City. Successful implementation of the supplemental study program will require coordination with a number of other interested parties in the basin. Tribal, state and federal resource managers, King County and many of the municipalities in the Lake Washington watershed are developing a broad array of study programs to support basin-wide salmon conservation efforts. The City supports these programs and wishes to cooperate with other jurisdictions in promoting sound understanding of the ecosystem that supports Lake Washington salmon and steelhead.

RATIONALE

The primary purpose of the instream flow conservation strategy is to provide stream flows in the Cedar River downstream of Chester Morse Lake that will help ensure the presence of high quality aquatic habitat throughout 34.2 miles of the mainstem river between Lower Cedar Falls and Lake Washington. This reach of river constitutes the entire natural historic range of anadromous fish in the Cedar River. Four anadromous salmonid species, chinook, coho, and sockeye salmon and steelhead trout presently occupy the lower 21.8 miles of the mainstem. The HCP provides for the reintroduction of chinook, coho, and steelhead into the additional 12.4 miles of mainstem and associated tributary habitat upstream of the Landsburg Diversion Dam.

Water quality and quantity are both important components of aquatic habitat. The instream flow conservation strategy deals primarily with water quantity. The HCP addresses water quality protection through the watershed management prescriptions described in Section 4.2. Water quality is generally excellent in the 12.5-mile reach of the mainstem within the City’s ownership boundary due to relatively large inputs of high quality groundwater and because much of this portion of the basin has recovered substantially after being intensively logged early in the twentieth century. Although many factors downstream of the City's ownership boundary pose threats to water quality in the lower reaches of the river, these threats are partially offset by the relatively large inputs of high quality water from the municipal watershed. In addition, the factors that threaten water quality are being addressed to various degrees through the implementation of King County's Lower Cedar River Basin and Nonpoint Pollution Action Plan (King County 1998).

The HCP views the four anadromous fish species as keystone species for the aquatic habitat in the Cedar River downstream of Chester Morse Lake. These species have relatively stringent freshwater habitat requirements and are present in at least one, and typically more, life stages throughout the year. Biophysical processes and anthropogenic activities throughout the area encompassed by the natural hydrographic boundary of the Cedar River Basin directly affect the quantity and quality of anadromous fish habitat in the Cedar River. The City does not have control over activities in the basin outside its ownership boundary, nor on conditions in the marine environment that can have very significant effects on anadromous fish. However, the City does have the ability to: shape land management practices in the upper two-thirds of the basin; address the effects of the migration barrier formed by the Landsburg Diversion Dam; exercise some level of control over stream flows in the mainstem throughout the historic range of Cedar River salmon and steelhead; and contribute funding for habitat protection and restoration outside the municipal watershed.

The general approach to instream flow management in the HCP rests on a foundation of three primary features: 1) Provision of a guaranteed instream flow management regime based on the best available science to protect aquatic resources on the Cedar River; 2) identification of remaining information gaps and commitment of resources to address these gaps through additional collaborative study; and 3) providing sufficient flexibility in the future to work collaboratively with resource managers to adapt and further improve the management practices as conditions change and new information becomes available. Additional conservation measures include funding contributions to protect and restore habitats downstream of the municipal watershed and to improve survival of smolts leaving the Lake Washington Basin.

Natural Hydrologic Patterns and Basis for the Conservation Strategies

During the last 10,000 years, salmon and steelhead in the northwest radiated into an array of habitats and have adapted to the general environmental conditions that were present in specific watersheds throughout the region as the continental glaciers receded at the end of the last ice age (National Research Council 1996). One of the key factors to which these species have adapted during this period is the general hydrologic pattern in the watershed to which they home as adults and in which they incubate as eggs and alevins, and rear as juveniles. Therefore, it seems prudent to consider general natural hydrologic patterns when developing an instream flow management regime for regulated rivers.

Scientists' understanding of the ecological benefits of natural patterns of river flows has increased in the last decade, and we can expect it to change more in the future (Poff et al. 1997, Richter et al. 1996). It is the City's intent to manage instream flows in a manner that is beneficial to fish and the ecosystems upon which they depend. The City will use information gained in the many studies to be performed under the HCP, and by others, to attempt to manage instream flows in a manner that, where biologically appropriate, more closely mimics natural hydrologic patterns and that encourages natural ecological and regenerative processes throughout the lower river. These efforts must necessarily also consider the altered conditions of the lower river, flood control needs and water customer needs.

In addition to this commitment to future flexibility, several features of the proposed instream flow conservation strategy attempt to reflect the natural hydrologic patterns of the Cedar River. The guaranteed flow regime has been shaped to mimic the general pattern of the annual hydrologic regime in the Cedar River basin. In addition, the relocation of the instream flow measurement point to Landsburg will promote a more natural short-term hydrologic pattern throughout the river and especially in the 21.8 stream miles downstream of Landsburg. Constraints on the rates at which City facilities can allow stream flows to drop (downramping rates) will help keep short term flow fluctuations more similar to rates and magnitudes of natural short-term fluctuations. The provision of supplemental flows when hydrologic conditions are appropriate will result in seasonal flows that tend to fluctuate in a more natural manner than the present relatively static IRPP minimum flow regime. And finally, the City will fund additional physical and biological studies to support collaborative management of stream flows above the guaranteed levels to more closely mimic natural hydrologic patterns where biologically appropriate, protect important ecological processes and provide additional benefits to fish.

While the instream flow conservation strategy considers natural hydrologic patterns, simply attempting to mimic general natural hydrologic patterns is perhaps overly simplistic and insufficient to provide high quality salmonid habitat in a highly altered environment. This rather broad, high-level approach is important and informative, but misses much of the complexity inherent in the relationships between stream flow and habitat quality. This added complexity can be partitioned into three general categories.

