Section 4.5 Contents

4.5 Monitoring and Research

4.5.1 Introduction and Objectives to Monitoring and Research

BACKGROUND

A program of monitoring and research is essential to assess the impact of the management activities and conservation strategies included in this HCP. Monitoring and research are especially important for a long-term management plan such as the City's HCP, which includes a broad range of long-term conservation, mitigation, and restoration objectives. The monitoring and research program will allow the City to ensure compliance with the plan, to determine effectiveness of mitigation, to track trends in habitats and key species populations, to test critical assumptions in the plan, and to provide for flexible, adaptive management of the conservation strategies.

The City will commit to a monitoring and research program that will be conducted in the Cedar River Municipal Watershed and the larger Lake Washington Basin as an integral part of the HCP. The monitoring and research program will be the primary means to assess if the HCP is working as intended, and the results and experience gained from the program will enable the City to make better management decisions over time.

DEVELOPMENT OF THE MONITORING AND RESEARCH PROGRAM

The monitoring and research program was developed to support the multiple programs and objectives established for this HCP, which are discussed throughout this document. The monitoring and research program was designed to support these programs by providing information needed to achieve their stated objectives. Important features of the monitoring and research program include: commitments to long-term funding and data collection; commitments to improve the quality and quantity of baseline information; commitments to track key species and habitats; and commitments to use the results of this program to provide feedback to the other management components of the HCP through the adaptive management approach (sections 4.5.7 and 5.5).

The monitoring and research program was developed and designed to use a broad range of methods. This was necessary to encompass the monitoring and research needs of the various HCP conservation and management strategies, and to provide a means to fill the gaps and uncertainties in information that were identified during the development of the HCP strategies.

IMPLEMENTATION PLANNING

Unless otherwise specified, the City intends that HCP years 1-3 will be used primarily to plan and further develop the methods and sampling plans to be used for the individual studies, and that full-scale implementation will occur afterwards. The design of individual monitoring and research studies will be developed in cooperation with agency biologists, consultants, and other experts through individual consultations, workshops, and on-site field trips. The overall program design will rely on an ecosystem-level integration of data collection and study results to support adaptive management decisions associated with implementation of this HCP.

OBJECTIVES

The primary objectives of the HCP monitoring and research program are:

(1) To determine whether HCP programs and elements are implemented as written (compliance monitoring);

(2) To determine whether HCP programs and elements result in anticipated changes in habitat or other conditions for the species of concern (effectiveness monitoring);

(3) To assist the adaptive management process by providing information on the species of concern or their habitats, testing critical assumptions in the plan, and by providing a learning experience to refine management decisions in order to better meet plan objectives;

(4) To assess and promote the recovery and maintenance of watershed fish and wildlife populations; and

(5) To help ensure a continued supply of high quality drinking water by providing data on management activities that could potentially affect water quality.

MONITORING AND RESEARCH PROGRAM ELEMENTS

This HCP's Monitoring and Research Program contains a comprehensive suite of studies that are designed to help achieve the above objectives. These include project-specific monitoring, baseline monitoring, experimental research projects, and cooperative studies.

The major elements of the City's Monitoring and Research Program include the following:

Section	*Element of Conservation, Management, or Mitigation Strategy*
4.5.2	Instream Flow Monitoring and Research: Consisting of monitoring the strategy for instream flow management (Section 4.4), including instream flow and downramping compliance and technical studies and adaptive management regarding flow switching criteria, accretion flows, monitoring of steelhead redds, and supplemental studies.

4.5.3 Anadromous Fish Monitoring and Research: Consisting of monitoring the strategy for anadromous fish (Section 4.3), including technical studies and adaptive management regarding fish passage at Landsburg Dam, sockeye salmon mitigation measures, and interim mitigation measures for steelhead, chinook, and coho.

4.5.4 Watershed Aquatic Monitoring and Research: Consisting of monitoring the strategies for watershed management (Section 4.2) related to aquatic and riparian species, including short- and long-term stream and riparian monitoring and research programs; monitoring of stream and riparian restoration projects; and monitoring, experimental research, and adaptive management for bull trout and common loons.

4.5.5 Watershed Terrestrial Monitoring and Research: Consisting of monitoring the strategies for watershed management (Section 4.2) related to upland species, including habitat monitoring and research; monitoring, research, and adaptive management related to marbled murrelets and spotted owls; and development of a basic predictive model for the relationships among forest growth, habitat characteristics, and selected watershed species.

4.5.6 Future Reservoir Management: Consisting of an evaluation of the potential environmental impacts of current reservoir operations on several species and an evaluation of the potential environmental impacts that may be associated with the Cedar Permanent Dead Storage Project.

4.5.7 Adaptive Management: Consisting of a commitment to an adaptive approach with two variations: (1) contingent responses for changed circumstances related to environmental events, and a formal approach with predefined criteria and decision thresholds for specific activities where considerable uncertainty exists; and (2) a second, less formal and more flexible approach that will be used as a simple tool or mechanism for responding to new information and experience that can be used to make conservation, management, and mitigation strategies more effective.

Within these specific programs, there are a number of projects that are identified as either experimental or research projects. The City regards the implementation of these projects as learning experiments for which monitoring results will aid in subsequent improvement in management decisions and restoration project designs. The City will encourage the cooperation and participation of outside agencies, educational institutions, research institutions, and independent researchers in the design, implementation, analysis, and funding of cooperative research investigations. If additional funding is provided, the City will consider extending the scopes and goals of the types of studies funded under the HCP.

HCP SCHEDULE CONVENTION AND HCP REPORTING

The effective date of the HCP is defined as the date that the Services issue the Incidental Take Permit (Appendix 1). HCP year 1 is defined as the period from the effective date of the HCP until the end of the first full calendar year following that date.

HCP compliance reports, unless otherwise specifically noted, will be submitted to the Services within 120 days following the end of HCP calendar years 2, 5, 8, 11, 15, 20, 25, 30, 35, 40, 45, and 50. For example, assuming the effective date of the HCP is in 2000, year 1 of the HCP will end December 31, 2001. The first report would then be submitted to the Services no later than 120 days after December 31, 2002. Instream flow compliance reports will be completed annually. The first instream flow compliance report will be submitted within 120 days of the end of HCP year 1. HCP compliance reports will contain summaries of all significant HCP-related activities and associated data and information. These activities and data include: planning, implementation, monitoring, research, compliance, expenditures, adaptive management, and the advice of the HCP Oversight Committee. For more details, see Appendix 30.

4.5.2 Instream Flow Monitoring and Research

BACKGROUND

Volume, changes in distribution, and the rate of change are important features of stream flows in aquatic ecosystems that have been subject to significant influence from anthropogenic activities during the twentieth century in the Pacific Northwest (National Research Council 1996). Through its water storage and supply activities in the Cedar River Basin, the City can exert considerable influence over stream flows in the 35.6 miles of the river downstream of Masonry Dam.

Stream flow regulation through the operation of the City's water storage and diversion facilities and hydroelectric generating plant can have very direct effects on the quantity and quality of fish habitat. Stream flow regulation can affect a number of environmental factors important to fish, including: the amount and distribution of spawning and rearing habitat in the river at any given time; the risk of damaging incubating eggs or larval fish by scour or desiccation; the risk of stranding fish during reductions in flow; conditions for upstream and downstream migration; and the biophysical factors that form and maintain stream channels.

The City will implement an instream flow monitoring and research program to: (1) ensure program and flow compliance; (2) verify accretion flows in the subbasin between the Landsburg Dam and Lake Washington; (3) improve flow-switching criteria; (4) develop better understanding of the relationship between river flows and the biology of anadromous fish; and (4) ultimately make better decisions about real-time flow management by learning from monitoring results.

A Cedar River Instream Flow Oversight Commission (the Commission) will be established to provide general oversight, coordination, and, where specifically authorized, direction regarding the implementation of the Instream Flow Agreement (Appendix 27).

Instream Flow Compliance

The City will monitor Cedar River instream flow compliance at the following locations:

(1) The existing USGS Gaging Station #12117600, Cedar River below Landsburg Dam, near RM 20.4. Monitoring at this location will begin on the effective date of the HCP.

(2) The existing USGS Gaging Station #12116500, Cedar River at Cedar Falls, near RM 33.2. Monitoring at this location will be initiated after construction of a fish ladder at Landsburg Dam and subsequent upstream passage of selected species of anadromous fish.

(3) A new site near RM 33.7 immediately above the Cedar Falls Powerhouse. Monitoring at this location will be initiated after construction of a fish ladder at Landsburg Diversion Dam and subsequent upstream passage of selected species of anadromous fish.

(4) The existing USGS Gaging Station #12119000, near Renton, or at a new gaging location nearby. Monitoring at this location will begin on the effective date of the HCP, and will terminate when the accretion flow study is completed (by or before HCP year 13).

(5) Up to two additional locations between Renton and Landsburg Dam. Monitoring at these locations would be for only a temporary period as a part of the accretion flow study (see "Accretion Flow Monitoring Study in the Lower Cedar River" below) to help monitor accretion flows between Landsburg Dam and Renton. Monitoring at these locations will begin when the accretion flow study is initiated and will terminate when the accretion flow study is completed (by or before HCP year 13).

The City will pay up to $30,000 for installation of a new USGS gage near RM 33.7 immediately above the Cedar Falls Powerhouse. The City will pay up to $11,000 per year for the maintenance of this gage. For the purpose of the accretion flow study, the City will pay up to $30,000 to install a new USGS gage in the vicinity of the current USGS Renton Gage, but at a better cross-sectional measuring site. As it has in the past, but only for the duration of the accretion flow study, the City will pay a portion ($9,100) of the annual maintenance for the gage in this vicinity. At the end of the accretion flow study, the City is willing to discuss and consider continuing to partially fund annual maintenance with other interested agencies on a cost-share basis, commensurate with the City's interests and the information provided. The City will pay for installation of new temporary gages between Landsburg Dam and Renton and their annual maintenance. The City will pay a gage installation cost of up to $15,000 per new temporary gage, and an annual maintenance cost of up to $5,000 per new temporary gage (see Table 4.5-7).

Instream flow compliance will be summarized annually in a written report, which will be submitted within 120 days of the end of the calendar year. The first instream flow compliance report will be submitted within 120 days of the end of HCP year 1.

Average daily flows and reservoir elevations will be provided to indicate compliance with minimum instream flow commitments and goals. The reports will include an explanation of decisions concerning provision of supplemental flows, including an analysis of cumulative progress toward achieving the goals for such flows. The frequency and detail of flow and reservoir elevation reports may be modified by the Instream Flow Commission.

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

Flow Downramping Compliance

Anadromous and resident fish are vulnerable to sudden flow reductions in the Cedar River downstream of the reservoir. Fish can be killed by stranding on open gravel bars or by isolation in potholes or side channels that subsequently dry up. Newly emerged fry that have just absorbed the yolk sac and have recently emerged from the gravel are by far the most vulnerable (Hunter 1992). They are relatively poor swimmers and use the shallow margins of rivers (Phinney 1974; Woodin 1984). Downramping guidelines prescribe the rates at which flows can be reduced in regulated rivers without causing significant detrimental impacts on aquatic resources.

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

(1) Masonry Dam: low-level outlet valve.

(2) Cedar Falls powerhouse: two turbines.

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

Presently, no formal downramping criteria are used to guide flow control operations at any of the three flow control points on the river.

Implementation of formal downramping rates that limit impacts on juvenile salmonids will provide a benefit to fisheries resources in the Cedar River Basin below Chester Morse Reservoir. The City will commit to the implementation of downramping prescriptions for each of the three locations within the constraints posed by the biological needs of the resource and reasonable considerations for facility operations. For periods affected by downramping operations, flow data will be provided in 1-hour increments to indicate compliance with downramping prescriptions. For downramping compliance report purposes, any USGS determination of gage error shall be factored into the actual ramping rate calculation.

The City will monitor Cedar River instream flow downramping according to the following:

(1) The downramping measurement point for operation of the diversion facilities and radial gates at the Landsburg Dam will be the existing USGS Gaging Station #12117600, Cedar River below Landsburg Dam near RM 20.4. Monitoring at this location will begin on the effective date of the HCP.

(2) Ramping of discharge from the Cedar Falls Hydroelectric Project will be measured at the existing USGS Gaging Station #12116500, Cedar River at Cedar Falls near RM 33.2. Monitoring at this location will be initiated after construction of a fish ladder at Landsburg Dam and subsequent upstream passage of selected species of anadromous fish.

(3) Ramping rates below the Masonry Dam will be measured at a new gage to be installed near RM 33.7, immediately above the Cedar Falls Powerhouse. Monitoring at this location will be initiated after construction of a fish ladder at Landsburg Dam and subsequent upstream passage of selected species of anadromous fish.

Downramping compliance will be summarized annually in the same written report as instream flow compliance, which will be submitted within 120 days of the end of the calendar year. The first downramping compliance report will be submitted within 120 days of the end of HCP year 1.

Technical Studies and Adaptive Management

The maintenance of the instream flow regime and other commitments contained in this HCP will benefit the fish populations of the Cedar River by protecting, improving, and increasing available habitat. The City recognizes the importance of monitoring the condition of the habitat to assure that the purposes of the HCP are met. The City also acknowledges that available information on certain complex ecological and hydrologic processes is not complete. Therefore, the City, in cooperation with the Instream Flow Commission, will sponsor and conduct certain studies and act on the results as indicated.

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

Accretion Flow Monitoring Study in the Lower Cedar River

The City will conduct a long-term (10 or more year) monitoring study of accretion flows in the lower Cedar River between Landsburg Dam and Renton. The purpose of this study is to verify the accretion flow assumptions developed in past technical studies and further refined by the Cedar River Instream Flow Committee. This is important because these accretion flow assumptions at times can have a significant effect on fish habitat, and future accretion flow patterns also may vary somewhat from those calculated from historical data.

The accretion flow monitoring study will: (1) specify the precise inflow assumptions to be evaluated; (2) establish and implement a long-term monitoring protocol; (3) establish analytical objectives; (4) identify any apparent long-term differences from the assumptions; and (5) perform additional investigations and analyses, if needed, to identify causes of any differences from the assumptions.

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

The study will begin not later than the end of HCP year 3 and will continue for not less than 10 years. Total costs for monitoring and analysis will not exceed $400,000. More details of the Accretion Flow Study are contained Section 4.4.2.

Improved Flow-switching Criteria Study

The objective of this study is to develop robust, measurable, reliable, and independently verifiable criteria that will allow a timely switch from normal to critical instream flows approximately 1 year in 10, and between high-normal flows and low-normal flows as described in Section 4.4.2

The current switching criteria established to guide reductions to critical flows and selection of the high- and low-normal flows in the fall are considered interim criteria. The City will sponsor and the parties to the IFA will support a collaborative analysis of alternatives to these criteria. The City and the parties to the IFA anticipate that revised switching criteria will be able to incorporate advancements in modeling and forecasting, and will be necessary to accommodate potentially significant changes to the operation of the water supply system arising from planned development of a new supply source and water treatment facilities. The City and the parties to the IFA further anticipate that improved switching criteria can have a significant effect on the water manager's ability to manage the water resource efficiently and can benefit fish by ensuring that decisions are appropriate to conditions of concern.

The analyses will involve evaluation of various switching criteria, including measured stream flows and reservoir conditions, forecasted stream flows and reservoir conditions, refill success, system-wide conditions (including other SPU water resources beyond the Cedar River), biological conditions, and watershed conditions, such as soil moisture, snowpack, and groundwater. Adaptive management techniques will also be investigated. The study may result in the retention of one or more of the existing criteria if such action is deemed appropriate in light of the additional analyses.

The study may cost up to $200,000 (see Table 4.5-7) and will be completed by the end of HCP year 4. More details on the Improved Flow-switching Criteria Study are contained in Section 4.4.2.

Cedar River Steelhead Redd and Incubation Monitoring

The HCP provides for a 2,500 acre-foot block of water in all normal years and an additional 3,500 acre-foot block of water in 63 percent of all years to supplement minimum flow commitments during the steelhead incubation period. In order to make better decisions regarding the provision of this water and to minimize dewatering of steelhead redds, the City will conduct and the parties to the Instream Flow Agreement will support annual monitoring of steelhead redds in HCP years 1-8 at a cost of $30,000 per year for a total cost of up to $240,000 (Table 4.5-7).

The monitoring program will: (1) locate and monitor steelhead redds from the time of their construction through the completion of fry emergence; and (2) trap emerging fry from a subsample of redds in order to determine total elapsed time between spawning and the completion of emergence.

The results of the study and the flow management experience gained during this period will be used to develop analytical tools that may be used to support subsequent decision making after HCP year 8. More details of the Cedar River Steelhead Redd and Incubation Monitoring Study are contained in Section 4.4.2.

Supplemental Studies

During the formal public review process for the Draft HCP, a number of parties raised several issues regarding persistent areas of uncertainty about the effects of instream flow management on aquatic resources. Some commenters indicated considerable interest in the City sponsoring further study of a number of topics, particularly focusing on obtaining enhanced information about chinook salmon, which were listed under the Endangered Species Act as "threatened" during the final year of preparing the HCP. In response this input, the City will provide an additional $1,000,000 to support further study of the effects of certain aspects of instream flow management on anadromous salmonids, with special emphasis on additional information about chinook salmon originating from the Cedar River. The City recognizes the key role of Tribal, state, and federal fisheries resource managers in the development and implementation of future studies. Therefore, all major aspects of study planning, implementation, and coordination with other related studies shall be subject to the approval of the Cedar River Instream Flow Oversight Commission (Commission) through a majority vote of its members as specified in paragraph F.3 of the Instream Flow Agreement (Appendix 27). The Commission shall have the opportunity to review and comment on drafts of all final study reports.

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

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

- Modeling analysis of the potential impacts of spring and early summer stream flows at Landsburg on water velocity vectors and water residence time in Lake Washington
- Vulnerability of chinook and sockeye salmon to redd scour
- The potential effects of redd superimposition on the survival of sockeye and chinook eggs and alevins
- Further investigations of the relationship between hydrologic features and the structure and function of instream and riparian habitat in altered stream channels

The Commission will prioritize the study topics and may add or delete topics with the consent of the City.

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

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

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

4.5.3 Anadromous Fish Monitoring And Research

BACKGROUND

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 regarding 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 mitigation facilities will be overseen by the parties to the Landsburg Mitigation Agreement, in consultation with the interagency Cedar River Anadromous Fish Committee (Section 4.3.2). Second, the City will provide compliance reports to the parties to the LMA 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, and adaptive management.

FISH PASSAGE MONITORING AT LANDSBURG DAM

Fish Ladder Counts

The objective of this task is to enumerate the number of adult anadromous fish migrating upstream past the Landsburg Diversion Dam in order to better understand run timing, rate of upstream passage, and the rate at which the upstream habitat is recolonized, and to monitor upstream fish passage facility performance. The City will purchase, install, and operate an electronic fish counter at the Landsburg Dam to count adult anadromous salmonids. The cost of purchase and installation of the fish counter may be up to $50,000. Annual operating and maintenance costs may be up to $5,000 per year (Table 4.5-7). The electronic fish counter will be installed and operated for 12 years after construction of a fish ladder at Landsburg Dam and subsequent upstream passage of selected species of anadromous fish. The City may operate this counter after HCP year 12 if adequate funding can be arranged.

Intake Screening Evaluation and Monitoring

The new fish screens to be installed at Landsburg Dam will meet all federal (NMFS) and state (WDFW) screening criteria. Designs will be provided for agency and Tribal review at the preliminary and final design stages. If there is a request, meetings will be held at the preliminary or final design phase, or both, to discuss facility layout, design, and operation. Following construction of the screens, a site visit will be held for the parties to the Landsburg Mitigation Agreement and the members of the Cedar River Anadromous Fish Committee.

After the site visit, a hydraulic evaluation of the facility will be performed to determine compliance with physical fish screening criteria. This evaluation will include measurement of approach and sweeping water velocity components at the face of the screen, water velocity at the entrance to the fish bypass, and effectiveness of the screen cleaning mechanism. Velocity measurements will be taken near the surface, at mid-depth, and near the panel floor. All measurements will be obtained while the rate of diversion into the municipal water supply system is near maximum operating levels. If areas are identified where the approach velocity vector exceeds design criteria, baffling (solid steel plates) will be installed on the downstream side (inside) of the fish screen.

Measurements will be retaken until all screen areas come within 5 percent of approach velocity criteria. Field measurements of approach and sweeping velocity vectors and identification of areas that have been baffled will be provided for review to the parties to the Landsburg Mitigation Agreement and the members of the Cedar River Anadromous Fish Committee. Cost of the screening evaluation is estimated to be up to $15,000 (Table 4.5-7). Reevaluation of screen hydraulics will be performed if facility modifications are made as a result of maintenance or repair.

Monitoring Fish Carcass Impacts on Drinking Water Quality

The City will monitor the effects on drinking water quality of allowing upstream passage of selected species of anadromous fish after construction of a fish ladder at Landsburg Dam. To achieve this objective, the City will supplement its regular water quality monitoring program by adding several new water quality parameters and increasing the current sampling frequency. One year of baseline data will be obtained prior to the introduction of anadromous fish, then data will be collected during 5 subsequent years after fish passage facilities have been completed and adult fish are passing above the Landsburg Dam. The estimated cost for this program is $60,000 (Table 4.5-7). Any cost overruns for this study will be funded solely by the City. 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.

SOCKEYE SALMON MONITORING

In order to protect drinking water quality, the City proposes to fund alternative mitigation for sockeye salmon in lieu of fish passage at the Landsburg Diversion Dam. After many years of discussion, analyses, and prototype testing, the interagency Cedar River Sockeye Technical and Policy Committees recommended that, as mitigation for the migration blockage at the Landsburg Dam, the City fund the construction and operation of a sockeye hatchery capable of producing 34 million fry annually and provide $1,637,000 to fund downstream habitat protection or restoration in the lower Cedar River downstream of the municipal watershed (Section 4.3). The City recognizes that, in order to fulfill the intent of the established sockeye mitigation goals for the hatchery, facility operators must have the resources to evaluate the number, condition, and performance of fry released from the hatchery. In addition, the fry production program must be managed in a manner that avoids or minimizes the risk of potential negative impacts to naturally reproducing sockeye populations and populations of other salmonids. Therefore, the City proposes to support a 50-year monitoring program at a total cost of $3,473,000 to ensure that program objectives are being met and to avoid potential negative effects on naturally reproducing sockeye and other salmonids.

The sockeye monitoring program (Table 4.5-1) has been designed to address the following key questions:

(1) Are sockeye fry released from the hatchery similar to naturally produced sockeye fry in the Cedar River?

- Are hatchery-produced sockeye fry developmentally, morphologically, and behaviorally similar to naturally produced sockeye fry?

- Is the development rate and emergence timing of incubating hatchery-produced fry similar to naturally produced fry?

- Do hatchery-produced sockeye fry survive to adulthood at same rate as naturally produced sockeye?

- What is the effect of short-term rearing (up to 2 weeks) on the condition and performance of hatchery-produced fry?

(2) Are returning adult sockeye originating from the hatchery similar to naturally produced adult sockeye?

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

- Can the molecular genetic attributes of hatchery-produced sockeye be distinguished from those of naturally produced Cedar River sockeye?

- Is the overall reproductive fitness of the Cedar River sockeye population changing over time as a result of the program?

(3) Is the program detrimental to sockeye in the north Lake Washington tributaries?

- Is the program increasing the rate at which adult Cedar River sockeye stray into the north Lake Washington tributaries? If so, is it significantly impacting the genetic character and diversity of the population as a whole?

- Are the molecular and phenotypic characteristics of the north Lake Washington sockeye population changing over time as a result of the program?

- If straying is a problem, are there ways to minimize the straying of adult sockeye originating from the hatchery?

(4) Is the carrying capacity of Lake Washington sufficient to support the proposed supplemental sockeye fry production, and what is the most appropriate manner and time of year to release supplemental fry into the system?

- What are the suitable zooplankton food sources available to sockeye fry in the lake and how does this change during the year?

