Section 4.3 Contents

4.3.1 Introduction 4.3-1
Background and Planning Context 4.3-1
Objectives 4.3-4
Overview of Anadromous Fish Conservation Measures 4.3-5
4.3.2 Conservation Strategies 4.3-6
Basic Approach 4.3-6
Conservation Strategy for Chinook and Coho Salmon and Steelhead Trout 4.3-6
Interim Measures for Chinook, Coho, and Steelhead 4.3-7
Long-term Measures for Chinook, Coho, and Steelhead 4.3-8
Conservation Strategy for Sockeye Salmon 4.3-10
Interim Measures for Sockeye Salmon 4.3-11
Long-term Measures for Sockeye Salmon 4.3-12
Rationale 4.3-19
Lost Buffering Capacity and Reduced Resiliency 4.3-20
Chinook and Coho Salmon and Steelhead Trout 4.3-21
Sockeye Salmon 4.3-22
4.3.3 Monitoring and Research 4.3-25
4.3.4 Effects of the Conservation Strategies 4.3-27

4.3 Minimizing and Mitigating the Effects of the Anadromous Fish Migration Barrier at the Landsburg Diversion Dam

4.3.1 Introduction

BACKGROUND AND PLANNING CONTEXT

Although it has been substantially altered, the Cedar River/Lake Washington subbasin of the Lake Washington Basin (Map 2) offers many features that, if properly arrayed and protected, can form the basis for a robust aquatic ecosystem. To be effective, an anadromous salmonid rehabilitation program must provide a comprehensive set of solutions that address the life history and habitat requirements of the fish from the headwaters to the sea. The institutional complexities associated with such an effort are substantial (Stouder et al. 1997). However, creative approaches for addressing the complex amalgam of human activities that affect anadromous salmonids are beginning to emerge (National Research Council 1996; Lee 1997).

During the last decade, naturally reproducing populations of anadromous fish in the Lake Washington Basin have declined in abundance. Since 1990, record low adult returns have been reported in at least one year for each of the four anadromous species in the Cedar River: chinook, coho, and sockeye salmon, and steelhead trout. Cutthroat trout populations are thought to have increased in recent years; however, most cutthroat in the basin are believed to exhibit adfluvial and fluvial life history patterns, rather than an anadromous pattern. While there have been several isolated examples of relatively strong runs of salmon and steelhead (1996 sockeye and coho returns, 1997 steelhead returns), the population trend for the four strictly anadromous populations has been one of substantial decline (see Chapter 3).

There are a number of factors that can potentially reduce the survival of anadromous fish originating from the Cedar River at various stages of their life histories, including: habitat loss and degradation as a result of a variety of land and water management activities; injury to outmigrating smolts at the Ballard Locks; harvest in sport, Tribal, and commercial fisheries; inappropriate artificial propagation practices; predation by native and non-native fish; food supplies in Lake Washington; predation by marine mammals; droughts and floods; and unfavorable ocean conditions. As a municipal water and power utility and land manager, the City can affect anadromous fish during significant portions of their freshwater life histories.

During the last 100 years, the City has gradually acquired full ownership of the upper two-thirds of the Cedar River Basin. Ownership now includes the entire watershed upstream and east of the municipal water supply diversion facilities at the Landsburg Diversion Dam (see Figure 1.2-2 and Map 2). For reasons of convenience, this area will be referred to as the municipal watershed. The City's land management activities in the municipal watershed can have a significant impact on water quality and aquatic, riparian,

and upland habitat within and, to a lesser degree, downstream of the City's ownership boundary (Section 4.2).

Through the operation of its water storage and diversion facilities, the City can influence stream flow, a clearly important component of fish habitat, throughout the entire 34.5 stream miles of naturally accessible mainstem habitat between Lower Cedar Falls and Lake Washington. However, only the mainstem of the Cedar River is subject to regulation from the reservoir storage facilities formed by Chester Morse Lake and the Masonry Pool, and the diversion at Landsburg. Stream flows and habitat below the reservoir are also strongly influenced by natural, unregulated inflows. On an annual basis, the Cedar River contributes approximately one-half of the total inflow to Lake Washington and is, therefore, important in maintaining water quality in the lake, and in managing lake levels, navigation, and fish passage at the Ballard Locks.

The Landsburg Diversion Dam is a low head, run-of-the-river facility at RM 21.8 from which the City draws water for municipal and industrial use. The dam has blocked anadromous fish migration to approximately 17 stream miles of formerly accessible habitat (mainstem plus tributaries) since the early part of the twentieth century. Two Washington State statutes, passed subsequent to the construction of the Landsburg Diversion Dam, stipulate the provision of fish passage facilities or, if passage facilities are not practical, fish cultural facilities, to address the effects of migration barriers such as the Landsburg Diversion Dam. In the past, the City has consistently held that construction of the Landsburg Diversion Dam predates these state laws and is therefore not bound by them (Section 2.3.7).

However, the City supports the intent of these state laws, and it is clear that restoration of this lost element of the ecosystem can provide substantial benefits to anadromous fish populations, and it is therefore a central component of the City's HCP. To resolve any potential issues concerning the Landsburg Diversion Dam and intake under state law, the City is entering into a Landsburg Mitigation Agreement with Washington State (Appendix 28), to which NMFS and USFWS are also signatory Parties.

An additional 3.4 miles of stream within the City's ownership boundary, in the Walsh Lake subbasin, were also accessible to anadromous fish prior to the construction of the diversion dam. In 1931, the outlet of Walsh Lake was diverted from upper Rock Creek into the Walsh Lake Diversion Ditch, which empties into the Cedar River below the Landsburg Diversion Dam. The degree to which anadromous fish can presently access this former habitat through the Walsh Lake Diversion Ditch is unclear. While there appears to be at least one partial fish migration barrier in the lower portion of the channel, juvenile coho salmon have been reported in Walsh Lake and its tributaries (Section 3.2.2).

In the last several years, a number of biophysical and institutional factors in the Lake Washington Basin have become aligned in a manner that can potentially lead to the rehabilitation of once-plentiful salmonid populations. Citizens and organizations concerned with the well being of aquatic resources in the basin are using salmon and steelhead as keystone species to help better understand potential pathways for protecting and restoring aquatic ecosystems. Table 4.3-1 portrays these efforts as five general areas of activity organized along a continuum from the crest of the Cascades to the marine environment.

Table 4.3-1. Summary of anadromous salmonid conservation efforts in the Lake Washington Basin.

LOCATION	ACTIVITY	PARTICIPANTS
1. Headwaters	**Cedar River Watershed HCP**: • Protect water quality, upland, riparian, and aquatic habitat • Provide improved instream flows throughout the entire river downstream of the reservoir • Restore fish passage into 17 stream miles of refuge habitat • Provide supplemental fish production	**City of Seattle** in collaboration with federal, state, and Muckleshoot Indian Tribal resource managers
2. Lower Cedar River	**Lower Cedar River Basin Plan:** • Protect water quality, upland, riparian, and aquatic habitat • Provide recommendations for land management prescriptions and habitat restoration projects to promote protection of water quality, upland, riparian, and aquatic habitat • Coordinate initiatives throughout the subbasin • Expand public involvement and education	**King County** in collaboration with City of Seattle, City of Renton, state and Muckleshoot Indian Tribal resource managers, and interested citizens
3. Lake Washington, Lake Sammamish, and associated lowland subbasins	**Lake Washington/Cedar River and Lake Sammamish Forums**: • Protect water quality and fish habitat in Lake Washington, Lake Sammamish, and their tributaries • Fund and administer the Lake Washington Ecological Studies to determine the causes of decline in juvenile sockeye survival • Improve regional cooperation and coordination	**King County** in collaboration with municipal governments in the watershed; state and Muckleshoot Indian Tribal resource managers; and the Army Corps of Engineers
4. Estuary	**Ballard Locks Fish Passage Improvements:** • Improve facilities and operations to reduce injury, mortality, and delay during upstream and downstream migrations *Note: All anadromous fish in the basin must pass through this facility twice during their lives.*	**U.S. Army Corps of Engineers** in collaboration with state, Tribal, and federal resource managers, and the Forums
5. Ocean	**Washington Wild Salmonid Policy** and other harvest management initiatives: • Improved harvest management to meet spawning goals	**State and Tribal harvest managers**

The importance of headwater areas in protecting water quality and the biophysical processes that form stream channels and aquatic and riparian habitat has been well documented (see Naiman et al. 1992; Sedell et al. 1997). As mentioned above, the City now owns the upper two-thirds of the Cedar River Basin. Protection and rehabilitation of the natural structure and function of the landscape in the municipal

watershed offers a potential foundation upon which to build a comprehensive salmonid conservation program for the Lake Washington Basin as a whole.

The City has been working with state, federal, and Muckleshoot Indian Tribal resource managers since 1989 to develop mitigation measures for the fish migration barrier at the Landsburg Diversion Dam. These efforts form the basis for the mitigation strategies presented here. By agreement, the mitigation actions have been directed at four anadromous salmonid species, chinook, coho and sockeye salmon and steelhead trout. Mitigation measures for these species will have effects on other species as well. In developing the anadromous fish components of the Cedar River Watershed HCP, we have attempted to use the conceptual framework of *rehabilitation* as described by the authors of *Upstream: Salmon and Society in the Pacific Northwest* (National Research Council 1996). Where possible, this HCP attempts to protect remaining functional components of the ecosystem, reconnect habitats that have been fragmented by anthropogenic activities, and rely on the natural regenerative capacity of the system to foster natural reproduction and production. In some situations, such as several of the measures prescribed to minimize and mitigate the effects of the anadromous fish migration barrier at the Landsburg Diversion Dam, the HCP includes elements of *substitution*, such as fish passage facilities, stream channel restoration, and artificial propagation. However, substitution measures are offered only when it is not possible to rely solely on natural regenerative processes. Substitution measures are offered as elements in a comprehensive, ecosystem-based program that attempts to allow target resources to fully benefit from natural rehabilitative processes. Because substitution measures can entail significant elements of uncertainty and risk, they have been linked to substantial monitoring and research programs and a commitment to adaptive management with broad-based oversight (sections 4.5.3, 4.5.7, 5.4, and 5.5; Appendix 28).

The Landsburg Mitigation Agreement (Appendix 28), to which both Washington State and the Services are signatories, provides for oversight of the implementation of the mitigation described in Section 4.3. The Parties to the Landsburg Mitigation Agreement will make decisions regarding operating guidelines, facility designs, monitoring plans, changes to mitigation actions and related issues. The Cedar River Anadromous Fish Committee will be established to advise the City during implementation. It will include the Parties to the Landsburg Mitigation Agreement, the Muckleshoot Indian Tribe, and other stakeholders. King County will be a member if it agrees in writing to support the HCP.