First, as an example, salmon and steelhead display a tendency to adapt to specific and unique conditions in particular watersheds, but they also display considerable plasticity. For example, robust anadromous salmonid populations are found in systems with a rather broad range of hydrologic conditions, from systems that exhibit quite sudden and dramatic flow fluctuations in response to phenomena such as rain-on-snow events, to very stable, spring fed systems in which flow variations are quite limited. Secondly, the specific micro-habitat preferences of various species and life stages of anadromous fish are complex, somewhat variable, and can be found in a relatively broad range of geomorphic conditions and stream channel types. And third, as discussed in section 3.2.5 and 4.3, the anadromous aquatic habitat in the Cedar River Basin has been rather dramatically altered by anthropogenic activities during the twentieth century. The relationships between aquatic habitat characteristics and stream flow in the present channel, which is highly constrained, much narrower, shorter and higher gradient than the original channel, are far different than the relationships that existed when the channel was in a natural condition. To further complicate matters, the changes in the drainage patterns of the Lake Washington basin that occurred with the construction of the Ballard Locks and re-routing of the Cedar River into Lake Washington resulted in rather dramatic ecological changes in the system and a shift in fish species composition

(Section 4.3.2). In the Cedar River, these alterations likely resulted in the extinction of pink and chum salmon, have created challenging conditions for ocean-type chinook salmon (Section 3.5.10) but have provided conditions under which sockeye salmon were able to flourish (Section 3.5.8).

Therefore, in addition to considering natural hydrologic patterns, the instream flow conservation strategy also makes use of an extensive body of scientific information developed during 10 years of collaborative study and analysis (Sections 3.3.2 and 4.4.1). This information provides detailed information on the habitat preferences of the anadromous fish species in the Cedar River and on many of the complex relationships between the quantity and quality of fish habitat and stream flow.

Prioritizing Species and Life stages

Various species and life stages have varying stream flow requirements that can, at times, be in conflict. Table 4.4-6 summarizes the primary species and life stages that the collaborative studies indicate should be carefully considered in the development of the HCP instream flow regime.

The CRIFC identified all life stages of chinook, coho, sockeye and steelhead as the primary focus of the studies. Theses species were considered keystone species in subsequent discussion and negotiations. An understanding of life history and periodicity of the various life stages is essential to understanding the habitat requirements of fish during the course of a year. Life history periodicity information for the four species is provided in Figure 4.4-6. A summary of key considerations for the various species and life stages throughout the year is presented in Table 4.4-6. The HCP instream flow regime attempts to address key species and life history requirements while minimizing conflicts between species.

Coastal cutthroat trout were not included in the studies because their smaller size and preference for small size streams and tributaries indicated they are much less influenced by Cedar River instream flows than other salmonids. Instream flows that meet the needs for the four studied species are expected to also provide adequately for cutthroat.

During the development of the HCP, the Services agreed that the Cedar River downstream of Cedar Falls does not presently support a viable population of bull trout, nor was such a population present in this area historically. If future information suggests that this is not the case and a viable population of bull trout is present in the Cedar River downstream of Cedar Falls, the City believes that the HCP instream flow management regime, which is designed to provide for the protection and recovery of chinook, coho, sockeye and steelhead, will also provide sufficient protection for bull trout.

Habitat Availability

Within the IFIM approach, Physical Habitat Simulation (PHABSIM) analyses provide an important tool for investigating the effects of stream flow on the physical components of fluvial fish habitat. PHABSIM analyses are based on the premise that habitat conditions preferred by different species and life stages of stream-dwelling fish vary within the channel as a function of flow. Or, stated more precisely, stream-dwelling fishes prefer specified ranges of depth, velocity, substrate, and cover type and the availability of these preferred habitat conditions varies with stream flow. PHABSIM analyses use a set of computer models developed by the USFWS to integrate individual species and life stage habitat preferences with measured, river specific stream depth, velocity, substrate, and cover type to generate an index of habitat availability for particular species and life stages over a range of stream flow levels. This index of habitat availability is termed Weighted Usable Area (WUA) and is measured in square feet of habitat for a defined species and life stage per linear length of stream (Bovee 1982, 1986).

From the strict standpoint of WUA, the primary species and life stages of interest are spawning and rearing chinook, coho, and steelhead and spawning sockeye (sockeye fry migrate immediately to Lake Washington after emergence and therefore do not rear in the river). For most of the year, HCP normal minimum flow commitments are equal to or greater than the flows required to provide maximum WUA for all life stages of the four anadromous fish species.

As flows increase above the levels required to provide maximum weighted usable area, water depths and velocities increase and the total amount of available habitat in the river generally decreases. Within this general pattern, spawning and rearing habitat availability vary independently and in different ways as flows change. For example, steelhead spawning WUA increases as flows increase to a level of approximately 150 cfs as measured at Landsburg. When flows increase above this level, the amount of spawning WUA decreases as depths and velocities in much of the channel increase beyond suitable ranges. In contrast, juvenile steelhead rearing WUA continues to increase as flows increase to a level of approximately 75 cfs, then decreases slightly as flows increase further (Figure 4.4-8).

By integrating the output from PHABSIM analyses for a particular species and life stage (such as spawning chinook salmon) with expected stream flows over a specified period of time (such as the fall chinook spawning season), habitat duration analyses may be generated to compare aggregate habitat availability for different potential flow regimes. In Appendix 36, the City presents analyses that describe and compare historic Cedar River stream flows, flows expected to occur over the next 50 years under the HCP flow regime, and flows expected to occur under future conditions without the HCP flow regime. This information, coupled with modeled unregulated flows, was then used to generate the series of habitat duration analyses provided in Appendix 37 for various life stages of chinook, coho, sockeye and steelhead. Habitat duration analyses allow investigators to compare total WUA and WUA distribution for given species and life stages for different stream flow regimes over specified time periods and at different seasons. For example, these analyses compare total aggregate chinook spawning WUA during the fall chinook spawning season as whole for three different stream flow regimes: flows expected under the HCP regime; flows that occurred historically under the IRPP regime; and predicted flows that would occur under natural conditions without regulation by the City's water management facilities. The results presented in Appendix 37 demonstrate that under nearly all hydrologic conditions that might occur, the HCP instream flow regime will provide more WUA for chinook spawning during the fall spawning season than either historical flows or predicted natural unregulated flows.