- Is the abundance and temporal distribution of the zooplankton forage base in Lake Washington sufficient to support supplemental sockeye fry production?

- How does the abundance of the zooplankton forage base for sockeye fry vary during the course of the year and from year to year?

- How much food do juvenile sockeye require at different times of the year?

(5) Do the hatchery-produced fry pose a significant health risk to naturally reproducing salmonids?

The quality and condition of newly emerged hatchery fry will be evaluated every year during the operation of the long-term facility. In an effort to implement a comprehensive monitoring program that will provide meaningful long-term information and provide support for ongoing program refinement for the duration of the HCP, the remainder of the sockeye monitoring program has been subdivided into three time intervals: initial period (HCP years 1-12), intermediate period (HCP years 24-31), and final period (HCP years 42-49). Each of the three monitoring intervals is further subdivided into two phases as follows:

Phase 1: Fry marking, mark evaluation, enumeration, and in-lake forage condition assessment; and

Phase 2: Evaluation of survival, behavior, and phenotypic and molecular genetic characteristics of marked fish when they return as adults.

Table 4.5-1. Summary of the sockeye salmon monitoring program.

ELEMENT	HCP YEARS	ANNUAL AMOUNT	TOTAL AMOUNT
PHASE 1 ACTIVITIES:			
Fry condition at release	5-50	$2,000	$92,000
Fry marking and mark evaluation	1-8, 24-27, 42-45	$20,000	$320,000
Wild and supplemental fry trapping/counting	1-8, 24-27, 42-45	$35,000	$560,000
Fish health	5-12, 24-27, 42-45 13-23, 28-41, 46-50	$20,000 $10,000	$620,000
Short-term fry rearing	1 2-4	$35,000 $10,000	$65,000
Plankton abundance, distribution, periodicity	1-4, 24-27, 42-45 5-12	$40,000 $7,000	$536,000
PHASE 2 ACTIVITIES			
Adult survival, distribution, and homing	1-12, 28-31, 46-49	$40,000	$800,000
Genetic analyses	1-4, 9-12, 28-31, 46-49	$30,000	$480,000
TOTAL			**$3,473,000**

MONITORING THE CONDITION OF NEWLY EMERGED SUPPLEMENTAL SOCKEYE FRY

As part of the compliance monitoring to ensure that supplemental fry are equivalent in quality to wild fry from the Cedar River, the City will provide up to $2,000 per year in HCP years 5-50 to measure fry condition factor, developmental stage, and other appropriate parameters to assess the relative physiological status of fry released from the hatchery.

Results from the prototype sockeye hatchery suggest that the hatchery-produced fry tend to emerge and outmigrate to Lake Washington slightly earlier than naturally produced fry (Seilor and Kishimoto 1997). It has been hypothesized that, by rearing artificially produced sockeye fry for a short period of approximately 2 weeks, operators will 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 an additional $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 7-14 days prior to release into the system.

Phase 1: Monitoring Sockeye Fry and Juveniles, and the Lake Washington Forage Conditions

Fry Marking and Mark Evaluation

To monitor the performance of supplemental fry and their behavior after release, and to support the collection of general life history information on Lake Washington sockeye salmon, the City will provide up to $320,000 to support otolith banding or other appropriate means of marking all, or a significant portion of, the fry released from the proposed hatchery. These funds will also support the evaluation of the success of the marking protocol by examining the otoliths of a representative sample of fry from each mark group collected prior to release. Funds will be provided at a rate of $20,000 per year in HCP years 1-8, 24-27, and 42-45 (Table 4.5-1).

Naturally Produced and Supplemental Fry Trapping and Counting

An accurate estimation of the number of hatchery-produced and naturally produced fry is important in assessing the relative performance of each group. Hatchery inventories can provide an accurate assessment of the number of hatchery fish released into the system, but an intensive fry trapping program at the mouth of the river is required to obtain an accurate estimate of the number of naturally produced fry that migrate from the system each year. These estimates will provide the basis for estimating a number of important parameters for naturally reproducing sockeye including: incubation survival; total fry production; the timing of fry emergence and migration; and in-lake, fry-to-smolt survival. The City will provide up to $560,000 to partially fund the ongoing sockeye fry trapping and enumeration program at the mouth of the Cedar River. Results from this program provide important information on naturally produced and hatchery fry recruitment to Lake Washington, naturally produced fry emergence timing, and naturally produced sockeye reproductive success. Funds will be provided at a rate of $35,000 per year in HCP years 1-8, 24-27, and 42-45 (Table 4.5-1).

Fish-Health Monitoring

Because of the presence of the viral fish pathogen, IHNV, in all populations of sockeye salmon, vigilant fish culture protocol and reinforced fish-health monitoring are essential for a successful sockeye supplementation program. To help ensure the success of the supplementation program and effectively manage the risks associated with the IHN virus, the City will provide a total of up to $620,000 in HCP years 5-50 for an enhanced fish-health monitoring program for Cedar River sockeye salmon.

Lake Washington Plankton Studies

Juvenile sockeye rear in the offshore areas of Lake Washington for 1 year prior to migrating to the ocean. During this time, they are actively feeding and growing at a rapid rate. Lake Washington is generally more productive than most lakes that support sockeye. In addition, the sockeye smolts that leave Lake Washington are among the largest sockeye smolts in the world. Nevertheless, the ability of Lake Washington to support juvenile sockeye is finite. It is not presently clear what sockeye stocking rate the lake can support. However, recent information suggests that, in years of high juvenile sockeye abundance and low plankton abundance, food supplies may limit sockeye growth and/or survival for short periods during the winter months.

In order to gain a better understanding of the capabilities of the lake to support large numbers of juvenile sockeye and to better understand the within-year and between-year dynamics of the zooplankton forage base, the City will provide up to $536,000 to the University of Washington to support a study program that will monitor zooplankton composition, abundance, and distribution in Lake Washington. This will provide information on the trophic factors that control the growth and survival of juvenile sockeye salmon in the lake and will help improve our understanding of the lake's carrying capacity. The program will also provide information that will help guide the timing of fry releases from the hatchery. Up to $40,000 per year will be made available in HCP years 1-4, 24-27, and 42-54 (Table 4.5-1).

Results from the initial 4-year investigation will be used to design and implement a smaller, real-time spring plankton monitoring program that will be used to determine the most appropriate time to release supplemental fry each spring. This more narrowly focused monitoring program will be conducted in HCP years 5-12 at a cost of up to $7,000 per year (Table 4.5-1).

Phase 2: Monitoring Survival and Characteristics of Returning Adult Sockeye

Adult Survival and Distribution Studies

The purpose of these investigations is to measure the fry-to-adult survival of the hatchery-produced fish, to monitor their spawning distribution in the lower Cedar River, and to assess the rate at which supplemental fish might stray into the Bear Creek system. Data from these studies will be used to evaluate and modify fry release strategies and other appropriate aspects of the supplementation program to improve performance and minimize the risks of deleterious effects on sockeye reproducing in the wild. These studies would be conducted during HCP years 1-12, 28-31, and 46-49 and may cost up to $40,000 per year to fund the following: (1) a two-person survey crew to collect otolith samples from spawned carcasses in the Cedar River and Bear Creek; and (2) processing of the otoliths collected by the survey crew and from the hatchery broodstock (Table 4.5-1).

Phenotypic and Molecular Genetic Study of Wild and Supplemental Fish

The City will provide up to $30,000 per year to the University of Washington in HCP years 1-4, 9-12, 28-31, and 46-49 to characterize and monitor changes in phenotypic and molecular genetic traits in Lake Washington sockeye salmon populations in the Cedar River and north Lake Washington tributaries.

Minimizing Impacts of Sockeye Broodstock Collection

As described in detail in Section 4.3.2, 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.

INTERIM STEELHEAD, CHINOOK, AND COHO SUPPLEMENTATION AND/OR MONITORING AND RESTORATION STUDIES

Prior to the construction of fish passage facilities at Landsburg Diversion Dam, the City proposes to implement interim restoration measures for steelhead, chinook, and coho. The purpose of these efforts is to gather needed life history and genetic information that will aid in developing recovery plans and/or to artificially supplement one or more of the populations if needed (see Section 4.3.2), or to use funds for other interim measures as agreed by the parties to the Landsburg Mitigation Agreement (Appendix 28).

Assuming that the City of Seattle funds an interim supplementation program for steelhead, chinook, and coho, the City will capture, culture, and produce the fish and then monitor the health and vigor of non-wild progeny prior to release. The City will do this monitoring by recording the length, weight, condition factor, color, and other pertinent morphological characteristics of the fish. If the City does not fund a supplementation program, the City instead will fund restoration studies for the three species. Examples of restoration studies would be life history, genetic investigations, or demographic studies. The City will fund: (1) fish production and monitoring; or (2) restoration studies, or both, up to a total cost of $540,000 for HCP years 1-6. For more details on these programs, see Section 4.3.2.

CEDAR RIVER STEELHEAD REDD AND INCUBATION MONITORING

See "Instream Flow Monitoring," Section 4.5.2 above.

4.5.4 Watershed Aquatic Monitoring and Research

BACKGROUND

A program of aquatic monitoring and research in the municipal watershed is essential to assess the impact of the management activities and conservation strategies implemented by this HCP. Assessments of stream and riparian conditions will be used to provide feedback on whether the objectives of the Watershed Management Mitigation and

Conservation Strategies (Section 4.2.2) for the Aquatic and Riparian Ecosystem are being met. The condition of the aquatic and riparian ecosystem is a key index of the overall condition of the watershed, because aquatic and riparian ecosystem functions are influenced by activities that occur throughout the landscape, including management of forests and roads, watershed restoration projects, and water management activities.

The Watershed Aquatic Monitoring and Research program contains elements specific to compliance and effectiveness monitoring, as well as specific research elements designed to improve understanding of ecological conditions and processes within the watershed. These elements are discussed below.

SHORT-TERM EXPERIMENTAL WATERSHED STREAM MONITORING AND RESEARCH PROGRAM

The City recently completed an experimental stream monitoring pilot program (Section 3.3.6). The goals of the program were to collect and analyze information on the condition of a broad range of streams in the watershed, and to use this information to develop a long-term stream-monitoring program. The objectives of the pilot study were to assess the condition of streams, determine possible explanations for their current condition, and to predict future trends. The study design involved three main components. These components include data on: (1) hydrology; (2) water quality; and (3) benthic macroinvertebrate communities. In order to collect this information, the City set up a total of 88 sampling sites. These included 30 stream flow monitoring stations, 7 channel-stability monitoring stations, 12 water quality monitoring stations, and 46 benthic macroinvertebrate monitoring stations. The pilot study was completed in 1999.

As part of the short-term experimental program described above, the use of benthic macroinvertebrate data as a monitoring tool is being evaluated through the development and use of a calibrated Benthic Index of Biological Integrity (BIBI) (Kerans and Karr 1994; Karr and Kerans 1992; Karr et al. 1986). The objective of a BIBI is to attempt to use the macroinvertebrate community and its structure as indicators and reflectors of natural and anthropogenic disturbances in the environment. Most BIBI work in the Pacific Northwest has been conducted on low-elevation streams. In those streams, the BIBI has been demonstrated to be a useful measure of overall stream health (Kleindl 1995). Because streams in the municipal watershed traverse a wide range of elevations, a BIBI is being custom-built specifically for the Cedar River Watershed based on the macroinvertebrate data collected in the experimental program. If it is determined that a Cedar River-specific BIBI can be a useful monitoring tool for the watershed, implementation of a long-term BIBI monitoring study will be considered as part of the long-term stream monitoring program in the HCP (see below).

Because the short-term stream monitoring and research pilot program was relatively successful, the City will consider using the results to assess the applicability of specific monitoring techniques, with appropriate modifications, for long-term monitoring, to develop a snapshot in time of baseline watershed conditions, and to provide an overview of stream conditions throughout the watershed that will help identify and prioritize sites for stream restoration efforts (Section 4.2.2). The total cost of the completed data collection and analysis was more than $280,000 (Table 4.5-7). The Short-term Experimental Watershed Stream Monitoring and Research Program is detailed in Section 3.3.6.

LONG-TERM STREAM AND RIPARIAN MONITORING AND RESEARCH PROGRAM

A long-term stream and riparian monitoring and research program will be implemented to measure the overall ecological response of the watershed to HCP management activities. Long-term monitoring is critical to provide the temporal context needed for adaptive management (Bisson 1996). This program will monitor stream health, document recovery from past water supply and land management operations, and evaluate the success of stream habitat restoration projects, as well as helping to identify any impacts of the City's operations on stream ecosystems during the term of the HCP.

Three long-term, integrated monitoring studies have been developed that may be used to provide an account of how stream ecosystems in the watershed respond to various management components of the HCP. These studies include measurements of stream temperature, channel morphology and stream habitat, and biotic integrity over a period of many years during the HCP. The results of the short-term experimental stream monitoring and research pilot program described above will be used to fine-tune or revise as necessary the long-term stream and riparian monitoring and research program.

The long-term stream and riparian monitoring and research program will implement studies to measure ecologically significant attributes that are affected by watershed activities. Stream temperature is an important attribute to track because altered thermal regimes can affect fish survival, growth, metabolism, reproduction, behavior, competition, and predation (McCullough, in preparation). Similarly, monitoring stream channel morphology is critical because alteration of stream channel structure is one of the most profound changes in habitat that can be associated with past and current forest practices (Gregory and Bisson 1997). Channel structure may be affected by sedimentation, mass failure, changes in rooting and vegetative cover, changes in hydrologic regime, and loss of in-channel wood (Cedarholm et al. 1981; Chamberlain et al. 1991). Stream habitat surveys are a useful tool for tracking changes in the condition of a stream and its suitability for fish. For example, a study in western Washington documented significant changes in pool habitat and amounts of large wood in streams draining old-growth forests, forests with moderate harvest (< 50 percent harvested within the last 40 years), and forests with intensive harvest (> 50 percent harvested within the last 40 years) (Ralph et al. 1994). Pool areas and depths were significantly greater in streams in old-growth forests than in harvested basins, and pools > 1 meter in depth were almost eliminated in harvested basins. The study also showed that a reduction in the abundance of large pieces of wood was also related to past logging. Finally, it has been clearly demonstrated that macroinvertebrate community assemblages can provide a biological index that is sensitive to both natural disturbances and many kinds of human-caused disturbances in the environment (Kerans and Karr 1994).

Although the stream temperature study, the channel stability and stream habitat study, and the BIBI study each focuses on measuring specific attributes at specific locations, the interpretation of collected data will concentrate on analyzing how these attributes contribute to ecological processes throughout the watershed. Additionally, the watershed-wide spatial design of the long-term monitoring program will provide baseline data necessary for evaluating future changes caused by modifications of management activities.

The City will conduct long-term stream and riparian monitoring studies that may include the following specific studies or other studies with similar objectives:

(1) A stream temperature study may be conducted to measure water temperatures in up to 10 stream segments per year during the period July 15 to September 15. Temperature studies will be conducted in HCP years 4, 5, 6, and 7. Additional temperature studies may be considered after HCP year 7, if the study indicates additional monitoring would be appropriate.

(2) A channel stability and stream habitat study may be conducted to assess up to 10 stream segments per year for HCP years 4, 7, 10, 15, 20, and 25. Stream channel characteristics (MacDonald et al. 1991) and various measures of ecological response will be used. The data may be collected concurrently or as appropriate. Surveys may include the following:

- Establishment of permanent response survey reaches with lengths approximately 20 - 30 times the channel widths;
- Measurement of cross-sectional and longitudinal channel profiles with width and depth measurements at regular intervals;
- Determination of substrate composition by methods such as the Wolman pebble count (Wolman 1954) or other similar methods;
- Counts, volumes, and channel influence of large woody debris;
- Assessment of instream habitat features, such as pools and riffles;
- Documentation of general riparian vegetation community structure and size composition; and
- Establishment of permanent photographic record points to document changes over time.

(3) A BIBI study may be conducted that will rely on benthic macroinvertebrate sampling from up to 10 locations per year. Initiation of this study is dependent on the successful development of an index specific to the Cedar River Watershed as discussed in the above section. If a useful BIBI is developed, BIBI sampling will be conducted in HCP years 4-8, 10, 12, 15, 20, 25, 30, 40, and 50. Sampling may be terminated earlier if results do not warrant continuation, in which case another approach would be developed.

Other long-term monitoring studies may be considered if it is demonstrated that alternative study designs or measurements of other attributes are needed to evaluate long-term changes in ecosystem functioning. The importance and purpose of this flexibility, which is built in to the long-term monitoring and research program, is discussed in Section 4.5.7 (Adaptive Management). HCP years 1-3 will be used to plan the long-term monitoring program based, in part, on the results of the short-term experimental stream monitoring and research pilot program discussed above. Results from the short-term program will help guide the use of monitoring methods appropriate for the long-term monitoring program.

The cost per year of the long-term stream monitoring and research program will be up to $50,000 per year in years of intensive data collection. In most years this would not be the case, and the cost would be proportionally less. The cost of the entire program over the term of the HCP may be up to $459,000 (Table 4.5-7).

MONITORING OF AQUATIC AND RIPARIAN PROJECTS

Monitoring will be used to track compliance with and the success of specific projects implemented through the conservation strategies for the aquatic and riparian ecosystem (Section 4.2.2. The monitoring program is designed to record the efforts and results of these conservation and mitigation measures, to assess their effectiveness in improving affected aquatic and riparian functions, and to provide information for adaptive management and project modification. In general, aquatic habitat restoration programs are excellent candidates for adaptive management (Bisson 1997).

The frequency and intensity of aquatic and riparian conservation project monitoring may vary over time in order to assess the long- and short-term success of projects throughout a broad range of environmental conditions. For example, observations of stream channel morphology may be scheduled to occur following completion of specific projects and after high flow events.

Specific project monitoring components may include:

- Monitoring of changes in fish distribution, relative abundance, or species composition associated with stream and riparian projects;
- Monitoring of stream channel changes in substrate composition, streambed, or streambank configuration associated with stream and riparian projects;
- Assessment of plant survival and vigor and the relative degree of streambank erosion associated with riparian revegetation, conifer under-planting, restoration thinning, and bank bio-stabilization projects;
- Assessment of water passage through replaced and/or upgraded culverts, and at stream crossings after culverts have been removed;
- Determination of fish migration through replaced and/or upgraded culverts, and at stream crossings after culverts have been removed; and
- Documentation of road miles constructed, improved, maintained, and deconstructed within the municipal watershed.

Other monitoring studies will be considered if it is demonstrated that alternative study designs or measurements of other attributes are needed to evaluate the success of aquatic and riparian projects.

The City will conduct and fund monitoring of aquatic and riparian projects in HCP years 4-16, 18, 20, 25, 30, 40, and 50. This monitoring program may cost up to $25,000 per year in HCP years 4-6 and up to $50,000 per year in HCP years 7-16, 18, 20, 25, 30, 40, and 50 (Table 4.5-7).

WATERSHED AQUATIC SPECIES MONITORING AND RESEARCH

Bull Trout Monitoring and Research

R2 Research Consultants (in preparation) estimated that Chester Morse Lake contains a population of at least 3,000 bull trout (Section 3.5.6). This is undoubtedly an underestimate, as it was based on hydroacoustic analysis, which is generally accepted to regularly underestimate numbers of fish near the bottom of a lake. This viable population of over 3,000 bull trout has persisted throughout the City's continued use of the Cedar River for water supply for almost 100 years. According to a 1998 inventory published by WDFW, the status of the bull trout stock in Chester Morse Lake and its tributaries is officially classified as unknown. However, the report states that "there are no data suggesting a chronically low condition, or short term decline" in population (WDFW 1998; also see Section 3.5.6).

The primary goal of the bull trout conservation strategy is to avoid, minimize, or mitigate for any incidental take of bull trout. The objectives of the bull trout monitoring and research program are to track the relative status of the Cedar River Watershed population, to examine factors associated with its relative health and viability, and to determine the effectiveness of the bull trout conservation strategy. Adaptive management will be a key component of all aspects of the bull trout monitoring and research program, and funds can be shifted among elements of the bull trout investigations, as needed. Additional studies concerning monitoring and research of bull trout are discussed in the subsection entitled "Environmental Evaluation of the Cedar Permanent Dead Storage Project" contained in Section 4.5.6.

Bull Trout Surveys and Relative Population Indices

A variety of methods have been used to monitor bull trout populations (Bonar et al. 1997). Range and distribution of this species have been examined using general stream fisheries survey methodologies, such as angling and streamside foot surveys (Johnson and Schrier 1989), electrofishing (Fraley and Shepard 1989; Schill 1991; Rieman and McIntyre 1995), and snorkeling (Hillman and Platts 1993; Bonneau et al. 1995; Rieman and McIntyre1995). Bull trout abundance has been determined using redd counts (Fraley and Shepard 1989; Brown 1992), trap counts (Fraley and Shepard 1989), snorkeling counts (Goetz 1991; Sexauer and James 1993), creel surveys (Fraley and Shepard 1989), and mark and recapture estimates (Faler 1995).

In order to monitor the health and viability of the Cedar River bull trout stock, the City will use a variety of survey methods to attempt to establish several relative population indices for bull trout. No one survey method or index is likely to be adequate by itself. But by using several survey methods in combination, the City hopes to obtain a more realistic assessment of the bull trout population than would otherwise be possible or practical. The types, frequencies, locations, and intensities of surveys may vary from year to year depending on results and environmental conditions.

Adult Surveys

Experimental Fish Weir and Live-Box Trap Counts

Traps are generally regarded as the most accurate technique available for enumerating the escapement of migrating fish (Cousens et al. 1982). However, traps are quite labor intensive and require constant maintenance (Bonar et al. 1997).

The City will design, construct, install, and operate an experimental fish weir and live-box trap on the upper Cedar River above Chester Morse Lake. The objectives of this project are to:

- Determine relative abundance of the Chester Morse Lake bull trout population over time;
- Determine migration timing;
- Determine the length, weight, and condition factor of the migrating bull trout; and
- If feasible, develop an index ratio of the number of adult upstream migrants trapped to the number of bull trout redds observed (see subsection entitled "Spawning Surveys" below). This index would be applied to the Rex River and other selected tributary streams on which spawning surveys will be conducted, but in which live trapping will not be employed.

Seasonal operation of the weir will be attempted annually during HCP years 1- 4. The feasibility and need for operation during additional years will be evaluated based on results from years 1- 4. If high flows or other negative factors make the operation of the weir impractical, the City will substitute other relative measures of the population's health and viability.

Experimental fish weir design, construction, installation, and operation over 4 years may cost up to $200,000. Continued operation in HCP years 5, 6, 10, 15, 20, and 30 is estimated to cost $25,000 per year (Table 4.5-7). If the Cedar Permanent Dead Storage Project (contained in Section 4.5.6) is implemented, the weir or alternative measures may be employed to monitor the project's impact on the bull trout population.

Spawning Surveys

In a recent comprehensive survey report comparing different techniques for sampling the distribution and abundance of bull trout/Dolly Varden, Bonar et al. (1997) state that redd surveys are one of the preferred methods (along with traps) for estimating adult abundance and escapement. The authors conclude that spawning redd surveys are suitable for both migrating and resident populations, while traps are best restricted to monitoring migrating fish.

The City will conduct bull trout spawning surveys in selected tributaries of Chester Morse Lake. The surveys will be performed annually in HCP years 1-8 and may cost up to $35,000 per year (Table 4.5-7). The frequency, location, and intensity of surveys may vary from year to year, depending on the previous years' results and the success and results from other survey methods, as well as prevailing environmental conditions.

Other Adult Surveys

Other adult survey methods might include day or night snorkel surveys, hydroacoustic surveys of staged adults, or other methods.

Juvenile and Emergent Fry Studies

A serious loss to a year class at the juvenile or fry life stages might not be discovered with an adult-only bull trout monitoring study until several years after the occurrence. Therefore, juvenile and fry surveys will be conducted in selected tributary streams. Alternative survey methods that may be implemented include: outmigrant netting, screw traps, minnow traps, electrofishing, day and night snorkeling, night spotlighting, and daylight counts timed to coincide with emergence. The surveys will be performed annually in HCP years 1-8 and may cost up to $35,000 per year (Table 4.5-7).