OBJECTIVES

The use of the upper portion of the Cedar River Basin for municipal water supply offers challenges and opportunities for anadromous fish. The success of efforts to rehabilitate Cedar River salmon and steelhead will depend, in large part, on our ability to manage the challenges while implementing creative solutions that allow the opportunities to unfold for the fish. The objectives established for this element of the HCP support the goal of avoiding, minimizing, and mitigating the incidental take of species listed as threatened or endangered, and the HCP treats unlisted species of concern as if they were listed. However, the objectives go beyond this goal and, like the more comprehensive planning objectives presented in Section 2.4, 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 avoid, minimize, and mitigate the effects of the migration barrier at the Landsburg Diversion Dam in a manner that helps anadromous fish and their habitat thrive while preserving and protecting the municipal water supply. These objectives include:

(1) Implement biologically sound short- and long-term solutions that help provide for the recovery and persistence of well-adapted, genetically diverse, healthy, harvestable populations of sockeye, coho, and chinook salmon, and steelhead trout in the Cedar River;

(2) Provide fish passage over the Landsburg Diversion Dam, consistent with drinking water quality protection, and in a manner that is coordinated with run recovery, biological need, water supply operations, and facility maintenance requirements;

(3) Maintain a safe, high-quality drinking water supply;

(4) Implement solutions that have a high likelihood of success and that provide substantial value for target resources and the ecosystems upon which they depend;

(5) Coordinate with and support other compatible rehabilitation activities to help realize the full benefits offered by aquatic resource conservation efforts in the Lake Washington Basin; and

(6) Design and implement measures that satisfy any mitigation obligations the City may have for the fish migration blockage created by the Landsburg Diversion Dam as defined by state and federal law and pursuant to City ordinance and initiatives.

OVERVIEW OF ANADROMOUS FISH CONSERVATION MEASURES

To meet the above objectives, the City has developed interim and long-term conservation strategies that cover four anadromous salmonid species. Long-term measures for chinook, coho, and steelhead are based upon provisions to allow the fish to recolonize their formerly occupied habitat upstream of the Landsburg Diversion Dam. Recent analyses, completed as part of the development of the HCP, demonstrate that the presence of steelhead, coho, and chinook, if carefully monitored, is very unlikely to pose a risk to drinking water quality (Appendix 5; Section 3.3.5). The analyses also demonstrated that, because of the unique life history pattern of sockeye salmon that typically results in a much larger spawning population size, fish passage is not advisable as a mitigation solution for sockeye. Therefore, a separate, additional mitigation component, based on an artificial propagation program, is provided for sockeye salmon.

A significant period of time will be required to complete final design, permitting, and construction of long-term mitigation facilities. During this time, it is quite possible that Cedar River anadromous fish populations will continue to decline. Therefore, the City will begin providing interim conservation measures immediately in HCP year 1 (Section 4.3.2).

The City's interim and long-term commitments have been designed in a manner that attempts to assure that anadromous fish receive maximum benefit from the rehabilitative measures prescribed in the plan. The provisions to avoid, minimize, and mitigate the impacts of the anadromous fish migration barrier at the Landsburg Diversion Dam form one component of a more comprehensive anadromous fish conservation strategy embodied in the HCP as a whole. The measures described here are linked to and rely on two additional key 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 City's commitments to provide beneficial instream flows, as described in Section 4.4, throughout the 34.5 mile reach of mainstem habitat historically accessible to anadromous fish. The hatchery will encourage the recovery of the naturally spawning sockeye population in the lower Cedar River by increasing the survival potential of returning sockeye through artificial propagation. As mentioned previously, the provisions of the HCP should themselves be viewed as one element in a broader, basin-wide restoration initiative in the Lake Washington system that addresses all life history stages of the four anadromous species (Table 4.3-1).

The following section, Section 4.3.2, first describes the specific approach and conservation measures applied to each of the two groups of anadromous fish, followed by a discussion of the underlying rationale used in the development of the respective conservation strategies. Next, Section 4.3.3 briefly discusses the

objectives and major components of the monitoring and research program (which are fully detailed in Section 4.5). Finally, Section 4.3.4 summarizes the anticipated effects of the conservation strategies.

4.3.2 Conservation Strategies

BASIC APPROACH

Charged by the National Research Council with the task of developing options for improving the prospects for the long-term sustainability of salmon in the Pacific Northwest, the authors of *Upstream: Salmon and Society in the Pacific Northwest* (National Research Council 1996) recommend an approach they call "rehabilitation," which they define in the following manner:

> …a pragmatic approach that relies on natural regenerative process in the long term and selected use of technology and human effort [substitution] in the short term - rather than on attempts to restore the landscape to some pristine former state and rather than on a primary reliance on substitution, i.e., the use of technologies and energy inputs, such as hatcheries, artificial transportation and modification of stream channels. Rehabilitation would protect what remains in an ecosystem and encourage natural regenerative processes.

Wherever possible, the HCP provides anadromous fish conservation measures that employ the rehabilitative approach described above. However, this approach could not be used in all situations because the Cedar River is located near and partially within the largest metropolitan area in the state and provides two-thirds of the municipal water supply to 1.25 million people. Therefore, the plan also employs additional substitution measures in an effort to realize the full benefit of the program's rehabilitative features.

CONSERVATION STRATEGY FOR CHINOOK AND COHO SALMON AND STEELHEAD TROUT

Four facilities are prescribed to provide safe upstream and downstream passage of migrating chinook, coho, and steelhead into and out of the municipal watershed upstream of the Landsburg Diversion Dam: (1) a fish ladder at the Landsburg Diversion Dam; (2) a fish ladder and holding and sorting facilities at the partial migration barrier created by the City's water supply line crossing approximately 1/3 mile downstream from the Landsburg Diversion Dam; (3) downstream fish passage facilities at the Landsburg Diversion Dam; and (4) new screening facilities on the municipal water supply intake to minimize juvenile fish injury or migration delays. Once fish passage facilities are completed, all native fish species in the Cedar River, with the exception of sockeye salmon, will be allowed access to the municipal watershed through the fish passage facilities.

Several factors are likely to affect the schedule for the construction of fish passage and protection facilities for steelhead, chinook, and coho. These include the need to: upgrade the 65-year-old Landsburg Diversion Dam to support new facilities for fish; coordinate construction with other facility improvements that are necessary for continued compliance with drinking water regulations; provide for protection of the dam during floods; and provide the normal time required for environmental assessment, facility design, permitting, and construction. However, the City also understands the potential importance of providing 17 miles of protected refuge habitat for anadromous fish populations in the Lake Washington watershed. Therefore the City will make every effort to complete the planning design and construction of upstream and downstream fish passage facilities by the end of HCP year 3. Oversight of the design, construction and operation of the fish passage facilities will be provided by the Parties to the Landsburg Mitigation Agreement, in consultation with the Cedar River Anadromous Fish Committee.

Prior to the completion of fish passage facilities, the City will provide interim funding to mitigate for the effects of migration barrier. This funding will be allocated as agreed upon by the Parties to the Landsburg Mitigation Agreement, with advice from the interagency Cedar River Anadromous Fish Committee, to support studies required to fill key information gaps and/or provide interim artificial propagation for one or more of the populations.

Design and permitting for fish passage and protection facilities will commence immediately upon federal approval of the HCP. Initiation of construction will be subject to the City's ability to gain the necessary permits and complete the SEPA/NEPA review process. If construction is delayed, the City will continue to provide interim mitigation as directed by the Parties to the Landsburg Mitigation Agreement.

Interim Measures for Chinook, Coho, and Steelhead

With Lake Washington chinook and coho salmon populations in decline and steelhead trout showing only tentative signs of recovery after dropping to record low levels in the early 1990s, rehabilitation efforts should start immediately. Toward that end, the City will begin providing funds for interim mitigation measures in HCP year 1, immediately after the plan is approved.

Prior to the construction of fish passage, the City will implement interim restoration measures for steelhead, coho, and chinook based on the following primary objectives: (1) gather biological information that is critical in designing and managing effective, biologically sound short- and long-term conservation measures; and (2) if appropriate, design and implement broodstock augmentation programs to help preserve one or more of the populations. Appropriateness of augmentation measures will be determined jointly by agreement of the Parties to the Landsburg Mitigation Agreement (Appendix 28), which includes the USFWS and NMFS, with advice from the Cedar River Anadromous Fish Committee. The City will commit up to $90,000 per year until all fish passage facilities have been constructed to implement either one or a combination of the following two interim mitigation measures, as agreed upon by the Parties:

- Conduct studies of life history, genetics, or demographics of the populations to support the development of the most appropriate measures to protect and rehabilitate the runs over the long-term; and
- Develop and implement an emergency artificial propagation program to help preserve one or more of the runs and prevent extinction, loss of genetic diversity, or loss of adaptive capacity associated with extremely small population size.

Emergency supplementation of chinook, coho, or steelhead will only be used as interim mitigation if the Parties to the Landsburg Mitigation Agreement all agree that:

- Such intervention is needed for the purpose of population support;
- Supplementation can be conducted without significant risks to the population being supplemented;
- Risks of supplementation can be effectively monitored and managed adaptively to protect the long-term genetic integrity and demographic viability of the target population; and
- Risks of supplementation of the target population will not result in significant risks to non-target salmonid populations.

Long-term Measures for Chinook, Coho, and Steelhead

Introduction

The City considers the provision of suitable upstream and downstream fish passage facilities at the Landsburg Diversion Dam as full mitigation for chinook, coho, and steelhead during the period for which the passage facilities are in operation. The habitat protection and restoration measures described in Section 4.2 for the City-owned municipal watershed upstream of the Landsburg Diversion Dam and the instream flow protection measures described in Section 4.4 will provide additional benefits by maintaining and protecting a significant freshwater refuge habitat for these species. Conceptual designs and cost estimates have been developed for all fish passage and protection facilities in collaboration with federal, state, and Tribal fish resource managers and are summarized in Appendix 6. Final facility design and construction will be guided by federal and state fish passage criteria and overseen under the terms of the Landsburg Mitigation Agreement.

The City based its funding commitment for the design, permitting and construction of the fish passage and protection facilities on the designs and projected costs identified in Appendix 6 and believes that these funding levels are sufficient. However, against the possibility that the committed funding levels may not be adequate, a special design contingency fund of $583,000 will be established by the City that is outside the cost caps and funding amounts described elsewhere in this HCP. As described in the Landsburg Mitigation Agreement (Appendix 28), this fund can be used, if needed, for construction of passage and protection facilities to achieve the objectives of the agreement. Fish passage facility design will commence immediately in HCP year 1. The target completion date for construction of all fish passage facilities is the end of HCP year 3.