For the three anadromous species that rear in the river, the Cedar River PHABSIM analyses demonstrate that WUA for juvenile rearing is generally much less sensitive to changes in flows than is WUA for spawning. That is, for a given incremental flow change, the change in WUA for juvenile rearing is typically much smaller than the change in WUA for spawning. The study also demonstrates that the flows required to provide maximum WUA for spawning are typically much higher than the flows required to provide maximum WUA for juvenile rearing. For these reasons, and because WUA for juvenile rearing during fall, winter and spring base flow conditions is not believed to be a major concern, spawning habitat and other considerations have generally been given higher priority in the Cedar River than availability of juvenile rearing habitat

There is one period during the year when there are no other overriding concerns and juvenile rearing is the primary focus of instream flow management. After the completion of steelhead incubation in early August and prior to the beginning of substantial chinook and sockeye spawning in mid-September, steelhead juvenile rearing is the key life history stage of concern. Juvenile coho salmon are also present at this time. However, the flows required to maximize WUA for juvenile steelhead are slightly greater than flows required to provide maximum WUA for either juvenile coho or juvenile chinook. Therefore, steelhead was selected as the key species of concern. During this time of year, instream flow considerations are typically important in determining the amount and quality of habitat available when juvenile fish are well dispersed and actively feeding and growing. Insufficient habitat availability at this time of year can potentially create a bottleneck for salmonids that rear in the river as juveniles. From August 4 through September 15, the HCP guaranteed flows are slightly below the levels required to provide maximum WUA for juvenile steelhead rearing, but still provide 98 to 99 percent of maximum WUA for this species and life stage. Habitat duration analyses summarized in Appendix 37 of the proposed HCP demonstrate that, for this period as a whole, expected flows under the HCP regime provide more WUA for juvenile steelhead rearing than expected flows under the existing IRPP regime or expected flows that would occur under natural conditions without the presence of water storage and diversion facilities. For the remainder of the year, from late September through the end of July, HCP guaranteed normal flows remain well above the levels required to provide maximum WUA for juvenile steelhead rearing. During this period, HCP normal flows provide between 65 and 93 percent of maximum WUA for juvenile steelhead rearing.

In the fall, spawning conditions for salmon become a key biological consideration. By mid-September, significant numbers of chinook and sockeye begin entering the river and maximizing chinook spawning habitat availability becomes a primary concern. HCP minimum flows in late September and early October rise well above the levels that provide maximum WUA for sockeye spawning, and are designed to rise to the level equal to the flow that provides maximum WUA for chinook spawning by the peak of the chinook spawning season in early to mid-October. After October 8, low-normal flows are set at the level that provides maximum WUA for chinook spawning for the remainder of the chinook spawning season. High-normal flows are greater than the level required to provide maximum WUA for chinook spawning. From late September through mid- to late October, HCP guaranteed flows are typically greater than would be provided under natural, unregulated conditions. Habitat duration analyses summarized in Appendix 37 demonstrate that, for the chinook spawning period as a whole, expected flows under the HCP regime will provide more WUA for chinook spawning than expected flows under either the existing IRPP regime or the natural flow regime.

With approximately 11 percent of the sockeye run typically in the river by September 16, the HCP normal flows already exceed the flows required to provide maximum WUA for sockeye spawning. By the approximate mid-point of the run in mid-October, the HCP low-normal flows are more than two and one-half times the level required to provide maximum WUA for sockeye spawning. Water depth and velocity increase throughout much of the channel at these elevated flows and the amount of total sockeye spawning habitat decreases. HCP low-normal flows provide approximately 70 percent of maximum WUA and the high-normal flows provide approximately 60 percent of maximum WUA for sockeye spawning. Habitat duration analyses summarized in Appendix 37 demonstrate that, for the sockeye spawning period as a whole, expected flows under the HCP regime will provide less WUA for sockeye spawning than expected flows under the existing IRPP regime, but more WUA than expected flows under the natural flow regime.

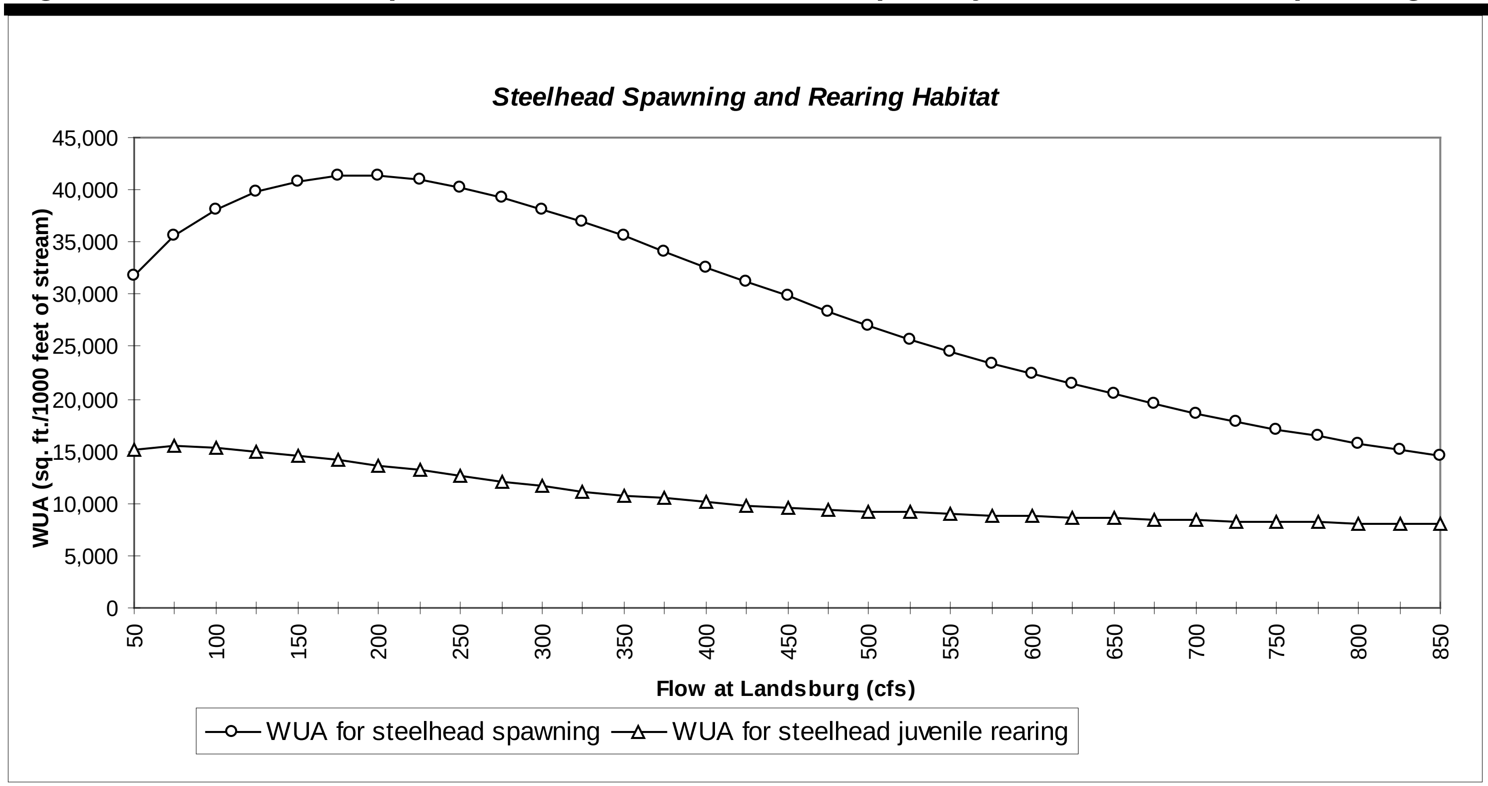
The HCP normal flows remain equal to or greater than the levels required to provide maximum WUA for chinook, sockeye, and coho spawning from October 8 throughout the rest of the salmon spawning season. Flows throughout the period of steelhead spawning in the spring also remain well above the level required to provide maximum WUA for steelhead spawning. Again, these higher flows result in a moderate reduction of the total amount of steelhead spawning habitat. Between mid-March and the end of May, the HCP flows provide between 78 and 98 percent of maximum WUA for steelhead spawning. Habitat duration analyses demonstrate that, for the steelhead spawning period as a whole, expected flows under the HCP regime provide more WUA for steelhead spawning than expected flows under natural flow conditions or expected flows under the IRPP regime.