Bull Trout Distribution Studies

Telemetry Studies

There is an apparent discrepancy between the number of bull trout redds actually counted in the Cedar River Municipal Watershed and the number that might be expected based on the population estimate for the Chester Morse/Masonry Pool Reservoir complex (Section 3.5.6). The actual number of bull trout redds counted per year in the watershed has ranged from 6 to 109 (all known spawning areas were not surveyed in every year). By proportionally comparing the Chester Morse population with the population in Flathead Lake, Montana, between 184 and 334 redds might have been expected in the Cedar River Watershed. It should be noted, however, that the population in Flathead Lake is fished, whereas the population in Chester Morse Lake is not fished and, thus, is likely to include a larger fraction of post-reproductive adults or adults with declining reproductive rates. Radio tagging has been successfully used to track adult bull trout to previously unknown spawning areas in Oregon (Thiesfield, S., Oregon Department of Fish and Wildlife, 1997, personal communication).

The City will design a study to tag and radio track bull trout in Chester Morse Lake tributary streams to refine the understanding of spatial and temporal habitat use patterns. This 2-year study will be initiated within HCP years 2-7. The cost of this study may be up to $60,000 per year (Table 4.5-7).

While it is unknown if bull trout spawn along the shores of Chester Morse Lake, lake spawning is known to sustain the population of at least one bull trout stock in Washington State (Middle Hidden Lake, Okanogan County) and possibly one other (First Hidden Lake, Okanogan County) (WDFW 1997a). The City may tag and acoustically track adult bull trout in the Chester Morse Lake to learn if they might be spawning at selected locations in the reservoir. The cost of this study may be up to $70,000 (Table 4.5-7) and may be initiated within HCP years 3-9.

Fish Distribution Surveys

Although it is possible that bull trout with a resident life history strategy exist in the municipal watershed, ongoing studies have not provided clear evidence to confirm the existence of fluvial bull trout. Nevertheless, as it has been doing for the past several years, the City will continue its qualitative surveys of unsampled streams to further document bull trout distribution. Survey methods may include day or night snorkeling, angling, minnow traps, redd surveys, outmigrant netting, electrofishing, night spotlighting, and daylight counts timed to coincide with emergence. Fish distribution surveys will not be conducted every year, but they will be performed periodically up to five times during HCP years 1-20. The cost of these surveys may be up to $12,000 per year (Table 4.5-7), and the total cost for all surveys may be up to $60,000.

Bull Trout Redd Inundation and Egg Mortality Study

Bull trout construct redds and spawn every fall in the lower reaches of the Rex and Cedar rivers above Chester Morse Lake. In most years, rising reservoir levels inundate some of these redds (Section 3.5.6). The City assumes, although this has not been demonstrated, that this inundation and the change from a running-water to a lacustrine environment, may kill a large fraction of the developing eggs or alevins in the inundated redds.

The actual level of mortality caused by inundation of redds in the lower Rex and Cedar rivers is not known. It is somewhat puzzling that such a high percentage of Rex River bull trout redds is built at elevations that have been annually inundated by Chester Morse Lake for almost 85 years. Severe mortality to eggs and alevins usually would be expected to exert a strong selective pressure against those bull trout spawning in the annually inundated stream reaches. Inundation of salmonid redds is known to cause mortality in some reservoirs (Seattle City Light 1989). In Chester Morse Lake, one hypothesis is that the degree of impact is somewhat reduced by water upwelling through the spawning gravels in the inundated stream reaches. Upwelling in spawning gravels serves to aerate eggs and alevins and remove metabolic wastes. It is not known whether upwelling actually occurs in bull trout spawning areas in the lower Cedar or Rex rivers. The fact that regular inundation has been occurring for many decades in much of the area in which bull trout spawn, however, suggests that there has been relatively little selection exerted on bull trout to avoid these areas. Furthermore, even if a high degree of mortality from inundation does occur, it is probable that the limiting life stage for bull trout in the watershed is not spawning and egg incubation (especially in the lower reaches of the tributaries) but is juvenile rearing.

The City believes that the substantial measures in this HCP for the protection of bull trout and bull trout habitat, the implementation of an extensive monitoring and research program, and the incorporation of an adaptive management approach are sufficient mitigation for any current or future (during the term of the HCP) potential negative impacts of the City’s operations on bull trout, including lethal redd inundation in tributary spawning streams. Nevertheless, as part of the City’s effort to learn more about bull trout ecology in the Cedar River Watershed, the City will conduct a study of bull trout egg mortality that results from redd inundation. Redd caps will be placed over bull trout redds in stream reaches that are above and below the zone of reservoir inundation. The percentage of alevins emerging will be monitored. Alternatively, ripe adults will be captured at the experimental fish weir discussed above, and eggs and sperm will be taken from them. Fertilized eggs will be buried in experimental incubation boxes above and below the zone of eventual redd inundation. The egg boxes will be monitored to determine embryo development. This study will be conducted in one or more years during HCP years 1-9 and may cost up to $55,000 per year (Table 4.5-7).

Common Loon Monitoring

All common loon nesting habitat currently identified within the municipal watershed is located at the margins of Chester Morse Lake and the Masonry Pool and is vulnerable to the effects of fluctuating reservoir levels (Section 3.5.5). Common loons typically nest at the shore or waterline, or on emergent surfaces such as logs. The common loon nests and eggs in this habitat are vulnerable to both inundation and stranding from relatively small water level changes.

In natural systems, loons can compensate for small changes in water levels, but the range of water levels on Chester Morse Lake during common loon nesting season is typically as much as 10 ft in most years, but can be substantially greater in some years (see Figure 4.5-1 in Section 4.5.6). Fluctuations such as these may have significant adverse impacts on loon reproductive success. Future reservoir water levels will be modeled during the loon nesting season under both the new HCP instream flow regime and under a potential flow regime for the Cedar Permanent Dead Storage Project. The physical effects of these two operational scenarios will be evaluated to determine their potential effects on nesting loons (Section 4.5.6).

The monitoring and research described in section 4.5.6 will be used to determine if the conservation strategy for the common loon achieves its conservation objectives. The information collected will also be used to support the adaptive management program (section 4.5.7), which is designed to provide a means by which mitigation and conservation strategies can be altered to better meet conservation objectives.

The City intends to continue to investigate the ecology of common loons within the municipal watershed on a long-term basis, including the deployment of experimental nest platforms, with particular focus on the reservoir complex. This intensive program has typically included the annual deployment of one or more experimental nest platforms within each of the territories of the three loon pairs currently using the reservoir complex during the breeding and nesting seasons. The 10-year ecological investigation has indicated, however, that deployment of experimental nest platforms may not be needed or even appropriate in some years, or may not be warranted for particular territories within any given year. For example, if reservoir elevations were very low for an extended period of time during the nest establishment and mating seasons, platforms would have to be deployed far from the shoreline, in open water away from protective cover, and would therefore be exposed to excessive wind and wave action. If loons were induced to utilize experimental nest platforms in such precarious environmental conditions, vulnerability of nests to exposure and predation would be increased substantially, and unwarranted, detrimental effects on reproductive success (e.g., nest abandonment, platform destruction) would likely result in nearly all cases.

The City will evaluate prevailing environmental conditions in the reservoir complex annually during the late winter early spring period, including lake elevations, habitat availability (e.g., cover), and whether or not potential breeding pairs are present within breeding territories, and in addition, examine predicted lake level elevations and track realized conditions in order to determine the advisability of deploying experimental nest platforms. If potential breeding loons are present on the reservoir complex, and environmental conditions, including projected lake elevations and operating regimes, are deemed to be conducive to allow loons to nest on platforms without unreasonable risk, then experimental nest platforms will be deployed when and where appropriate based on and in accordance with cumulative results of the ongoing ecological investigations within the municipal watershed.

Surveys of common loon nesting success on Chester Morse Lake and Masonry Pool and the deployment of experimental nest platforms, when and where warranted based on evaluation of environmental conditions and results of ecological studies as discussed above, will be conducted on an annual basis throughout the term of the HCP. The City may discontinue or modify this program as appropriate, depending on the results of monitoring and research and with approval of the Services. The cost of these surveys and experimental research and monitoring will be up to $25,000 in each HCP year interval 1-10, 11-20, 21-30, 31-40, and 41-50 (Table 4.5-7).

4.5.5 Watershed Terrestrial Monitoring and Research

BACKGROUND

The watershed management, mitigation, and conservation strategies (Section 4.2.2) are designed to protect and restore fish and wildlife habitat, especially aquatic, riparian, and late-successional and old-growth forest communities. The Species Conservation Strategies and the control of public access to the watershed (also described in Section 4.2.2) will also to protect both habitat and species that are present within the watershed. These latter strategies are focused largely on controlling disturbance and impacts to individuals and reproductive pairs.

The Watershed Terrestrial Monitoring and Research Program is designed primarily to assess the effects of management and conservation strategies on key and sensitive vegetation communities and selected, closely associated wildlife species to support adaptive management over the term of the HCP (Section 4.5.7). Secondly, the program is designed to provide accurate and updated information on both forested and non-forested habitat types present in the watershed landscape throughout the 50-year term of the HCP. Elements of this program are designed to augment the existing knowledge of habitat conditions and selected wildlife species use in the watershed by providing an integrated system of monitoring and research projects that will: (1) improve the accuracy of the data that describes baseline habitat conditions; (2) develop systematic procedures to better identify, classify, and track changing habitat conditions; (3) establish both short-term and long-term monitoring projects to support adaptive management decisions and document HCP compliance; (4) predict future trends in forest habitat development, change, and potential use by selected wildlife species; and (5) ensure that management and conservation activities do not adversely impact species of concern, particularly those that rely on late-successional and old-growth forest communities.

A major focus of the Watershed Terrestrial Monitoring and Research Program is to more accurately characterize and classify upland habitats (forested and non-forested) in the municipal watershed so that significant expected trends in habitat and landscape changes over the 50-year term of the HCP (Section 4.2.2) can be documented and tracked. It is anticipated that a substantial amount of beneficial change will be realized in both upland and riparian forest habitats, including a more natural distribution of forested and non-forested habitats over the entire watershed landscape, as a result of implementing the integrated management and conservation strategies provided in the HCP. These changes in the municipal watershed will likely include: (1) advancement of forest seral stages overall, with development of forest in recently harvested areas; (2) recruitment, over time, of more areas of mature and late-successional forest that progressively exhibits a greater degree of late-successional and old-growth characteristics; (3) increased overall maturity and structural complexity of forests by the end of the HCP term; (4) improved habitat quality throughout the municipal watershed for most species of concern; and (5) increased contiguity and connectivity among habitats throughout the watershed, as well as between watershed and adjacent lands.

Accurate characterization and classification of habitats is a useful tool to help monitor certain wildlife populations, because wildlife abundance and species diversity are dependent on habitat quality and availability (Irwin et al. 1989). Although the City does not intend to specifically measure wildlife populations, several Watershed Terrestrial Monitoring and Research Program elements are designed to generally evaluate the effects of management and conservation strategies on specific at-risk species in the municipal watershed through the collection and interpretation of accurate habitat information. This is an especially useful approach for monitoring potential impacts on individuals or populations of mobile species (Irwin et al. 1989), such as species that occur on adjacent lands, on a regional basis, or migrate, and can be significantly affected by conditions and activities outside the influence of the municipal watershed. In addition to tracking the availability and general condition of specific habitats types in the watershed, the use of reproductive habitat by two species, the marbled murrelet and the northern spotted owl, will also be monitored periodically.

The City intends to develop and implement a *coordinated* system of monitoring and research methods that both will support evaluation of the success of the watershed management and conservation strategies at different scales of space and time, and will substantially augment scientific knowledge of selected site-specific, habitat-specific, and species-specific attributes within the municipal watershed. The biological and ecological information gathered from coordinated sampling and data collection will provide information needed for compliance monitoring, reporting, and adaptive management. Better understanding of the relationships between species and their habitats in the watershed will be necessary for the development of useful experimental, interactive habitat and species relationship models customized to the municipal watershed. The elements of the program were designed to be integrated at an ecosystem level by providing both site-specific information on projects and landscape level information on habitats that can be used to track changes in habitat patterns over time.

The tasks included in the Terrestrial Monitoring and Research Program will be accomplished using City staff supported by other appropriate means including cooperating agency personnel, consulting firms, consultation with experts in selected fields, workshops, academic students, and input from other interested parties when appropriate.

Unless otherwise specified, it is generally intended that HCP years 1-3 will be used to design the methods and sampling plans for the individual program tasks. HCP years 5-8 will focus on experimental implementation of sampling, monitoring, and modeling programs. Full implementation of sampling, data collection, and analysis will mostly occur after HCP year 8. Some elements are designed to provide monitoring data over a longer time period, and some tasks may proceed more quickly than anticipated and certain work products may be produced sooner than expected.

The community-based watershed management, mitigation, and conservation strategies (Section 4.2.2) are designed to protect and restore fish and wildlife habitat, especially aquatic, riparian, and late-successional and old-growth forest communities. These community-based strategies are integrated in Section 4.2.2 with the Species Conservation Strategies and Controlled Public Access to the Watershed to protect both habitat and species that are present within the watershed. These latter strategies are focused largely on controlling disturbance and impacts to individuals and reproductive pairs.

Principle monitoring and research program elements are designed to provide high quality information that will facilitate successful achievement of the objectives of the Watershed Management Mitigation and Conservation Strategies (Section 4.2.2) through adaptive management principles. Additionally, the program will potentially establish monitoring techniques, methods, and data that will contribute pertinent environmental information that will support beneficial land management decisions both by SPU and other agencies throughout the region.

The objectives of the Watershed Terrestrial Monitoring and Research Program are to develop and implement a coordinated system of monitoring and research methods to evaluate the success of the watershed management and conservation strategies, as well as to substantially augment scientific knowledge that can form the basis for both habitat and species management decisions within the municipal watershed. This information will be necessary for the development of basic experimental, interactive habitat and species relationship models customized to the municipal watershed. In addition, the biological and ecological information gathered from coordinated sampling and data collection will provide information needed for compliance monitoring, reporting, and adaptive management.

Although each monitoring and research element in this program is designed to provide independent information on the status and dynamics of particular resources within the watershed, the program is also designed to be integrated at an ecosystem level and landscape scale. This holistic design will be critical for the support of adaptive management decisions related to implementation of this HCP (Section 4.5.7). Because of reliance on adaptive management, most program elements are described in general terms so the adaptive management process can be used to adjust and refine sampling schemes, techniques, and management guidelines as data is gathered, analyzed, and evaluated.

The tasks included in the Terrestrial Monitoring and Research Program will be accomplished using City staff supported by other appropriate means including cooperating agency personnel, consulting firms, consultation with experts in selected fields, workshops, academic students, and input from other interested parties when appropriate.

Unless otherwise specified, it is generally intended that HCP years 1-3 will be used to design the methods, specific techniques, and sampling plans for the individual program tasks. HCP years 5-8 will focus on experimental implementation of sampling, monitoring, and modeling programs. Full implementation of sampling, data collection, and analysis will mostly occur after HCP year 8. Some elements are designed to provide monitoring data over a longer time period, and some tasks may proceed more quickly than anticipated and certain work products may be produced sooner than expected.

WATERSHED LANDSCAPE AND HABITAT RESEARCH AND MONITORING PROGRAM

In addition to refining the application of remote-sensing data as was utilized in the preparation of the HCP, several ground-based methods will continue to be used to identify and classify habitats, tabulate acreage, and depict habitats and other landscape features within the Cedar River Municipal Watershed. These methods will be used to characterize existing conditions, document future changes in habitats and communities, and evaluate the effects of watershed management and conservation strategies that are implemented through this HCP.

Each of the elements in the Watershed Landscape and Habitat Research and Monitoring Program listed below is designed to support the watershed management and conservation strategies by improving the precision and accuracy of the existing habitat classification system and associated ecological data. The tasks are integrated, basically sequential, and include measures to provide quality control for existing data as well as for the updated and refined databases throughout the term of the HCP. Specific emphasis is placed on short-term refinement of habitat information, and on long-term documentation of habitat changes and development. Additionally, specific emphasis is placed on habitat changes and development resulting from restoration activities and experimental silivicultural techniques (Section 4.2.2).

Overall objectives of the Watershed Landscape and Habitat Research and Monitoring Program are to: (1) develop an improved habitat identification system (based on structural characteristics) that can be used to more accurately classify forested and non-forested habitats over the watershed landscape; (2) provide information necessary to evaluate restoration activities and experimental si**l**vicultural applications, especially in riparian corridors; and (3) document and track trends in the development and change in habitat structure within selected types of forest or other selected habitats. These objectives will aid in documenting HCP compliance, supporting analyses of habitat potential for threatened, endangered, and sensitive species, and guiding land use management decisions through adaptive management. The individual elements of this program are described below.

Watershed Terrestrial Habitat Inventory

An accurate inventory of habitat types (forested and non-forested) existing at any given time over the entire watershed landscape is necessary to evaluate, even qualitatively, but especially quantitatively, the potential availability of wildlife habitat for any given species or group of species. In a similar manner, an accurate inventory of both upland and riparian forest and extensive attribute data associated with those forests are necessary in order to efficiently and effectively design and conduct a program of habitat restoration. This same inventory information is also necessary to assess compliance with specific elements of the HCP (see below).

The development of habitat conservation strategies for this HCP relied on the most up-to-date habitat inventory information contained in the City's GIS and Stand Projection System (SPS) databases (Section 3.3.7). These databases were used to produce the maps, tabular data, and appropriate analyses detailing baseline habitat classification, habitat condition, and habitat protection measures. The program tasks outlined below will provide supplemental data that, over the short term, will be used to update these databases and perform analyses of projected future habitat conditions. Over the 50-year term of the HCP, this program will track landscape changes, identify trends, and assess compliance. In addition, these databases will provide input for the Forest Growth and Habitat Development Model discussed in a following subsection.

The Watershed Terrestrial Habitat Inventory is composed of the specific elements described in the following subsections.

Assessment of Expanded Forest Polygon Data

Remote sensing data were used in a GIS analysis to delineate and classify polygons with similar reflectance values, indicating relatively homogeneous attributes of tree size, tree density, and species composition over the landscape of the municipal watershed. A specific subset of these polygons was sampled in the field and *standard* forest inventory information including tree species, height, dbh, crown volume, and defect was collected; all of these variables are typically used by forest land owners to characterize forest polygons to determine appropriate silvicultural applications and to estimate timber harvest volumes. Following standard practices of analysis, this standard polygon inventory information was related to the watershed-wide forest polygon classification based on satellite imagery, then field sampling data were expanded (extrapolated) to non-sampled polygons determined to be of similar type in an analysis of the remote sensing data used to delineate and classify polygons. The accuracy of the expanded classification of non-sampled forest polygons has not been verified to date, and an assessment of accuracy is necessary in order to effectively and appropriately plan management activities relative to habitat restoration and wildlife conservation activities within the watershed under the HCP.

The City will design and conduct a sampling program to evaluate the accuracy and applicability of expanded *standard* forest polygon data (typically called stand data) presently existing in the SPS and GIS databases (Section 3.3.7). These data used in the expansion consist of *standard* forest inventory information from selected forest polygons that were sub-sampled (see above).

The purpose of the evaluation included in this element is to determine the degree of accuracy of forest polygon characterization that can be achieved by this method of data expansion, to determine the extent to which further sampling may be needed in areas previously sampled, as well as in those not yet sampled. If the expanded forest polygon data are found to inadequately characterize sampled and/or unsampled areas based on a preliminary field survey, the City will conduct a comprehensive sampling program to correct these data. The cost of this program will be up to $50,000 in HCP years 1-5 for preliminary design and evaluation, and up to $25,000 in HCP years 6-10 to modify preliminary designs and complete the comprehensive sampling effort, if necessary, for a total cost of $75,000 (Table 4.5-7).

Assessment of Expanded Secondary Forest Attribute Data

Similar to the above element, the City will design and conduct a sampling program to evaluate the accuracy and applicability of FPS/GIS expanded forest attribute data collected by the City and its consultants that are *not* typically included in standard forest stand-based inventory procedures (see above). These s*econdary attribute* data consist of measurements and/or estimates of internal forest structure that were recorded in the same forest polygons, and at the same time, that the standard data were collected, and include estimates of (1) snag density by decay class, (2) large woody debris density, (3) understory vegetation characteristics, and (4) ground-level cover of herbaceous indicator species. Such secondary attributes, combined with standard inventory data, may be of use to characterize areas of watershed forest in terms of potential wildlife habitat availability and relative quality. As with the standard forest polygon data, the secondary forest attribute data were related to the watershed-wide forest polygon classification based on satellite imagery, then sampling data were subsequently expanded (extrapolated) to non-sampled polygons determined to be of similar type in an analysis of the remote sensing data used to delineate and classify polygons (see above).

The purpose of the evaluation included in this element is to determine if the existing secondary forest attribute data (combined with the standard forest inventory data) and expansion methods are adequate to effectively characterize wildlife habitat in order to determine the extent to which further sampling may be needed in areas previously sampled and/or those not yet sampled. If a preliminary field survey indicates that these expanded secondary forest attribute data are inadequate to characterize forest habitat in areas previously sampled and/or in unsampled areas, the City will design and conduct a comprehensive sampling program to correct and provide appropriate information necessary to support habitat management decisions. The cost of this program will be up to $50,000 in HCP years 1-5 for design and evaluation of the preliminary sampling effort, and up to $25,000 in HCP years 6-10 for completion of a comprehensive sampling effort, if necessary, for a total cost of $75,000 (Table 4.5-7).

Augmentation of Forest and Habitat Inventory

If, based on the evaluations of standard forest inventory data and secondary forest attribute data associated with GIS polygons as described in the two preceding elements above, the City determines that additional attributes need to be sampled or that more areas need to be sampled than can be sampled with the funding for the above two elements, the City will design and conduct an appropriate sampling program to augment existing forest and habitat inventory data for the watershed. The cost of this program will be up to $75,000 in HCP years 1-5 (Table 4.5-7).

Ecological Old Growth Classification

The City will design and conduct a sampling program to assess existing old-growth and late-successional forests within the Cedar River Watershed and classify these habitats on an ecological basis, extending the simple age-based classification used in developing the HCP. This new classification will not be based solely on chronological age, but will include structural attribute characteristics such as snag density, large woody debris density, and horizontal and vertical complexity. The purpose of more specifically classifying old-growth forest is to determine the relative habitat value of the remaining late-successional and old-growth forests in the watershed for both selected individual species and groups of species of concern, especially those threatened and endangered species dependent on old-growth ecosystems, such as marbled murrelets and spotted owls. The cost of this program will be up to $74,970 in HCP years 3-10 (Table 4.5-7).

Field Verification

The City will complete field verification of habitat classifications of forested and non-forested polygons in the watershed GIS that is not accomplished as part of the four program elements above. The cost of this program will be up to $56,220 in HCP years 1-5 (Table 4.5-7).

Long-term Forest and Habitat Inventory

Based on the evaluations of standard forest inventory and secondary forest attribute data, and augmentation of the forest and habitat inventory described in the elements above, the City will design and conduct a long-term program of sampling and monitoring to update the forest and habitat inventory periodically over the full term of the HCP. The cost of this program will be up to $18,750 for design in HCP years 1-5, up to $62,600 in HCP years 6-10, up to $42,500 in HCP years 11-15, up to $37,500 in HCP year interval 16-20, up to $75,000 in each HCP year intervals 21-30 and 31-40, and up to $82,500 in HCP year interval 41-50, for a total cost of $393,850 (Table 4.5-7).

WATERSHED HABITAT RESTORATION RESEARCH AND MONITORING

Although many riparian and upland forest restoration methods are derived from traditional silvicultural principles and techniques, their specific application in a wide array of restoration scenarios remains basically experimental, and long-term results have not been widely demonstrated to accomplish the ecological objectives of such methods. Therefore, it is critical that restoration projects be monitored, on both a short- and long-term time basis, to determine if the applied methods have produced the intended results. Many projects may also require modifications over time and would need to be evaluated, not merely from the biological perspective, but also from a cost-benefit perspective.