Upstream Fish Passage

The City will provide up to $965,000 for the design, permitting, and construction of an adult fish ladder at the Landsburg Diversion Dam. The City will also provide up to $1,046,000 for the design, permitting, and construction of a fish ladder and fish holding and sorting facilities at the partial fish barrier created by the SPU water supply line that crosses under the Cedar River at Landsburg Park, approximately 1/3 mile downstream of the Landsburg Diversion Dam.

Upstream fish passage facilities at both locations will be constructed according to federal and state criteria to minimize migration delay and provide safe and efficient passage upstream of the migration barriers. Fish sorting and holding facilities will be designed to allow safe and efficient sorting of coho and chinook from the more numerous sockeye and to provide for the safe and efficient return of sockeye to the river downstream of the passage facilities.

Downstream Fish Passage

With the present configuration at the Landsburg Diversion Dam, downstream migrating juvenile and adult fish must pass over the radial spill gates on the dam and may be injured as they strike suspended spill gate supports and the concrete apron below. To reduce this risk, an alternative downstream passage route will be provided. The City will provide up to $958,000 for the design, permitting, and construction of downstream fish passage facilities at the Landsburg Diversion Dam.

Facilities will be designed and constructed to ensure the safe passage of juvenile and adult fish past the dam and into the plunge pool downstream over a broad range of flows. The configuration of downstream passage facilities will be designed to complement entrance conditions at the downstream end of the fish ladder.

Fish Screening Facilities

The present screening facility at the municipal water supply intake on the Cedar River at the Landsburg Diversion Dam does not meet federal and state fish protection standards and poses a risk of mortality for under-yearling fish. To reduce this risk, the City will provide up to $2,859,000 for the design, permitting, and construction of fish screening facilities at the Landsburg Diversion Dam.

Fish screens will be designed to meet federal and state criteria for protecting young-of-the-year salmonids from injury at the intake facilities over the full range of flows that can be diverted into the water supply lines at Landsburg. In addition to screens, an appropriate bypass pathway will be provided for downstream movement of fish past the screen and diversion facilities. Appropriate screen cleaning facilities will be provided to ensure that screens will remain in operation continuously over a wide range of stream flows.

Fish Passage Facility Operations and Maintenance

Once fish passage facilities are constructed, the City will provide up to $50,000 per year for passage facility operation and maintenance for the term of the HCP.

Water Quality Monitoring

Once fish passage facilities are in operation, the City will provide up to $10,000 per year for up to 6 years to implement a water quality sampling program to monitor the effects of coho and chinook salmon spawning carcasses on drinking water quality (Section 4.3.3). Pending the results of this monitoring program, the number of adult salmon allowed to pass over the diversion dam may be adjusted either upward or downward from the allowable maximum target of 46,500 pounds of spawning carcasses, based on 1,000 chinook and 4,500 coho salmon. If, in the future, the number of fish allowed to pass upstream must be adjusted downward to protect drinking water quality, the City will provide up to $30,000 per species per year, prorated according to the deficit (based on the target) in the biomass of chinook and coho passed, for alternative mitigation as agreed upon by the Parties to the Landsburg Mitigation Agreement, with advice from the Cedar River Anadromous Fish Committee. If agreement on alternative mitigation cannot be reached by the Parties, then the City will spend the remaining funds for fish habitat acquisition, restoration, enhancement or monitoring in the Lake Washington Basin (Appendix 28). The City will also provide $60,000 in HCP year 1 to help fund collaborative studies with NMFS regarding recolonization of habitat within the municipal watershed by anadromous fish (Section 4.5.3).

Fish passage Facility Monitoring

The City will provide up to a total of $110,000 during the first 12 years after completion of upstream fish passage facilities to monitor adult fish passage and to better understand run timing, the rate of passage, and the rate at which the populations recolonize previously blocked habitat. Once fish screening facilities are constructed, the City will provide up to $15,000 to perform hydraulic analyses to refine flow characteristics of the screens to demonstrate conformity with hydraulic parameters established during the design of the facilities.

Land and Water Management Practices in the Municipal Watershed

Stream habitat throughout the Lake Washington Basin has been significantly degraded by human activities during the twentieth century. Productive spawning and rearing habitat is of vital importance for the recovery and persistence of salmonid resources. Much productive fish habitat has been lost in the basin, and that which remains is subject to increasing risk from development pressures. The reconnection of the Cedar River above the Landsburg Diversion Dam with the rest of the ecosystem that supports anadromous

fish offers an opportunity to reverse this trend and provide a substantial increase in the quantity and quality of anadromous fish habitat available in the Lake Washington Basin.

The subbasin between Landsburg and Lower Cedar Falls, and the entire watershed above it, are wholly owned by the City of Seattle and will be managed according to the commitments described in section 4.2 of this HCP. The land management prescriptions in the HCP will effectively create a watershed ecological reserve consisting of the entire municipal watershed, because no timber harvest for commercial purposes will be allowed in the watershed. Land management practices in the municipal watershed will be designed exclusively to protect water quality, aquatic, riparian and upland habitat and the natural ecological processes that form and maintain habitat. Watershed management conservation and mitigation measures include a substantial road decommissioning and improvement program designed to reduce sediment loading to streams, culvert replacement at stream crossings to improve degraded habitat conditions and restore aquatic habitat connectivity throughout the entire municipal watershed, and silvicultural interventions to restore riparian and upland forests. These commitments will help protect, restore, and reconnect aquatic and riparian habitat and the processes that create and maintain habitat complexity and integrity throughout the natural range of anadromous fish upstream of the Landsburg Diversion Dam.

The instream flow protections described in Section 4.4 will further help protect the quality of aquatic habitat in this area by providing assurance that flows throughout the majority of the reach between Landsburg and Lower Cedar Falls will remain near or above the flows that provide maximum habitat availability (Maximum Weighted Usable Area) for key life history stages of all three anadromous species throughout the year. In addition, instream flow prescriptions ensure continuous delivery of rearing flows in the bypass reach between Masonry Dam and the Cedar Falls hydroelectric facility. Once anadromous fish are present in the river above Landsburg, downramping prescriptions will be implemented to moderate the rate at which City operations may reduce stream flows to decrease the risk of stranding juvenile fish. And finally, fish barriers will be installed at the tailrace of the Cedar Falls hydroelectric project to minimize injury to fish migrating upstream.

CONSERVATION STRATEGY FOR SOCKEYE SALMON

The City's short- and long-term mitigation commitments for sockeye salmon are derived from direction provided by Senate Bill 5156, passed in 1989 by the Washington State Legislature and codified in R.C.W. 75.52, and by the work of the formal interagency policy and technical committees established by this legislation. Senate Bill 5156 enables the City to receive full mitigation credit under state law for the effects of the migration barrier on sockeye salmon in exchange for funding the planning, design, construction, and operation of a facility to produce sockeye fry, “comparable in quality to those produced in the Cedar River and in equal number to what could be produced naturally by the estimated 262,000 adults that could have spawned upstream of the Landsburg diversion.”

The City will provide funding for a comprehensive sockeye mitigation program with four primary components:

(1) Continuation of the Landsburg interim sockeye hatchery program for an additional 4 years;

(2) After HCP year 4, implementation of a long-term artificial propagation program that will be capable of meeting the mitigation goals described in the state legislation and help ensure that relatively large and robust populations of sockeye fry are recruited into Lake Washington each year;

(3) A monitoring and research program to provide the scientific foundation for adaptively managing the mitigation program to minimize risk and help ensure that a diverse, well-adapted sockeye population remains an integral component of a robust aquatic ecosystem in the future; and

(4) Restoration or protection, or both, of sockeye spawning habitat in the lower 21.8 miles of the Cedar River, downstream of the City's ownership boundary (see also Section 4.4.2).

Interim Measures for Sockeye Salmon

Introduction

Because of the complex and comprehensive nature of the long-term sockeye mitigation program, the City estimates that planning, design, permitting, and construction activities for artificial propagation facilities will require approximately 4 years to complete. Returns of Cedar River sockeye salmon have generally declined in recent years. The average return between 1989 and 1996 was 135,000, while it was nearly 243,000 between 1967 and 1988. The lowest return on record occurred in 1995. The City will implement interim measures prior to completion of long-term mitigation facilities in an effort to slow the rate of decline in the population and to gather additional information that will be useful in managing the long-term mitigation program.

In 1993, the Cedar River Sockeye Policy Committee decided to postpone construction of a proposed sockeye spawning channel and to initiate a 5-year, emergency sockeye recovery effort to reverse the precipitous decline of Lake Washington sockeye salmon populations and to gather the information required to develop and implement an effective long-term sockeye mitigation program. The emergency recovery effort is composed of two major components: the Landsburg Interim Sockeye Hatchery Program and the Lake Washington Ecological Studies (Section 2.3.8). The interim hatchery program, begun in 1991, has three primary objectives: (1) to slow the rate of decline in the sockeye population by augmenting fry production from the Cedar River; (2) to test the efficacy of recently developed sockeye salmon culture techniques in the Cedar River (McDaniel 1994); and (3) to provide a large number of differentially marked fish to support the second program component, the Lake Washington Ecological Studies. The primary objective of the Lake Washington Ecological Studies Program is to determine the factors contributing to reduced juvenile sockeye salmon survival in Lake Washington and to make recommendations for improving in-lake fry-to-smolt survival. Information gathered during the emergency recovery effort has been, and will continue to be, used to guide the development of the long-term mitigation program.

Extended Funding for the Landsburg Interim Sockeye Hatchery

Established as a prototype facility in 1991, the Landsburg interim sockeye hatchery has been operated by the WDFW under a series of cooperative funding agreements with the City (Appendix 2). It has successfully produced healthy, high-quality sockeye fry for release into the Cedar River every spring for the past 7 years. Since 1991, production has been gradually increased from 2,000,000 to 14,000,000 fry. All fry have been successfully marked while in the incubators using recently developed otolith (ear bone) marking techniques that use minor variations in incubation water temperature to create differential banding patterns on the developing otoliths of larval fish (Volk et al.1990). Prototype testing is considered well advanced at this time, and many of the functional elements and procedural insights developed during the testing will be used as the basis for final design of the long-term artificial propagation facility.

Operations at the interim sockeye hatchery have demonstrated that the incubation period in the hatchery is usually shorter than that of fry produced by natural spawning. Two potential causes are the slightly warmer winter temperature of spring-fed incubation water in the hatchery compared to water temperature in the river and the tendency toward shorter development periods in hatcheries. A slightly shorter incubation period could have ramifications on in-lake fry survival rates due to concomitant effects on the timing of fry emergence, release, and entry into Lake Washington. Also, egg take timing is closely associated with emergence timing, and the egg take schedule for the hatchery needs to match the timing of the run in so far as possible. Facilities will be designed to include the ability to chill incubation water, to

allow volitional fry emergence and release, and to rear fry for up to two weeks in order to more closely simulate the condition of naturally produced fish (if determined to be appropriate after experimental testing; see next subsection). In an effort to promote a thoughtful, stepwise approach to the mitigation program, and to continue to provide support for the sockeye population, the City will extend its funding of the interim hatchery program. Under a current Memorandum of Agreement (Appendix 2), the City will fund the operation of the Landsburg interim hatchery. Beginning no later than HCP year 1, and continuing through HCP year 4, the City will provide up to $256,000 per year to cover the costs of producing up to 16 million fry at the Landsburg Interim Sockeye Hatchery. In addition, the City will initiate a comprehensive monitoring and research program to evaluate program effectiveness and manage risks (see Section 4.3.3).

