Section 3.2 Contents

3.2 Fish and Wildlife Habitat in the Cedar River Basin

3.2.1 Introduction to Fish and Wildlife Habitat

The Cedar River Municipal Watershed contains a variety of habitat types and habitat conditions for regional fish and wildlife. The elevation and topography of the predominantly forested watershed ranges from the steep crest of the Cascades along its mountainous, eastern boundary to a low-elevation, rolling foothills landscape along its western edge. The Cedar River flows through this basin, continues past the western boundary of the municipal watershed, and flows approximately 22 additional miles to Lake Washington, which is connected to the ocean via the Ballard Locks and Lake Washington Ship Canal (Map 2).

The habitats within the Cedar River Basin have been influenced by major natural and anthropogenic events. The Puget Sound glaciers had a major influence on basin topography, geology, and hydrography of the municipal watershed (Section 3.2.2). In 1916, the ACOE diverted the course of the Cedar River into Lake Washington, from its original discharge into the Duwamish River, and created a new outlet to the lake when it constructed the Ballard Locks and Lake Washington Ship Canal (Chrzsastowski 1983).

In the Cedar River Basin below the Landsburg Diversion Dam, urbanization has been the major influence on aquatic habitats in recent decades, although timber harvest has also been ongoing. In the municipal watershed, timber harvest over the last 100 years has shaped the forested habitats now present, and affected aquatic habitats as well. Water resource management has affected aquatic habitats in the reservoir and the mainstem of the Cedar River below the Masonry Dam. Finally, the fact that the land within the municipal watershed has been managed as surface water supply for nearly a century has had major implications for current conditions in the municipal watershed and downstream in the mainstem.

Wildlife habitat and landscape conditions in the Cedar River Municipal Watershed are discussed in Section 3.2.2. This section focuses on forested habitat, which has been most heavily impacted by past timber harvest management activities. Other habitat types, such as wetlands, lakes, and cliffs are also described.

Section 3.2.3 gives general information on the life cycle of salmon, trout, char, and whitefish as background for the discussion of instream flows and measures to protect and restore stream habitats in the basin. Section 3.2.4 provides information on the status and distribution of fish species and their habitats within the municipal watershed, and Section 3.2.5 provides information on fish habitats in the mainstem of the Cedar River below the Landsburg Diversion Dam.

3.2.2 Terrestrial Habitat in the Cedar River Watershed

BACKGROUND

The ecological basis for the range of plant associations present in the Cedar River Watershed is firmly grounded in the geologic, glacial, and climatic history of the region (Franklin and Dyrness 1973). The distribution of habitat types across the landscape today is not only a product of that ancient history, but also a reflection of a legacy of land use, particularly commercial clearcut logging over the past 120 years (Table 3.2-1; maps 4 and 5). Fire, both naturally occurring and human-caused, has also exerted substantial influence on the successional development of many naturally regenerated stands and previously harvested second-growth forest stands as they now exist.

Managed second-growth coniferous forest that is typical of the public lands on the west slope of the Cascades predominates throughout a majority of the municipal watershed. This second growth exhibits a range of seral stages from recent clearcuts through mature forest. Only 13,889 acres of unharvested native forest, all at least 190 years of age, still remains in the municipal watershed, about 95 percent of which is in the eastern portion of the municipal watershed. Throughout this HCP, this unharvested native forest in the watershed is called old-growth forest.

Forests characteristic of three vegetative zones, based on climax stage, as described by Franklin and Dyrness (1973) are represented within the municipal watershed. The lower municipal watershed is included within the Western Hemlock (*Tsuga heterophylla*) Zone, largely below 2,000 ft. The greater elevation range of the upper watershed encompasses the Pacific Silver Fir (*Abies amabilis*) Zone at mid-elevations (2,000-4,300 ft) and the Mountain Hemlock (*Tsuga mertensiana*) Zone at the highest elevations (above 4,300 ft), especially along ridge crests. Forest vegetation dynamics within the Pacific Silver Fir Zone in the municipal watershed have been described by Long (1976). Vegetation in second-growth forest stands within the Western Hemlock Zone of the watershed has also been described by Long (1973) and by Scott and Long (1972).

In order to describe the existing terrestrial habitat and distribution within the municipal watershed, it is most effective to divide the watershed into two distinct natural regions, generally referred to as the upper and lower municipal watersheds. These designations are based primarily on substantial differences between the two areas relative to their major physiographic features, hydrologic drainage patterns, elevation and aspect, and substantial contrasts in topography, all of which have resulted directly from the divergent geologic and glacial histories of the two areas (see below). In addition to these environmental factors, the 120-year legacy of traditional logging activity carried out by multiple land owners has both dramatically and differentially influenced the myriad types and distribution of habitat types (especially forested types) as they now exist within the upper and lower watersheds.

Table 3.2-1. Acres of forest in different age classes within the upper and lower municipal watershed.