HCP normal flows are also well above the level required to provide maximum WUA for juvenile steelhead rearing for the entire period from late September through the end of July. During this period, HCP normal flows provide between 65 and 93 percent maximum WUA of juvenile steelhead rearing.

Additional Habitat Quality Considerations

The first consideration in designing the HCP flow regime has been to provide flows that meet or exceed the flows required to provide maximum WUA as defined by the PHABSIM analyses for key species and life stages throughout the year. PHABSIM is a powerful tool that is helpful in describing the relationship between stream flow and fish habitat and is a generally accepted methodology used to establish instream flow requirements for fish. However, the methodology entails some uncertainty and does not address all aspects of the biological requirements of fish in the Cedar River (Castleberry et al. 1996; Seiler and Kishimoto 1996; Thorne and Ames 1987). Recognizing that the PHABSIM would not provide all the necessary information for establishing the appropriate instream flow regime, the CRIFC requested many additional studies be conducted to complement the PHABSIM information base (see Section 3.3.2). The flows required to provide maximum WUA have been used here as a foundation upon which additional flow is added to better address uncertainty and help meet ancillary biological requirements of anadromous fish as described by the companion investigations conducted during the collaborative study program.

Figure 4.4-8. Relationship between stream flow and the quantity of steelhead trout spawning and rearing habitat.



Fish Passage

Shallow depths across a riffle or gravel bar can create a low flow blockage that limits a fish's ability to swim upstream. The shallowest and widest riffle in the Cedar River downstream of Landsburg was identified during the collaborative instream flow studies. Using the field data from the cross section measurements and hydraulic information developed for the PHABSIM analyses, the studies investigated the flow required to allow adult chinook to pass over the low-flow passage barrier. Although the absolute lowest minimum flow that would allow passage was not determined, the study demonstrated that passage of adult chinook would not be impeded at flows of 94 cfs or more as measured at the low flow blockage located approximately 0.5 miles upstream of the confluence with Rock Creek. HCP minimum flows are substantially greater than 94 cfs at this location from September 15 throughout the entire salmon and steelhead spawning seasons.

Salmon Spawning Habitat in the Fall

In addition to providing adequate spawning habitat availability for chinook and sockeye, the guaranteed flows in the fall have been designed to provide additional benefits for sockeye in two ways. First, the flows employ the potential benefits of a cumulative approach to providing sockeye spawning habitat in contrast to a static approach. The regime attempts to increase available sockeye habitat over and above the amount provided by the static flow providing maximum WUA by incrementally increasing flows to recruit new habitat after habitat recruited at lower flows has been previously seeded. As flows increase, depths and velocities over previously seeded habitat exceed suitable levels for spawning and fish are forced to spawn in other areas including new habitat recruited by the increasing flows. As flows increase, the rate of habitat loss is greater than the rate at which new habitat is acquired. If, however, this lost habitat was previously seeded when flows were lower, then it still contributes to the total productive cumulative sockeye spawning habitat. Flows at the beginning of the sockeye spawning season have been established at, or slightly above, the value providing maximum WUA. Flows are then gradually stepped up over the next 3 weeks of the spawning season to recruit additional new habitat. After 3 weeks of flow increases, significant amounts of sockeye spawning habitat have been lost. However, if this lost habitat was previously seeded, it remains productive and is now less vulnerable to damage from the activities of subsequent spawning fish.

Secondly, the increasing flow levels recruit new spawning habitat along the margins of the streams that is believed to be less vulnerable to scour than areas of the mid-channel. Thus, the loss in WUA for sockeye spawning during flow increases in the fall can be offset by an increase in cumulative spawning habitat and recruitment of sockeye spawning habitat that is less vulnerable to scour. By spreading the eggs throughout the channel, incubation habitat is diversified and, over the long-term, can be more resilient and less vulnerable to variations in environmental conditions.

Because chinook tend to spawn in deeper, faster water, use larger substrate, and bury their eggs deeper than sockeye, the flow increases early in the fall actually increase WUA for chinook spawning. Thus both chinook and sockeye can potentially benefit from the gradual flow increases in the fall that generally follow the shape of the natural hydrograph.

Incubation Protection

Incubating alevins can experience significant mortality during short periods of dewatering. By providing guaranteed flows at appropriate levels, risks to incubating salmon and steelhead can be greatly reduced. In the Cedar River, incubating salmonids are present in substantial numbers from approximately mid-September until the end of July. Minimum-flow commitments during this time have been designed to help reduce the risk of short-term redd dewatering.

Because steelhead incubate during the period of a naturally declining hydrograph in the Cedar River, they can be especially vulnerable to dewatering under certain circumstances. In addition to increased minimum flows during the latter portion of the incubation season, the HCP also provides real-time monitoring coupled with supplemental blocks of water that may be applied by the Commission in a manner that will minimize risk to incubating steelhead.