Fry-rearing Evaluations

Results from the prototype hatchery suggest that the hatchery-produced fry tend to emerge and outmigrate to Lake Washington slightly earlier than naturally produced fry (Seiler and Kishimoto 1997). It has been hypothesized that by rearing artificially produced sockeye fry for a short period of approximately 2 weeks operators may be able to more closely simulate the condition and timing of naturally produced fry emerging from the Cedar River and will therefore enable hatchery fry to perform and behave in a manner more similar to naturally produced fry. To test this hypothesis, the City will provide up to $65,000 during a selected 4-year period between HCP years 1 and 8 to short-term rear specially marked sample groups of fry for approximately 10 days to 2 weeks prior to release into the system.

If the Parties to the Landsburg Mitigation Agreement agree, prior to its initiation, not to pursue this feeding program or to terminate the program before it is complete, then the Parties, in consultation with the Cedar River Anadromous Fish Committee, may agree to instruct hatchery operators to try other approaches to delay fry movement into the lake until food supplies might increase.

Long-term Measures for Sockeye Salmon

Introduction

The primary objective of long-term mitigation measures for sockeye is to implement an effective, comprehensive, and biologically sound artificial propagation program that has the capacity to produce up to 34 million sockeye fry annually. These fry must be comparable in quality to naturally produced fry and must be produced in a manner that preserves the long-term reproductive fitness and genetic diversity of the Cedar River sockeye population, while minimizing genetic, ecological, and demographic risks to other wild salmonid populations in the Lake Washington Basin.

To help meet these objectives, the City commits to a monitoring and adaptive management program with the Parties to the Landsburg Mitigation Agreement, in consultation with the Cedar River Anadromous Fish Committee. This program is summarized below and described in Sections 4.3.3 and 4.5.3. Decisions regarding long-term and annual facility production targets for sockeye fry are under the purview of the fisheries co-managers -- the WDFW and the Muckleshoot Indian Tribe, -- and the Parties to the Landsburg Mitigation Agreement

Artificial Propagation Facility

The City has agreed to follow the recommendation of the Cedar River Sockeye Technical and Policy Committees to construct a hatchery with the capacity to produce up to 34 million sockeye fry per year. As described in Appendix 26, the Cedar River Sockeye Technical Committee recommended that a hatchery, rather than the originally planned spawning channel, should be pursued. Committee members concluded that a spawning channel would pose relatively higher, less manageable risks. The committee also recommended that fry release be incrementally increased over time, and that habitat enhancement and

protection efforts should also be a priority for all resource management agencies involved in the Cedar River Basin.

The hatchery program will employ recently developed sockeye culture techniques, as further refined during prototype testing at the Landsburg interim hatchery, to help ensure the production of robust, disease-free fish.

The City will provide up to $7,678,000 during HCP years 1-4 for planning, design, permitting, and construction of a sockeye salmon hatchery. Beginning in HCP year 5, the City will provide up to $300,000 per year to fund facility operations (see Appendix 28). The production facility will consist of five major components: (1) water collection and delivery facilities to provide up to 4 cfs of high-quality, disease-free fresh water; (2) an incubation facility with the capacity to successfully incubate approximately 37 million sockeye eggs and larval fish according to sockeye culture disinfection and isolation protocols; (3) emergent fry collection, short-term holding, and transport facilities for the release of 34 million fry; (4) broodstock trapping, collection, transport, and holding facilities capable of capturing up to 27,000 adult Cedar River sockeye per year from a representative sample of the run between mid-September and mid-December; and (5) various operations and staff support facilities. The Parties to the LMA will ensure that a comprehensive public involvement and environmental review process for the long-term hatchery program is carried out prior to the end of HCP year 3 when the Parties will make final decisions regarding the production capacity, design, operating guidelines, and adaptive management features for the hatchery program. If the total cost of hatchery facilities or their operation is less than the amount provided above, then any savings may be used to provide further benefits to any or all anadromous salmonid species, including chinook salmon, as directed by the Parties in consultation with the Cedar River Anadromous Fish Committee.

Habitat Restoration

Protection and restoration of naturally spawning sockeye salmon and their habitat is vital to successful long-term recovery of sockeye salmon in the Lake Washington Basin. The City will provide $1,637,000 to protect and restore fish habitat in the lower Cedar River downstream of the City's ownership boundary (see Section 4.4.2 for additional downstream habitat funding commitments). Projects will be designed in a manner that will benefit any or all anadromous salmonid species, especially chinook salmon, and enhance natural ecological processes that shape and maintain riparian and aquatic habitat. Projects may be selected from the many mainstem protection and rehabilitation opportunities identified in King County's Cedar River Basin Plan (King County 1993). The dispensation of these funds will be allocated at the discretion of the Parties to the Landsburg Mitigation Agreement, with advice from the Cedar River Anadromous Fish Committee, and may be directed into passive, rehabilitative approaches, such as riparian habitat acquisition, if the Parties agree. The funds for habitat restoration will become available in HCP years 2-4.

Managing the Risks: Program Guidelines, Research, and Monitoring

A number of sources have detailed the problems associated with the misapplication of artificial propagation in the past and have cautioned against the continued misuse of this approach in the future (Hard et al. 1992; Hilborn 1992; National Research Council 1996; Reisenbichler 1997; WDFW 1997b). In many years, the number of fry released from the hatchery will represent a significant portion of the total sockeye fry produced in the Lake Washington Basin. Clearly, the artificial propagation program should not be viewed in isolation from the many rehabilitative features of the HCP. Nor should the risks associated with a relatively high energy, technological approach be dismissed.

Prototype testing with the interim hatchery since 1991 indicates that it is quite feasible to consistently produce healthy, high-quality sockeye fry in a hatchery setting using recently developed protocol for managing the fish health risks associated with IHNV (McDaniels et al. 1994). Data from the 1997 adult

returns are presently being analyzed by the WDFW and will provide the first substantial body of information on the rate at which hatchery fry survive to adulthood. This recently collected data set is still being analyzed and will require corroboration with data collected in subsequent years to adequately address a number of the uncertainties associated with the sockeye fry production program. The City recognizes that, while the sockeye fry production program offers potential benefits for the population, it also entails a level of uncertainty and risk.

Because the origin of the sockeye run in the Cedar River is believed to be the Baker River in northern Washington State, the NMFS does not consider the Cedar River stock to be part of a recognized Evolutionarily Significant Unit (ESU) under the ESA (Fed. Reg., Vol. 63, No. 46, pp. 11749-11771). Thus, potential adverse genetic changes in the Cedar River population potentially caused by artificial production are of concern for the well being of wild spawning sockeye, but are not an issue under ESA (Waples 1998). However, the sockeye in Bear Creek, a tributary to the Sammamish River, could possibly be of natural origin and are at least *potentially* part of an ESU (Waples 1998). The Bear Creek population is not currently believed to be in danger of extinction nor likely to become endangered in the foreseeable future if present conditions continue (Fed. Reg., Vol. 63, No. 46, pp. 11749-11771).

There are a number of types of risk associated with operation of the proposed artificial propagation program (Waples 1998):

- Genetic risks to the Bear Creek population of sockeye (a provisional ESU) that could result from straying of Cedar River fish into Bear Creek, with particular concern for fish of hatchery origin;
- Genetic risks to the Cedar River population that could result from a large number of hatchery produced adults interbreeding with fish of natural origin, with potential for loss in reproductive fitness over time; and
- Ecological risks to other naturally reproducing salmonids in the Lake Washington Basin, such as spawning interactions and transfer of diseases.

Another risk associated with the sockeye mitigation program involves the collection of broodstock. The operation of traps in tributaries to the Columbia River to collect broodstock for supplementation efforts have sometimes failed to obtain a representative subset of the target population, delayed migration to target and non-target stocks, or resulted in the redistribution of the spawning population (Bugert 1998). During sockeye broodstock collection in the Cedar River, chinook salmon and early coho salmon will also be migrating upstream. Depending on the design and operation of broodstock collection facilities, the migration and spawning distribution of non-target species such chinook and coho can be affected to some extent. Annual facility installation and removal activities can also potentially affect migrating and spawning fish and their redds.

However, there are also demographic risks (risks of extinction) to the Cedar River/Lake Washington sockeye population if overall population size becomes very low. If the return per spawner ratio of the past ten years persists, and measures to reverse this trend are not implemented, the population could be reduced to extremely low levels within as little as two or three generations. It should also be noted that *any* measure that increases the production of sockeye from the Cedar River, or from any other streams in the Lake Washington Basin that may contain Baker River stock, could lead to more straying into Bear Creek and other north end creeks and to increased ecological interactions with other salmonids in the basin.

Kapuscinski (1997) suggests two guiding principles for the use of artificial propagation in rehabilitating Pacific salmon:

> …(1) use hatcheries only as part of a comprehensive rehabilitation strategy, with rigorous adherence to adaptive management and (2) ensure that all hatchery programs maintain genetic diversity between and within salmon populations and avoid disruption of all other levels of biodiversity in salmonid watersheds.

As part of the sockeye mitigation program, the City intends to implement these principles, first, through the development of rigorous pre-project planning, and, second, through implementation of an effective monitoring and adaptive management program (see Kapuscinski and Miller 1993; Kapuscinski 1997).

Prior to final design, construction, and operation of the hatchery facility, program guidelines will be developed to maximize the chances for long-term success and minimize potential negative impacts on naturally reproducing salmonids in the Cedar River and elsewhere in the basin. The City will provide up to $32,000 in HCP year 1 for the development of specific guidelines to support the design and management of the long-term sockeye fry production program to help ensure the long-term success of the program and minimize genetic and ecological risks.