Forested Stand Age (years)[1,2]	Lower Municipal Watershed (acres)	Upper Municipal Watershed (acres)	Total Acres	Total Percent
0-9	1,037	900	1,937	2.1
10-19	600	5,435	6,035	6.7
20-29	669	6.969	7,638	8.4
30-39	2,323	5,281	7,605	8.4
40-49	3,179	7.588	10,767	11.9
50-59	3,239	3,231	6,470	7.1
60-69	11,417	6,462	17,879	19.7
70-79	11,094	777	11,871	13.1
80-89	950	0	950	1.0
90-99	99	13	112	0.1
100-119	12	0	12	0.0
120-189	91	0	91	0.1
Old Growth (>189)	734	13,155	13,889	15.3
Age undetermined	36	185	222	0.2
Sub-Total	35,481	49,996	85,477	94.4
Other Habitat Elements[2]				
Palustrine Scrub Shrub	201	264	464	0.5
Palustrine Emergent Wetland	44	192	236	0.3
Non-vegetated Habitat	25	1,217	1,242	1.4
Vegetated Talus and Felsenmeer	27	302	329	0.4
Upland Meadows and Persistent Shrub	1	203	203	0.2
Developed	319	26	346	0.4
Unclassified	19	15	33	0.0
Open Water	339	1,876	2,214	2.4
Sub-Total	975	4,094	5,069	5.6
Grand Total	36,456	54,090	90,546	100.0%

1 Primarily conifer or mixed conifer/deciduous, but also includes about 1,836 acres of deciduous forest (1,594 acres in lower municipal watershed, 242 acres in upper municipal watershed).

2 Mapped forested wetlands included with forested stands. Shown on Map 6, forested wetlands total 1,063 acres (749 acres in lower municipal watershed, 315acres in upper municipal watershed).

For the purpose of this discussion, the division between upper and lower sections of the municipal watershed is generally represented by the hydrographic boundary separating subbasins east of Cedar Falls, which drain northward into the Chester Morse Lake basin and upper reaches of the Cedar River, from those west and south of Cedar Falls, primarily the Taylor Creek subbasin, which drain into the Cedar River between Cedar Falls and the Landsburg Diversion Dam (Map 1). The upper and lower sections encompass approximately 60 percent and 40 percent, respectively, of the total 90,546-acre watershed.

PHYSIOGRAPHY AND GLACIAL HISTORY OF THE WATERSHED

The marked contrasts in the topography and surficial geology between the upper (eastern) and lower (western) sections of the watershed that are evident today dramatically reflect the origin of parent materials and the divergent glacial histories of the two areas. The combined effects of these geologic and topographic differences, interacting with a marine climate and a wide range of precipitation resulting from the orographic effects of the Cascade Mountains, has largely determined the potential for development of native vegetation communities across respective sections of the watershed landscape. The watershed elevation ranges from 543 ft at the Landsburg Diversion Dam to 5,414 ft at Meadow Mountain in the eastern portion of the watershed. Most of the lower municipal watershed, with the exception of the upper reaches of the Taylor subbasin, is situated below 2,000 ft elevation. In contrast, the upper watershed varies more broadly in elevation, ranging from approximately 900 ft near Cedar Falls to 5,400 ft at the Cascade Crest.

The geologic and topographic differences evident between upper and lower sections of the Cedar River Watershed are the result of the underlying bedrock formations and divergent glacial history of the two areas. A series of volcanic and volcaniclastic rock underlays the entire area of the municipal watershed (Frizzell et al. 1984). These volcanics include rhyolites, andesites, and minor basaltics. The volcaniclastics include flow breccias, conglomerates, siltstones, and pyroclasitic flow deposits. Most of the volcaniclastics are highly weathered.

The lower watershed has undergone repeated glaciation, the most recent activity during successive advances and retreats of the Puget Lobe of the Cordilleran ice sheet, a glacier that originated in British Columbia and extended over much of the Puget Sound Lowland (Mackin 1941; Crandell 1965; Rosengreen 1965). This ice sheet, which occurred between 23,000 and 14,000 years ago, is responsible for much of the present surficial geology of these lower elevations in western portions of the watershed. However, deposits from previous glacial episodes are also present, underlying the younger, more recent deposits.

The final retreat of the Puget Lobe of the Cordilleran ice sheet created a generally uniform topography, including small terraces and low gently rolling hills. Glacial meltwater channels are visible in several areas and glacial eratics are scattered throughout the landscape. Soil parent materials in this area consist mainly of glacial till and outwash, overlying siltstone, sandstone, and volcanic bedrock. Soils derived from these parent materials are typically coarse and well drained, providing moderate to high site class growing conditions for coniferous tree species, as well as understory shrub and herbaceous vegetation types.

In contrast, the geomorphology and topography of the eastern portion of the Cedar River Watershed is the result of alpine glaciation between 20,000 and 15,000 years ago (Rosengreen 1965; Hirsch 1975). The majority of the landscape is characterized by mountainous terrain consisting of both glacial U-shaped valleys, narrow valleys where streams have incised into the hillslopes, steep slopes (60-85 percent), glacial cirques, and broad river floodplains adjacent to Chester Morse Lake. Bedrock formations in this area include volcanic and volcaniclastic rocks of the Huckleberry Mountain Formation, with areas of intrusive igneous rock (Frizzell et al. 1984). Soils derived from these parent materials through differential weathering, movement, and deposition exhibit wide variation throughout the area. The valley bottoms have a veneer of glacial and alluvial deposits usually consisting of basal till and outwash. The wider variation of soil types, in combination with the greater elevation gradient and resultant orographically affected precipitation, has produced an array of both forested and non-forested habitat types across the landscape of the upper municipal watershed that is significantly more diverse than that found in the lower watershed.