Outmigration Conditions for Sockeye

Sockeye fry emerge from the gravel during the late winter and spring and migrate directly downstream to Lake Washington where they rear for a year prior to migrating to sea. Preliminary studies conducted independently by WDFW suggest that most fry arrive at Lake Washington within 48 hours of emergence and that their survival during their downstream migration is positively correlated with stream flow (Seiler and Kishimoto 1996).

Spring is a challenging time for water management on the Cedar River. Management strategies are attempting to meet multiple objectives, including: refilling the Chester Morse Lake Reservoir; providing suitable flows for sockeye outmigration; preventing sustained high flows to avoid inducing steelhead to spawn in areas that are at high risk of being dewatered; flood management; and minimizing the impact of reservoir level fluctuations on nesting loons, incubating bull trout and shoreline wetlands. In an effort to benefit outmigrating sockeye, minimum flow commitments have been set higher than the non-binding IRPP regime during this period. The HCP regime also provides even higher supplemental flows 70 percent of the time in a manner that attempts to minimize subsequent risks to incubating steelhead.

Protection from Stranding

Many of the benefits of the previously described conservation measures can be negated by excessive and frequent flow fluctuations that strand juvenile fish. Therefore, to help secure all the benefits provided by the various components of the instream flow conservation strategy, the City will commit to a set of downramping prescriptions that are very similar to downramping guidelines established by the State of Washington (Hunter 1992).

Contributions to Fish Passage at the Ballard Locks

On an annual basis, the Cedar River provides approximately one-half the total inflow to Lake Washington. The total volume of inflow to Lake Washington during the dry season is especially important for protecting water quality, for managing water levels in Lake Washington and providing suitable conditions for fish passage and vessel traffic at the Ballard Locks. Therefore, a comprehensive approach to managing Cedar River instream flows must also address factors beyond the river itself. As a result of all the provisions listed above, the HCP instream flow regime will ensure that, under conditions of minimum flow, more water will flow down the Cedar River into Lake Washington than under the existing IRPP regime. Anticipated dry season inflows to Lake Washington under IRPP and HCP minimum flow conditions are summarized in Table 4.4-7.

Recognizing the importance of providing safe fish passage conditions for anadromous fish migrating to and from Lake Washington, the City will also provide $1.85 million to help support enhanced water conservation and the construction of improved downstream fish passage facilities at the Ballard Locks.

Funding for Habitat Protection and Restoration in the Lower Cedar River

Protection and restoration of aquatic and riparian habitat in the lowlands of the Lake Washington basin represent a critical element in regional salmonid recovery efforts. As discussed in Section 4.3 and shown in Table 4.3-1, these efforts will require cooperation of many jurisdictions and agencies if they are to be successful. To contribute to the protection and restoration of habitat in the Cedar River downstream of the municipal watershed and within the Walsh Lake subbasin, the City will contribute over $3 million dollars. Projects in the lower river may include habitat acquisition and will be directed toward habitat for any and/or all species of naturally reproducing salmonids. These funds are in addition to the $1.6 million provided for lower river habitat as part of the mitigation program for the migration blockage at the Landsburg Dam (Section 4.3.2). The HCP's nearly $5 million in contributions to habitat outside the municipal watershed will increase the probability that the potential benefits of the instream flow regime can be realized for anadromous fish.

4.4.3 Monitoring and Research

The City will commit to a program of monitoring and research to determine whether the instream flow management program elements are implemented as written (compliance), to track the results of efforts to protect and restore species of concern and their habitats (effectiveness), to obtain more information on species of concern, to test critical assumptions and reduce uncertainty, and to gain understanding needed to refine management decisions to better meet plan objectives. The instream flow monitoring and research program is described in detail in Section 4.5; the adaptive management program is described in Section 4.5.7 .

Monitoring and research elements are summarized in Table 4.4-10 and include real-time and longer-term programs to monitor and investigate hydrologic and biological factors influencing fish and their habitat in Chester Morse Lake in the river downstream of the lake. All monitoring and research activities will be conducted in collaboration with the Parties to the IFA and the Cedar River Instream Flow Commission. Periodic reports detailing all activities and data will be submitted to the Parties and the Commission as detailed in the IFA and Section 4.5 of the HCP.

Elements of the monitoring and research program directly related to Instream Flow Management Strategies include:

- Funding to support measurement of regulated and unregulated stream flow at key locations throughout the basin;

- Steelhead incubation and redd monitoring program;
- Additional biological and physical studies to gather additional information on key life stages of fish in the Cedar River with special emphasis on juvenile chinook and to further explore the effects of stream flow on aquatic habitat in altered stream channels;
- Studies to support the development of potentially improved criteria to govern switching between normal and critical flows and high-normal and low-normal flows;
- Further investigations of accretion inflows into the river between Landsburg and Renton;
- Further evaluation of the potential effects of ongoing reservoir management on bull trout and common loons;
- Investigation of the feasibility of tapping Chester Morse Lake dead storage to provide more water for downstream aquatic resources, and potential improvements in municipal water supply and reliability;
- Investigation of the possible effects of the potential Chester Morse Lake Dead Storage project dynamics of river delta fans in the reservoir and potential impacts on aquatic resources;
- Evaluation of the effects of the Dead Storage Project on bull trout spawning migration and the potential need for and feasibility of providing migration assistance; and
- Evaluation of the potential effects of the Dead Storage Project on pygmy whitefish and rainbow trout in Chester Morse Lake.

Table 4.4-10. Summarized Cedar River instream flow monitoring and research program.

Elements	HCP Years	Costs	Notes
Stream Flow Measurement	1-50		The City will bear any expense not borne by the USGS and other cooperating agencies for installation, telemetry, relocation, rehabilitation and maintenance of gages at all measuring points specified in IFA
Steelhead Redd Monitoring	1-8	$240,000	
Supplemental Biological and Physical Studies	1-9	$1,000,000	Additional information on key aspects of life history of fish in the Cedar River with special emphasis on chinook early life history and relationships between hydrologic characteristics and fish habitat in altered systems.
Monitor Downramping Rates	1-50	Included in other costs	Use same gages as above
Flow Switching Criteria Study	Completed by the end of year 4	$200,000	
Lower Cedar River Accretion Flow Monitoring Study	For an estimated 10 continuous years within 1-13	$400,000	Study may be extended or shortened by agreement between Parties and City
Reservoir Elevation Management			
Bull trout redd inundation studies	1 or more years within 1-8	$110,000	$55,000/year
Common Loon Monitoring	1-50	$125,000	Up to $25,000/interval: years 1-10, 11-20, 21-30, 31-40, 41-50
Cedar Permanent Dead Storage Project Evaluation			
Engineering studies	1-5	$700,000	Project feasibility, concept design, costs
Delta fans geomorphologic investigations and modeling; plant studies	1-3	$370,000	Includes plant community studies
Loon habitat studies		$30,000	
Bull trout passage assistance plan	Completed by the end of year 5	$65,000	
Pygmy whitefish and rainbow trout impact investigations	Begin in 3 or 4	$280,000	