The hatchery facility and operating budgets have been designed to meet the following initial guidelines:

- Broodstock will be taken only from sockeye returning to the Cedar River;
- Broodstock will be collected randomly from a representative sample of the entire spawning population continuously from mid-September through mid-December;
- The number of fish collected for broodstock may be as great as 27,000 fish per year, but will never be greater than 50 percent of the total number of fish returning to spawn in the Cedar River;
- Matings will be randomized and conducted at a ratio of one male to one female, unless other protocols can be developed to more closely simulate natural mating selection (Waples 1998);
- Fish culture and fish health management practices will strictly adhere to established sockeye culture protocol (McDaniel et al. 1994) to minimize the risks associated with the IHN virus and ensure the production of healthy fry;
- All hatchery fry will be marked by manipulating incubation temperatures to place an identifying series of bands on their otoliths (Volk et al. 1990);
- Emergent fry will be allowed to volitionally outmigrate from incubators;
- Fry will be released into the Cedar River and allowed to outmigrate to Lake Washington in a manner that approximates the timing of emergence and outmigration of naturally produced fry;
- Although it may be necessary to hold early emerging fry for a short period of up to 2 weeks to ensure that the developmental condition and timing of hatchery fry migration into Lake Washington corresponds with that of naturally produced fry, there will be no extended rearing of hatchery fry;
- Fry production will be increased gradually while monitoring forage conditions in Lake Washington and the performance of wild and hatchery produced fry;
- Fry production for any given year may be set at less than maximum facility capacity in response to information gained from the monitoring program or other considerations; and

- Fry production for any given period may be limited if monitoring indicates a level of straying of hatchery fish into Bear Creek that exceeds the threshold for acceptable straying rate as established by the Parties to the Landsburg Mitigation Agreement, in consultation with the Cedar River Anadromous Fish Committee.

Prior to beginning final design of the long-term fry production facility, the City will sponsor a process that will reexamine the potential genetic and ecological risks associated with the sockeye mitigation program. The results of this exercise will be used to refine facility design criteria and operating protocols in conjunction with the monitoring results from the interim hatchery program. Final approval of the hatchery design, capacity, operating guidelines, and adaptive management program by the Parties to the Landsburg Mitigation Agreement will be deferred until the end of HCP year 3 to allow sufficient time to complete the Lake Washington ecological studies, gather sufficient information on adult returns and other aspects of the interim hatchery program, develop operational guidelines, finalize the adaptive management program, determine the replacement hatchery capacity, and complete a project-specific environmental review.

The sockeye broodstock collection program has two primary objectives: (i) to capture an adequate number of adult sockeye salmon in a manner that provides a representative subset of the entire Cedar River sockeye population, and (ii) to avoid and minimize any impacts the program may have on naturally reproducing fish in the Cedar River. In 1999, the Cedar River Technical Committee developed and implemented interim operational guidelines for the existing broodstock collection weir that were designed to help meet these objectives. Beginning in HCP year 1, the City will provide up to $200,000 to evaluate alternative broodstock collection methodologies, analyze the potential effects of these methodologies, and develop solutions that will avoid and minimize potential negative impacts on naturally reproducing fish while effectively capturing sufficient sockeye broodstock to meet program goals. Additional considerations in the selection of broodstock collection facilities will be to minimize, insofar as possible, impacts on nutrient and substrate movement within the river and the risk of loss or damage to broodstock collection facilities or equipment during floods.

Specific aspects of the design and operation of interim and long-term sockeye broodstock collection facilities will be further refined during the development of program guidelines and long-term facility design by the Parties to the Landsburg Mitigation Agreement, in consultation with the Cedar River Anadromous Fish Committee. Prior to the end of HCP year 3, long-term broodstock collection facilities and practices will be described and reviewed as part of a project-specific environmental review for the long-term sockeye mitigation program. The City believes that the potential risks associated with installation, operation, and removal of interim and long-term broodstock collection facilities can be minimized and avoided through the development of a rigorous broodstock collection protocol and implementation of improved broodstock collection practices beginning in HCP year 1.

The City will provide up to $3,473,000 for monitoring and research (Section 4.5.3) to help ensure the success of the mitigation program and to reduce the risk of deleterious effects on naturally reproducing sockeye salmon. Monitoring and research activities will commence in year 1 of the HCP and will be overseen by the Parties to the Landsburg Mitigation Agreement, in consultation with the Cedar River Anadromous Fish Committee. Specifically, the monitoring program is focused on the following questions:

- Are hatchery-produced sockeye fry developmentally, morphologically, and behaviorally similar to naturally produced sockeye fry in the Cedar River?

- Are morphological and behavioral characteristics (such as adult body size, run timing, and spawning distribution) of hatchery-produced fish different from naturally produced fish in the Cedar River?

- Do hatchery fry survive at the same rate as naturally produced fry?
- Can the molecular genetic attributes of hatchery-produced fish be distinguished from those of naturally produced fish?
- Is the reproductive fitness of the Cedar River sockeye population changing over time as a result of the mitigation program?
- Is the mitigation program increasing the rate at which Cedar River sockeye stray into the north Lake Washington tributaries to levels that pose an unacceptable level of risk to the genetic diversity and adaptive character of the population as a whole?
- Is the carrying capacity of the lake sufficient to support the supplemental fry without negatively affecting naturally produced sockeye fry from the Cedar River and elsewhere in the basin?
- Does the artificial production program pose a significant health risk to naturally reproducing salmonids in the Lake Washington Basin?

The monitoring program will also be refined and reexamined prior to the construction of the long-term sockeye mitigation facility. Results from the monitoring program will be used by the Parties to the Landsburg Mitigation Agreement, in consultation with the Cedar River Anadromous Fish Committee, to manage the implementation of the sockeye mitigation program.

Program Oversight and Provisions for Adaptive Management

The interim and long-term mitigation and monitoring programs will be overseen by the Parties to the Landsburg Mitigation Agreement, in consultation with the Cedar River Anadromous Fish Committee. The Parties to the Landsburg Mitigation Agreement will use the results of the monitoring and research program (sections 4.3.3 and 4.5.3) to evaluate the performance of the program and agree on program alterations. The Parties will approve annual operating and monitoring plans, review annual operating and monitoring reports, and govern annual operating plans and procedures.

As specified in Appendix 28, the adaptive management program for the sockeye fry-production program will include a number of important provisions. First, key objectives will be established for the sockeye fry-production program as follows:

- The replacement sockeye hatchery should be designed with the capacity to produce up to 34 million fry;
- The program should be designed to produce fry that are similar in quality to those that are produced naturally;
- The program should avoid or minimize detrimental impacts on the reproductive fitness and genetic diversity of naturally reproducing sockeye salmon populations in the Cedar River and Bear Creek subbasins; and
- The program should avoid or minimize detrimental ecological impacts on native salmonids throughout the watershed.

Second, during HCP year 1, the Parties will develop guidelines to govern the design, construction, operation, and monitoring phases of the sockeye fry production program. These guidelines will include procedures for developing and modifying annual production targets.

Third, the Parties recognize that adaptive responses to emerging issues are desirable in management of the hatchery and the monitoring program. The Parties also recognize that circumstances might occur that could cause them to modify expected outcomes that could result in an inability to achieve production objectives, and that the City will not be responsible for such circumstances or results.

Fourth, to ensure that the program is successful, the City will provide up to $3,473,000 to monitor the performance and potential impacts of the sockeye fry production program. Decisions will be made by the Parties regarding interpretation of monitoring results, alterations in the monitoring program, and alterations in production program operations.

Fifth, if, based on the monitoring results, the Parties, in consultation with the Cedar River Anadromous Fish Committee, conclude that certain components of the program implementation are not meeting program objectives, then the Parties, by agreement, may alter the program to meet those objectives, provided such alterations do not result in expenditures earlier than scheduled nor change the total dollar amount allocated by the City to the sockeye salmon mitigation program.

Sixth, if the sockeye fry-production program is discontinued by agreement, or if the City is unable to complete construction of the replacement sockeye hatchery, then the City will commit remaining monitoring (as well as remaining operation and construction) funds, at a level not to exceed the total of its original commitments, to alternative mitigation or monitoring as directed by the Parties. If the Parties cannot agree on alternative mitigation or monitoring, then the City will spend the remaining funds for fish habitat acquisition, restoration, enhancement or monitoring in the Lake Washington Basin.

Managing the Risks: Expected Outcomes

The City believes that the risks of the hatchery program to wild-spawning sockeye salmon can be adequately managed for the following reasons:

- The program will be guided by measurable, relevant objectives to help control ecological and genetic risk;
- A monitoring program will be designed, developed, implemented, and adjusted to provide information necessary to evaluate performance of the production facility with respect to the objectives;
- In order to further assess and address incremental risks, production will be ramped up gradually. Program performance will be monitored to provide sufficient information to manage incremental risks. The Parties, in consultation with the Cedar River Anadromous Fish Committee, will make appropriate adjustments in production levels and other operational procedures to meet program objectives and minimize risk.
- An adaptive approach will be followed that includes provisions for altering the program if adverse impacts occur, including provisions to reduce production, alter hatchery operations, or develop alternative mitigation if established thresholds are exceeded.

Because harvests of sockeye will be managed by the fisheries co-managers, competition with naturally reproducing fish can also be managed and controlled. As noted above, any measures that increase sockeye production in the Lake Washington Basin might produce competitive effects, but harvest management to achieve escapement levels allows the level of competition as well as the harvest level to be managed as well. Because hatchery production will be increased gradually, and because otolith-marked fish can be tracked and monitored, the effects of such potential competition on naturally reproducing fish in the Basin can be monitored and managed. Funding for studies of the plankton food source in Lake Washington will

provide information that will allow fisheries co-managers to adjust production from the hatchery, on both annual and long-term bases, to levels appropriate for the carrying capacity of the lake.

Besides the potential effects of sockeye on other species through competition for limited food resources, there is the potential for other ecological effects on other salmonids, including chinook salmon and steelhead trout. These include the potential for transmission of diseases such as IHN virus from sockeye to other species and interference with spawners of these species by spawning sockeye (Waples, 1998).

Again, it should be noted that increases in the production of sockeye salmon through the use of *any* measures (not just a hatchery) could increase the risk of disease transfer or adverse spawning interactions as well. As demonstrated by the interim hatchery program, the incidence of IHN in hatchery-produced fry is substantially reduced or eliminated by recently developed sockeye culture protocol. Therefore, the proposed hatchery program entails lower risks of IHN transmissions than many alternative approaches to sockeye mitigation. Potential competitive interactions between spawning sockeye and other species that spawn at the same time (coho and chinook) can be addressed through harvest management practices. Because coho, chinook and sockeye salmon have coexisted naturally in many watersheds, neither disease transmission nor spawning competition would be expected to be significant concerns associated with restored sockeye production. Spawning distribution outside the Cedar River will be monitored through spawner surveys in Bear Creek to determine the extent to which Cedar River hatchery sockeye stray within the Lake Washington basin. Threshold levels will be defined under the adaptive management program that triggers an appropriate response to avoid undue impact to this natural sockeye stock.