FORESTED HABITAT IN THE LOWER WATERSHED

Introduction

About 95 percent of the landscape of the lower municipal watershed is occupied by forested habitat types, with only a few non-forested habitats (e.g., open water, palustrine wetlands, and rights-of-way) represented in any appreciable amounts (Table 3.2-1). The current forested landscape of the lower watershed is dominated by a relatively homogeneous canopy of second-growth coniferous or mixed coniferous/deciduous forest that has regenerated after the original timber harvest. Major species present include Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), western red cedar (*Thuja plicata*), and red alder (*Alnus rubra*), with a minor presence of true firs (*Abies* spp.), Sitka spruce (*Picea sitchensis*), big leaf maple (*Acer macrophyllum*), and vine maple (*Acer circinatum*).

The spatial distribution and condition of forest stands visible today basically reflect the historic pattern of logging activity, primarily the harvest of old-growth forest, on the municipal watershed. Harvest began in the lower watershed during the 1880s and rapidly expanded throughout the lower elevations until the 1930s. Harvest of low-elevation forests declined during the next few decades as intensive activities shifted to higher elevations in the upper watershed, with the shift from railroad-based to truck-based logging operations (see below). Little, if any, harvest of second-growth forest was undertaken until a low level of scattered harvest units including some commercial thinning and windthrow salvage was carried out during the 1960s, 1970s, and early 1980s. Since 1985, only a few hundred acres of second growth, and no old growth has been harvested by the City (Section 2.3.10). In this same period, about 2,300 acres of old growth was harvested by the USFS, and about 1,300 acres by private landowners.

Old-growth Forest in the Lower Watershed

Only about 734 acres of unharvested native forest remain in the lower watershed. The old growth that does persist exists in relatively small, isolated stands that are surrounded and widely separated by continuous stands of young and mature second-growth forest. These stands are found at several different elevations (Map 5).

Second-growth Forest in the Lower Watershed

About 12,255 acres of the lower watershed is in 70-119 year old forest. Over 99 percent of the forest in that age class is between 70 and 99 years old. The 91 acres between 120 and 189 years represents remnant stands that were high-graded, leaving a mix of some older legacy trees with the new second growth.

The earliest logging activity took place in the middle reaches of the Taylor Creek and the lowest reaches of the Walsh Lake subbasins (Map 1), and in several areas both north and south of the mainstem of the Cedar River. Most stands in these areas that are a result of regeneration harvest are presently 60-89 years old and represent most of the older second-growth forest in the lower watershed. A total of 23,461 acres is in this age class in the lower watershed. Because soils within much of this area provide moderate to high-quality growing conditions, many stands in this area have the relatively large trees, vertical and horizontal structure, and higher snag densities of mature forest habitat.

Forest stands in the lower watershed that are between 40 and 79 years old, including by far the majority of age classes, are spread throughout the landscape, mostly at low and mid elevations. These even-aged stands occupy a relatively wide range of soil types that have mostly moderate, although varied, growing conditions. For the most part, forest development is well advanced in these stands. Some self-thinning has taken place below the canopy, and a limited understory is present in some stands. The degree of development of the shrub layer in these stands directly reflects the extent of canopy opening (and light penetration), which is a result of natural self-thinning or commercial thinning.

With few exceptions, forest stands in the lower watershed of age 20-39 years (totaling 2,992 acres) are mostly found in the upper reaches of the Walsh Lake and Taylor Creek subbasins (Map 1). These stands are typically dense, with nearly complete canopy closure in many cases. A sparse to moderate shrub layer is present in some stands, but development of an herbaceous layer is typically lacking.

Recent Timber Harvest in the Lower Watershed

Harvest of second-growth forest during the past 20 years in the lower watershed has been limited to a few clearcuts and windthrow salvage sales during the 1970s and early 1980s north of the Cedar River and along the southern boundary of the municipal watershed. In addition, approximately a dozen harvest units completed since 1985 are present in the lower Taylor Creek subbasin. These units were harvested with the New Forestry approach, which emphasizes the retention of biological legacies, such as large living trees and snags (Franklin 1989). The units have been replanted with a diversity of conifer species, and some have been precommercially thinned.

Shrub and herbaceous layer development varies widely throughout recently harvested stands depending on the relative degrees of ground disturbance, planting density, commercial thinning application, and canopy retention. One particularly significant difference between the traditional clearcut and salvage units and the New Forestry type of harvest units is that in the New Forestry units a percentage of the original overstory trees are retained. The trees are retained either in aggregate or dispersed patterns to foster the development of mixed-aged, biologically diverse stands, instead of even-aged, homogeneous stands regenerated by clearcutting.

Douglas-fir and western hemlock are the dominant species comprising both pure and mixed species stands throughout the lower watershed. Western hemlock dominates the mid-understory of most stands and is also the most commonly found and most prolific tree species naturally regenerating under existing canopies in second-growth forest stands. Shrub layers are usually dominated by vine maple, salal (*Gaultheria shallon*), and sword fern (*Polystichum munitum*) where canopies are relatively closed, and include salmonberry (*Rubus spectabilis*) and other *Rubus* species where canopies are more open. Mixed stands containing both coniferous and deciduous species are also present in many areas of the lower watershed, but are found mostly in forested wetland and riparian habitats. Pure hardwood stands, dominated by red alder, are infrequent and found mostly in especially wet or riparian areas.