The objective of the Watershed Habitat Restoration and Monitoring Program is to provide a feedback mechanism to be used to evaluate and modify, where necessary, experimental techniques and applications (such as thinning and underplanting) that are implemented in forest as part of riparian and upland forest restoration programs in the watershed.

Riparian Restoration Structural Development

The City will design and conduct a sampling program to monitor habitat structural development and plant species composition changes, including pretreatment baseline information, in representative forest sites, and on other sites as needed, after implementation of selected riparian habitat restoration projects and application of experimental silvicultural treatments described in Section 4.2.2. The cost of this project will be up to $35,000 in HCP years 3-8 for design and initiation, and up to $75,000 in each HCP year intervals 9-15, 16-25, 26-35, 36-50, for a total cost of $335,000 (Table 4.5-7).

Upland Restoration Structural Development

The City will design and conduct a sampling program to assess pretreatment baseline information and will monitor habitat structural development and plant species composition changes in representative forests, and on other sites as needed, after implementation of selected upland habitat restoration projects and application of experimental silvicultural treatments. The cost of this program will be up to $35,000 in HCP years 3-8 to design and initiate, and up to $75,000 in each HCP year interval 9-15, 16-25, 26-35, 36-50, for a total cost of $335,000 (Table 4.5-7).

TERRESTRIAL SPECIES RESEARCH AND MONITORING PROGRAM

Recent planning guidelines for the USFWS (CFR Title 36, Vol. 2, Part 219) prescribe the use of management indicator species, selected because their population changes are believed to indicate the effects of management activities on other species. The assumption in this approach is that if habitat that is required by indicator species is provided, all other species dependent on the same limiting habitat conditions would be protected. Although the City does not intend to measure or track populations of individual species, it recognizes the value of periodic monitoring to determine the presence, or probable absence, of selected indicator species or other species of concern. In addition, the reproductive status and success of such species is also deemed to be a significant indication of the relative quality of available habitat, when such species are present.

Because northern spotted owls are considered an indicator species for other late-successional and old-growth forest dependent species, program elements designed to provide general information relative to habitat availability, habitat use, and reproductive success of this species will be established to not only monitor this species, but to also gain an understanding of habitat conditions available for other late-successional and old-growth forest dependent species in the municipal watershed. Additionally, marbled murrelets and their habitat will also be monitored, largely because this species uses forests in a unique manner.

Spotted owls and marbled murrelets were also selected for the Terrestrial Species Research and Monitoring Program because: (1) the City's HCP focuses on the protection of late-successional and old-growth forest and ecosystems within the watershed; (2) both of these avian species are presently thought to be obligates in late-successional and old-growth forest habitats; and (3) both are currently listed as threatened under the Endangered Species Act. In addition, spotted owl reproductive site centers have been documented over the past 10 years in and immediately adjacent to the watershed, thus providing a record of the species upon which to develop a long-term monitoring program and regional history.

Limited marbled murrelet activity has been recently detected in the watershed by WDFW surveys, but little is known about their local or regional status or what their specific habitat use patterns or requirements are in the watershed. This situation presents a wide variety of opportunities not only to document the present status of murrelets in the watershed but also to increase information on species ecology in the existing late-successional and old-growth habitats of the watershed and the region, as well as to gain valuable perspective on the success of habitat protection, development, and enhancement under the HCP.

The objectives of the elements in this program are to provide baseline information on the status and general distribution of selected threatened and endangered species (marbled murrelet and spotted owl) within the Cedar River Watershed, and to periodically update that information over the 50-year term of the HCP as habitat availability and potential for wildlife use change.

Northern Spotted Owl Monitoring and Research

A major component of the City's HCP is a commitment to forgo commercial timber harvest within the municipal watershed, thus effectively placing all forested land outside limited developed areas in reserve status for the 50-year term of the HCP (Section 4.2.2). This commitment will protect all watershed forest, in particular, all old-growth forest remaining in the Cedar River Watershed, all existing mature forest, all low-elevation, maturing second-growth forest, and all stream corridors. Placing virtually all watershed forest in reserve status will serve to protect existing spotted owl habitat and provide for the development of additional potential habitat in some areas of the watershed over the 50-year term of the HCP.

Spotted Owl Baseline Survey

The City will survey old-growth forest within the municipal watershed for spotted owl activity, if those areas are not actively being monitored by other agencies or interested parties (USFS, DNR, timber company), one or more years during HCP years 3-10. The City will either use an existing survey protocol (e.g., a USFWS protocol) or develop an appropriate modified protocol based on the best information available at the time of the survey and on consultation with regional experts and appropriate federal and state agency staff. The survey data collected as part of this monitoring and research program will be used, through adaptive management (Section 4.5.7), to determine if the mitigation and minimization strategies for spotted owls are achieving their conservation objectives and facilitating the adjustments needed to make the strategies better achieve their objectives. These data will also be used to ensure that active spotted owl nests and their surrounding habitat will be protected. The cost of the survey will be up to $75,000 in HCP years 3-10 (Table 4.5-7).

Spotted Owl Site Center Survey

The City will conduct, or coordinate with other agencies or interested parties to conduct, an annual survey of identified reproductive site centers for a period of 5 years after the last documented activity of spotted owls within a site. The cost of this survey will be up to $25,000 in each HCP year interval 11-20, 21-30, and 31-50, for a total cost of $75,000 (Table 4.5-7).

Marbled Murrelet Monitoring and Research

A major component of the City's HCP is a commitment to forgo commercial timber harvest within the municipal watershed, thus effectively placing all forested land outside limited developed areas in reserve status for the 50-year term of the HCP (Section 4.2.2). This commitment will protect all watershed forest, in particular, all old-growth forest remaining in the Cedar River Watershed, all existing mature forest, all low-elevation, maturing second-growth forest, and all stream corridors. Placing virtually all watershed forest in reserve status will serve to protect existing murrelet habitat in old-growth forest, and also provide for the development of additional potential habitat in many second-growth forests throughout the watershed over the 50-year term of the HCP. In addition, potential marbled murrelet habitat may currently exist within some areas of second-growth forest, especially in the lower elevations of the watershed. Because of this, the City will also evaluate the habitat potential of those second-growth stands and develop appropriate management prescriptions for those areas.

Marbled Murrelet Baseline Surveys, Old-growth Forest

The City will conduct baseline surveys for marbled murrelets in selected old-growth forest within the watershed according to established protocols during any two of HCP years 3-7. The cost of this program will be up to $75,000 in HCP years 3-7 (Table 4.5-7).

Marbled Murrelet Baseline Surveys, Second-growth Forest

Potential marbled murrelet habitat in second-growth forest stands will be evaluated by means of a multi-step assessment process based on the most current murrelet habitat evaluation criteria at the time of the initiation of the surveys, as recommended by WDFW and USFWS. The City recognizes the necessity to protect existing murrelet habitat, especially in low-elevation coniferous forest, and will initially focus habitat assessment efforts in areas deemed most likely capable of supporting use by murrelets, those areas with the most substantial potential for future development of murrelet habitat, and those areas where restoration activities (e.g., ecological thinning) may be conducted. In general, the assessment process will be based on stand attribute information such as density and distribution of large-diameter trees, and density of suitable nest platforms in large trees within forest stands.

Initially, second-growth forests will be classified according to parameters such as age, diameter class, and density of large trees. These classifications will be assigned using existing forest attribute data from GIS, SPS, or other data management systems available at the municipal watershed's headquarters. Extrapolation of measured forest attributes to unsampled areas will be field verified by subsampling. Those areas not meeting minimum attribute classification criteria for murrelets can then be eliminated from the assessment process. Areas that meet the minimum attribute criteria will be examined in the field to determine the density of suitable platforms available. Both of these steps will be based on appropriate statistical sampling designs and sampling methodologies. Depending upon the total amount of acreage necessary to be surveyed, subsampling may be used if appropriate.

At the completion of forest attribute and platform density evaluations, areas not meeting minimum criteria for either type of murrelet habitat classification will be eliminated from further assessment and will require no additional measures of protection or habitat management other than the protection conferred by reserve status. No additional surveys, evaluation, protection, or special management will be required for areas that do not meet the minimum criteria established during this assessment process, even if agency evaluation criteria and survey protocols are modified in the future, although the City may cooperate in any such surveys performed by WDFW or USFWS.

Areas of forest, or an appropriate subsample thereof, meeting minimum forest attribute and nest platform criteria for murrelets will be surveyed for marbled murrelet occupancy according to WDFW or USFWS protocols current at the initiation of the surveys. Forest found to be unoccupied by murrelets will not be required to be specially protected over and above protection in reserve status. However, at the City's discretion, unoccupied forest may be evaluated and considered on an individual basis for additional protection and special management, when appropriate.

The City will develop and implement a prioritized habitat sampling plan and conduct relevant field surveys in second-growth forests to evaluate marbled murrelet habitat potential, with emphasis on specific categories of sites as indicated above, and subsequently develop and implement a prioritized sampling plan to document occupancy within identified potential habitat in second-growth forests, during HCP years 5-8. The cost of this program will be up to $150,000 in HCP years 5-8 (Table 4.5-7).

Long-term Marbled Murrelet Surveys

If marbled murrelets have not been detected by HCP year 25 within second-growth forest in the watershed, the City will develop a prioritized sampling plan and conduct appropriate surveys in selected mature and late-successional forests within the watershed. These surveys will be conducted during HCP years 25-28 and HCP years 45-48. The cost of this program will be up to $50,000 per study period in HCP years 25-28 and 45-48, for a total cost of $100,000 (Table 4.5-7).

Experimental Marbled Murrelet Habitat Enhancement

The City will consider developing a monitoring and research program, in cooperation with the USFWS, to enhance potential marbled murrelet nesting habitat in selected second-growth within the watershed. The cost of this program will be up to $40,000 in HCP years 7-10 for development and initiation; up to $80,000 in HCP years 11-20 and $10,000 in HCP years 21-30 for habitat enhancement; up to $25,000 in HCP years 31-40 for monitoring and survey; and up to $30,000 in HCP years 45-48 for monitoring and survey, for a total cost of $185,000 (Table 4.5-7).

Optional Species Surveys and Research in Experimental and Sensitive Habitats

Specific monitoring and research programs have been described for selected terrestrial habitats, experimental treatments, and species in the sections above. Unspecified habitat conditions may develop, unexpected environmental circumstances might occur, or specific information may be lacking relative to a species of concern or other at-risk species, however, that is not addressed by monitoring and research as originally designed. The element described below serves to maintain the ability and flexibility to address such circumstances within the context of the HCP. Optional surveys and research conducted under this element may be designed and accomplished in cooperation with USFWS, other appropriate agencies, experts, and City personnel through a series of consultations and work groups.

The objective of this element is to provide a means for additional monitoring and research to help achieve the HCP objectives to avoid, minimize, or mitigate for the taking of species of concern. This program will be used to provide pertinent information on other wildlife species when necessary for compliance with the terms of the HCP. This program may also be implemented when it significantly contributes to adaptive management decisions that relate to specific aspects of the HCP.

The City will fund selected species surveys, monitoring, or research projects (the particular species or species groups and project scopes to be determined), as needed to support the efficient and successful implementation of HCP with respect to its conservation objectives. Reasons for implementation of this element may include increasing habitat quality assessments for a particular species or species group. The cost of this research will be up to $50,000 in HCP year interval 9-20, 21-35, and 36-48, for a total cost of $150,000 (Table 4.5-7).

DATA FORMATS AND GEOGRAPHIC INFORMATION SYSTEM COMPATIBILITY PROGRAM

Maintaining a well-organized and efficient system of accurate databases, integrated and compatible with the GIS, is essential to support many aspects of the HCP within the Cedar River Municipal Watershed. In addition, as indicated in this section, most of the program elements are interdependent and rely on data and analyses from several tasks in order to be fully functional and effective as management tools. Therefore, it is critical that all databases are designed, maintained, and updated by a procedure that will ensure accuracy and integration of information, including the acquisition and incorporation of pertinent information from outside sources.

The objective of this program is to provide a systematic and efficient means by which data collection formats, incorporation of data in databases, database management, and integration with modeling efforts can be designed and maintained to maximize the system's ability to support HCP-related management activities. In addition, databases should be updated with the most current and best available information whenever possible from both departmental and appropriate external sources.

For all monitoring and research programs indicated above, the City will integrate data collection formats to make them compatible with watershed GIS systems and provide for mapping and analysis capability. All data collected and incorporated into the GIS system that could support refinement and operation of the modeling efforts proposed below will be collected in a format appropriate for that purpose and compatible with all integrated processing systems to the greatest extent possible. The cost of this linkage will be up to $50,000 in HCP years 1-8 and then up to $25,000 in each HCP year interval 9-15, 16-25, 26-35, 36-50, for a total cost of $150,000 (Table 4.5-7).

FOREST GROWTH AND HABITAT DEVELOPMENT MODELING PROGRAM

Forest growth and habitat development models provide a valuable tool with which to predict and visually depict the general structural changes that are expected to take place within watershed forests over time. Typically, models have been designed to track forest succession and structural development using tree species and site characteristics under scenarios of fire or timber harvest, most often clearcutting. These models might be appropriate to characterize forest succession in a large portion of the Cedar River Watershed that has been logged over the past 100 years if specific site characteristics and environmental conditions are used in the modeling process. However, it is expected that existing models will need to be modified or new models developed to represent and predict habitat structure of forests generated from non-traditional forestry applications such as ecological thinning that may include variable tree densities, multiple species plantings, or conifer underplanting, in riparian corridors.

In addition, because wildlife respond to variations in vegetation structure and composition, an understanding of wildlife responses to changes in forest environments requires a basic knowledge of vegetation potential and changes over time (Irwin et al. 1989). Forest growth and habitat development models linked with wildlife habitat relationship models can be used to assess and predict habitat suitability and distribution for forest dwelling species over time. Therefore, development of an accurate integrated forest growth model customized to the Cedar River Municipal Watershed is important to provide the basic capability to effectively model wildlife habitat relationships (see below).

The objectives of the Forest Growth and Habitat Development Modeling Program are to develop and support a predictive model of forest growth and habitat structural development under varied condition and treatment scenarios. The goals of the program are to depict the resultant structure and distribution in both graphic and map formats for the purpose of fostering appropriate land and habitat management decisions, and to support the Species and Habitat Relationships Experimental Modeling Program discussed below. The City will evaluate applicable existing models and develop a set of forest and habitat growth models (e.g., SNAP) that include the capabilities of scheduling management activities and characterizing forest stand and wildlife habitat structural and spatial development in statistical, graphical, and visually conceptual formats. The cost of modeling will be up to $75,000 in HCP years 1-8 for design (Table 4.5-7).

SPECIES AND HABITAT RELATIONSHIPS EXPERIMENTAL MODELING PROGRAM

Computer modeling of the ecological relationships between selected wildlife species and existing, or potentially available, habitat on variable spatial and temporal scales can be an effective tool for comparing existing and expected habitat distributions over a given landscape area. Although models are necessarily based on many assumptions, the predictive capability of such comparative modeling can be effectively used in many cases as one means to evaluate various habitat conditions for wildlife. The capability both to assess existing habitat conditions and to make comparisons to potential future conditions and distributions can also provide information to support and guide land management and wildlife conservation strategies.

The effectiveness of wildlife habitat models is typically dependent on the extent of ecological knowledge available for an individual or group of wildlife species and the quality of the habitat attribute information. Therefore, in order to support the development of an effective wildlife habitat model for the Cedar River Municipal Watershed, it will be necessary to carefully plan, design, and integrate each aspect (variables measured, data types, formats, analyses, etc.) of all of the monitoring and research programs and their individual tasks described above. Coordinating environmental monitoring and research within the Cedar River Municipal Watershed in this manner will ensure that the information generated and the knowledge gained can be integrated into and can effectively support both the ongoing development and functional refinement of this Species and Habitat Relationship Experimental Model.

The objective of the Species and Habitat Relationship Experimental Modeling Program is to develop an effective model that can predict and test the potential effects of different habitat management scenarios on selected individual species or species groups within the landscape of the Cedar River Watershed. The management scenarios will be specifically customized to both existing and projected future potential habitat distribution and relative quality within the Cedar River Municipal Watershed.

The City will evaluate selected existing species and habitat relationship models for appropriateness of application to the landscape of the Cedar River Municipal Watershed. The City will incorporate appropriate existing models or develop a separate interactive and predictive wildlife species and habitat relationship model that can link with the existing watershed GIS system. This model will also be developed to have the capability to depict forest and wildlife habitat structure customized for use in the Cedar River Municipal Watershed. This may be accomplished in cooperation with appropriate agencies, experts, and City personnel through a series of consultations, workshops, and work groups. The cost of this modeling will be up to $100,000 in HCP years 1-5 for evaluation and design; up to $50,000 in HCP years 6-10 for development; and up $25,000 in HCP years 11-50 for maintenance, for a total cost of $175,000 (Table 4.5-7).

TERRESTRIAL HABITATS AND SPECIES COMPLIANCE MONITORING

The development and continued refinement of a coordinated system of sampling methodologies and data collection for terrestrial habitats and species, combined with customized GIS capability and integrated forest stand management models (e.g., FPS or SNAP), as described above, will provide a systematic means by which to track the effectiveness of specific management prescriptions (e.g., ecological thinning, riparian and upland habitat rehabilitation, and underplanting), natural habitat changes, and ecological relationships of selected species. This coordinated system of information management will contribute, in large part, to the City's ability to provide an assessment of compliance with the terms of the Habitat Conservation Plan.

The City will provide the following types of information, based on the most reliable sources available at the time of reporting, to evaluate compliance with all related terms of the HCP agreement applicable to management and conservation strategies of terrestrial habitats (forested and non-forested):

(1) Maps and appropriate tabular data for all forest restoration activities (acreage of each type of forest restoration activity by year, location, before and after density of any thinning, species planting densities, and other pertinent data).

(2) Tabular data (leave tree density, distribution) and appropriate diagrams representing adherence to management prescriptions associated with restoration and ecological thinning in upland and riparian areas.

(3) Maps and appropriate tabular data (location, acreage, species, etc.) indicating any necessary tree removals in riparian forest and within 200 ft of Special Habitats or in cases where reproductive pairs of covered species are potentially affected (Section 4.2.2).

(4) Maps and appropriate tabular data (location, acreage) documenting habitat classification as habitat units (polygons) are reclassified and remapped after field verification. This would also include new, unmapped habitat units (forested or small wetlands, caves, rock features, etc.) that are identified during the course of ongoing management activities or systematic surveys.

(5) Maps and appropriate tabular data (location, acreage) documenting habitat classification changes as a result of natural and human-caused catastrophic events such as fire, windthrow, or disease.

(6) Maps, tabular data, and relative modeling analyses on an appropriate periodic basis documenting habitat protection, habitat change, and habitat availability over time for species covered by this HCP.

(7) Maps and appropriate supporting information and justification documenting boundary and acreage revisions.

(8) Maps, appropriate tabular data (location, miles, prescription), and brief written summaries documenting road construction, maintenance, and decommissioning activities.

(9) Written and tabular summaries of wildlife surveys and research project results that provide information pertinent to the protection and management of terrestrial species of concern within the Cedar River Watershed (spotted owls, marbled murrelets, and other species that have disturbance restrictions).

4.5.6 Future Reservoir Management

BACKGROUND AND HISTORY

Potential benefits exist for augmentation of both stream flows and water supply through the development of permanent, non-emergency access to water stored below the natural gravity outlet of Chester Morse Lake. The natural lake outlet, at elevation 1,532 ft, limits the amount of water available by gravity flow. The volume of water that remains in the lake below the outlet elevation is referred to as water in dead storage. This water is not accessible for supply without pumping, creating a new drainage structure at lower elevation, or dredging the outlet.

Prior to this HCP, the City could access and use the dead storage of Chester Morse Lake under a permit from the WDOE only in the case of an emergency caused by an extremely severe drought. Under this emergency scenario, the expected frequency of dead storage use is estimated to be only 1 year in 50. A temporary pumping plant was constructed on Chester Morse Lake in 1987 for this emergency purpose.

During the course of the instream flow negotiations, the idea of using a portion of Chester Morse Lake’s dead storage to enhance or supplement instream flows for anadromous fish downstream of Masonry Dam was first raised by agency and Muckleshoot Tribal fisheries biologists. Initial discussions focused on a long-term and regular use that would access the reservoir’s dead storage by a permanent means and not by using the existing temporary pumps. Among the range of possible alternatives discussed was the construction of a permanent drainage tunnel or the installation of permanent pumps.

As a result of these discussions, a proposal was made that the City study and evaluate the water supply, environmental, economic, and engineering aspects of using a portion of the dead storage of Chester Morse Lake on a permanent basis to increase downstream anadromous fish flows as well as to augment municipal and industrial water supply

(Section 4.4.2). A major project such as the permanent use of dead storage takes many years to study, evaluate, plan, and build. For this reason, the operating details of the Cedar Permanent Dead Storage Project have not yet been determined. The frequency that the reservoir's dead storage could be accessed and the lake level elevation that the reservoir could be drawn down to will be key factors in establishing both the value of the project and its potential environmental impacts.

For these reasons, the feasibility and timing of a Cedar Permanent Dead Storage Project are uncertain. If the project is ever built, it may not be built until many years in the future. Partly because they were faced with this realization, agency and Muckleshoot Tribal biologists with the City began exploring the possibility of a more immediate but less regular use of the reservoir's dead storage for anadromous fish flows by using the existing temporary pumps. As a result of these discussions, a new HCP flow regime was negotiated that allows additional water to be released during summer for steelhead incubation. This release of water causes a slight increase in risk to water supply and instream flows in the fall. This slight increase in risk may be partially mitigated by increased flexibility to use the existing temporary pumps to tap the reservoir's dead storage or by reducing instream flows during years of extreme drought. As described in Section 4.4.2, WDOE modified the permit for the temporary pumping plant to allow access to dead storage as a backup under circumstances in which water releases in the summer for fish creates water shortages in the fall, increasing the expected rate of use for the pumps. More details of this provision in the new HCP flow regime are explained in a subsection below entitled "Environmental Evaluation of the New HCP Flow Regime" and also in Section 4.4.

Reservoir management under both the new HCP instream flow regime and under the Cedar Permanent Dead Storage Project may alter lake levels. The potential environmental impacts of changes in reservoir levels are discussed below.

POTENTIAL ENVIRONMENTAL IMPACTS RELATED TO CHANGES IN RESERVOIR LEVELS

The current instream flow regime on the Cedar River, the new HCP instream flow regime, and the as yet undetermined instream flow regime under the Cedar Permanent Dead Storage Project all have the potential to make use of the reservoir's dead storage to a lesser or greater extent. As such, all three operating scenarios have potential environmental benefits and impacts. The negative environmental effects of all three instream flow regimes fall somewhere on an impact continuum, which ranges from very minor to potentially significant. Because the current instream flow regime uses the reservoir's dead storage only under emergency conditions brought on by a severe drought year (approximately 1 year in 50), its environmental impacts are extremely infrequent. The new HCP instream flow regime could access the reservoir's dead storage slightly more frequently, but only to recover a relatively moderate volume of water (alternatively, instream flows may be reduced to recover water). In addition, the HCP flow regime's dead storage access is limited by a strict procedural protocol (see the subsection below entitled "Evaluation of the New HCP Flow Regime" below). In contrast, the Cedar Permanent Dead Storage Project, depending on its specific configuration and operation, has a greater potential for significant environmental impacts. These potential environmental impacts, however, will be thoroughly investigated in a comprehensive environmental evaluation, and potential mitigation options will also be explored prior to implementation of this project. This study is discussed in more detail in the subsection below entitled "Environmental Evaluation of the Cedar Permanent Dead Storage Project."

Both the new HCP flow regime and the Cedar Permanent Dead Storage Project may alter current reservoir levels and the timing of those levels. Both operating scenarios (but particularly the Cedar Permanent Dead Storage Project) may have potential negative impacts to a lesser or greater extent on three species of greatest concern that rely on the reservoir for key habitat. These three species are bull trout, pygmy whitefish, and common loons. Basic habitat needs for these species are discussed in sections 3.6, 3.7, and 3.5, respectively. Potential negative impacts of both operating scenarios on all three species are discussed below.