Little or no impact from spawning sockeye would be expected on spawning steelhead because steelhead spawn well after the sockeye spawning season is over. Effects on chinook should be minor for several reasons. Chinook are very aggressive to other species, most individuals spawn in considerably deeper water than do most sockeye, and chinook females typically place their eggs deeper in the gravel than do sockeye (Chambers et al. 1955). While there is potential for such interference between sockeye and coho, the majority of coho in the Cedar River spawn after most sockeye have completed spawning. Because coho, chinook and sockeye occur together naturally, they can be expected to have developed adaptations that tend to minimize the effects of interspecific competition during spawning.

RATIONALE

Past impacts to the freshwater habitat of anadromous fish in the Lake Washington Basin may be divided into three major categories: (1) structural alteration of the system's drainage pattern resulting from the construction of the Ballard Locks and rerouting the Cedar River into Lake Washington; (2) degradation of spawning, incubation, and rearing habitat due to a variety of land and water management activities such as land clearing and development and water storage and diversion; and (3) loss of habitat connectivity as a result of construction of dams and road crossings and other activities in and near stream channels. As a component of the larger regional framework for anadromous fish conservation outlined in Table 4.3-1, the HCP addresses the need to rehabilitate spawning, incubation, and rearing habitat, and restore connectivity in much of the Cedar River Basin by providing commitments to implement protective land and water management regimes and by avoiding, minimizing, and mitigating the effects of the migration blockage at the Landsburg Diversion Dam. Addressing the structural alterations in the drainage pattern of the Lake Washington Basin is beyond the scope of this HCP.

The measures described in this section of the HCP address a major source of lost habitat connectivity: the Landsburg Diversion Dam. These measures are closely linked to, and dependent upon, the land management and instream flow prescriptions described in sections 4.2 and 4.4.

Complete restoration of the Cedar River system would require: elimination of all water diversion and storage facilities in the Cedar, Green, and White rivers; reestablishing the Black River as the outlet of Lake Washington; rerouting the Cedar River into the Black River; rerouting the White River into the Duwamish; and removal of all anthropogenic structures and activities from the floodplains of the Cedar, Black, Green, White, and Duwamish rivers and the Duwamish estuary. Such actions would provide significant benefits for aquatic resources in the long term, and may serve as a planning model for comparison of alternative approaches to fish conservation. However, there is very little chance that the Cedar and Green rivers will cease to be a source of regional municipal water supply. Nor is it likely that the lower Cedar, Black, Green, White, and Duwamish river systems will be returned to a natural state during the 50-year term of the HCP.

Given this context, the City recognizes that methods of substitution such as construction of hatcheries and fish ladders, and alterations of stream channels, can play a role as components in a comprehensive conservation program that is guided by a rehabilitative conceptual framework. Because the use of some substitution measures can entail various levels of risk to naturally reproducing fish, they will be employed with caution, monitored closely, and adjusted based upon their measured performance and impacts.

Lost Buffering Capacity and Reduced Resiliency

Fish habitat in the Cedar River has been affected by human activities in several important ways. First, the Landsburg Diversion Dam excludes the populations from approximately 32 percent of their potential spawning, incubation, and rearing range in the Cedar River Basin. Second, much of the 21.8 miles of currently accessible stream channel downstream of the City's ownership boundary is now confined by levees and various forms of bank armoring. Thus, the river has lost much of its ability to spread into the former floodplain during high flow events. Consequently, high flows tend to be confined, which concentrates energy, increases bedload transport, and increases the frequency with which incubating eggs and alevins are scoured. Several studies suggest that redd scour during periods of high stream flow can markedly reduce the survival of incubating sockeye eggs and alevins in the Cedar River (Thorne and Ames 1987; Cascades Environmental Services 1991; Seiler and Kishimoto 1997).

In addition, channel confinement, riparian clearing, and other activities have reduced channel complexity and reduced the quality and quantity of rearing habitat for stream-dwelling juvenile salmonids in the river below Landsburg Diversion Dam. And finally, streamflow regulation through the operation of the City's water storage and diversion facilities and hydroelectric generating plant affects the quantity and quality of fish habitat. Streamflow regulation can affect a number of factors, including the amount and distribution of spawning and rearing habitat in the river at any given time, the risk of damaging incubating eggs or alevins by scour or desiccation, the risk of stranding fish during reductions in flow, the conditions for upstream and downstream migration, and the processes that shape stream channels.

The loss of 17 stream miles of spawning, incubation, and rearing habitat upstream of the Landsburg Diversion Dam and the effects of land use and water management activities throughout the lower subbasin have impaired the buffering capacity of the ecosystem and reduced the resiliency of the anadromous fish populations. The productive capacity of the system upstream of the Landsburg Diversion Dam is presently lost to all four anadromous species. Reductions in the quantity and quality of the habitat downstream of Landsburg have further reduced the productive capacity of the populations. As a result of this lost productive capacity, anadromous fish are less resilient to change and less able to sustain themselves during periods of environmental adversity, such as poor ocean conditions. In addition, the altered condition of the river downstream of Landsburg has created an environment that is less able to buffer the effects of floods, and, therefore, results in incubation habitat that is less stable and more vulnerable to damage during high flow events. The net result of all these activities for anadromous fish is a reduction in their capacity to

sustain themselves under adverse environmental conditions, while simultaneously being subjected to an increasingly hostile incubation and rearing environment.

Chinook and Coho Salmon and Steelhead Trout

The status of coho, chinook, and steelhead populations in the Cedar River is, to some degree, reflective of the condition of their habitat. All three species spawn, incubate, and, unlike sockeye, rear as juveniles in the Cedar River and its tributaries. With the exception of some very recent hopeful signs for steelhead, all three populations have exhibited declines in the Lake Washington Basin during the last decade (Fresh 1994). Improvement in the condition of stream habitat is especially important to the recovery of these three species that must rear in streams for extended periods as juveniles.

In the past, strong concerns have been expressed by the City and by state and federal drinking water regulators about the human health risks associated with the passage of large numbers of salmon into the municipal water supply above the Landsburg Diversion Dam (SWD 1985, 1993). Spawning carcass biomass, and therefore relative run size, is an important factor when considering the impacts of anadromous fish reintroduction above the drinking water intake at the Landsburg Diversion Dam.

As part of the development of the Cedar River HCP, the City contracted CH2M HILL, Inc., to conduct an assessment of the public health risks posed by the passage of anadromous salmonids over the Landsburg Diversion Dam (see Appendix 5). The consultant concluded that, for the following three reasons, steelhead passage does not present a significant threat to drinking water: (1) most adult steelhead do not die on the spawning grounds after spawning; (2) steelhead typically spawn in much lower numbers than either of the other three anadromous species; and (3) steelhead spawn in the late winter and spring, and thus do not compound the effects from other anadromous runs.

The risk assessment also included an analysis of the potential effects of the return of 1,000 chinook and 4,500 coho salmon spawners to the river upstream of the Landsburg Diversion Dam, estimated to produce about 46,500 pounds of carcass biomass. Although chinook and coho escapement goals have not been established for this reach of river, methods used to establish target spawner returns in similar habitats suggest that the adult run sizes used in the water quality analysis are approximately equal to the number required to fully seed the habitat upstream of the dam. The analysis demonstrated that the passage of 1,000 adult chinook and 4,500 adult coho salmon was very unlikely to degrade water quality or pose a risk to public health.

The establishment of a watershed ecological reserve (Section 4.2.2), which will protect 17 stream miles of spawning and rearing habitat for coho, chinook, and steelhead (as well as upstream areas) within the municipal watershed, is a primary focus of the City's conservation program for anadromous salmonids affected by its facilities and operations on the Cedar River. The City views this component as a key application of the concept of rehabilitation. Although heavily logged early in the twentieth century, this portion of the watershed has largely become reforested with mid- seral conifer forests, largely between 60 and 80 years old (Section 3.2.2). The biophysical processes that form and maintain aquatic and riparian habitat have been largely reestablished and, with the protections and restoration activities provided by the HCP, will be sustained in the future. The quality of the aquatic habitat is generally very good today and is expected to improve in the future as a result of these processes.

However, additional substitution measures (fish passage facilities) are required to allow anadromous fish to receive the full benefits of the spawning and rearing habitat offered by the watershed ecological reserve. Fish passage facilities will substantially increase the present restricted freshwater range of coho, chinook, and steelhead. The reconnection of this habitat will significantly increase the system's buffering capacity

with respect to anadromous fish and will improve the capacity of the populations to sustain themselves over a broad range of environmental conditions.

Sockeye Salmon

The most numerous anadromous salmonids in the eastern Pacific are pink, chum, and sockeye salmon. Their abundance is due, in large part, to their ability to live in lakes (sockeye) or near-shore marine areas (pink and chum) as very young fish, where they can take advantage of extensive rearing areas and relatively vast planktonic food resources. In contrast, young coho, chinook, and steelhead typically rear for variable, often extended, periods in streams and rivers, which, by comparison, offer far less area and a much smaller food base to support juvenile fish. Thus, the capacity of a stream to support large spawning populations of pink, chum, or sockeye is typically much greater than the capacity to support species for which juveniles must rear for extended periods in the stream environment.

As described in Section 3.4.7, the major drainage pattern alterations that occurred in the Lake Washington Basin in the early twentieth century allowed the previously rare sockeye to flourish. The expansion of the sockeye population was certainly enhanced by plantings of Baker River sockeye into the Cedar River and Issaquah Creek during the 1940s. However, the expansion of the sockeye population in the north Lake Washington tributaries, which is thought to be derived from a native Lake Washington stock (Hendry and Quinn 1996), suggests that sockeye populations could have expanded and perhaps colonized the Cedar River even without the plantings of Baker River fish. In spite of the benefits provided to sockeye by drainage pattern alterations in the basin, habitat loss and degradation resulting from land and water management activities during the latter half of the twentieth century have clearly limited the potential productivity of sockeye throughout the basin.

The presently impaired condition of the sockeye habitat in the Cedar River system is likely reflected in the status of the population. The opportunity to meet the full escapement goal for Cedar River sockeye of 350,000 spawning fish has occurred only twice in the last 10 years and only eight times since 1967. The average spawner return ratio (spawner/recruit ratio) for the most recent 10 complete brood years (1982-1991) has declined to 0.79 adult fish returning per fish that spawned in the previous generation (WDFW, 1997e). This number is well below the threshold value of 1.0 required to maintain the population over the long term and is much lower than ratios in excess of 2.0 reported for robust sockeye populations (Burgner et al. 1969). It is possible that, in the future, a strong return of spawners may sometimes serendipitously coincide with an unusually mild flood season. However, under existing conditions, sockeye fry recruitment from the Cedar River will likely continue to be suppressed by under-escapement or high incubation mortality, or both.