Riparian Corridors in the Lower Watershed

The most extensive riparian habitat in the lower watershed exists adjacent to the main, low-gradient channel of the mainstem Cedar River between Cedar Falls and the Landsburg Diversion Dam. The floodplain of the Cedar River in this reach is relatively narrow and is dominated by pure and mixed stands of second-growth conifer forest. Historically, the City has managed the forests in this corridor, especially immediately adjacent to the river channel, in a manner that discourages deciduous forest species, such as red alder and cottonwood, and maintains conifers next to the river channel. This practice has resulted in a mature, conifer-dominated forest along most of the river course. Red alder is present in a patchy distribution either where natural disturbance has opened the canopy adjacent to the river channel or in some areas where the river frequently exceeds its banks during high and peak flows and covers portions of the floodplain. Conifer species most prevalent in this riparian corridor are Douglas-fir, western hemlock, Sitka spruce, and western red cedar.

Other streams in the lower watershed are substantially smaller in physical dimensions and annual discharge volume than the mainstem Cedar River. These streams are typically of low gradient over most of their length and only become steep in their relatively short, uppermost reaches. Most of the old-growth forest originally adjacent to these streams was completely removed when the area was harvested in the late 1800s and early 1900s, and consequently, the forest in these riparian corridors is presently in some stage of recovery.

Forest vegetation adjacent to many of the lower gradient stream reaches has regenerated since harvest and is presently 50-80 years old, with trees of large size. In these areas, conifer forest extends to the channel edge or completely spans the channel, and deciduous species are essentially excluded. However, in some reaches substrates are unstable, channels are meandering on narrow floodplains, and red alder repeatedly colonizes the stream corridors. Where red alder persists, the area it occupies is usually relatively narrow and not extensive. Site-specific conditions typically vary widely in these smaller stream channels and adjacent forest habitat varies accordingly (Cupp and Metzler 1995).

Ecological Considerations in the Lower Watershed

Lack of Biological Legacies and the Historical Effects of Fire in the Lower Watershed

One characteristic of the majority of forest stands throughout the lower watershed, with the exception of some of the oldest second-growth and remnant old-growth stands, is the conspicuous absence of biological legacies (large old-growth trees, snags, and logs) typical of stands regenerated after moderate natural disturbances (Spies and Cline 1988). The obvious lack of this type of ecological structure in the second-growth forest of the lower watershed can be directly attributed to a combination of historical logging techniques – including clearcutting, and slash burning and removal - and fires. Snags and logs not removed during original logging activities were either destroyed during these fires, which were frequent in the first 2 decades of the century, or they were later salvaged.

Natural lightning-caused fires have not played a major role during the last 100 years in determining either the types or the distribution of second-growth forest stands in the lower municipal watershed. However, human-caused fire has played a definite role in determining the structural diversity of most second-growth stands, as well as the timing of forest development in some cases.

Broadcast burning of slash was typically practiced as a form of site clearing and preparation after logging during the time when a majority of the lower watershed was being harvested. This standard practice removed or severely damaged much of the large woody debris present on the forest floor and destroyed most of the large snags originally present in the old-growth forests being harvested. These components are an integral component of naturally functioning forest ecosystems, especially old growth, and are extremely difficult to restore.

A second type of human-caused fire also affected the establishment and timing of successional development in many second-growth stands in the lower watershed, and as a result also affected their structural development to some degree. This type of fire was typically caused by ignition from trains passing through young regenerating stands. These fires also destroyed woody debris and snags, but more importantly, destroyed conifer regeneration and delayed stand development. As a result, some areas that should have stands at a more mature stage of development are younger and less developed than would otherwise be expected relative to the date of initial harvest.

An ecological benefit of human-caused fires might be that stands affected by fires of this type potentially develop greater structural diversity than planted or managed stands or stands developing in theses areas without such fires. Whatever the effects of fire within these second-growth forests, they are largely overshadowed by the cumulative effects of logging.

Lack of Diversity in Even-aged Stands in the Lower Watershed

Most second-growth forest stands in the lower watershed that have regenerated since initial harvest in the late 1800s and early 1900s have developed a uniform stand structure characteristic of even-aged stand management applications. Even-aged stands are typically of single species composition, with trees of relatively uniform height and diameter. Canopy foliage is consistently at the same height, and multiple layers of understory subordinate tree species are seldom present. The canopy in such stands effectively prevents sufficient light penetration to support shrub or herbaceous vegetation layers in the understory or on the forest floor. As a result, even-aged stands presenting these conditions are generally considered of lower habitat quality for most wildlife species than more biologically diverse, uneven-aged stands (Brown 1985a).

In contrast, uneven-aged stands typically contain multiple coniferous and deciduous tree species, multiple vegetative layers, an uneven canopy, more understory shrub and ground-level herbaceous vegetation, and generally a greater degree of vertical and horizontal internal structure. Because these features collectively provide more niches for a greater variety of wildlife species, uneven-aged forest stands are considered of higher quality as habitat for animals (Brown 1985a).

One of the major challenges of habitat management is the restoration of biological diversity to even-aged forest stands, especially because many components such as large snags and logs are essentially absent. Major investments of labor and finances have been used in many habitat restoration, research, and monitoring studies to determine the most efficient and effective methods to accomplish the task of replacing biological diversity in forest stands and restoring natural ecological function. Altering harvest methods to retain biological diversity and protecting habitat with reserve systems would appear to be a viable and efficient alternative to continued efforts at restoration (Franklin and Forman 1987; Franklin 1992).