POTENTIAL BLOCKAGE OR IMPEDANCE OF BULL TROUT SPAWNING MIGRATIONS

A potential impact to bull trout from both the new HCP instream flow regime and the Cedar Permanent Dead Storage Project is the possible blockage or impedance of bull trout spawning migrations in the fall (mid-September through mid-December). The current average, low-water, drawdown elevation of Chester Morse Lake is approximately 1,540 ft. The reservoir's minimum drawdown elevation (lowest elevation) without using the temporary pumps is 1,532 ft. If the Cedar Permanent Dead Storage Project is constructed, the average drawdown elevation of the reservoir will be lower and the new minimum drawdown elevation could be as low or lower than 1,517 ft. At elevations below 1,540 ft, the reservoir's receding waterline begins to expose steeply sloped delta fans at the mouth of the Cedar and Rex rivers. A delta is an accumulation of sediment formed in standing water by deposition at the mouth of a river. When a river enters a reservoir the water velocity and energy are greatly reduced. Therefore, when the sediment-laden water reaches a reservoir, the larger suspended particles and the bedload are deposited as a delta, usually near the head of the reservoir (Linsley et al. 1992). The finer material is carried farther into the reservoir before deposition on the delta. The gradient of the face of the Cedar River's delta fan is about 14 percent, and the gradient of the face of the Rex River's fan is about 17 percent. If exposed by lowered reservoir levels, these steeply sloped delta faces might be potential barriers to bull trout spawning migrations.

The degree of potential impact is smallest immediately below 1,540 ft, as only a short distance of steep gradient stream channel may be exposed. However, as the reservoir level drops below 1,535 ft, the steep channel gradients are believed to extend for sufficient length to potentially impede or block migration (R2 Resource Consultants, in preparation). Actual field observations of this phenomenon with low reservoir levels have never been made.

In an effort to learn if similar situations exist or have ever existed in other Pacific Northwest reservoirs, SPU staff conducted an informal, non-systematic telephone survey of water and hydroelectric utility biologists and managers. Almost all responses fell into one of two categories: (1) respondents either said that currently there *was not* a migration blockage or impedance problem at their reservoir and that they did not know if there ever had been one in the past, or (2) respondents said that they were *uncertain* if there was a current migration blockage or impedance problem at their reservoir and that they did not know if there ever had been one in the past.

The one instance in which SPU staff found that there was a problem occurred in Tabor Reservoir (also known as St. Mary's Lake), Montana, on the Flathead Indian Reservation (Hansen, B., Confederated Salish and Kootenai Tribes, 1997, personal communication). In the 1980's a new reservoir drawdown rule curve was implemented after the signing of a new irrigation agreement. The reservoir's new operating regime caused historically low reservoir drawdowns to occur. Because of the nature of the substrate of the newly exposed reservoir bottom, the reservoir's one bull trout tributary spawning stream braided into a number of critically shallow channels in the newly exposed zone. These shallow braided channels blocked 100 percent of the upstream bull trout spawning migration. An attempt to mechanically dig a new, deeper channel was successful for only 2 days before a higher flow washed it out. The ultimately successful solution was to revise the reservoir's rule curve, which kept the water level higher during the spawning season. The higher reservoir level allowed bull trout to avoid and bypass the shallow braided channel areas.

After construction of the Cedar Permanent Dead Storage Project on Chester Morse Lake, the annual lower drawdown levels may cause the steeply sloped delta fans to flatten out and eventually re-equilibrate to the new average operating conditions. Without detailed field investigations, it is impossible to accurately predict if this re-equilibration will take place, and if it does, how long it might take or whether a new migration barrier might eventually become exposed. Bases on information gained during a preliminary telephone and literature search, the City believes that the re-equilibration of the delta fans could take from one to many years if the Cedar Permanent Dead Storage Project is built. Because the vast majority of bull trout need to migrate through the deltas to reach their spawning grounds, this time before re-equilibration of the delta fans might prevent some or all of the lake's bull trout from spawning in certain years.

POTENTIAL BLOCKAGE OR IMPEDANCE OF PYGMY WHITEFISH SPAWNING MIGRATIONS

Pygmy whitefish spend most of their lives in the deeper portions of Chester Morse Lake and Masonry Pool (Section 3.5.7). However, during early December 1996, City biologists observed spawning migrations of thousands of pygmy whitefish in the Cedar River above Chester Morse Lake. In early December 1997, hundreds or thousands of pygmy whitefish were also observed during spawning migrations in Boulder Creek and the Rex River, as well as in the Cedar River. As the fish make these migrations from the lake into the tributary streams, pygmy whitefish spawners may be vulnerable to potential blockage or impedance of their migrations in the same way that bull trout may be. Because pygmy whitefish appear to spawn later in the fall than most of reservoir's bull trout, however, the lake's elevation is usually higher when their spawning migration takes place. This later timing of spawning combined with the usually higher reservoir levels during this period will tend to reduce substantially but not eliminate entirely the risk of blockage or impedance to pygmy whitefish spawning migrations.

POTENTIAL IMPACTS TO COMMON LOON NESTING

Common loons typically nest at the water's edge (WDFW 1991). On natural lakes and ponds, loons can compensate for small changes in water levels. However, large fluctuations in reservoir levels that can inundate or strand nests, can pose substantial, adverse impacts to the reproductive success of loons. Nesting habitat is potentially available in willow-dominated zones of the Cedar and Rex river deltas and in small areas of Masonry Pool. However, this nesting habitat is currently subjected to springtime water level fluctuations over the course of the nesting season (April through mid-June) of up to 10 ft under the present reservoir operating regime. Implementation of the new HCP instream flow regime or implementation of the Cedar Permanent Dead Storage Project may have an impact on the current level of reservoir fluctuations during the common loon nesting season from April through mid-June.

ENVIRONMENTAL EVALUATION OF THE NEW HCP FLOW REGIME

Background

In some years, high stream flows during the late spring can force steelhead to spawn in areas where their redds will subsequently experience increased risks of dewatering. To address these situations, the City has agreed to provide an additional supplemental block of water to be allocated, as directed by the Instream Flow Commission, in normal years when the need exists for increased steelhead incubation protection and if specific hydrologic conditions and risk-sharing mechanisms provide the flexibility to do so (Section 4.4). The City will, under a defined protocol, supplement normal minimum instream flows by an additional 3,500 acre-feet of water in 63 percent of all years between June 17 and August 4. In addition to providing benefits for incubating steelhead, this supplemental water will benefit rearing steelhead and rearing coho and chinook salmon.

The parties to the Instream Flow Agreement recognize that supplementation of minimum instream flows for anadromous fish early in the dry season increases the overall risk of shortage in meeting both water supply needs and minimum instream flow commitments as actual conditions unfold throughout the summer and fall. In years of shortage, the parties to the Instream Flow Agreement have agreed to allow the City to elect to recover a volume of water equal to the volume released from storage. At the recommendation of the Instream Flow Commission, the City's recovery options may include modifications to the use of the low-normal instream flow curve or use of the existing temporary Chester Morse Lake pumping plant.

Because of this ability to use or even to plan to use some of the reservoir's dead storage and because of other changes in water management under the HCP flow regime, the new regime has the potential to alter water levels in Chester Morse Lake at certain times of year. Lower reservoir levels in the fall potentially may impact the spawning migrations of bull trout and pygmy whitefish, and reservoir fluctuations in the spring may affect the nesting of common loons. In order to compare the frequency and magnitude of potential changes in reservoir levels as a result of the new HCP instream flow regime, the City modeled the current and proposed regimes as described below.

Modeling and Analyses

To assess the incremental effect of the new HCP instream flow regime on Chester Morse Lake reservoir levels, a simplified numerical water balance model of the Cedar River system was used that incorporated representations of (1) the new HCP instream flow regime, and (2) the 1979 Washington State Instream Resources Protection Program (IRPP) minimum instream flow requirements (Section 3.3.2). This model was used for the purpose of providing a comparison of modeled weekly Chester Morse Lake reservoir levels resulting from the two different instream flow scenarios. Both modeled scenarios used simplified assumptions about the Cedar River system and operational constraints. The results from the model are not intended to precisely predict actual future or past reservoir levels in Chester Morse Lake, but rather are used to predict if there will be significant differences in reservoir levels as a consequence of providing the new HCP instream flow regime compared to following the IRPP instream flow regime.

The major assumptions in the model include: (1) historical streamflows are used to represent future streamflows, with historical streamflow records used for this reservoir modeling covering the period from October 1, 1928, to March 24, 1993; (2) the reservoir's full pool elevation is modeled as 1,560 ft for both the IRPP and the new HCP flow scenarios; (3) under the IRPP scenario, the City voluntarily follows the 1979 Washington State IRPP instream flow regime requirements even though the City considers them non-binding; (4) under the new HCP scenario, the City follows the proposed new minimum instream flow regime requirements; and (5) under the HCP scenario, the City provides the supplemental HCP instream flow commitments and uses its best professional judgment to model them. The City notes the difficulty associated with modeling actual real-time operational constraints, and the difficulty in modeling the outcome of the collaborative decision-making processes that will occur between the City, state, and federal resource agencies, and the Muckleshoot Indian Tribe.

Model analyses involved comparisons of weekly reservoir levels between the two regimes during the 13-week bull trout spawning period from 9/16-12/16, the 3-week pygmy whitefish spawning period from 11/26-12/16, and the 11-week common loon nesting period from 4/1-6/16. Additional discussion of the analysis of reservoir operations can be found in Section 4.6 in the effects analyses for bull trout, pygmy whitefish, and common loon.

Results and Discussion

Differences in Lake Levels during the Bull Trout Spawning Season

Table 4.5-2 shows the differences in occurrence and frequency between projected reservoir levels during the 13-week bull trout spawning period modeled under the IRPP flow regime and the new HCP flow regime. On average, the HCP flow regime generally results in slightly lower reservoir levels during the bull trout spawning season compared to the IRPP flow regime. This is understandable because the 13-week bull trout spawning season follows the release by the City of the summer non-firm block of water for downstream anadromous fish. In addition, if necessary for municipal and industrial purposes, the City may recover this previously released water volume from the reservoir in the late summer and fall.

The difference between the projected lake levels for the two operating regimes is less than 1 ft higher or lower 77.9 percent of the time. Under the new HCP flow regime, the reservoir levels are more than 1 ft lower than under the IRPP flow regime 18.1 percent of the time, and 3.9 percent of the time they are more than 1 ft higher. Over the 64+ bull trout spawning seasons, the projected lake levels under the new HCP operating scenario average 0.41 ft lower (1,547.74 ft) than under the IRPP operating scenario (1,548.15 ft)

(Table 4.5-2). Both of these mean elevations are well above the 1,540 ft elevation at which the steeply sloped delta fans begin to be exposed.

Field observations are necessary for verification, but it is believed that an incremental change in lake levels projected for the new HCP flow regime of up to plus or minus 1 ft would likely have little additional impact on bull trout spawning migrations. Modeled HCP reservoir levels are more than 2 ft lower than modeled reservoir levels under the IRPP flow regime 6.7 percent of the time (57 weeks out of 843 weeks), more than 3 ft lower 4.1 percent of the time (35 weeks), and they are more than 4 ft lower only 2.1 percent of the time (18 weeks) (Table 4.5-2).

Table 4.5-2. Differences and frequency of occurrence between modeled weekly Chester Morse Lake levels under the new HCP flow regime and under the IRPP flow regime during the 64+ bull trout 13-week spawning periods (9/16-12/16) using the historical streamflow record between October 1, 1928, and March 24, 1993.

Difference between HCP regime compared to IRPP regime	Number of weeks	Percent of weeks
more than 6 ft higher	0	0.0
5 to 6 ft higher	4	0.5
4 to 5 ft higher	4	0.5
3 to 4 ft higher	0	0.0
2 to 3 ft higher	7	0.8
1 to 2 ft higher	18	2.1
0 to 1 ft higher	54	6.4
0	406	48.2
0 to 1 ft lower	197	23.4
1 to 2 ft lower	96	11.4
2 to 3 ft lower	22	2.6
3 to 4 ft lower	17	2.0
4 to 5 ft lower	9	1.1
5 to 6 ft lower	2	0.2
6 to 7ft lower	5	0.6
7 to 8 ft lower	1	0.1
8 to 9 ft lower	1	0.1
more than 9 ft lower	0	0.0
Total	**843**	**100.0**
No difference (0 ft) to difference less than +1ft or -1 ft	657	77.9
Difference greater than +1 ft or -1 ft	186	22.1
Difference more than 1 ft lower	153	18.1
Difference more than 1 ft higher	33	3.9
Average elevation under IRPP	**Average elevation under HCP**	**Average weekly difference**
1,548.15 ft	1,547.74 ft	- 0.41 ft

The elevation at which the steeply sloped delta fans begin to be exposed is approximately 1,540 ft. There is relatively little difference between the two flow regimes in the amount of time that the modeled reservoir elevations fall below the 1,540 ft level. The IRPP flow regime results in modeled reservoir levels below 1,540 ft elevation 5.1 percent of the time (43 weeks) and the HCP flow regime results in modeled reservoir levels below 1,540 ft elevation 6.4 percent of the time (54 weeks). It is believed that the new HCP flow regime will probably have little additional impact on bull trout spawning migrations.

Differences in Lake Levels during the Pygmy Whitefish Spawning Season

Table 4.5-3 shows the differences in occurrence and frequency between projected lake levels during the 3-week pygmy whitefish spawning period under the IRPP flow regime and the new HCP flow regime. On average, the HCP flow regime generally results in slightly lower reservoir levels during the pygmy whitefish spawning season compared to the IRPP flow regime.

The difference between projected lake levels for the two operating scenarios is less than 1 ft higher or lower 92.8 percent of the time. Under the HCP operating regime, reservoir levels are more than 1 ft lower than under the IRPP operating regime 5.1 percent of the time, and 2.1 percent of the time they are more than 1 ft higher. Over the 65 years of pygmy whitefish spawning seasons, the projected lake levels under the new HCP flow regime average 0.23 ft lower (1,548.47 ft) than those under the IRPP flow regime (1,548.70 ft) (Table 4.5-3).

Field observations are necessary for verification, but it is believed that an incremental change in lake levels projected for the new HCP flow regime of less than plus or minus 1 ft would likely have little additional impact on pygmy whitefish spawning migrations. HCP reservoir levels are more than 3 ft lower than IRPP reservoir levels 4.6 percent of the time (9 weeks), more than 4 ft lower 2.5 percent of the time (5 weeks), and more than 5 ft lower only 1.0 percent of the time (2 weeks).

The elevation at which the steeply sloped delta fans begin to be exposed is approximately 1,540 ft. There is relatively little difference between the two flow regimes in the amount of time that the modeled reservoir elevations falls below the 1,540 ft level. The IRPP flow regime results in reservoir levels below 1,540 ft elevation 6.2 percent of the time (12 weeks) and the HCP flow regime results in reservoir levels below 1,540 ft elevation 6.7 percent of the time (13 weeks).

Differences in Lake Levels and Lake Level Fluctuations during the Common Loon Nesting Season

Common loons, bull trout, and pygmy whitefish are vulnerable to long-term seasonal water level fluctuations over the course of their critical life history periods (typically associated with reproduction). However, in addition to this long-term seasonal vulnerability, loons are also susceptible to short-term (daily) reservoir fluctuations. This is especially true during the time of nest establishment and incubation because nests are typically built at a fixed elevation relative to the current lake level. Unfortunately, the City’s numerical water balance model is capable of predicting only weekly reservoir levels. This modeling limitation should be kept in mind while reading the results and discussion below.

Table 4.5-3. Differences and frequency of occurrence between modeled weekly Chester Morse Lake levels under the new HCP flow regime and under the IRPP flow regime during the 65 pygmy whitefish 3-week spawning periods (11/26-12/16) using the historical streamflow record between October 1, 1928, and March 24, 1993.

Difference between HCP regime compared to IRPP regime	Number of weeks	Percent of weeks
more than 2 ft higher	0	0.0
1 to 2 ft higher	4	2.1
0 to 1 ft higher	7	3.6
0	158	81.0
0 to 1 ft lower	16	8.2
1 to 2 ft lower	1	0.5
2 to 3 ft lower	0	0.0
3 to 4 ft lower	4	2.1
4 to 5 ft lower	3	1.5
5 to 6 ft lower	0	0.0
6 to 7ft lower	1	0.5
7 to 8 ft lower	0	0.0
8 to 9 ft lower	1	0.5
more than 9 ft lower	0	0.0
Total	**195**	**100.0**
No difference (0 ft) to difference less than +1 ft or -1 ft	181	92.8
Difference greater than +1 ft or -1 ft	14	7.2
Difference more than 1 ft lower	10	5.1
Difference more than 1 ft higher	4	2.1
Average elevation under IRPP	**Average elevation under HCP**	**Average weekly difference**
1,548.70 ft	1,548.47 ft	- 0.23 ft

Table 4.5-4 shows the differences in occurrence and frequency between projected lake levels during the 11-week common loon nesting and incubation season under the IRPP flow regime and the new HCP flow regime. Because the non-firm block of water for anadromous fish instream flows is released (if it is available) in the summer and because loons nest in the spring after the winter precipitation has occurred, the comparison of projected differences between lake levels for the IRPP and new HCP operating regimes shows the least difference for any of the three species of greatest concern examined.

On average, during the common loon nesting season, the HCP flow regime results in similar or only slightly lower reservoir levels than are predicted under the IRPP flow regime. The change in modeled lake levels between the two operating regimes during the loon nesting season is within 1 ft higher or 1 ft lower 94.9 percent of the time.

Table 4.5-4. Differences and frequency of occurrence between modeled weekly Chester Morse Lake levels under the new HCP flow regime and under the IRPP flow regime during the 64 common loon 11-week nesting periods (4/1-6/16) using the historical streamflow record between October 1, 1928, and March 24, 1993.

Difference between HCP regime compared to IRPP regime	Number of weeks	Percent of weeks
more than 4 ft higher	0	0.0
3 to 4 ft higher	3	0.4
2 to 3 ft higher	2	0.3
1 to 2 ft higher	12	1.7
0 to 1 ft higher	55	7.8
0	547	77.7
0 to 1 ft lower	66	9.4
1 to 2 ft lower	10	1.4
2 to 3 ft lower	6	0.9
3 to 4 ft lower	3	0.4
more than 4 ft lower	0	0.0
Total	**704**	**100.0**
No difference (0 ft) to difference less than +1 ft or -1 ft	668	94.9
Difference greater than +1 ft or -1 ft	36	5.1
Difference more than 1 ft lower	19	2.7
Difference more than 1 ft higher	17	2.4
Average elevation under IRPP	**Average elevation under HCP**	**Average weekly difference**
1,557.67 ft	1,557.66 ft	- 0.01 ft

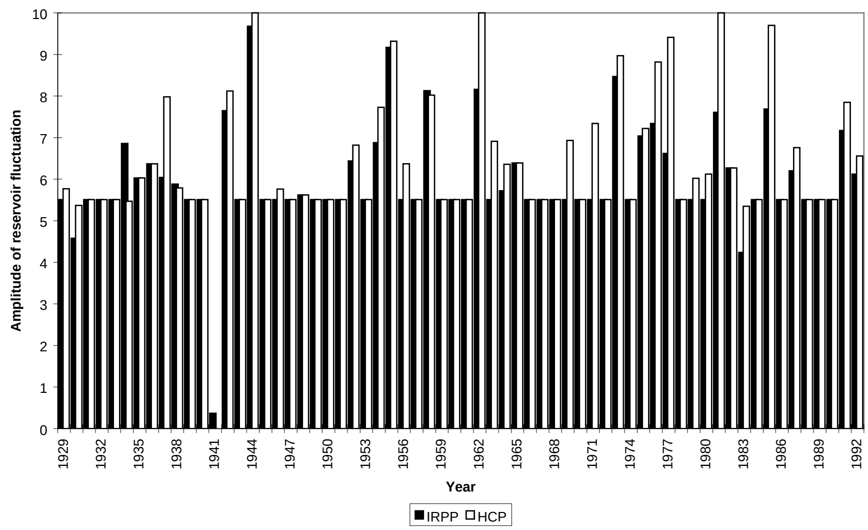
Reservoir levels modeled under the HCP flow regime are more than 1 ft lower than reservoir levels modeled under the IRPP flow regime only 2.7 percent of the time, and they are more than 1 ft higher only 2.4 percent of the time. Over the 64 common loon nesting seasons, the lake levels under the new HCP flow regime are predicted to average only 0.01 ft lower (1,557.66 ft) than those under the IRPP regime (1,557.67 ft) (Table 4.5-4). Field observations are necessary for verification, but in general, it is believed that the relatively small change in modeled lake levels due to the HCP flow regime would likely have no or only minor additional impacts on loon nesting and incubation in the great majority of years.

The loon nesting season roughly corresponds to the time period in which potential inundation of bull trout redds occurs. Because of a relative lack of data and the City's stated assumption that mortality in inundated redds is probably very high (see "Bull Trout Redd Inundation and Egg Mortality Study" contained in section 4.5.4), the potential impacts of the two different flow regimes and their corresponding lake levels on bull trout redd inundation were not analyzed. However, it can be seen from the analysis of reservoir elevations during the loon nesting season that the differences between the two flow regimes during this roughly similar period are very small or nonexistent (~0.01 ft). Another measure of the potential incremental impact of the new HCP flow regime on the nesting of common loons is the amplitude of the reservoir's fluctuations during the nesting season. Amplitude is defined as the maximum absolute value of a periodic fluctuation. The fluctuation amplitude of Chester Morse Lake during loon nesting is the maximum absolute value of the periodic seasonal fluctuations in reservoir elevation that the loons experience over the 11-week nesting season. Nesting loons adapt poorly to fluctuating water levels unless they choose naturally floating logs or are provided with floating artificial nest platforms. Even if floating platforms are used by loons, nests can still be stranded by severe drops in water levels, or if the platforms are under substantial overhead vegetation, nests can be obstructed or tipped over by the overhead vegetation as a result of large increases in water levels. The seasonal fluctuation amplitude may be considered a relative overall index of suitability for successful loon nesting. The additional incremental impact of the HCP flow regime may be examined by comparing its projected amplitude fluctuations with those of the IRPP flow regime during the 11-week loon nesting season over the 64 years of record.

Figure 4.5-1 illustrates that in many years the seasonal reservoir fluctuation amplitudes predicted from the two instream flow regimes are nearly identical. In those years when the reservoir fluctuation amplitudes are greater under the HCP flow regime, the mean amplitude is 0.99 ft greater and the range in amplitude is from 0.15 ft to 2.79 ft greater. In these particular years, loons that use non-floating natural nest sites could potentially have more problems nesting successfully than they would have under the IRPP flow regime. During these same years, loon pairs that select floating nest platforms (natural or artificial) are more likely to be successful.

The mean amplitude of reservoir fluctuations during the 11-week loon nesting season under the IRPP operating regime is 5.99 ft, and the mean amplitude of reservoir fluctuations under the new HCP operating regime is 6.37 ft, or 0.38 ft greater than under the IRPP regime. The seasonal amplitudes of reservoir fluctuations under the IRPP flow regime range from 0.37 ft to 9.68 ft, while the amplitudes of reservoir fluctuations modeled under the new HCP flow regime have a slightly greater range from 0 to 10.00 ft. In the 64 years examined, the mean amplitude of reservoir fluctuations modeled for both flow regimes is the same 51.6 percent of the time (33 years), is greater under IRPP flows 6.3 percent of the time (4 years), and is greater under HCP flows 42.2 percent of the time (27 years).

Figure 4.5-1. Amplitudes of modeled Chester Morse Lake Reservoir fluctuations under the new HCP flow regime and under the IRPP flow regime during the 64 common loon 11-week nesting periods (4/1-6/16) using the historical streamflow record between October 1, 1928, and March 24, 1993.