The sockeye salmon escapement goal for the habitat upstream of the Landsburg Diversion Dam has been established by the WDFW to be 262,000 adult fish (see Appendix 4). This is also the number established in Senate Bill 5256, passed in 1989 by the Washington State Legislature and codified in R.C.W. 75.52, as the basis for the mitigation requirement for the sockeye salmon migration barrier created by the Landsburg Diversion Dam. This number of adult sockeye, or a substantial portion of the number, would pose an unacceptable risk to public health if allowed to spawn naturally above the diversion and water intake at Landsburg. In recognition of this substantial risk, and in consideration of the City's central mission to protect public health, an alternative strategy has been developed to mitigate for the lost sockeye salmon production capacity upstream of the Landsburg Diversion Dam.

Sockeye in the lower 21.8 miles of river below the diversion will derive benefit from the watershed management prescriptions described in Section 4.2, primarily through the delivery of high quality water and the maintenance of a relatively stable sediment delivery regime. However, the lost spawning and incubation capacity for sockeye upstream of the Landsburg Diversion Dam is not addressed by the HCP's

rehabilitative measures prescribed for coho, chinook, and steelhead. Here, the HCP will also employ substitution measures, including an artificial propagation program, and habitat enhancement projects in addition to further habitat protection in the lower river downstream of the City's ownership boundary. The allocation of funding between habitat enhancement projects and habitat protection projects will be determined by the Parties in consultation with the Cedar River Anadromous Fish Committee with the objective of protecting and restoring habitat for coho, chinook, sockeye, and steelhead.

The sockeye fry production program is offered as an alternative solution that can, as a component of a larger comprehensive, watershed-based rehabilitation program (Table 4.3-1), help restore some of the system's lost buffering capacity and resiliency by providing an incubation refuge for sockeye salmon. The construction of groundwater-fed side channels can potentially serve a similar function, although the potential risks and benefits of production from constructed groundwater-fed side channels and artificial production differ (Waples 1998). It should be recognized, however, that both measures substitute for, rather than restore, features of the natural system. The fry production program attempts to substitute for the lost production capacity upstream of Landsburg Diversion Dam. The groundwater-fed side channels attempt to substitute for the effects of increased scour in the main channel by providing newly created habitat elsewhere. When employed, substitution measures should be applied cautiously as part of a comprehensive rehabilitation program and with substantial provisions for monitoring and adaptive management (National Research Council 1996).

Although constructed side-channel projects pose little risk to the genetic integrity of the Cedar River sockeye population, relying on these experimental habitat-restoration projects may result in more demographic risk than reliance on artificial production. For example, the following factors may reduce or preclude the long-term production of sockeye fry for some of the potential side-channel projects: production in side-channels is more readily limited by the number of returning adults, which has been declining; the groundwater supply may be limited or lacking in some otherwise suitable areas; some property owners may not cooperate on specific projects; predation on emerging sockeye fry by coho presmolts and other species in the side-channels may be significant, there is risk of increased sedimentation over time in side-channels gravels not exposed to the higher storm flows of the river; there is a higher likelihood that eggs and fry will carry and be susceptible to IHN; and there is some risk of flood damage to channels in the floodplain.

Artificial production is more likely to provide demographic support under a broad range of population levels and will reduce the likelihood of negative impacts associated with IHN. However, this approach poses greater potential genetic risks for the Cedar River sockeye population and, through straying, for the Bear Creek sockeye population. If the risks of the artificial production can be managed, as argued above, the artificial production program and associated habitat enhancement and protection programs can be complementary strategies that combine to reduce the likelihood of population extinction and increase the chance of producing harvestable runs of sockeye. And together, the two programs increase the likelihood that the mitigation goals for sockeye can be met.

As originally conceived, the sockeye fry production program was slated to produce approximately 34 million fry per year, which was expected to result in an average return of approximately 260,000 adult fish (James M. Montgomery, Inc. 1990). More recent analyses that integrate the declining trend in spawner/recruit ratios during the last 10 years suggest that the fry production target will more likely result in an average annual return of approximately 225,000 adult fish (SPU, unpublished data). A total of 27,000 adult fish will be required each year to refill the hatchery, leaving an average of approximately 198,000 fish available to spawn naturally in the river. Thus, the majority of returning, supplementally produced fish will reproduce naturally in the river, thereby increasing the degree to which the system's natural regenerative capacity can contribute to maintaining the fitness and viability of the population.

The return of additional supplementally produced adult fish increases the likelihood that the natural spawning areas in the river will be fully seeded and will have an opportunity to significantly contribute to subsequent fry production. Incubation refuges offered by the hatchery and newly constructed groundwater-fed side channels reduce the risks associated with elevated incubation mortality during floods and poor recruitment of fry to the lake. This general conceptual approach, which manages Cedar River sockeye as a composite population derived both from naturally and hatchery produced fry, rests on a key assumption: fry produced in the hatchery will be similar enough to naturally produced fry to be considered their genetic and ecological equivalent. This assumption and a number of supporting assumptions are the focus of the sockeye research and monitoring program (Section 4.5.3).

The recently adopted Washington State Wild Salmonid Policy addresses programs such as the sockeye fry production program included in the City's HCP and proposes strict criteria for implementation. Quoting from page 13 of *Additional Policy Guidance on Deferred Issues Concerning Wild Salmonid Policy* (Washington Fish and Wildlife Commission 1997):

> Only fish whose parents spawned in the wild shall be counted toward meeting the spawner abundance goals. The exception to this guidance is where a formal supplementation program has been established (or where existing law requires otherwise and has not been changed by agreement or subsequent proceedings). Further, WDFW staff may count locally –adapted, hatchery-origin fish toward meeting natural spawning escapement objectives if there is empirical evidence that hatchery fish spawning in the wild had the same short- and long-term reproductive performance as wild fish. To count, fish must meet all of the following criteria:
>
> a) distribution throughout the watershed area normally used by the wild population;
>
> b) matching the genetic profile, size, age and run timing characteristics developed by the wild population in its evolutionary history; and
>
> c) yielding progeny with survival rates and population dynamics comparable to the wild population.

In a footnote on the same page of the document, the Washington Fish and Wildlife Commission states:

> It is anticipated that only a few fish culture production projects (i.e., Lake Washington sockeye mitigation hatchery for the Landsburg Diversion Dam as it is designed) will be able to meet these criteria. Projects meeting these criteria will not be expected to meet the gene flow standards until it is technically feasible to mark fish externally and then selectively fish the resultant progeny. These situations would be the exception compared to the numbers of wild stocks of each species that do not have hatchery fish reproducing successfully in the wild.

The proposed sockeye mitigation program has been developed in close collaboration with technical and policy staff from the WDFW to meet the criteria established by the state's Wild Salmonid Policy. As part of its research and monitoring commitment, the City will fund a program to monitor the performance of the sockeye program, its adherence to the criteria stated above, and its success in meeting the objectives of the mitigation strategy.

4.3.3 Monitoring and Research

The City will implement a comprehensive monitoring and research program to ensure program compliance, evaluate the effectiveness of the conservation measures, and obtain the necessary information required to successfully implement an adaptive approach to managing uncertainty (sections 4.5.7 and 5.5). The monitoring and research program for anadromous fish conservation has the following primary objectives: (1) track program implementation and assure that actual activities comply with stated commitments in the HCP; (2) monitor the effectiveness of the conservation measures in meeting stated objectives; (3) track trends in the condition of habitats and key species populations; (4) test key assumptions; and (5) provide information to help refine future decision making and implementation of the conservation strategies.

Two mechanisms are provided to help ensure that program implementation complies with stated commitments. First, design, construction, and operation of conservation facilities will be overseen by the Parties to the Landsburg Mitigation Agreement, in consultation with the interagency Cedar River Anadromous Fish Committee. Second, the City will provide compliance reports to the Parties within 120 days after the end of HCP years 2, 5, 8, 11, 15, 25, 30, 35, 40, 45, and 50. These reports will contain summaries of all significant HCP-related activities and associated data, including program planning, facility design and construction, program operation, expenditures, adaptive management, and decisions of the HCP Oversight Committee.

The elements of the research and monitoring program for anadromous fish, and their associated funding levels, are given in Table 4.3-2. These elements are described in detail in Section 4.5.3, but several clarifications are warranted here. First, monitoring of chinook, steelhead, coho, and sockeye at the fish ladders to be constructed at Landsburg will provide valuable information on the timing and size of the runs that will be useful to both the fisheries co-managers (WDFW and Tribe) and the Cedar River Anadromous Fish Committee. Additional information on run timing and size for sockeye, chinook, and coho may be collected during operation of sockeye broodstock collection facilities in the lower Cedar River. The foregoing information will provide a valuable supplement to data collected by WDFW in their annual surveys on the Cedar River.

Second, because all hatchery fry will be otolith-marked, the reproductive fitness of wild-origin versus hatchery-origin sockeye in the Cedar River can be compared by a combination of measures of (1) physical and physiological condition of emergent fry and the timing of their outmigration; (2) spawner recruit ratios, derived from studies of fry-to-adult survival and spawning distribution (otolith recovery of adults); and (3) potential genetic differences and morphological changes in adults collected from the Cedar River.

Third, a portion of the funding for the otolith recovery and genetic analyses shown in Table 4.3-2 will be used to monitor the straying rate into Bear Creek and to evaluate its potential impact, so that hatchery operations can be modified, if necessary, to meet the straying rate standards established by the Parties to the Landsburg Mitigation Agreement.

Table 4.3-2. Summary of Anadromous Fish Research and Monitoring Program.

ELEMENT	HCP YEARS	ANNUAL AMOUNT	TOTAL AMOUNT	Key Issue
Chinook, Coho, and Steelhead				
Performance of upstream fish passage facilities	First 12 years after construction of upstream passage facilities	$50,000 in first year for fish counting equipment, then $5,000 per year to operate there after	$110,000	Rate of passage and behavior of adult fish during migration. Rate at which upstream habitat is recolonized
Evaluate and fine tune velocity profiles at fish screening facilities	As soon as fish screening facilities are constructed	$15,000	$15,000	Engineering analyses and previous experience predicts the need to make fine adjustments on facilities to optimize performance and meet state and federal fish passage criteria
Effects of salmon carcasses on drinking water quality[1]	Years 1, 6, 8, 13, 18, 23	$10,000	$60,000	Help ensure that full escapement of chinook, coho, and steelhead can be achieved with no significant decline in drinking water quality or risk to public health
Elements of the Watershed Aquatic and Terrestrial Monitoring and Research Program	See sections 4.5.4 and 4.5.5	See section s 4.5.4 and 4.5.5	See section s 4.5.4 and 4.5.5	Aquatic and riparian habitat conditions and responses to land management regime between Lower Cedar Falls and the Landsburg Diversion Dam
Sockeye Salmon				
Fry condition at release	5-50	$2,000	$92,000	Physiological, developmental and morphological similarity between artificial and naturally produced fry
Fry marking and mark evaluation	1-8, 24-27, 42-45	$20,000	$320,000	Fry to adult survival, spawning distribution
In-river fry trapping and counting	1-8, 24-27, 42-45	$35,000	$560,000	Outmigration timing and comparative fry to adult survival for naturally and artificially produced fry
Fish health	5-12, 24-27, 42-45 --- 13-23, 28-41, 46-50	$20,000 --- $10,000	$620,000	Risks associated w/IHN

ELEMENT	HCP YEARS	ANNUAL AMOUNT	TOTAL AMOUNT	Key Issue
Short term fry rearing	1 ---------- 2-4	$35,000 ---------- $10,000	$65,000	Similarity to naturally produced fry, fry to adult survival
Plankton abundance, distribution, periodicity	1-4, 24-27 42-45 ---------- 5-12	$40,000 ---------- $7,000	$536,000	Fry outmigration timing and in-lake carrying capacity
Otolith recovery from returning adults	1-12, 28-31, 46-49	$40,000	$800,000	Fry to adult survival, spawning distribution
Genetic analyses	1-4, 9-12, 28-31, 46-49	$30,000	$480,000	Preserving genetic diversity and adaptive character

[1] The City will also provide $60,000 in HCP year 1 to help fund collaborative studies with NMFS regarding recolonization of habitat within the municipal watershed by anadromous fish.