NON-FORESTED HABITAT IN THE LOWER WATERSHED

Only small patches of non-forested habitat break the nearly homogeneous canopy of second-growth conifer forest in the lower municipal watershed. This non-forested area is comprised almost exclusively of open water, a few wetlands, several rights-of-way, and roads (maps 1 and 6).

Open Water in the Lower Watershed

Very few bodies of open water are present in the lower watershed (Map 6). Only two exist of appreciable size: Walsh Lake (69 acres) near the western watershed boundary and Rattlesnake Lake (111 acres) near Cedar Falls. Of the other bodies of open water present, none exceeds 5 acres in size.

Wetlands in the Lower Watershed

The major wetland habitats in the lower watershed are a small scrub-shrub system at the northern boundary and a larger more complex system surrounding and east of Walsh Lake (Map 6). The Walsh Lake complex includes emergent, scrub-shrub wetlands and an extensive forested wetland area along lower Rock Creek. A few smaller, less diverse areas of wetland habitat are dispersed within the lower watershed at Fourteen Lakes, Rattlesnake Lake, and at Barneston. Other small wetland areas exist, but are dispersed and not associated with larger complexes.

Rights-of-way in the Lower Watershed

Three power line rights-of-way, the Raver-Monroe line running north-south, the large Bonneville line at the southern border, and the small transmission line immediately adjacent to the 50 Road (Map 13), represent the only significant open, non-forested terrestrial habitat within the lower watershed. Apart from recently harvested areas, these small areas represent the majority of open habitat that provides any appreciable amount of grass-forb vegetation for grazing wildlife species. They also create travel corridors.

Roads in the Lower Watershed

The lower watershed contains approximately 290 miles of forest roads that act as travel corridors and foraging areas (edges) for many larger wildlife species and provide edge habitat for many smaller species. These roads are shown on Map 11 and discussed in Appendix 17. As indicated in Table 17-1 in Appendix 17, road densities in the lower watershed vary among subbasins from 2.8 to 5.4 miles per square mile.

FORESTED HABITAT IN THE UPPER MUNICIPAL WATERSHED

In contrast to the nearly unbroken second-growth forest canopy of the lower municipal watershed, the upper municipal watershed landscape displays a substantially wider range of seral stages, as well as more diversity within both forested and non-forested habitat types. As in the lower watershed, the forested landscape of the upper watershed is dominated by coniferous forest types, and the distribution and condition of forest stands reflects a characteristic pattern of logging activity. However, only traditional clearcut harvesting has been employed in the upper watershed, and no New Forestry units with green-tree retention have been established.

In contrast to the uniformly older second-growth forest of the lower municipal watershed, the forested landscape of much of the upper municipal watershed is largely a mix of recently harvested areas and unharvested old growth. The younger stands range from recent clearcuts through young second-growth forest, and the old-growth forest ranges from 190 to 850 years of age. Further contrasting with the lower watershed is the more diverse range of non-forested habitats of the upper watershed, which includes Chester Morse Lake, Masonry Pool, other lakes and ponds, wetlands, talus and felsenmeer rock slopes, cliffs, and upland meadows interspersed throughout the forested landscape.

Major logging activity shifted from the lower watershed and began in the upper watershed by the early 1920s, within two decades of the development of Cedar Lake (now Chester Morse Lake) as the primary source of Seattle’s water supply. Until the mid-1940s, logging of old-growth forest was concentrated around Chester Morse Lake and at the lowest elevations in the lower two-thirds of the Rex River drainage and the lower reaches of the upper Cedar River, east of the lake, up to an elevation of approximately 2,500 ft. From the mid 1940s through the 1960s, logging activity expanded eastward through the lower elevations of the Cedar River drainage into mid-reaches of the Rex River system, moved higher into many smaller tributary systems within the lake basin, and also moved into most major stream systems in eastern and southern sections.

In the 1970s and early 1980s, logging activity intensified and was concentrated in the upper, higher-elevation basins of both major and minor tributaries, including Boulder, Lindsay, Seattle, and Goat creeks and the Rex River, as well as in smaller basins along the northern boundary of the municipal watershed. While only harvest since 1985 by the City was in the lower watershed, some harvest of old-growth forest took place on USFS land between 1985 and the time when the land exchange with the City was completed in 1996, giving the City complete ownership of land within the municipal watershed (Section 2.3.10).

Old-growth Forest in the Upper Watershed

Of the 13,889 acres of unharvested native coniferous forest over 190 years old that remains within the municipal watershed, 13,155 acres (95 percent) lies within the upper watershed. Little of that unharvested native forest remains below an elevation of 2,500 ft, or west of the Cedar River delta in Chester Morse Lake. There are a few fragmented and isolated unharvested native stands in small upper drainage basins and scattered along the highest ridge lines, but the majority of the unharvested forest is located in relatively large, high-elevation, essentially roadless and contiguous blocks of habitat in the eastern one-third of the municipal watershed.