4.4.4 Effects of Instream Flow Conservation Strategies on Anadromous Fish

GENERAL EFFECTS

The HCP Instream Flow Management Strategies are expected to provide a substantial improvement over existing conditions for aquatic resources in the Cedar River. The management regime is expected to avoid, minimize and mitigate for the effects of the City's water supply and hydroelectric operations on aquatic resources in the Cedar River basin. Further, the proposed management practices are expected to contribute substantially to the recovery and persistence of species currently listed under the federal Endangered Species Act and to those that might reasonably be expected to listed in the future.

The HCP guaranteed flow regime and associated protective provisions attempt to reflect natural hydrologic patterns in several ways. First, the minimum flow regime has been designed to follow the general shape of the natural annual hydrograph in the Cedar River Basin. Flows begin to increase between mid-September and mid-October when fall rains typically begin to arrive, soil moisture increases, and surface runoff begins to increase. Flows remain elevated for the duration of the normal wet period of the year. In late spring, flows begin to decrease as runoff from rainfall and snowmelt in the relatively low-elevation Cedar River basin begins to decline. Flows continue to recede throughout the summer, reach dry season base flow levels by early August, and remain at that level until the return of the wet season in the fall.

Second, the primary instream flow measurement point will be relocated from its present location near the mouth of the river at Lake Washington, to the vicinity of the City's water supply diversion facilities approximately 20 miles upstream. The relocated measurement point will encourage more natural short-term variations in flow throughout the river and especially in the 21.8 miles downstream of the Landsburg Dam.

Third, constraints on the rates at which City facilities can allow stream flows to drop (downramping rates) will help keep short term flow fluctuations more similar to rates and magnitudes of natural short-term fluctuations.

Fourth, the provision of additional supplemental flows when conditions allow will encourage a trend toward more natural fluctuations in the annual hydrologic patterns than under the current, relatively static regime.

Finally, through the HCP, the City commits to manage stream flows above the guaranteed levels in a manner that, where biologically appropriate, more closely mimics natural hydrologic patterns to protect important ecological processes and provide additional benefits to fish.

In addition to providing a regime that is more similar to the natural hydrologic regime, the HCP instream flow strategy will provide many specific prescriptions, safeguards, operating constraints, and financial commitments, none of which exist under the present management regime, to improve conditions for Cedar River anadromous fish. These measures have been developed with an extensive information base that has been developed collaboratively with state, federal, and Tribal resource managers over the last

10 years. The primary improvements provided by the HCP instream flow regime over existing conditions are summarized below.

- Binding minimum flow commitments, where none presently exist, that provide more water and better habitat conditions throughout the river between the natural anadromous fish migration barrier at Lower Cedar Falls and Lake Washington;
- Supplemental flows that provide additional water above minimums, as conditions allow, to further improve anadromous fish habitat;
- Downramping prescriptions to constrain the rate at which flows may be reduced in the Cedar River and, therefore, limit the risks of stranding juvenile fish;
- Relocation of the flow measurement point to Landsburg for increased operating precision, better protection of habitat in the upper reaches of the lower river, and a more natural hydrologic pattern;
- The provision of rearing flows in the bypass reach between Lower Cedar Falls and the Cedar Falls hydroelectric facility;
- Higher guaranteed flows from the Cedar River into Lake Washington, especially during the dry season;
- Funds to support improvements in downstream fish passage and water use efficiency at the Ballard Locks;
- Funds for protection and restoration of aquatic and riparian habitat in the lower Cedar River Basin;
- Funds for additional studies to enhance existing information on key life stages of anadromous salmonids, with special emphasis on juvenile chinook salmon;
- Preservation of sufficient flexibility to adapt and improve instream flow management practices, by reservation of 1/3 of the City's water claim for instream resources and by dedication to manage diversions from the Cedar River at existing levels for the next 5 to 10 years.
- Collaborative management of flows above guaranteed levels to protect important ecological benefits and provide benefits to fish.

SUMMARY OF SPECIFIC EFFECTS

The discussion of the specific effects of the HCP flow regime will center on the key life stages for the four anadromous salmonids as described in Figure 4.4-6 and Table 4.4-6. Coastal cutthroat trout were not included in the studies because their smaller size and preference for small size streams and tributaries indicated they are much less influenced by Cedar River instream flows than other salmonids. Instream flows that meet the needs for chinook, coho, sockeye and steelhead are expected to also provide adequately for cutthroat. During the development of the HCP, the Services agreed that the Cedar River downstream of Cedar Falls does not presently support a viable population of bull trout, nor was such a population present in this area historically. If future information suggests that this is not the case and a viable population of bull trout is present in the Cedar River downstream of Cedar Falls, the City believes that the HCP instream flow management regime, which is designed to provide for the protection and recovery of chinook, coho, sockeye and steelhead, will also provide sufficient protection for bull trout. A detailed analysis of effects on particular species can be found in Section 4.6, which includes a discussion of potential effects on cutthroat trout and bull trout.

From September 23 through May 12, the HCP guaranteed flows will, on average, be significantly greater than the existing non-binding IRPP minimum flow regime and are typically well above the flow levels that provide maximum WUA for key life stages of all four anadromous fish species as determined by the collaborative PHABSIM analyses (Figure 4.4-2). As flows increase above the level required to provide maximum WUA, water depths and velocities in much of the stream channel increase beyond suitable levels and the total amount of spawning and rearing habitat generally decreases (Figure 4.4-7). However, the increased flows will provide a variety of significant benefits that improve habitat quality for salmon spawning, incubation, and outmigration.

From May 13 through June 16, the HCP guaranteed flow commitments slowly decline in a pattern that follows the shape of the natural hydrograph and will, on average, be slightly lower than IRPP flows. These lower flows provide more WUA for steelhead spawning and juvenile steelhead, coho, and chinook rearing than the existing IRPP regime.