Further examination of fluctuations in reservoir elevations during the loon nesting season indicates that reservoir levels typically increase during this period in response to melting snow and the planned filling of the reservoir's flood pocket (Section 2.2.4). On average, the reservoir reaches full pool (modeled as 1,560 ft) around the second week of May, which is about the sixth week (5/6 - 5/12) of the loon nesting season.

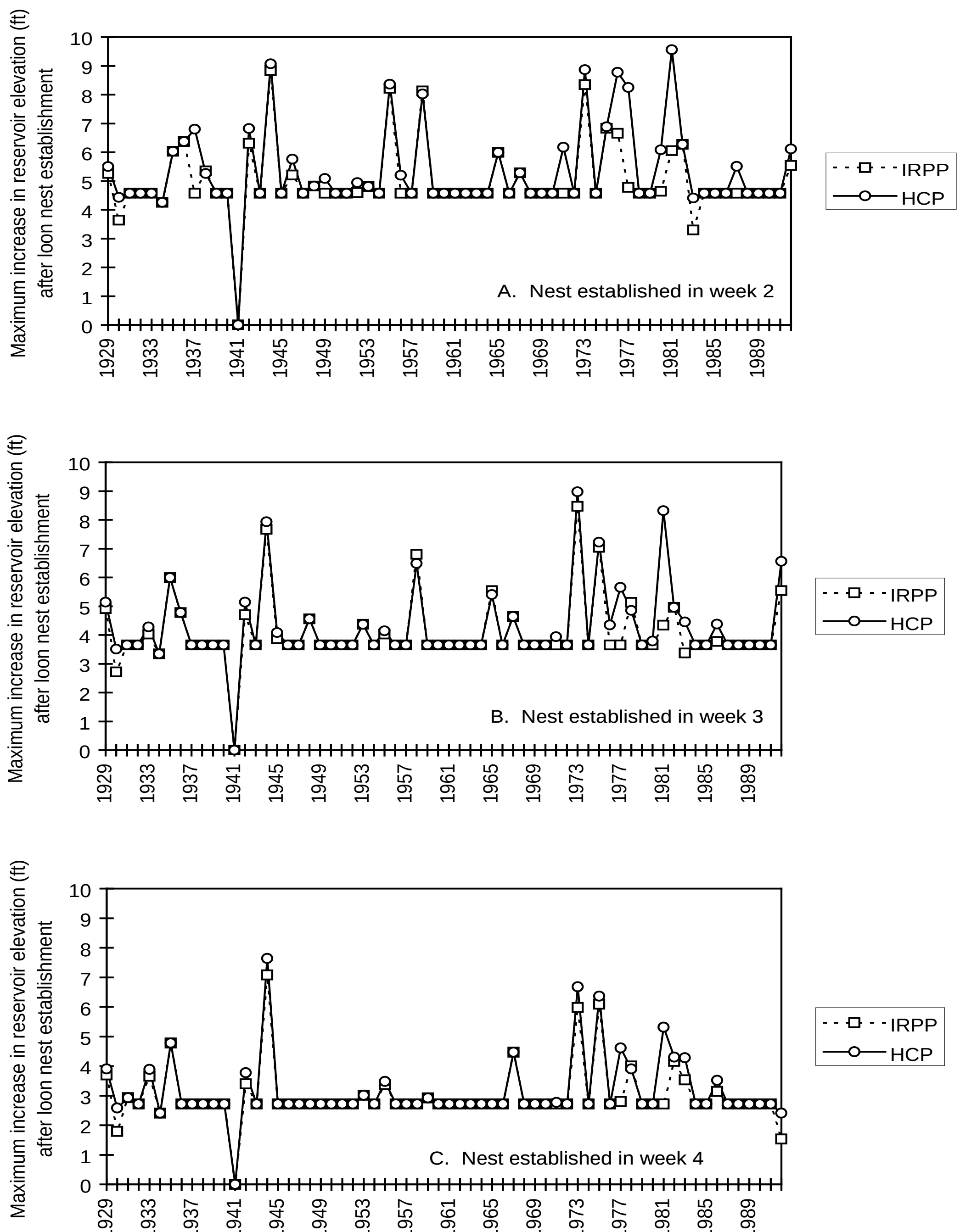
The additional incremental impact of the rise in reservoir levels during the loon nesting season that is a result of the new HCP flow regime is probably relatively small in most years. Averaged over the 3 weeks (4/8 - 4/28) of potential nest establishment for the 64 years of record, the average maximum increase in reservoir levels under the HCP regime is 0.22 ft greater than the average maximum increase in reservoir levels under the IRPP flow regime (Table 4.5-5).

Table 4.5-5. Average maximum increase in modeled Chester Morse Lake levels after each of 3 potential weeks of loon nest establishment under the new HCP flow regime and under the IRPP flow regime during the 64 common loon nesting periods using the historical streamflow record between October 1, 1928, and March 24, 1993. Week 2 of nest establishment is 4/8-4/14; week 3 of nest establishment is 4/15-4/21; and week 4 of nest establishment is 4/22-4/28.

Week of loon nest establishment	Increase in lake levels (ft) under IRPP flows	Increase in lake levels (ft) under HCP flows
2	4.99	5.32
3	4.07	4.26
4	3.00	3.15
Mean of the 3 weeks	4.02	4.24

Loon nest establishment on the reservoir typically occurs between the second and fourth weeks (4/8-4/28) of the 11-week nesting season. Depending on the week of nest establishment, modeled water levels typically continue to rise a maximum of approximately 3-5 ft under both flow regimes. If a loon nest is established in the second week of the nesting season (4/8-4/14), the coincident reservoir level is estimated to increase by an average maximum of 4.99 ft under the IRPP flow regime and 5.32 ft under the new HCP flow regime (Table 457.4). If loon nest establishment occurs later than week 2, it is predicted that the coincident maximum increase in reservoir levels decreases by approximately 1 ft for each week that nesting is delayed. This relationship between the week of loon nest establishment and the average maximum rise in reservoir levels is illustrated in Figure 4.5-2.

Figure 4.5-2. Maximum increase in modeled Chester Morse Lake levels after each of 3 potential weeks of loon nest establishment under the new HCP flow regime and under the IRPP flow regime during the 64 common loon nesting periods using the historical streamflow record between October 1, 1928, and March 24, 1993. Week 2 of nest establishment is 4/8-4/14; week 3 of nest establishment is 4/15-4/21; and week 4 of nest establishment is 4/22-4/28.

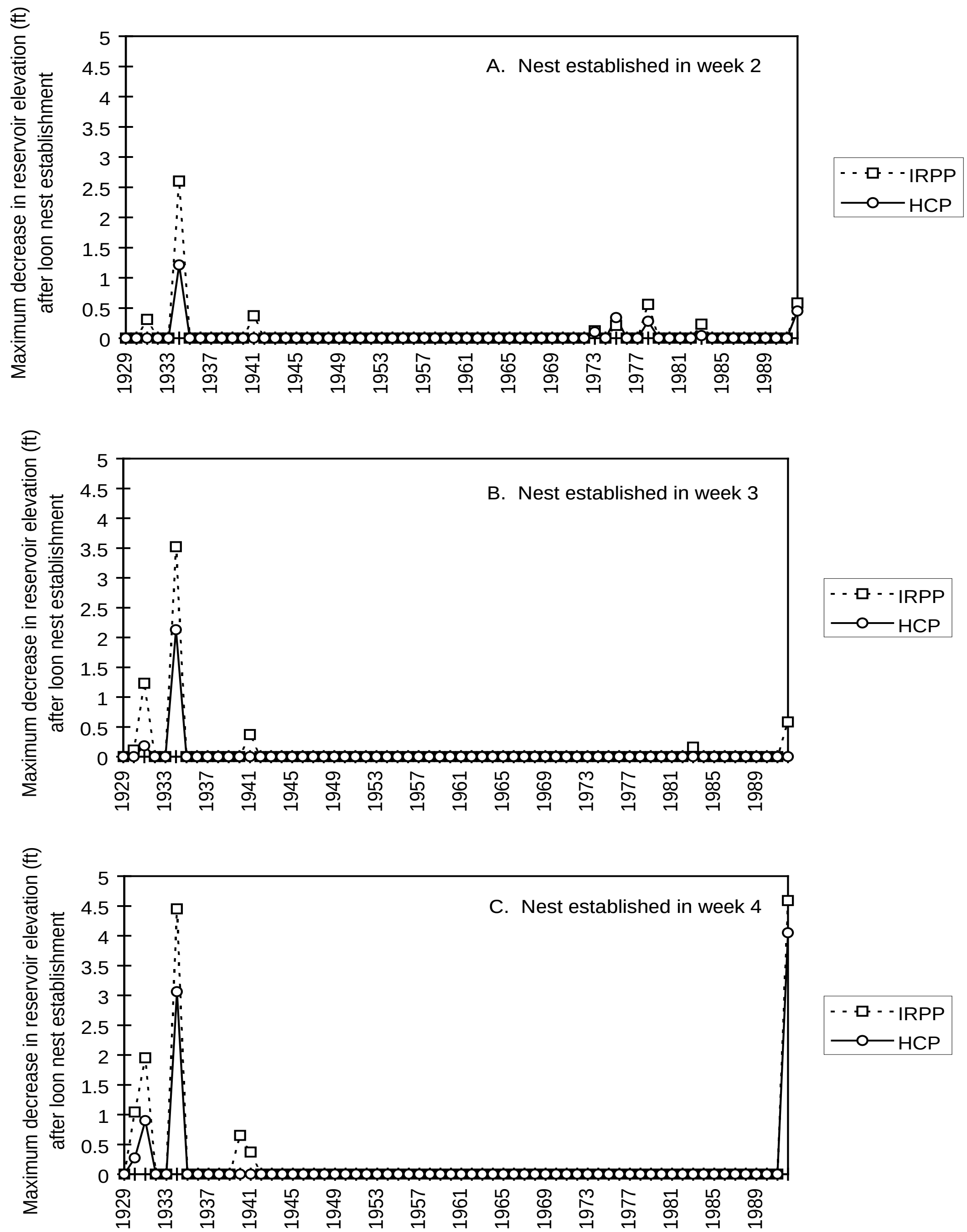


Reservoir water levels in most years typically do not decrease or decrease very little during the loon nesting season. Averaged over the 3 weeks of potential nest establishment for the 64 years of record, the average maximum decrease in reservoir levels under the HCP regime is 0.07 ft and the average maximum decrease in reservoir levels under the IRPP flow regime is 0.12 ft (Table 4.5-6). However, in very dry years loons can experience maximum decreases in reservoir levels from less than 1 ft to almost 4.5 ft (Figure 4.5-3). The incremental impact of the new HCP flow regime on maximum reservoir decreases during the loon nesting season appears to be positive. Although decreases in lake levels are predicted to occur infrequently, the model indicates that they are larger and occur more frequently under the IRPP flow regime.

Table 4.5-6. Average maximum decrease in modeled Chester Morse Lake levels after each of 3 potential weeks of loon nest establishment under the new HCP flow regime and under the IRPP flow regime during the 64 common loon nesting periods using the historical streamflow record between October 1, 1928, and March 24, 1993. Week 2 of nest establishment is 4/8-4/14; week 3 of nest establishment is 4/15-4/21; and week 4 of nest establishment is 4/22-4/28.

Week of loon nest establishment	Decrease in lake levels (ft) under IRPP flows	Decrease in lake levels (ft) under HCP flows
2	0.08	0.04
3	0.09	0.04
4	0.20	0.13
Mean of the 3 weeks	0.12	0.07

Figure 4.5-3. Maximum decrease in modeled Chester Morse Lake levels after each of 3 potential weeks of loon nest establishment under the new HCP flow regime and under the IRPP flow regime during the 64 common loon nesting periods using the historical streamflow record between October 1, 1928, and March 24, 1993. Week 2 of nest establishment is 4/8-4/14; week 3 of nest establishment is 4/15-4/21; and week 4 of nest establishment is 4/22-4/28.



Although the additional incremental impact of the fluctuations in reservoir levels resulting from the HCP flow regime probably is relatively small, the overall negative impact of the large seasonal fluctuations in reservoir water levels under either flow scenario during the loon nesting season is much more significant. This is because nesting loons adapt poorly to fluctuating water levels (unless they choose naturally floating logs or are provided with floating artificial nest platforms, and even then loons often experience nesting difficulties). The largest fluctuations usually occur during the first 6 weeks of the loon nesting season and these coincide with the critical period of nest establishment.

SUMMARY AND CONCLUSIONS

Over the 64+ projected bull trout spawning seasons, 65 projected pygmy whitefish spawning seasons, and 64 projected common loon nesting seasons, the modeled lake levels under the new HCP flow regime average 0.41, 0.23, and 0.01 ft lower, respectively, than under the IRPP flow regime. The differences between the projected lake levels for the two operating regimes are less than 1 ft higher or lower 77.9, 92.8, and 94.9 percent of the time for the bull trout spawning season, the pygmy white fish spawning season, and the common loon nesting season, respectively. For all three species, it is believed that the incremental differences in lake levels projected under the new HCP flow regime will probably have little additional impact on bull trout and pygmy whitefish spawning migrations and common loon nesting success.

In many years the reservoir fluctuation amplitudes during the common loon nesting season predicted under the two instream flow regimes are nearly identical. Over the 64 loon nesting seasons, the mean amplitude of the modeled reservoir fluctuations under the HCP flow regime (6.37 ft) is 0.38 ft greater than under the IRPP flow regime (5.99 ft).

The additional incremental impact of the rise in reservoir levels during the loon nesting season that results from the new HCP flow regime is probably relatively small in most years. Averaged over the 3 weeks (4/8-4/28) of potential nest establishment for the 64 years of record, the average maximum increase in modeled reservoir levels under the HCP regime (4.24 ft) is 0.22 ft greater than the average maximum increase in reservoir levels under the IRPP flow regime (4.02 ft).

Reservoir water levels in most years typically do not decrease or decrease very little during the loon nesting season. Averaged over the 3 weeks of potential nest establishment for the 64 years of record, the average maximum decrease in modeled reservoir levels under the HCP regime (0.07 ft) is actually 0.05 ft less than the average maximum decrease in reservoir levels under the IRPP flow regime (0.12 ft).

The additional incremental impact of the fluctuations in reservoir levels during the common loon nesting season due to the HCP flow regime is probably relatively small. But, the overall negative impact of the large seasonal fluctuations in reservoir water levels during the loon nesting season under either the IRPP or the new HCP flow scenarios is much more significant. Under these circumstances, loon pairs that select floating nest platforms (natural or artificial) are more likely to be successful.

ENVIRONMENTAL EVALUATION OF THE CEDAR PERMANENT DEAD STORAGE PROJECT

The City has agreed to conduct a multi-year evaluation of the Cedar Permanent Dead Storage Project. The Permanent Dead Storage Project has many potential benefits for downstream anadromous and resident fish (Section 4.4). However, the primary focus of the environmental portion of the study and evaluation will be on the potential impacts of the Cedar Permanent Dead Storage Project on resident fish and wildlife upstream of Masonry Dam, particularly bull trout, pygmy whitefish, and common loons. Adaptive management will be a key component of all aspects of the study (Section 4.5.7), and funds can be shifted (Appendix 1) among elements of the biological investigations.

The study of the Cedar Permanent Dead Storage Project will occur concurrently with other reservoir-related HCP studies. To the extent possible and practicable, the City will coordinate all these efforts to maximize their efficiency. The environmental studies may cost up to $745,000 for the period from years 1999 through 2003 (HCP years 1-5). The engineering studies are estimated to cost $700,000 for the same period (Table 4.5-7). If, subsequent to the preparation of this HCP, a decision is made to build the Permanent Dead Storage Project, a site-specific EIS will be developed under SEPA, and an EA or EIS will be developed under NEPA.

Reservoir Modeling

Planning-level reservoir modeling will be conducted to help assess potential environmental impacts of the Cedar Permanent Dead Storage Project. One of the possible first steps in the study may be to model the projected reservoir elevations that likely will occur after the project is constructed and is operational. The frequency and magnitude of potential changes in reservoir elevations may be compared to the timing of the adfluvial bull trout spawning migration, pygmy whitefish spawning migration, and loon nesting season to see if and how often potential conflicts may occur.

Delta Fans Geomorphological Investigation and Modeling

To better understand and determine if bull trout or pygmy whitefish might have difficulty migrating through the delta fan areas, a detailed geomorphological field investigation and modeling analysis may be performed. The objective of this analysis will be to assess the nature of the deltas, their shape, composition, and potential persistence or reconfiguration under the new operating regime for the reservoir.

The investigation and modeling project may include the following four phases:

(1) The initial phase will entail gathering relevant information to facilitate the effective design of more detailed studies later. This information will be used for making decisions regarding the surface area and the depth of the deltas that will need to be mapped, and the preferred methods to be used. Design of this first phase will be based on a literature search, consultation with experts, and an analysis of existing acoustic survey data produced for an earlier dead storage study completed for City Light (Quinlan 1984). Additional fieldwork is anticipated during the first study phase to determine the presence or absence, spatial distribution, and depth of larger-size sediments. The presence of sediments of coarse gravel size or larger or coarse woody debris has been found to seriously limit several survey methods (USDI 1995b). Knowing the maximum

sediment size to be sampled will allow effective choice of the methods and size of apparatus to be used for ground truthing and detailed mapping of the deltas in phase 2.

(2) The second phase of the study will entail mapping the structure of the delta fans to provide information on the response of the deltas to various stream flows at potentially different lowered reservoir levels as input for the final phase modeling effort.

(3) Phase 3 of the study will entail characterizing and quantifying the sediments carried to the deltas by the Cedar and Rex rivers, otherwise known as a sediment delivery budget.

(4) The final study phase will entail developing and calibrating models to predict streamflow and associated delta down-cutting.

Geomorphological sampling and modeling may cost up to $290,000 in HCP years 1-4 (Table 4.5-7).

Bull Trout Passage Assistance Plan

After completion of the delta fans geomorphological investigation and modeling, the City will analyze the results and integrate them with the results of the reservoir modeling study. If the results indicate that the morphology and persistence of the steeply sloped delta fans poses a significant threat to bull trout spawning migrations, either before or after the potential implementation of the Cedar Permanent Dead Storage Project, the City will develop a bull trout passage assistance plan to aid successful upstream passage of bull trout.

In writing the bull trout passage assistance plan, the City will take into consideration the fact that bull trout may be sensitive to handling and the presence of instream structures such as traps. Research indicates that some individual bull trout, after being trapped and released upstream, have altered their spawning migrations and returned downstream (Stelfox and Eden 1995; Oliver 1979).

The final assistance plan can be implemented whenever a relatively dry water year results in an extraordinary low reservoir level, *regardless of whether the proposed Cedar Permanent Dead Storage Project is ever built*. It should be noted, however, that an extraordinary low reservoir water level is more likely to occur after the Cedar Permanent Dead Storage Project is operational, if that project is built. The bull trout passage assistance plan will be completed by HCP year 5 and may cost up to $65,000 (Table 4.5-7). If an extraordinary low reservoir level occurs before the bull trout passage assistance plan is completed, the occasion will be treated as an empirical learning experience. If this occurs, the principles of adaptive management will be applied to minimize the impacts to the bull trout population and to gain an understanding of the consequences of the event.

Adaptive Management and Risks to the Bull Trout Population

The City and the Services recognize that while the Cedar Permanent Dead Storage Project will provide quantifiable flow benefits for downstream anadromous fish, the project poses some risks to the bull trout population in Chester Morse Lake. The City and the Services believe that the watershed management conservation and mitigation measures included Section 4.2.2, along with monitoring and research program (this section) and adaptive management (Sections 4.5.7) proposed in this HCP, will minimize, but may not completely eliminate, those risks. Under an unlikely but worst-case scenario, bull trout could become extinct in Chester Morse Lake. The City acknowledges the grave and extremely unsatisfactory nature of this result. If the Cedar Permanent Dead Storage Project is built, and, in spite of the City's conservation strategies and mitigation efforts described in this HCP, the project endangers the survival of Chester Morse Lake's bull trout population, the City, in consultation with the Services, will take all necessary and reasonable additional steps to correct the problem.

Additional Studies of Impacts to Pygmy Whitefish and Rainbow Trout

The City will conduct an examination of the potential impacts of the Cedar Permanent Dead Storage Project on pygmy whitefish and rainbow trout. The investigation will begin in HCP year 3 or 4. Study design and methods will be worked out at that time with the Cedar Permanent Dead Storage Work Group.

Relatively little is known about pygmy whitefish life history (Section 3.4.6). In order to adequately assess the potential impacts of the Cedar Permanent Dead Storage Project on the population of pygmy whitefish, the City will fund a study to investigate their life history including general seasonal distribution and reproductive habits. The City may conduct a telemetry study as a part of this investigation. Significantly more effort will be spent studying pygmy whitefish than rainbow trout because so little is known about pygmy whitefish, and they are a key item in the diet of bull trout (R2 Resource Consultants, in preparation). The study of the potential impacts of the Cedar Permanent Dead Storage Project on pygmy whitefish and rainbow trout may cost up to $280,000 (Table 4.5-7).

Assessment of Potential Impacts to Common Loon Nesting Habitat

As part of the Cedar Permanent Dead Storage Project evaluation, the City will model the new reservoir operating regime and evaluate the potential for future adverse impacts to common loon nesting habitat on the reservoir complex resulting from fluctuating lake levels. The City may also evaluate the results of the delta vegetation monitoring project in relation to projections of new reservoir fill and drawdown regimes. The purpose would be to determine if impacts to vegetation, such as recession and re-establishment of willow vegetation, might have potential adverse impacts to loon nesting habitat and behavior. Surveys of common loon nesting success on Chester Morse Lake and Masonry Pool will be conducted on an annual basis throughout the term of the HCP. Based on the evaluations above, and any additional pertinent information, the City will decide if and what type of continued monitoring or mitigation is appropriate. The assessment of impacts to loon nesting habitat will cost up to $30,000 (Table 4.5-7).

River Delta Wetland Plant Community Monitoring

Background

In 1987, the City of Seattle completed minor modifications to the two dams on its Chester Morse Lake/Masonry Pool reservoir system and implemented a modified water management program (Section 2.2.5). At that time, a 10-year study was initiated to document baseline conditions in the extensive wetland communities of the two major river deltas in the system, the Cedar and Rex river deltas (Raedeke 1998). Although the study was designed to document changes to vegetation communities resulting from both modified fill and drawdown regimes, particular attention was given to potential effects of extended drawdown conditions created by use of emergency pumps during low water supply conditions at cessation of gravity flow. However, drawdown conditions did not approach extended low levels, and it was not possible to measure impacts to the delta vegetation communities resulting from extended low levels (see Figure 22-1 in Appendix 22). However, impacts to delta wetland vegetation communities resulting from higher late winter and early spring water levels and extended fill regimes were documented (Appendix 20). Impacts included recession of delta sedge and willow communities, and death of mature deciduous and coniferous trees on some of the Cedar River floodplain (Raedeke 1998).

If the Cedar Permanent Dead Storage Project is constructed, both fill and drawdown regimes in the reservoir system may be significantly modified. A key element of those modifications would be a potential new minimum drawdown elevation significantly lower than the natural gravity outlet of the lake at an elevation of 1,532 ft. Potential new extremes of fill and drawdown could create conditions such as inundation, exposure, and desiccation, which significantly affect delta vegetation communities. However, the Raedeke (1998) report suggests that the seasonal timing and especially the duration and persistence of particular conditions may be of even greater significance, as evidenced by the recession of sedges after prolonged inundation during the growing season.

Delta Plant Community Monitoring

As part of the Cedar Permanent Dead Storage Project evaluation, the City will model the new reservoir operating regime, make comparisons to past conditions, and evaluate the potential for future adverse impacts to the delta plant communities (including floodplains). In addition, the City will evaluate the results of the delta vegetation monitoring project (Raedeke 1998) in relation to new reservoir fill and drawdown regimes predicted by modeling exercises. Based on these evaluations and other additional pertinent information, the City will decide if continued monitoring of the delta plant communities is needed. If continued monitoring is necessary, the City then will design and implement the appropriate studies. If needed, future monitoring efforts could be developed as an extension of the recent delta vegetation monitoring project. These could include necessary modifications to the original design to accommodate the potential new lower drawdown elevation resulting from Cedar Permanent Dead Storage Project. The additional study will occur within HCP years 1-5 and may cost up to $80,000 (Table 4.5-7).