In most cases, broad expanses of relatively young second-growth forest either completely surround or separate adjacent blocks. These unharvested forest blocks are concentrated in areas that (1) surround Abiel and Tinkham Peaks along the northeastern boundary; (2) are immediately west of Meadow Mountain at the eastern boundary; (3) surround Goat Peak on the southeastern boundary; (4) surround Findley Lake; and (5) include the upper Rex River basin. The considerable acreage formerly in USFS ownership in this area was included in the Critical Habitat Unit (CHU) intended to be protected for the benefit of the spotted owl (Northern Spotted Owl CHU WA-33: USDI 1992b), and also as a part of the federal late-successional reserve system in the Northwest Forest Plan (Section 2.3.4).

Most of the old-growth forest in the upper watershed is between 190 and 350 years old, but a few scattered stands, particularly in the upper Rex River basin, contain individual trees up to 850 years of age. All of these stands may be referred to as old growth from the perspective of chronological age. However, from the perspective of ecological function, they vary widely in the extent of development of both vertical and horizontal structural components that may meet old-growth definitions (e.g., see Bolsinger and Waddell 1993). Because it is likely that the relative state of development of these structural components within a stand determines its relative level of ecological function within a dynamic old-growth ecosystem, it is reasonable to assume that the relative habitat value also varies substantially throughout the unharvested forest of the upper watershed.

Many stands, especially on south-facing slopes, have high stem and canopy densities, relatively small diameter trees, and very limited understory development; others are more open and park-like. However, nearby stands of similar chronological age but under better growing conditions have fewer but larger trees, a partially open canopy, understory and shrub layer development, and large woody debris on the forest floor. Individual stands exhibiting more of the ecological characteristics and structural development of old growth are present in the upper Rex River basin, the North Fork of the Cedar River drainage, and the area surrounding Goat Peak.

Second-growth Forest in the Upper Watershed

Most second-growth coniferous forest below 2,500 ft in the Chester Morse Lake basin ranges in age from 40 to 69 years old and has regenerated under a variety of growing conditions. These variable conditions have produced stands that are of similar age but widely variable ecological structural development. The predominantly even-aged stands that are growing on deeper, level substrates (e.g., north of Masonry Pool) have mostly developed a closed canopy. However, openings have been created or maintained by natural thinning, windthrow or breakage, and disease. These openings allow light penetration and support development of a sparse to moderate shrub layer, but only limited herbaceous ground cover.

Stands of similar age on steeper, south-facing slopes with thin well-drained soils have developed more slowly (e.g., north of Chester Morse Lake), but have also attained a mostly closed canopy stage and are devoid of any appreciable shrub or herbaceous vegetative layers. Some stands in these areas are shaded because of their slope aspect or individual topographic position, or are located near streams or on less well-drained soil types. These stands tend to develop at a moderate rate, sustain substantial shrub and herbaceous layers, especially under canopy openings, and may typically be comprised of a mixture of both coniferous and deciduous tree species. Stands on gentler, north facing slopes within the basin typically exhibit similar structural characteristics.

A majority of stands in the lower two-thirds of the Rex River drainage and lower Boulder Creek that fall into the range of ages between 40 and 59 years present a structure in marked contrast to similar-aged stands in other areas of the upper watershed. Such stands in the Rex and Boulder drainages are extremely dense, with completely closed canopies that allow minimal light penetration. As a result, stands throughout this area of the watershed are effectively devoid of tree and shrub understory layers, and herbaceous vegetation is almost non-existent in stand interiors.

Second-growth Forest Habitat in the Cedar River Basin above Chester Morse Lake

Second-growth stands east of Chester Morse Lake in areas adjacent to the mainstem and North and South Forks of the Cedar River represent a mixture of age classes that range from 30 to 69 years. Most of this area, especially closer to the valley floor and riparian areas, represents good growing conditions. Some of the stands in this area are particularly dense, as neither self-thinning nor precommercial thinning has taken place. Many stands in these areas, especially on wetter soils and adjacent to small drainage systems, exhibit a significant deciduous component that typically decreases as slope and elevation increase. Understory shrub and herbaceous layer development is variable depending on specific canopy coverage, soil moisture, and extent of deciduous species coverage as in other similar areas discussed above.

Recent Harvest in the Upper Watershed

With the exception of areas adjacent to the upper mainstem and North and South Forks of the Cedar River, the majority of commercial timber harvest in old-growth forest within the upper watershed during the last four decades (especially during the last 20 years) has been concentrated above 2,500 ft elevation. Most forested land above 2,500 ft is located in the upper reaches of drainage basins (e.g., Rack, Boulder, and Lindsay creeks, and Rex River) or on the upper portions of steep slopes immediately adjacent to high-elevation ridgelines. These areas, most of which have been planted with conifer seedlings and augmented by natural seeding and post-harvest release, exist today in various stages of regeneration. The degree of development and present stand condition is dependent mainly on the soil types and climatic regimes present at specific sites.

Regeneration stands in these areas vary widely from open areas with few seedlings dominated by shrub and herbaceous vegetation (e.g., *Vaccinium* spp., *Xerophyllum tenax*) to over-stocked stands of conifer regeneration so dense that walking through them is challenging. Natural thinning in these dense regeneration stands has not taken place and, until recently, little precommercial thinning has occurred. Less than 2,000 acres of stands of this type in upper elevations have been precommercially thinned since this program began in 1995, but thinning will continue under this HCP (Section 4.2.2).