From late June to August 4, the HCP guaranteed flow commitments will generally be greater than the existing IRPP flows. The actual flows during this period will vary from year to year as prescribed by the Commission to provide protection of incubating steelhead. However, throughout this period, the elevated flows will be greater than the flows required to provide maximum WUA for steelhead, coho, and chinook rearing and will generally result in a small reduction in juvenile rearing habitat. From August 5 to September 15, the HCP guaranteed flow commitments are essentially equal to the existing IRPP flows. Both sets of flows are slightly below the levels required to provide maximum WUA for juvenile salmonid rearing. However, both regimes provide quantities of juvenile salmonid rearing habitat that are very near maximum WUA.

Fall Flows

As significant numbers of adult chinook and sockeye salmon begin to enter the Cedar River by mid-September, considerations for juvenile rearing conditions become secondary to considerations for sockeye and chinook spawning. By mid-September guaranteed flow commitments increase beyond the levels that provide maximum WUA for coho and steelhead juvenile rearing. However, the resultant losses in rearing habitat associated with these increased flows are moderate and are not believed to pose a threat to the populations. By the middle of September, the HCP flows are greater than required to provide maximum WUA for sockeye spawning, but are still less than the flows required to provide maximum WUA for chinook spawning. After October 7, HCP flows are equal to or greater than the level required to provide maximum WUA for chinook spawning. Habitat duration analyses summarized in Appendix 37 demonstrate that, for the chinook spawning period as a whole, expected flows under the HCP regime will provide more WUA for chinook spawning than expected flows under either the existing IRPP regime or the natural flow regime. Habitat duration analyses also demonstrate that the HCP provides more WUA for sockeye spawning than expected flows under the natural flow regime, but less WUA for sockeye spawning that expected flows under the existing IRPP regime.

The HCP flow regime attempts to balance three sometimes competing spawning habitat considerations during the fall: (1) maximizing WUA for chinook and sockeye spawning t at any given time; (2) further increasing the cumulative amount of sockeye spawning habitat available during the spawning season by gradually increasing flows above the level that provides maximum WUA; and (3) increasing flows above the level required to create maximum WUA for spawning to recruit additional sockeye spawning habitat along the stream margins in an effort to reduce the risk of redd scour during subsequent flood events.

During the third week in September and first week of October, the HCP guaranteed flow commitments are equal to the existing IRPP minimum flows. During the fourth week of September, HCP flows are significantly greater than existing IRPP flows and provide significantly greater WUA for chinook spawning. These increased flows result in a reduction in WUA for sockeye spawning and reduced capacity to provide additional cumulative spawning habitat for sockeye. However, these losses in sockeye spawning habitat are believed to be offset by the benefits provided to chinook salmon that tend to spawn slightly earlier than sockeye.

From October 8 through mid-November the HCP low-normal flows are approximately equal to the flows that provide maximum WUA for chinook spawning, are lower than IRPP flows, and provide more chinook spawning habitat than IRPP flows. HCP high-normal flows during this period are greater than the flows that provide maximum WUA for chinook spawning, are greater than IRPP flows, and provide slightly less chinook spawning habitat than IRPP flows. Although the elevated high-normal flows reduce WUA for chinook spawning, these losses are very small (less than 3.5 percent) and are offset by benefits of providing additional incubation protection for all salmon species, increased cumulative sockeye spawning habitat, and increased sockeye spawning habitat along the stream margins where redd scour is believed to be less frequent and less severe.

Winter Flows

Chinook spawning is complete by mid-November, but sockeye continue to spawn in the mainstem through the end of December, and coho continue to spawn until mid-February. Sockeye spawning remains the primary focus through December, but salmon incubation protection is also important during this period. By January, protection of incubating salmon becomes the primary consideration for instream flows. Flows remain elevated well above the level that provides maximum WUA for coho spawning and above the levels provided by IRPP to reduce the risk of redd dewatering. Although the elevated flows reduce WUA for coho spawning, most coho are thought to spawn in tributaries to the mainstem and chinook and sockeye incubation protection is considered a higher priority for mainstem flow considerations.

By early February, significant numbers of sockeye fry are emerging and migrating downstream to Lake Washington. Fry emergence and migration peaks in late March, continues through mid- to late May, and is the primary concern for instream flows through mid-April. From February 11 through April 14, HCP flows are elevated further to improve conditions for outmigrating sockeye fry. Steelhead begin to spawn in early March and continue through early June. HCP guaranteed flow commitments remain well above the levels that provide maximum WUA for steelhead spawning, resulting in a moderate loss of steelhead spawning habitat during this entire period. Although important, WUA for steelhead spawning is considered to be of secondary importance to sockeye outmigration conditions and salmon incubation protection during this period.

Spring Flows

After April 14, steelhead spawning flows become increasingly important. Incubating steelhead that are spawned after April 14 will remain in the gravel through the period during which flows begin to drop to summer base flow levels and are therefore more vulnerable to dewatering than the offspring of early spawners. If stream flows remain significantly elevated for extended periods of time after April 14, significant numbers of steelhead may be forced to spawn in areas that are at significant risk of being dewatered prior to the completion of fry emergence. Therefore, HCP guaranteed flow commitments between April 14 and May 12 trend downward. However, to provide continued protection for incubating salmon, HCP guaranteed flow remain well above the levels required to provide maximum WUA for steelhead spawning and remain higher than existing IRPP flows.

After May 12, flows are allowed to drop slightly closer to the levels that create maximum WUA for steelhead spawning to coincide with peak steelhead spawning activity in early to mid-May. Water temperatures begin to warm during this time of year and juvenile rearing becomes increasingly important as young steelhead, coho, and chinook enter a period of active feeding and rapid growth. After May 12, flows begin to drop slightly below existing IRPP flows to provide increased WUA for steelhead spawning and juvenile salmonid rearing. However, to protect incubating steelhead, flows remain well above levels that provide maximum WUA for steelhead spawning and rearing. Although these higher flows result in a loss of habitat, they provide more steelhead spawning and juvenile rearing habitat than the existing IRPP flows. Habitat duration analyses demonstrate that, for the steelhead spawning period as a whole, expected flows under the HCP regime provide more WUA for steelhead spawning than expected flows under natural flow conditions or expected flows under the IRPP regime.