4.5.7 Adaptive Management

RELATIONSHIP OF CHANGED AND UNFORESEEN CIRCUMSTANCES TO ADAPTIVE MANAGEMENT

The final No Surprises Policy for HCPs (Fed. Reg. Vol. 63, No. 35, pp. 8859-8873) requires that HCPs identify potential "changed circumstances" that may arise during plan implementation and include measures to respond to those changed circumstances. As defined in the final rule, "Changed circumstances means changes in circumstances affecting a species or geographic area covered by a conservation plan *that can reasonably be anticipated* by plan developers and the [USFWS *or* NMFS] *and that can be planned for* (e.g., the listing of new species, or a fire or other natural catastrophic event in areas prone to such events)" (italics added for emphasis).

In effect, the final rule requires that the adaptive management program in an HCP incorporate provisions for changes in circumstances that an applicant can expect to occur during the term of an HCP and that could affect either the species addressed in the HCP or the potential effectiveness of the mitigation and conservation measures in the HCP. In the case of this HCP, such changed circumstances include moderate forest fires, windstorms, insect and disease outbreaks, landslides, floods, and droughts.

Changed circumstances in this HCP also include the results of three studies described in preceding subsections of Section 4.5 that could provide new information requiring an adaptive response, including (1) the study of accretion flows downstream of Landsburg, with the possible need to adjust instream flows if assumptions are shown to be incorrect; (2) drinking water quality monitoring related to passage of chinook and coho salmon over the Landsburg water intake, with the potential need to restrict the numbers of chinook and/or coho salmon passed above the water intake in order to protect drinking water quality; and (3)studies related to the operation of the sockeye hatchery under adaptive management to minimize impacts on wild fish. The HCP includes mitigation and conservation measures for the 76 unlisted species the City believes most likely to be listed during the term of the HCP; therefore, the potential for new listings of species during the term of the HCP has already been addressed.

Unforeseen Circumstances and Responses by the City and Services

The final No Surprises rule distinguishes "unforeseen circumstances" from changed circumstances in terms of predictability and required actions by a permittee. Under the final rule, unforeseen circumstances are defined as "changes in circumstances affecting a species or geographic area covered by a conservation plan that *could not reasonably have been anticipated* by plan developers and the [USFWS or NMFS] at the time of the conservation plan's negotiation and development, *and that result in a substantial and adverse change in the status of the covered species*" (italics added for emphasis).

In effect, unforeseen circumstances include severe, catastrophic *environmental events that are not predictable as to occurrence or severity*. For this HCP, unforeseen circumstances include (1) the effects of global climate change; (2) earthquakes; (3) significant natural or human-caused events (not the responsibility of the City) that are outside the municipal watershed and that affect species for which some or all individuals spend part of their lives outside the municipal watershed; and (4) and severe forest fires, windstorms, insect and disease outbreaks, droughts, floods, landslides. The criteria for distinguishing changed circumstances from unforeseen circumstances for severe forest fires, windstorms, insect and disease outbreaks, droughts, floods, and landslides are discussed below.

Although some scientists are beginning to speculate as to what changes in disturbance regimes could occur as a result of global climatic change (e.g., Franklin et al. 1991), it is unlikely that consensus among scientists could be achieved regarding the details of such scenarios. Nor could consensus be achieved regarding the type and magnitude of severe earthquakes that might occur in the municipal watershed (or the relevant damage they might cause), nor regarding the type or magnitude of severe events outside the watershed that could affect species addressed in the HCP. Because unforeseen circumstances cannot, by definition, be reasonably anticipated, then such unforeseen circumstances cannot be and are not addressed by the provisions for adaptive management described below under the section entitled "Specific Applications of Adaptive Management for Changed Circumstances."

However, both the City and Services would be greatly concerned should unforeseen circumstances occur. Should a severe environmental event or unexpected facility failure occur, such as an earthquakes or a large-scale forest fire, the City intends to take whatever actions, including emergency actions, that it deems necessary and appropriate to protect water quality, infrastructure, and the environment. Under such circumstances, the Services intend to use their authority under the ESA and other laws to protect listed species and unlisted species covered by the incidental take permit.

The final No Surprises rule provides for response to unforeseen circumstances. Should such circumstances occur, the City and Services would consult as soon as feasible regarding appropriate actions. The final rule states that if additional conservation and mitigation measures are deemed necessary by the Services to respond to unforeseen circumstances, the Services ". . . may require additional measures of the permittee where the conservation plan is being properly implemented, but only if such measures are limited to modifications within conserved habitat areas, if any, or to the conservation plan's operating conservation program for the affected species, and maintain the original terms of the conservation plan to the maximum extent possible." The rule further states that "Additional conservation and mitigation measures will not involve the commitment of additional land, water or financial compensation or additional restrictions on the use of land, water, or other natural resources otherwise available for development or use under the original terms of the conservation plan without the consent of the permittee."

The Services have the burden of demonstrating that unforeseen circumstances exist, using the best scientific and commercial data available. If additional mitigation measures are subsequently deemed necessary to provide for the conservation of a species that was otherwise adequately covered under the terms of a properly implemented HCP, the obligation for such measures does not rest with the HCP permittee, except as provided for under the final No Surprises rule described above. Changes to the HCP could be accomplished by reallocation of resources within the commitments in the HCP, or mitigation could be provided by the Services.

Summary

The provisions in sections 4.2, 4.3, and 4.4 of the HCP were developed to provide for minor disturbances and environmental events, including such events as small forest fires, windthrow, landslides related to expected road failures during winter storms, and fluctuations in precipitation that affect inflows to the Cedar River. The adaptive management program described below includes provisions to respond to the moderate disturbances or environmental events defined as changed circumstances, but does not include provisions for events defined as unforeseen circumstances.

In the discussion below, the range of severity or extent of moderate environmental events that qualify as changed circumstances are defined and distinguished from the levels of the more severe events of the same type that qualify as unforeseen circumstances. Contingency plans for changed circumstances are described that include the actions the City would take in response to such events. The three types of monitoring or studies included as changed circumstances are identified and cross-referenced to other sections of the HCP and appendices in which adaptive responses are described. In addition, adaptive management as used in this HCP is defined and the overall adaptive management program is described. A changed circumstance is just one type of condition that the adaptive management program is designed to encompass.

THE CONCEPT OF ADAPTIVE MANAGEMENT AS USED IN THE CITY'S HCP

Frissell and Bayles (1996) point out that each generation believes that the current ecological management paradigm is the good and proper one, yet history has consistently shown this assumption to be false. These authors argue that none of the schemes for managing ecological systems so far has resulted in truly sustainable resource use and ecological integrity (for a related discussion of the biological integrity of aquatic systems see Karr 1991). Many applications of ecosystem management include commodity production, which increases the challenge of maintaining biological integrity in manifold ways. Acknowledging this challenge, Jensen et al. (1996) argue that ecosystem management should only go forward with the knowledge that it is a continual learning process requiring clear goals, iterative monitoring, evaluation, and redirection.

Adaptive management is an approach that incorporates monitoring and research to allow projects and activities, including projects designed to produce environmental benefits, to go forward in the face of some uncertainty regarding consequences (Holling 1978; Walters 1986). The key provision of adaptive management is the ability and willingness to change adaptively in response to new understanding or information after an action is initiated.

Adaptive management has been used in many ways since the initial development of the concept. It has sometimes been simply a means to move forward in the face of uncertainty, lacking the safeguards inherent in a proper application of the concept. This can occur if some of the components of adaptive management are not clearly defined for a particular application.

One reason why the use of adaptive management has sometimes been less than successful is that no provision was made to limit or define the nature and magnitude of adjustments to a project or activity that may be required. For example, abandonment of a large capital project after it has been constructed and used could produce significant economic dislocations and failure of an organization to fulfill its mission. This outcome is unsatisfactory. Even when changes in levels or types of mitigation may be appropriate, such changes may be perceived as acceptable or unacceptable to different parties to an agreement. Clarifying the limits to and types of such changes early in a project can help to avoid conflict later. The final No Surprises rule (Fed. Reg. Vol. 63, No. 35, pp. 8859-8873), including its provisions for changed circumstances, is an example of both providing for adaptive responses and constraining those responses by prior agreement.

On the other hand, there are circumstances in which management can be adaptive without such a rigorous application of criteria for adjustments developed *a priori*. The City believes that a more flexible approach may be most appropriate for decision-making bodies that deal with real-time decisions and/or a variety of decisions that collectively affect species covered by this HCP. A more flexible approach may also be most appropriate for mitigation or conservation programs that have many elements or projects, each of which has an idiosyncratic set of design constraints and objectives within the overall conservation objectives of the HCP. In these less well defined or more numerous situations, the important concept underlying a successful application of adaptive management is that *cumulative learning* takes place, so that decisions and projects can become more effective over time with respect to the conservation objectives of the HCP.

Adaptive management will generally be used for some elements of this HCP where impacts of activities are uncertain but could be adverse, and, in a general sense, for all restoration elements where techniques are highly experimental. The use of adaptive management within the HCP will provide flexibility to modify specific programs to respond to specified monitoring results, changes in circumstances, or new scientific information, if applicable. It will be applied, in general, to meet the long-term, overall biological goals of the HCP and to ensure that conservation strategies are producing the desired results. For any application of adaptive management in the HCP, no changes to mitigation or conservation strategies will be made that reduce the net biological benefit of the HCP.

The City intends to use adaptive management in this HCP in both of the ways described above: (1) for specific activities and events (changed circumstances), with development of criteria for adaptive changes; and (2) in a more general, flexible sense, with no formal criteria, but with a focus on cumulative learning to make mitigation activities more effective and successful. For specific applications of adaptive management to three key issues where substantial uncertainty exists, plans will be developed based on specific criteria within prearranged and agreed-upon limits, as necessary to meet plan objectives. For events that are defined as changed circumstances, contingency responses are described below. Because they are provided for in this HCP, such changes and responses under adaptive management do not constitute unforeseen circumstances or require amendment of the permit or HCP, unless specified in the Implementation Agreement (Appendix 1). A general description of how adaptive management will be implemented for this HCP is given in Section 5.5, including the schedule for development of specific approaches.

SPECIFIC APPLICATIONS OF ADAPTIVE MANAGEMENT FOR CHANGED CIRCUMSTANCES

General Approach

The City intends to apply adaptive management to many elements of the HCP, but will, at a minimum, develop specific adaptive management approaches for the three issues listed below in this subsection. As discussed above, these three issues meet the definition of "changed circumstances." In addition, contingency plans are described for those types of environmental events defined below as changed circumstances.

In the event of changed circumstances related to environmental events, the City will consult with the Services regarding implementation of the contingency plans described below, including whether alteration of mitigation, within the scope of the HCP, might be warranted. If the City and Services agree that alteration of mitigation is needed, then the City and Services will agree upon any changes to the mitigation described in the HCP. After such agreement, the City will implement the changes to mitigation on a schedule agreed upon by the parties.

Environmental Events Defined as Changed Circumstances

Types of Events Covered by Changed Circumstances

In addition to the three issues related to monitoring mentioned above and discussed below, the Services have also identified six types of environmental events for which they believe this HCP should address changed circumstances: forest fires, windstorms, insect infestations and disease outbreaks, floods, landslides, and droughts. To qualify for treatment under *changed circumstances*, as opposed to *unforeseeable circumstances*, the City and Services *must be reasonably able to anticipate and plan for them*. As described below, relatively small events – in some cases moderate events – of all six types are addressed through the mitigation and conservation measures described in preceding sections of Chapter 4.

Adaptive Management for Forest Fires

Major Considerations Regarding Forest Fires

Fire is the major agent of forest regeneration on the western slopes of the Cascades Mountains in the Pacific Northwest (Spies and Franklin 1988; Agee 1993; Bunnell 1995). The average return interval of severe, landscape-level (stand replacing) fires is about 300 years for Douglas-fir/western hemlock forests (Western Hemlock Zone) in the Mt. Baker-Snoqualmie National Forest (Henderson 1993), and the return intervals for higher elevation forests (Pacific Silver Fir Zone and Mountain Hemlock Zone) are even longer (Agee 1993; Bunnell 1995).

If these average return intervals could be applied directly in this HCP, then there would be about a one in six chance of such a fire affecting any area in the Western Hemlock Zone of the municipal watershed during the 50-year term of the HCP (50/300 years), and a lower chance of fire affecting any area the Pacific Silver Fir Zone (perhaps one in eight to one in twenty). If fires were predictable in this manner, one might predict that about one-sixth of the Western Hemlock Zone might be affected and one-eighth to one-twentieth of higher elevation forests might be affected over a 50-year period.

However, fire return interval in western Washington is *not* a predictable quantity, nor are the specific results of such a severe fire (Spies and Franklin 1988). Historic return intervals are highly variable in western Washington (Campbell and Liegel 1996), and Agee (1993) points out that the notion of a regular fire cycle or return interval is not as meaningful in western Washington as in drier forests, such as those on the eastern slopes of the Cascade Mountains. Agee (1993) describes the fire regime in Douglas-fir forests west of the Cascades as "episodic," as opposed to cyclic, and points out that the observed return intervals are substantially less than predicted by climatic models (900-3,500 years), suggesting that ignitions by Native Americans may have occurred.

Fires can be human caused or of natural origin, and fuel buildup (in the form of woody debris) from insect and disease outbreaks or substantial windthrow can foster ignition, spread, and severity of fires (Oliver and Larson 1990; Agee 1993). Small patch fires create canopy openings and habitat diversity, and are natural processes in forests that should not require mitigation (e.g., see McComb et al. 1993). Frequent, moderate fires that do not burn the canopy are rare in this region compared to such regions as southwest Oregon or eastern Washington (Agee 1993).

The watershed management conservation and mitigation strategies (Section 4.2.2) should provide sufficient buffering in the HCP in the event of relatively small fires. These strategies have the following relevant features:

(1) No timber will be harvested for commercial purposes, so that the removal rate of forest will be largely be determined by the nature, rate, and intensity of natural disturbances such as fire and wind. Absent any such disturbances, at HCP year 50 the acreage of mature, late-successional, and old-growth forest is projected to increase fourfold, producing a landscape much more similar to the average conditions over the last millennium than conditions today (Henderson 1990; Section 4.2.2).

(2) The restoration thinning proposed for the watershed (Section 4.2.2) will be designed to reduce the chance of forest fires by limiting development of conditions that can increase the probability of fire ignition, such as buildup of fuels and development of conditions that might lead to disease outbreaks or insect infestations.

(3) The pattern of mixed ages across the watershed landscape should serve to retard, to some extent, the spread of fires across a large area (Oliver and Larson 1990).

(4) The combination of controlled public access and aggressive fire suppression and control (Section 4.2.2) should serve to keep the chance of a serious human-caused fire starting and spreading lower than for most areas in the region (see also FEMAT 1993).

However, a large fire could cause the destruction of large areas of forest, which could impact habitat connectivity and result in soil erosion, slope failures, and sedimentation of streams, depending on the location, extent, and severity of the fire. If a substantial forest fire were to occur in the municipal watershed, the City would have significant concern for protecting water quality, and the City acknowledges that large fires can cause landscape-level impacts that could alter the effectiveness of forest restoration strategies in providing landscape-level ecological benefits for the covered species. Thus, the primary concerns in the event of a forest fire defined under changed circumstances would be (1) protection of water quality and aquatic habitat, and (2) landscape connectivity and fragmentation for forest habitat.

Changed Circumstances for Forest Fires

Changed circumstances for forest fires are defined as forest fires that remove forest cover on at least 300 acres but less than 2,000 acres in any major subbasin (Map 1). The lower threshold (300 acres) is equal to 10 percent of the smallest major subbasin and 2 percent of the largest major subbasin in the municipal watershed. The upper limit (2,000 acres) is equal to 30 percent of the smallest major subbasin and 6 percent of the largest major subbasin.

Unforeseen Circumstances for Forest Fires

Unforeseen circumstances for forest fires are defined as forest fires that remove forest cover on more than 2,000 acres in any major subbasin (Map 1).

Contingency Plan for Forest Fires

The contingency plan for forest fires under changed circumstances includes the following:

- Measures to reduce erosion and sedimentation, including stabilization of slopes and soils by such steps as reseeding, reforestation, and log terracing, and stabilization of streams and stream banks, if needed;
- Consultation with the Services regarding any planned salvage logging to develop a plan to minimize and mitigate impacts and to best meet the mitigation and conservation goals of the HCP; and
- Reconsideration and adjustment of forest restoration activities (e.g., thinning and planting), with potential changes where needed to minimize further impacts on streams and to accelerate redevelopment of forest in the most impacted areas.

Adaptive Management for Windstorms

Major Considerations Regarding Windstorms

Windstorms in the western Cascades produce small- to mid-scale disturbances that create habitat structure and foster biodiversity in developing stands (Spies et al. 1990). Wind damage is expected to be far less significant than fire in the western Cascade Mountains and generally occurs at a relatively finer scale, typically with damage to single trees or patches of trees less than 10 acres in extent (McComb et al. 1993). The City does not believe that the risk of severe damage from windstorms occurring in the municipal watershed over the term of the HCP is substantial. The landscape forest management proposed in the HCP, as described above for forest fires, provides significant buffering for relatively small losses of forest habitat to windthrow.

However, exposed groups of trees along streams may be particularly vulnerable to wind damage. If such trees were to blow down, the ecological functions of the riparian forest could be reduced or eliminated, resulting in the potential for erosion and sedimentation of streams, depending on the severity and location of the event, with potential impacts to water quality and aquatic habitats. Thus, the primary concerns in the event of a windstorm defined under changed circumstances would be (1) protection of water quality and aquatic habitat, and (2) the ecological functions of riparian forest habitat.

Changed Circumstances for Windstorms

Changed circumstances for windstorms are defined as events that result in (1) complete blowdown of 200 - 500 ft of riparian forest along any fish-bearing stream; or (2) complete blowdown along any stream from which substantial amounts of sediment could be delivered downstream as a result of the blowdown that would result in significant adverse impacts to reaches equal to 200 - 500 ft of a fish-bearing stream (Map 8).

Unforeseen Circumstances for Windstorms

Unforeseen circumstances for windstorms are defined as events that result in (1) complete blowdown of more than 500 ft of riparian forest along any fish-bearing stream; or (2) complete blowdown along any stream from which substantial amounts of sediment could be delivered downstream as a result of the blowdown that would result in significant adverse impacts to reaches equal to more than 500 ft of a fish-bearing stream (Map 8).

Contingency Plan for Windstorms

The contingency plan for windstorms under changed circumstances includes the following:

- Measures to reduce sedimentation, including measures to stabilize slopes, if feasible, by reprioritizing use of funds for riparian and/or stream restoration activities in the HCP;
- Measures to restore riparian forest, including such measures as replanting trees by reprioritizing HCP funds for riparian restoration or other restoration activities; and
- Reconsideration and adjustment of forest restoration activities (e.g., thinning and planting), with potential changes where needed to minimize further impacts on streams and to accelerate redevelopment of forest in the most impacted areas.

Adaptive Management for Disease Outbreaks and Insect Infestations

Major Considerations Regarding Disease Outbreaks and Insect Infestations

Based on historic patterns in western Washington, the chance that a large proportion of the forest in the municipal watershed would suffer disease outbreaks or insect infestations, such as severe episodes of widespread defoliation, can be expected to be small relative to many areas in the Pacific Northwest (Campbell and Liegel 1996). Spies and Franklin (1988) consider disturbances from wind, insects, and pathogens in this region to be “finer scale” than disturbances by fire, and point out that disease spreads slowly, is widely distributed, and may affect 10 percent of stands in a region. McComb et al. (1993) note that such fine-scale disturbances generate forest diversity.

The HCP includes measures to reduce the risk of disease outbreak and serious insect infestations. As Campbell and Liegel (1996) point out, planting and managing for tree species diversity and maintaining a mosaic of age classes should ameliorate risk of such outbreaks. The provisions in the HCP to plant and manage for tree species diversity and the forest thinning regimes (Section 4.2.2) should collectively reduce the chance of developing conditions that might lead to disease outbreaks or severe insect infestations. Should relatively small outbreaks or infestations occur, the projected amount of late seral forest should be adequate to buffer effects on a landscape level (Section 4.2.2). On a small to moderate scale, such events can be considered to be natural phenomena that generate biological diversity (Spies and Franklin 1988; McComb et al. 1993).

However, a substantial insect infestation or disease outbreak that led to defoliation of large areas of forest could impact habitat connectivity, increase the risk of fire through fuel (woody debris) buildup, and result in erosion and sedimentation of streams, depending on severity and location, with potential impacts to water quality and aquatic habitats. If a substantial area were to be affected in this way, the City would have significant concern for protecting water quality, and the City acknowledges that large fires can cause landscape-level impacts that could alter the effectiveness of the watershed management mitigation and conservation strategies in providing landscape-level ecological benefits for the covered species. Thus, the primary concerns in the event of a substantial disease outbreak or insect infestation defined under changed circumstances would be (1) protection of water quality and aquatic habitat, (2) increased risk of forest fire through fuel buildup, and (3) landscape connectivity and fragmentation for forest habitat.

Changed Circumstances for Disease Outbreaks or Insect Infestations

Changed circumstances for disease outbreaks or insect infestations are defined as events that defoliate forests on at least 300 acres but less than 2,000 acres in any major subbasin (Map 1).

Unforeseen Circumstances for Disease Outbreaks or Insect Infestations

Unforeseen circumstances for disease outbreaks or insect infestations are defined as events that defoliate forests on more than 2,000 acres in any major subbasin (Map 1).

Contingency Plan for Disease Outbreaks or Insect Infestations

The contingency plan for disease outbreaks or insect infestations under changed circumstances includes the following:

- Measures to reduce risk of forest fires, such as reduction of fuels from woody debris, but consistent with biological goals of HCP regarding maintenance of large woody debris for ecological reasons;
- Measures to reduce sedimentation, if needed to limit impacts to streams, including measures to stabilize slopes, if feasible by reprioritizing HCP funds for other restoration activities;

- Measures to restore defoliated forest, including such measures as replanting trees; and
- Reconsideration and adjustment of forest restoration activities (e.g., thinning and planting) in the most impacted areas, with potential changes where needed to minimize further impacts on streams and to accelerate redevelopment of forest.

Adaptive Management for Floods

Major Considerations Regarding Floods

Flooding from severe storms is a concern both within the municipal watershed and downstream of Landsburg in mainstem of the Cedar River. Natural peak flows (flood events) perform ecological functions in stream and riparian habitats that create and maintain habitat, such as channel formation, regeneration of deciduous components of riparian forests, sediment transport, and cleaning of spawning gravels (National Research Council 1996). The frequency and magnitude of flood events depends on regional climate and weather, but both the magnitude of peak flows and the severity of impacts can be influenced by human activities and alterations of the landscape.

Large flood events can damage aquatic habitats, particularly in developed areas where the natural capacity of streams and their associated floodplains to absorb floodwaters can be significantly reduced (Booth 1991; Booth and Reinelt 1993; Booth and Jackson 1994). In the Cedar River below Landsburg, narrowing of the river channels to about half its original width, bank hardening along about 64 percent of the river, and extensive development in the floodplain have significantly reduced the natural capacity of the river/floodplain system to absorb floodwaters without damage to fish habitats (King County 1993). Flood flows in the lower river can produce significant scouring of the river bed and loss of the eggs of salmon and steelhead. Because of the development in the floodplain, there is also a public interest in reducing the magnitude of floods for the purpose of protecting property along the river and in the floodplain.