Riparian Corridors in the Upper Watershed

The most extensive riparian corridors in the upper municipal watershed exist within the broad, forested floodplains and lower gradient reaches of the Cedar and Rex rivers, east and south of Chester Morse Lake, respectively. The broad floodplain of the Cedar River immediately east of Chester Morse Lake is characterized by deciduous forest dominated by red alder, black cottonwood (*Populus trichocarpa*), and scattered Sitka spruce in the overstory. Sitka spruce is the most common conifer regenerating under the deciduous dominated canopy. Vine maple and salmonberry dominate the shrub layer (Raedeke Associates, Inc. 1997; Hanley 1980).

Most other stands within the Cedar floodplain corridor are mixed stands with Douglas-fir, western hemlock, and red alder all present in varying densities. Douglas-fir and western hemlock dominate drier sites, with red alder occupying wetter sites and many sections of the river bank. Where the floodplain narrows and the channel margins become steep, conifers tend to become more dominant in the forest and typically extend to the stream banks. The stream gradient increases gradually in this system. Red alder is dominant on almost all unstable sites where the river is actively meandering across the floodplain.

In contrast, the broad floodplain of the lower Rex River is characterized by mixed conifer forest composed of Douglas-fir and western hemlock dominating the canopy, with Sitka spruce and true firs (*Abies* spp.) scattered throughout. Below the closed canopy of conifers, understory is sparse or completely absent. On wetter sites where the canopy is more open, red alder, vine maple, and salmonberry occur. No extensive deciduous stands exist in the Rex River floodplain as they do in the Cedar River floodplain, but they do occur in patchy distribution on wetter sites and along some portion of stream banks.

As in the floodplain of the lower Cedar River, conifers tend to become more dominant and typically extend to the stream banks where the floodplain narrows and the channel margins become steep. The channel narrows and adjacent slopes become steep within a much shorter length of stream in the Rex drainage than in the Cedar drainage. Red alder is also dominant on almost all such unstable sites (meanders and gravel bars) in the lower Rex system as in the Cedar. However, this type of unstable channel is less common in the Rex system than in the Cedar system because the stream gradient increases more sharply moving upstream of the main floodplain, and the channel becomes confined in lower reaches.

Riparian corridors are generally relatively narrow in upper reaches of both the Cedar and Rex river drainages. Where old-growth conifer forest still exists, it extends to the channel edge and in most reaches the canopy completely spans the channel. Deciduous species are typically absent or infrequent in these stands. However, the old-growth forest has been harvested in most of these upper reaches of both the Cedar and Rex rivers. Typically, forest cover was completely removed and is currently in some state of regeneration. Young, linear stands of red alder border the channel in most of these reaches, except where dense conifer regeneration extends to the channel margins. The forest canopy does not span the channel in many of these areas, with the exception of uppermost stream reaches where the channel is of high gradient and is relatively narrow.

Other streams in the upper watershed are substantially smaller in physical dimensions and flow volume than either the Cedar or Rex rivers and are typically of substantially higher gradient. Forest cover has been completely harvested from most of these streams except for the uppermost reaches where patches of old growth may still remain. Many of these stream corridors, especially in higher-gradient and more deeply incised reaches, are dominated by second-growth conifer stands. However, in sections where channel substrates are unstable or a narrow floodplain exists, red alder may colonize and persist for a variable period of time. Site-specific conditions typically vary widely in these smaller stream channels, and adjacent forest habitat varies accordingly (Cupp and Metzler 1995).

Ecological Considerations

Major Habitat Distribution

The timing and methods of logging within the municipal watershed, and the differences among areas, have been the most influential factors directly determining the types, stages of succession, and pattern of forested habitats present today across the landscape. Logging activity began in the low-elevation western portion of the watershed, was concentrated there until native old-growth forest was extirpated, and then steadily progressed eastward and upward to the highest elevations along ridge lines. As a result, there are two distinct patterns in the predominant seral stages present in major sections of the lower and upper watersheds, one with respect to elevation and one with respect to east-west location.

First, most mature second-growth forest occurs in the lower elevation of the lower municipal watershed, whereas the majority of recent harvest, and therefore early-successional forest, is predominant in the higher elevations of the upper watershed. This effect is especially evident in the subbasins north and south of Chester Morse Lake and in some subbasins draining to the eastern reaches of the Cedar River. Secondly, the lower watershed has only 734 acres of unharvested native forest remaining, while the upper watershed has 13,155 acres remaining, most at high elevation in eastern subbasins.

Also, specifically within the upper watershed, substantial differences exist between the distribution of both old-growth and second-growth forest over the elevation gradients. First, the oldest second-growth forest predominates at lower elevation, and early successional stands are generally more common at high elevations in upper subbasins. Secondly, old-growth forest is concentrated in the eastern sections of the upper watershed; the western section of the upper watershed is predominantly second growth, much of which is in younger seral stages.

NON-FORESTED HABITAT IN THE UPPER WATERSHED

Open Water in the Upper Watershed

In addition to Chester Morse Lake and the Masonry Pool, which are of significant size, approximately 25-30 small lakes (e.g., Findley Lake, Twilight Lake, Sutton Lake), ponds, and unnamed bodies of open water are scattered over the higher elevation landscape within the upper watershed (Map 6). Although the total number of small areas of open water is not great, it is substantially greater than the number present in the lower municipal watershed. Also, the density of small lakes and ponds within the watershed is noticeably lower on a regional basis than within drainages immediately to the north and south of the watershed boundaries. Thus, these open water habitats contribute significantly to habitat diversity, not only within the upper watershed, but across the entire area of the Cedar River Watershed. Fish are not known to occur in most of these open waters. However, these lakes and ponds represent a unique habitat type and an aquatic community that is especially important to amphibian fauna present in these higher elevations.