Summer Flows

From early June through early August, steelhead incubation protection is the primary focus of instream flow management. Flows during this period remain well above the level required to provide maximum WUA for juvenile steelhead, coho, and chinook and therefore result in a loss in rearing habitat. However, these habitat losses are quite small and are not believed to pose a threat to the populations. The amount of water available for instream flows from June 17 through August 4 is greater than the amount available under the existing IRPP regime. The actual flow levels during this period will be determined each year by the Commission based upon needs for steelhead incubation protection as demonstrated by in-season redd monitoring studies, water supply conditions, and other factors deemed appropriate.

After the completion of steelhead incubation in early August and prior to the start of salmon spawning in mid-September, juvenile coho and steelhead rearing are the primary concerns for instream flow management. This is a period of active feeding and growth for juvenile salmonids. The HCP and the existing IRPP flows are essentially equivalent during this time period. Although the flows are slightly lower than the flows required to provide maximum WUA, they are sufficient to provide 98 - 99 percent of maximum WUA for juvenile steelhead and coho rearing.

Management of Flows Above the Guaranteed Levels

As described above, the HCP commitments provide funding to enhance our understanding of key life history stages of anadromous fish and to further explore the relationships between basin hydrology and fish habitat in altered systems. Further, the HCP commitments preserve future flexibility to work with the Commission to adapt and enhance the management of stream flows above the guaranteed levels as new information is gathered and conditions change. This adaptive approach is expected to help protect important ecological processes and preserve options to provide additional benefits to fish should such opportunities arise in the future.

Downramping Prescriptions

The City's small hydroelectric facilities at Cedar Falls and water supply facilities at Landsburg operate at relatively constant levels and are not operated in a manner that provides for daily peaking and associated flow oscillations. Therefore, downramping is perhaps less of a concern on the Cedar River than in other regulated rivers with large hydroelectric facilities that vary flows to meet varying electrical demands during the course of a day. Nevertheless, adjustments to the City's water supply and hydroelectric facilities do result in a significant number of stream flow reductions during the course of a year.

At present, there are no downramping prescriptions on the Cedar River. The HCP provides downramping prescriptions that are patterned after WDFW downramping prescriptions (Hunter 1992). Downramping prescriptions will significantly reduce the risks of stranding salmonids and other species of fish throughout the river downstream of the Landsburg Dam beginning in HCP year 1. These protections will be extended to the river above the Landsburg Dam once anadromous fish are allowed to pass upstream.

Relocated and Enhanced Measurement Points

The stream flow measurement point for the present non-binding IRPP instream flow regime is located at the existing USGS stream gage #12119000 in Renton, 1.6 miles upstream from Lake Washington (Map 2). The new configuration of measurement points will provide improved conditions for anadromous fish in several ways. First, measurement at Landsburg provides added protection for the upper portions of the lower river below Landsburg. Under the current measurement regime, actual flows at Landsburg can be varied in a quite unnatural manner to meet target flows 22 miles downstream at Renton (Figure 4.4-3). In fact, there are times when releases from Landsburg can approach zero while still meeting IRPP target flows at Renton. By moving the measurement point to Landsburg, the upper reaches of the lower river will be better protected and flows downstream of the diversion dam will vary in a much more natural manner according to changes in natural inflows to the lower river. Secondly, the establishment of downramping measurement points at Landsburg and Cedar Falls will significantly reduce the risk of stranding juvenile fish during operational reductions in stream flow. Finally, the establishment of a stream flow measurement point upstream of the Cedar Falls powerhouse will provide added protection for the bypass reach and upper portions of middle Cedar River downstream from the powerhouse.

Funding for Improvements at the Ballard Locks

All anadromous fish in Lake Washington must pass through the locks twice during their lives. Recent investigations suggest that opportunities may exist to improve the efficiency with which freshwater is used at the locks (ACOE 1991) and provide better conditions for downstream migrating anadromous fish (Goetz et al. 1997). Water flow at the locks must be shared between vessel traffic and upstream and downstream migrating fish. Between June 15 and September 30, the typical dry season, the HCP guaranteed flow regime ensures that, under minimum flow conditions, significantly more water will flow into Lake Washington than under the existing IRPP minimum flow regime (Table 4.4-7).

In addition, the City will help fund measures at the Locks to improve fish passage conditions and improve water use efficiency in an effort to make even more water available for fish passage. These measures are expected to help improve the survival of juvenile anadromous salmonids as they migrate downstream through the facilities to saltwater.

Conditions in the River Upstream of the Landsburg Dam

The construction of emergency flow bypass facilities at the City's Hydroelectric Facility will help reduce the risks of fish stranding throughout the Cedar River downstream of Cedar Falls. The construction of a tailrace barrier at the facility will reduce hazards to upstream migrating fish. The provision of flows in the bypass reach upstream of the hydroelectric facility will improve conditions for juvenile salmon rearing and adult spawning.

Flows in the river immediately upstream of the Landsburg Dam will be significantly greater than flows immediately downstream of the dam except during relatively infrequent shut down of the municipal water supply intake. The HCP guaranteed stream flows coupled with the relocation of the measurement point to Landsburg ensures that flows in the Cedar River upstream of the Landsburg Dam will typically be near or greater than the flows required to provide maximum WUA for key species and life stages once anadromous fish are allowed to pass upstream of the Landsburg Dam (Table 4.4-2).

Contributions to Aquatic and Riparian Habitat Downstream of Landsburg

Many elements of the HCP are expected to provide benefits for water quality and fish habitat downstream of Landsburg. In addition to benefits discussed elsewhere, the City will provide $3.27 million to protect and restore habitat in the Walsh Lake system and in the mainstem of the Cedar River downstream of the Landsburg Diversion Dam as part of the proposed instream flow management program. This commitment is expected to contribute to improved habitat conditions in stream channels and riparian areas in the lower Cedar River. Habitat improvements are expected to provide substantial benefits for aquatic resources, including all salmonid species, in the lower river downstream of the municipal watershed boundary.

Conditions in Chester Morse Lake

The HCP flow regime generally ensures that, under minimum flow conditions, more water is provided for instream flows during the dry season than in the past. Therefore, it is possible that, in some years, water levels in Chester Morse Lake will be slightly lower during the summer and fall than under existing conditions. The differences in water level are expected to be relatively minor and the effects of these lower water levels on the aquatic community in Chester Morse Lake are also expected to be minor. These potential effects are analyzed in the section Environmental Evaluation of the New HCP Flow Regime (contained in Section 4.5.6) and in Section 4.6.