Mitigation to minimize the risk of above-normal peak flows and the effects of such events *within* the municipal watershed is provided in the HCP by designation of watershed forests in reserve status (Section 4.2.2), and by a variety of management guidelines and prescriptions. These guidelines and prescriptions include measures to reduce impacts, such as road improvement and commissioning, and the modification or replacement of undersized culverts with larger culverts or bridges to avoid failures of stream crossing structures during storms, which cause sediment loading to streams (Sections 4.2.2). The proposed mitigation for watershed management (Section 4.2.2) includes funding for road repair and improvements, culvert replacements, and stream restoration in the municipal watershed that is designed to address not only current problems but also expected rates of damage from future storms.

Although the reservoir complex is not designed as a flood control facility, the City attempts to control the effects of river flooding on property and fisheries resources downstream of the Masonry Dam. Some mitigation of flood events downstream of the Masonry Dam is provided by the City's flood control management, but limitations of storage capacity constrain the City's ability to reduce peak downstream flows during such events (Section 2.2.4). The City's flood control activities, however, do not materially impair the habitat-forming effects of floods on the Cedar River, such as channel formation or gravel cleaning. The redesign of the Masonry Dam in the 1980s now allows the City to be able to pass floodwaters from the reservoir equivalent to the probable maximal flood, a capability that protects the dam from failure and protects habitat downstream from the consequences of a dam failure.

Thus, the primary concerns in the occurrence of large flood events defined under changed circumstances would be (1) sedimentation of streams within the municipal watershed as a result of landslides related to road or timber harvest, (2) damage to stream habitats within the municipal watershed from debris flows, and (3) effects on fish habitat downstream of Masonry Dam. A primary effect of floods in the municipal watershed is slope failure related to forest roads or past timber harvest, for which a response is provided below in the subsection discussing landslides.

Changed Circumstances for Floods

Changed circumstances for floods are defined as (1) floods that cause, or are likely to cause, significant long-term adverse alteration of stream habitat conditions in 10-25 percent of the total reach of any fish-bearing stream within the municipal watershed; and (2) floods within the capacity for control by the reservoir facilities.

Unforeseen Circumstances for Floods

Unforeseen circumstances for floods are defined as (1) floods that cause, or are likely to cause, significant alteration of stream habitat conditions in more than 25 percent of the total reach of any fish-bearing stream within the municipal watershed; and (2) floods beyond the capacity for control by the reservoir facilities.

Contingency Plan for Floods

The contingency plan for floods under changed circumstances includes the following:

- Measures to stabilize the unstable material added to the stream and any unstable material that could be the source of further damage to the stream if a flood causes debris flows that have impacted or could impact stream habitat conditions in 10-25 percent of the total reach of any fish-bearing stream; and

- Best efforts by the City to reduce damage to downstream fish habitat, consistent with its other responsibilities regarding water supply and protection of covered species and their habitats, in the event of a severe flood with potential consequences downstream of the reservoir.

Adaptive Management for Landslides

Major Considerations Regarding Landslides

Landslides can be natural or human-caused (Sidle et al. 1985), but the cause of deep-seated landslides (as opposed to shallow, rapid landslides) often cannot be determined. Deep-seated landslides are unpredictable and typically severe in their impacts. Naturally caused landslides are natural processes that create forest openings and provide sediment to streams that creates habitat for a wide variety of species (National Research Council 1996). Human-caused landslides on lands managed for timber production are typically related to forest roads or timber harvest, and often occur as a result of storm events (Sidle e al. 1985).

Mitigation to minimize the risk of human-caused landslides is provided in the HCP by management guidelines and prescriptions, and by a program to decommission and improve forest roads, with predicted long-term improvement of aquatic habitat quality (Section 4.2.2). The program of forest road maintenance, repair, improvement, and decommissioning provides mitigation not only to deal with problems identified during development of the HCP but also to deal with expected future road problems that could cause or do cause landslides that could affect aquatic habitat and water quality.

The primary concern in the event of large landslides defined under changed circumstances is sedimentation of streams within the municipal watershed as a result of landslides related to road or timber harvest.

Changed Circumstances for Landslides

Changed circumstances for landslides are defined as shallow, rapid landslides that are demonstrably related to roads or past timber harvest and that cause, or are likely to cause, significant long-term adverse alteration of stream habitat conditions in 10-25 percent of the total reach of any fish-bearing stream.

Unforeseen Circumstances for Landslides

Unforeseen circumstances for landslides are defined as deep-seated landslides and human-caused landslides that cause, or are likely to cause, significant alteration of stream habitat conditions in more than 25 percent of the total reach of any fish-bearing stream.

Contingency Plan for Landslides

The contingency plan for landslides under changed circumstances includes measures to minimize the occurrence of sediment inputs that could accumulate with the landslide event and exacerbate impacts to streams and covered species that use streams, accomplishing these measures, if feasible, by reprioritizing HCP funds for road maintenance or improvement.

Adaptive Management for Drought

Major Considerations Regarding Drought

Droughts are natural phenomena in the region that affect the City’s ability to provide instream flows for fish and meet its water supply responsibilities. Low stream flows that occur during natural droughts reduce habitat for fish and can be accompanied by increased water temperatures that may reduce survival (National Research Council 1996). Droughts also could affect bull trout and pygmy whitefish, species that use the reservoir but spawn in tributaries, if the reservoir were to be drawn down such that access to those tributaries could be impaired for some period during their spawning seasons (Section 4.5.6).

Mitigation for the effects of droughts on the City’s ability to maintain instream flows for fish is provided in the HCP by commitment to a set of critical flows and procedures and criteria for switching to critical flows (Section 4.4.2). Mitigation for the effects of drought on reservoir operations, and potentially on bull trout and pygmy whitefish, is already provided in the HCP by the mitigation and conservation measures benefiting bull trout and pygmy whitefish, including (1) measures to protect and restore spawning and rearing habitat for both species; and (2) development of a passage assistance plan for bull trout that could be used, if needed, under conditions of significant reservoir drawdown.

In addition, the operation of the Cedar River Instream Flow Oversight Commission (see Appendix 27) provides a large degree of adaptive capability for improving responses to drought conditions over the term of the HCP to best protect fish species addressed. Provisions for water conservation, water shortage contingency planning, and criteria for shifting to critical flows collectively address the issue of drought directly (Section 4.4.2).

The major concerns during droughts are (1) management of instream flows to protect anadromous fish and (2) effects of reservoir drawdown on bull trout.

Changed Circumstances for Droughts

Changed circumstances for droughts are defined as hydrological conditions producing relatively low streamflows characteristic of the worst 10 percent of years for the 64.5-year period of record for the Cedar River (see Exhibit A to the Instream Flow Agreement, Appendix 27).

Unforeseen Circumstances for Droughts

Unforeseen circumstances for droughts are defined as droughts of severity beyond those experienced in the 64.5 period of record for the Cedar River.

Contingency Plan for Droughts

The contingency plan for droughts under changed circumstances includes the following:

- Implementation of the instream flow management included in the HCP, which provides for dealing with droughts through switching to critical flows and criteria for switching to critical flows, as described in Section 4.4.2, and the Instream Flow Agreement (Appendix 27), which includes following a water shortage contingency plan for reducing drinking water demand and use; and

- Implementation of a passage assistance plan for bull trout, after its development, in years when drawdown can be shown to likely jeopardize the ability of the species to move upstream to spawn during a significant portion of the spawning season.

Adaptive Management for Studies or Monitoring under Changed Circumstances

The three issues listed below, and the contingent responses to potential outcomes, are discussed in the sections of the HCP that are cited for each. Each of these issues is defined as a changed circumstance for the HCP. All three issues entail monitoring or other studies related to outcomes about which there is uncertainty. In each case, there is a commitment to adjusting measures in the HCP based on the results of the studies or monitoring.

(1) <u>Accretion Flows</u>. The study of accretion flows downstream of Landsburg, with limited potential adjustment in instream flows based on results (sections 4.4.2 and 4.5.2), as provided for in the Instream Flow Agreement (Appendix 27).

(2) Landsburg Fish Passage. Contingent mitigation if, based on monitoring results, the City must curtail passage of chinook and/or coho salmon over the Landsburg Dam for water quality reasons, including regulatory changes (sections 4.3.2 and 4.5.3), as provided for in the Landsburg Mitigation Agreement (Appendix 28).

(3) Sockeye Hatchery Operation and Effectiveness. Monitoring and operation of the sockeye hatchery needed to control undesired impacts on wild fish and to determine effectiveness in helping to meet long-term goals for harvestable runs (sections 4.3 and 4.5.3), with provisions for altering hatchery operations or developing alternative mitigation, as provided for in the Landsburg Mitigation Agreement (Appendix 28).

The sections cited for each of the three issues described above specify the type and extent of additional or alternative mitigation that would occur under changed circumstances, describe a process for determining that alternative or additional mitigation, or do both.

For each of the three specific applications of adaptive management described above, the City will develop and present in a document, as provided for in the Implementation Agreement (Appendix 1), the following elements and criteria:

(1) A general monitoring and/or research plan based on explicit hypotheses, the biological objectives described in this HCP, and the appropriate research and/or monitoring plans described in the foregoing parts of Section 4.5;

(2) Threshold criteria for triggering additional or changed mitigation;

(3) Limits to the type of and commitments to any long-term mitigation triggered by monitoring criteria;

(4) A procedure for dispute resolution over interpretation of results consistent with dispute resolution procedures specific to the relevant agreement; and

(5) A process for developing and implementing any additional mitigation for which the need is demonstrated and that clearly identifies the responsibilities of the parties involved.

The timing for preparation of the adaptive management plans for the three issues referenced above is specified in Section 5.5.1.

OTHER APPLICATIONS OF ADAPTIVE MANAGEMENT

Adaptive Management as a General Tool

In those cases where adaptive management is used simply as a general tool for adaptively responding to new information or understanding, decisions about effectiveness and changes to mitigation or conservation strategies will be based on the conservation objectives of the relevant mitigation or conservation strategies. Such cases include experimental projects for watershed restoration (Section 4.2) for which adaptive responses can be expected to be needed yet the results of which are not predictable without specific project designs. The adaptive management program and the procedures in Section 5.3.2 (related to shifting funds among HCP mitigation elements) allow flexibility to make changes in this mitigation as needed, even shifting priorities among related types of mitigation or conservation activities. All such changes will be based on whether the projects are appropriately meeting their specific conservation objectives, and each project will be planned expressly so that such judgments can be made through follow-up monitoring. For any such applications of adaptive management, no changes to mitigation or conservation strategies will be made that reduce the net biological benefit of the HCP.

Adaptive Management Related to Instream Flows

Adaptive changes in the allocation of “discretionary water” and other decisions regarding instream flow management will be handled under the provisions of the Instream Flow Agreement through operation of the Cedar River Instream Flow Oversight Commission (Section 4.4.2 and Appendix 27). As described in Section 4.4.2 and Appendix 27, the City will prepare annual instream flow compliance reports, which will include descriptions of decisions made by the City and the Commission with respect to provisions of the non-firm flows and volumes of water. The Commission will review relevant decisions at the end of each year and recommend measures that could improve performance. The City expects that this forum and procedure will result in cumulative learning and incrementally better decisions over time to best protect the anadromous salmonid for which the instream flow regime was developed.

Oversight and Flexibility to Alter Mitigation

Other ways in which implementation of the HCP provides for adaptive management include:

- The operation of oversight committees that will provide advice on project planning, review of progress during the term of the HCP, and adjustments to the plan (Section 5.4).
- The ability to transfer funds among elements of the HCP, or to new elements, but within limits to ensure that the integrity of the plan is maintained (Section 5.3.2; Appendix 1).

New information may become available for some of the species addressed in the HCP during the term of the HCP, either from monitoring or from outside sources. For example, a better general understanding of habitat relations may develop for a particular species dependent on riparian habitat, or survey results may reveal a habitat association in the municipal watershed different from that assumed for such species in developing mitigation and conservation strategies. In addition, the population status or legal status of one or more of the species addressed in the HCP may change during the term of the HCP.

In each of these two above cases, or for other reasons, it may be appropriate to alter mitigation or conservation measures to better achieve the overall conservation goals and objectives of the HCP. Several features of the HCP allow application of adaptive management in such cases: (1) the ability to reprioritize habitat restoration projects and (2) the ability to reprioritize funds or transfer funds among elements of the HCP to new elements (Section 5.3.2; Appendix 1).

For any such applications of adaptive management, no changes to mitigation or conservation strategies will be made that reduce the net biological benefit of the HCP.

Such changes in mitigation and conservation measures would also have to be consistent with provisions of the Instream Flow Agreement (Appendix 27) or Landsburg Mitigation Agreement (Appendix 28), if the affected activities fall within the scope of either of these agreements. The Implementation Agreement (Appendix 1) also provides for minor modifications to the HCP (Appendix 1, § 12.1) and procedures for amending the plan to implement major modifications (Appendix 1, § 12.2).

Limitations on City Commitments

The effects of adaptive management on mitigation measures in the HCP are specified in the Implementation Agreement (Appendix 1). Reduction of specific mitigation may be allowed, but only if such changes maintain or increase the net biological benefits of the HCP (Appendix 1, § 9.3). Except as specified above under the subsection entitled "Specific Applications of Adaptive Management for Changed Circumstances," application of adaptive management in this HCP is subject to the overall cost constraints described in Section 5.3.1, and §§ 7.4 and 9.1 of Appendix 1.

Table 4.5-7. Monitoring and research schedule and costs.

CATEGORY			
Major Element •Element +Sub-element	HCP Years	Costs	Notes
INSTREAM FLOW MONITORING			
Instream Flows			
•Maintain two existing gages	1. year 1-50	$547,000	1. USGS Cedar River below Landsburg Dam $10,940/yr
	2. year 6-50, following fish ladder installation	$246,150	2. USGS Cedar River at Cedar Falls $5,470/yr
•Establish and maintain a new gage above Cedar Falls Powerhouse	6-50, following fish ladder installation	$525,000	$30K to install $11K/yr to maintain
•Install and temporarily maintain a new Renton gage	For an estimated 10 continuous years within 1-13	$121,000	For accretion flow study $30K to install, $9100/yr to maintain
•Establish 2 temporary gages between Landsburg Dam and Renton	For an estimated 10 continuous years within 1-13	$130,000	For accretion flow study $15K/gage to install, $5K/gage/yr to maintain.
Flow Downramping Monitoring	1-50	Included in other costs	Use same gages as above
Lower Cedar River Accretion Monitoring Study	For an estimated 10 continuous years within 1-13	$400,000	
Flow Switching Criteria Study	Completed by the end of year 4	$200,000	
Cedar River Steelhead Redd and Incubation Monitoring	1-8	$240,000	$30K/year
Supplemental Studies	1-8	$1,000,000	Varies by year

CATEGORY			
Major Element •Element +Sub-element	HCP Years	Costs	Notes
ANADROMOUS FISH MONITORING AND RESEARCH			
Fish Passage Monitoring at Landsburg Dam			
•Fish Ladder Counts	For 12 years after fish ladders built	$110,000	$50K equip. $5K/year O&M
•Intake Screening Evaluation and Monitoring			
+Installation evaluation	~6	$15,000	
•Monitoring Fish Carcass Impacts on Drinking Water Quality			
	Most likely in 1, 6, 8, 13, 18, 23	$120,000	$60K in Year 1 for recolonization studies, $10K each year for other monitoring
Sockeye Salmon Monitoring			
•Phase 1: Sockeye Fry and Juvenile Studies			
+Fry condition at release	5-50	$92,000	$2K/year
+Fry marking and mark evaluation			
	1-8, 24-27, 42-45	$320,000	$20K/year
+Wild and supplemental fry trapping/counting			
	1-8, 24-27, 42-45	$560,000	$35K/year
+Fish health	5-12, 24-27, 42-45	$320,000	$20K/year
	13-23, 28-41, 46-50	$300,000	$10K/year
+Evaluation of short-term fry rearing			
	1	$35,000	$35K
	2-4	$30,000	$10K/year
+Lake Washington plankton studies			
°Year-round studies	1-4, 24-27, 42-45	$480,000	$40K/year
°Spring studies	5-12	$56,000	$7K/year
•Phase 2: Monitoring Survival, Distribution, and Characteristics of Returning Adults			
+Adult survival, distribution, and homing studies			
	1-12, 28-31, 46-49	$800,000	$40K/year
+Phenotypic and molecular genetic study of supplemental and wild fish			
	1-4, 9-12, 28-31, 46-49	$480,000	$30K/year

CATEGORY			
Major Element			
•Element +Sub-element	HCP Years	Costs	Notes
ANADROMOUS FISH MONITORING AND RESEARCH (continued)			
Interim Steelhead, Chinook, and Coho Supplementation Monitoring or Restoration Studies			
	1-6		Cost ($720,000) included in supplementation or restoration studies
WATERSHED AQUATIC MONITORING AND RESEARCH			
Experimental Two-year Watershed Stream Monitoring and Research Program			
	-2, -1(project begun prior to effective date of HCP)	($280,000)	Study completed; no further funding needed under HCP
Long-term Watershed Stream Monitoring and Research Program			
		$459,000 total	$50K cap in any one year. Includes temp., channel stability, and BIBI
•Temperature	4-7	$16,000 (estimate)	$4K equip. $3K/year Additional study depending on results
•Channel stability and stream habitat surveys			
	4, 7, 10, 15, 20, 25	$144,000 (estimate)	$24K/year
•Benthic macroinvertebrate sampling and BIBI			
	4-8, 10, 12, 15, 20, 25, 30, 40, 50	$299,000 (estimate)	Only to be initiated if initial BIBI is successful. Early termination if warranted by results. $23K/year

CATEGORY			
Major Element •Element +Sub-element	HCP Years	Costs	Notes
WATERSHED AQUATIC MONITORING AND RESEARCH (continued)			
Watershed Aquatic Habitat Restoration Monitoring			
	4-16, 18, 20, 25, 30, 40, 50	$875,000	Up to $25K/year for years 4, 5, 6. Up to $50K/year for remaining 16 years
Watershed Aquatic Species Monitoring and Research			
•Bull Trout Monitoring and Studies			
+ Bull Trout Surveys and Relative Population Indices			
° Adult Surveys			
- Experimental Fish Weir and Live-Box Trap Counts			
	1-4 (5, 6, 10, 15, 20, 30 depending on results)	$350,000	$200K for year 1-4. Additional years and methods dependent on study results ($25K/year).
-Spawning Surveys			
	1-8	$280,000	$35K/year
-Other Adult Surveys			Included with money for other indices.
°Juvenile/Fry Surveys			
	1-8	$280,000	$35K/year
+ Bull Trout Distribution Studies			
°Bull Trout Telemetry Studies			
- Stream	For 2 years w/in 2- 7	$120,000	$60K/year
- Lake	Within years 3-9	$70,000	
°Stream Distribution Surveys			
	Five times periodically, within 1-20	$60,000	$12K/year
°Bull Trout Redd Inundation and Egg Mortality Verification Study			
	1 or more years within 1-9	$110,000	$55K/year

CATEGORY			
Major Element			
•Element +Sub-element	HCP Years	Costs	Notes
WATERSHED AQUATIC MONITORING AND RESEARCH (continued)			
Watershed Aquatic Species Monitoring and Research (continued)			
•Common Loon Monitoring	1-50	$125,000	Up to $25K/interval: 1-10, 11-20, 21-30, 31-40, 41-50
WATERSHED TERRESTRIAL MONITORING AND RESEARCH			
Watershed Habitat Research and Monitoring			
•Watershed Terrestrial Habitat Inventory			
+Assess "Expanded" Forest Polygon Data			
°Sample and evaluate	1-5	$50,000	
° Redesign and sample	6-10	$25,000	If existing data found inadequate
+Assess "Expanded" Secondary Forest Attribute Data			
° Sample and evaluate	1-5	$50,000	
°Redesign and sample	6-10	$25,000	If existing data found inadequate
+Augment Forest/Habitat Inventory	1-5	$75,000	Finish forest polygon inventory sampling if data incomplete after "assessment" sampling above

CATEGORY			
Major Element •Element +Sub-element	HCP Years	Costs	Notes
WATERSHED TERRESTRIAL MONITORING AND RESEARCH (continued)			
Watershed Habitat Research and Monitoring (continued)			
•Watershed Terrestrial Habitat Inventory (continued)			
+Long-term Forest/Habitat Inventory			
°Design	1-5	$18,750	
°Sample/ Monitor	During intervals: 6-10, 11-15 16-20 21-30 31-40 41-50	 $62,600 $42,500 $37,500 $75,000 $75,000 $82,500	Total $393,850 (including $18,750 above) over HCP years 1-50
+Field Verification	1-5	1-5	$56,220
+Ecological Old Growth Classification	3-10	$74,970	
•Watershed Habitat Restoration Research and Monitoring			
+Riparian Restoration Structural Development			
°Design/initiate	3-8	$35,000	
°Sample/monitor	During intervals: 9-15, 16-25, 26-35, 36-50	$300,000	Up to $75K/interval
+Upland Restoration Structural Development			
°Design/initiate	3-8	$35,000	
°Sample/monitor	During intervals: 9-15, 16-25, 26-35, 36-50	$300,000	Up to $75K/interval

CATEGORY			
Major Element			
•Element +Sub-element	HCP Years	Costs	Notes
WATERSHED TERRESTRIAL MONITORING AND RESEARCH (continued)			
Terrestrial Species Research and Monitoring Program			
•Marbled Murrelet			
+Baseline Survey, Old Growth Forest			
	Any two years of 3-7	$75,000	
+Baseline Survey, Second Growth			
- Design and implement habitat sampling with subsequent sampling to document occupancy, if appropriate	5-8	$150,000	
+Long-term Survey	During intervals: 25-28 and 45-48	$100,000	If murrelets not detected in 2nd growth prior to year 25. Up to $50K/interval
+Experimental Habitat Enhancement			
° Develop/ initiate	7-10	$40,000	
°Habitat enhancement			
	11-20 21-30	$80,000 $10,000	
° Monitor/ survey	During intervals: 31-40 45-48	 $25,000 $60,000	
•Spotted Owl			
+Baseline Survey	One or more years during 3-10	$75,000	
+Site Center Survey	Annually for up to 5 years during intervals: 11-20, 21-30, 31-50	$75,000	Up to $25K/interval
•Optional Species/Habitat Survey(s) in Experimental/Sensitive Habitats			
+Species Survey/Research			
	During intervals: 9-20, 21-35, 36-48	$150,000	Up to $50K/interval

CATEGORY			
Major Element •Element +Sub-element	HCP Years	Costs	Notes
WATERSHED TERRESTRIAL MONITORING AND RESEARCH (continued)			
Data Formats and Geographic Information System (GIS) Compatibility			
	1-50	$150,000	Up to $50K for years 1-8, up to $25K/interval: 9-15, 16-25, 26-35, 35-50
Forest Growth/Habitat Development Modeling Program			
•Forest/Habitat Spatial and Structural Modeling			
	1-8	$75,000	
Species/Habitat Relationship Modeling Program			
•Species/Habitat Relationship Model(s)			
+Evaluate/Design	1-5	$100,000	
+Develop	6-10	$50,000	
+Maintain	11-50	$25,000	
Terrestrial Habitats and Species - Compliance Monitoring		Included in other costs	see text
FUTURE RESERVOIR MANAGEMENT			
Environmental Evaluation of the Cedar Permanent Dead Storage Project			
•Engineering Studies	1-5	$700,000	
•Delta Fans Geomorphological Investigation and Modeling			
	1-4	$290,000	
•Bull Trout Passage Assistance Plan			
	Completed by year 5	$65,000	
•Adaptive Management and Risks to the Bull Trout Population			
			see text
•Study of Impacts to Pygmy Whitefish and Rainbow Trout			
	Begins in 3 or 4	$280,000	Design and methodology to be worked out when study begins.

CATEGORY			
Major Element •Element +Sub-element	HCP Years	Costs	Notes
FUTURE RESERVOIR MANAGEMENT (continued)			
•Common Loon Nesting Habitat Monitoring +Loon Nesting Habitat Assessment		$30,000	see text
•River Delta Wetland Plant Community Monitoring	Twice within years 1-5	$80,000	$60K for dry years, $20K for wet years. (In budget for Cedar Permanent Dead Storage Project Evaluation)