4.3.4 Effects of the Conservation Strategies

The City has attempted to approach anadromous fish conservation in a comprehensive, ecosystem-based context that, to the greatest extent practicable, relies on natural regenerative processes complemented by selected substitution elements in an effort to provide the full measure of potential benefits to aquatic resources. The City's activities on the Cedar River are important factors to be considered when developing a successful anadromous fish conservation program for the Lake Washington Basin. As discussed above, the provisions offered in the HCP should be viewed as one component in a larger and more comprehensive multi-jurisdictional conservation initiative that considers all aspects of the fish's life history from headwaters to and including the marine environment (Table 4.3-1).

The conservation strategies provided to minimize and mitigate the effects of the anadromous fish migration barrier formed by the Landsburg Diversion Dam will improve conditions for Cedar River salmon and steelhead in five primary ways:

(1) Chinook, coho, steelhead as well as other migratory species, such as river lamprey and Pacific lamprey, will regain access to 17 stream miles of reconnected, productive habitat that will be protected and restored as part of a watershed ecological reserve and that will serve as a refuge for spawning, incubation, and juvenile rearing.

(2) Immediate implementation of interim measures will help reduce the rate of decline in the chinook, coho and steelhead populations and provide key information that will be used to refine and manage long-term conservation measures.

(3) The artificial propagation program for sockeye salmon will provide an incubation refuge, increase fry recruitment from the river, help ensure that adequate numbers of adult fish return to spawn naturally in the river, and help restore the capacity of the population to sustain itself during periods of adverse environmental conditions, while avoiding and minimizing risks to naturally reproducing salmonids.

(4) The commitment to fund habitat protection and restoration in the lower river outside the City's ownership boundary will help restore natural stream structure and function and improve system buffering capacity by contributing to the protection and development of important riparian and stream channel features and functions and by providing high flow refuge areas for spawning, incubation, and rearing.

(5) The monitoring and research program will provide useful information on Lake Washington sockeye salmon. It will help ensure the effectiveness of the conservation strategies, and will provide information that may be used to refine conservation measures, adapt them to changing conditions, and avoid and minimize risk.

The City's commitments to habitat protection and restoration, fish passage, and instream flows will significantly increase the quantity and quality of spawning and rearing habitat available to Cedar River coho, chinook, steelhead and other migratory species/forms (except sockeye). Above Landsburg, these species will be provided the opportunity to regenerate themselves through the processes of natural reproduction and production in a protected environment where natural biophysical processes are allowed to shape the structure and function of riparian and aquatic habitat. Recolonization of the habitat upstream of the Landsburg Diversion Dam will increase the resiliency and productive capacity of the system for the species that are allowed to pass upstream. Sockeye, while excluded from the area above the Landsburg Diversion Dam, will benefit from improved water quality and habitat conditions as well as from artificial production.

The effects of anadromous fish recolonization on existing aquatic communities upstream of the Landsburg Diversion Dam are uncertain. Populations that serve as prey for juvenile salmonids and populations that prey upon juvenile salmonids may both be affected by recolonization. The presence of juvenile coho, chinook, and steelhead could increase competition for food and rearing space and could potentially have a negative effect on the resident rainbow trout population, for example. However, the potential negative effects of competitive pressures may be mitigated and offset, to some extent, by a number of factors, including the contribution of anadromous fish carcasses, eggs, and larval and juvenile fish to the aquatic food web, and an increase in the efficiency with which a given trophic level can exploit a given forage base due to an increase in the intensity of niche partitioning. Riparian communities are expected to benefit from the introduction of marine-derived nutrients as anadromous salmon colonize the upstream area. While all of the effects of recolonization are difficult to precisely predict, it is not unreasonable to expect that aquatic community assemblages will tend toward a condition similar to the state that existed in the watershed prior to the construction of the Landsburg Diversion Dam.

The majority of the spawning and incubation habitat for Lake Washington sockeye is provided by the Cedar River. As described earlier, spawning habitat loss and degradation have decreased the buffering capacity of the system and reduced the capacity of the sockeye population to sustain itself when faced with adverse environmental conditions. In the last 10 years, average spawner/recruit ratios have dropped sharply and the population trend is one of relatively steep decline. The sockeye fry production program provides an incubation refuge that will help ensure sufficient recruitment of fry into Lake Washington and, therefore, help ensure that sufficient numbers of adult fish return to spawn naturally in the river. This restored fry production capability will increase the capacity of the population to maintain itself when challenged with adverse environmental conditions. If habitat conditions in the rest of the Cedar River Basin can be maintained or improved, and if spawner/recruit ratios can be maintained at or above present levels, then we can expect significantly more opportunities to meet full escapement goals and provide more frequent opportunities for sport and Tribal sockeye harvests in Lake Washington.

Information collected during the operation of the prototype sockeye hatchery and the implementation of the emergency recovery program (sections 3.4.7 and 4.3.2) indicate that the program prescribed by the HCP

has a high likelihood of success. The application of recently developed sockeye culture techniques has been successful in generating consistently high in-hatchery survival rates and producing IHN-free fry. In spite of a growing history of successful hatchery production of sockeye fry and the potential benefits associated with the long-term sockeye mitigation program, there are some remaining uncertainties and risks associated with artificial production of sockeye salmon fry. These concerns focus on the impacts that increased sockeye production might have on naturally spawning stocks in the Lake Washington basin, specifically on the chinook spawning in the Cedar River and the sockeye spawning in Bear Creek. Potential influences on these natural stocks include overharvest, competition and changes in predation rates.

It is important to differentiate the impacts that would occur through increasing sockeye returns and the impacts that occur as a result of artificial propagation. Historically, sockeye returns to the Cedar River have been much greater than they are at present, without hatchery production, and presumably the impacts of these larger sockeye returns have already been experienced by other species/stocks. The concerns that specifically relate to artificial propagation center on genetic effects and the influence that hatchery returns may have on the fitness of fish spawning in the wild. Overharvest of non-target species/stocks, interactions on the spawning grounds, influences on predation rates and competition during rearing are concerns that result from higher sockeye production, irrespective of the origin of fish. Overharvest of non-target species and stocks can be controlled through appropriate sockeye harvest management by WDFW and Tribal co-managers. The larger size of chinook and their spawning site preferences suggest little impact on chinook by sockeye. Predation impacts are difficult to predict, but larger numbers of sockeye fry may have a sparing effect on other, less abundant, species/stocks. Little competition is expected between sockeye and other species, due to differences in rearing strategies and distribution. The primary concerns over hatchery production of sockeye are the potential for adverse impacts on the fitness of naturally spawning sockeye and the impacts of broodstock collection procedures. Evaluation of both of these concerns is included in the HCP and the results will be used to inform program decisions. These risks and uncertainties will be managed through the implementation of operational guidelines, in association with a monitoring and research program and a commitment to adaptive management, all of which will be guided by an interagency oversight body (sections 4.5.3, 4.5.7, 5.4, and 5.5).

The HCP's adaptive management program will be developed to ensure that the monitoring program is focussed on the evaluation of results with respect to specific objectives and risks. The adaptive management program will direct the monitoring activities so that critical data are collected to assess impacts, both positive and negative. Adaptive management criteria will be established to identify thresholds when program adjustments will be considered to meet program objectives, either by reducing undesirable impacts or improving performance. Program adjustments could include provisions for modifying hatchery operations or even the development of alternative mitigation. Adaptive management is a critical element of the HCP program in that it provides the means of responding to the uncertainty associated with changing conditions and new information.

The monitoring and research program, in addition to informing the adaptive management process, will contribute to a broader understanding of salmon ecology. Information gained from the monitoring and research program will be used to refine the implementation of the mitigation program to help ensure that program objectives are being met. The monitoring and research program will be regularly reviewed by a multi-agency technical committee to ensure that the program is addressing both the need to document the achievement of performance objectives and the need to minimize and avoid undesirable impacts. Some of the information from monitoring and research activity is expected to have relevance beyond the boundaries of the Cedar River and Lake Washington and contribute to a better overall understanding of salmon throughout their range.

The general effect of the mitigation and minimization measures contained in the HCP is to promote sustainable populations of fish by one or more of the following measures: by providing the means for emergency propagation for selected species, if needed, or alternatively for species-oriented research; by improving habitat conditions through acquisition, protection and restoration actions; by providing watershed stewardship commitments that ensure a high quality water source; through instream flow measures; and by increasing returns of sockeye through artificial production to help restore the natural spawning population. Various monitoring activities will generate additional information on some species using the downstream area that will be useful to the City and to Tribal and state resource managers. If larger returns result from the measures included in the HCP, as expected, additional productivity would, through increased importation of marine nutrients, aid the growth and survival of species that rear in the Cedar River Basin. While the mitigation efforts described in the HCP are designed specifically to benefit four anadromous salmonid species -- sockeye, chinook and coho salmon and steelhead trout -- these efforts will likely have effects on other migratory and resident species using the Cedar River as well (see chapter 4.6 for detailed descriptions of effects on individual species). While impacts from the HCP program could be beneficial, harmful or neutral to these non-targeted species, the nature of the actions and the ecosystem scope of the HCP is generally likely to provide some benefit to other species in the Cedar River in ways that are similar in their effects on the targeted species. Perhaps more importantly, the focus of the HCP on protecting and restoring ecosystem capacity and key ecological processes should, over the long term, produce conditions in parts of the Cedar River Basin more similar to the conditions to which the species are adapted than the conditions that exist today.