Wetlands in the Upper Watershed

Several wetland habitat types are found throughout the upper municipal watershed. These wetland habitats vary widely in size and are distributed over the entire elevation range of the many, interconnected subbasins. Although frequently unrecognized, recharge areas supplying groundwater to each wetland are integral components of these aquatic habitats and need similar protection. Each of these components is critical to maintaining the natural ecological function of the aquatic ecosystem network within the municipal watershed.

Beginning within the Chester Morse Lake subbasin (Map 1), the most obvious wetland communities are represented by the large expanses of sedge (*Carex* spp.) and willow (*Salix* spp.) present on the deltas formed at the confluences of the Cedar and Rex Rivers with Chester Morse Lake (Paige 1988; Raedeke Associates 1997). One other small delta plant community exists at the mouth of Bridge Creek on the north side of Chester Morse Lake. Also unique are the sphagnum bogs south of Little Mountain that support a wide variety of sedge, grass, and unique wetland species (Paige 1988).

Several wetland types are found associated with higher elevations. These include sphagnum bogs, sedge-dominated wetlands associated with small lakes and ponds (e.g., Findley Lake, Sutton Lake), streams, and upland wet meadows supporting sedge and forb communities (e.g., headwater basins of Boulder and Lindsay creeks). Of particular interest is the wet meadow complex comprised of interrelated wet meadows in the upper Rex River basin, which represents the largest concentration of this habitat type within the watershed.

Upland Shrub-Forb Meadows in the Upper Watershed

Another type of vegetation that adds a component of habitat diversity to the upper watershed is the area of upland shrub-forb meadow, which is located on the south-facing slopes of Mt. Baldy and Tinkham Peak on the northeast boundary of the watershed. This habitat is unique within the municipal watershed and has not been identified in any other area within the watershed.

Rock, Talus, and Felsenmeer Features in the Upper Watershed

In contrast to the lower watershed, the higher elevations of the upper municipal watershed contain several areas where different types of rock formations are conspicuously prevalent, other areas where these types are represented in small, scattered patches, and still others where they are exposed as specific isolated features of the landscape. As examples, talus and felsenmeer rock formations are prevalent on the steep slopes north of Findley Lake and on the south-facing slopes of Tinkham Peak at the northeast boundary. Rock outcrops and cliffs are evident in Seattle Creek, in the upper reaches of Rack Creek, and above Rattlesnake Lake. A third type of rock formation is represented by the sheer rock walls in the U-shaped glacial cirques of upper Goat Creek, Troublesome Creek, and Findley Lake basins (maps 1 and 6).

Rights-of-way in the Upper Watershed

Right-of-way habitat is very limited within the upper watershed. Existing transmission rights-of-way are relatively small, both in terms of the width of open habitat created and the total cumulative length, especially compared to those located in the lower watershed (see above). All of these corridors are concentrated in the vicinity of Cedar Falls and from Masonry Dam to Cedar Falls. As such, they provide relatively little habitat for wildlife species.

Roads in the Upper Watershed

The upper municipal watershed has an extensive transportation system (Map 13; Appendix 17) consisting of 339 miles of forest roads that extend to all subbasins and to the eastern boundary of the watershed at the Cascade Crest. As indicated in Table 17-1 in Appendix 17, road densities in the upper watershed vary among subbasins from 1.6 to 6.6 miles per square mile.

The only areas that are not densely roaded are substantial portions of the large contiguous blocks of old growth in the spotted owl CHU. As in the lower watershed, forest roads in the upper watershed act as travel corridors and foraging areas (edges) for many larger wildlife species and provide edge habitat for many smaller species. In addition, roads, especially in the upper watershed during winter, may also attract predators, because elk and deer are concentrated and consistently use forest roads as routes of travel. The transportation plan is discussed in detail in Appendix 17.

Ecological Considerations in the Upper Watershed

Until the 1990s, minimal buffers were left during logging operations near streams, wetlands, and small lakes and ponds. Historically, all trees were harvested to the banks of both large and small streams, including many reaches of the Cedar River, especially in the upper watershed. Archival photographs document the clearcut harvest of native forest to the banks of the lower reaches of the Rex and Cedar rivers in the upper watershed (Figure 3.2-1). Similar harvest practices were employed on the upper reaches of the mainstem and North and South Forks of the Cedar River east of Chester Morse Lake. For example, all forest cover was removed from the wetland area and shoreline of the pond that forms the headwaters of the Rex River, and partially removed from the shoreline of Sutton Lake. Although vegetation has at least partially recovered along many of the stream reaches, it currently has not recovered sufficiently to shade or provide mature forest habitat adjacent to these unique aquatic habitats. Complete recovery may not occur for many years in these areas. Also, even in the case of partially recovered riparian vegetation, structure and species composition may not be ecologically capable of moderating temperature fluctuations and extremes or to provide functional large woody debris to the stream system.

Figure 3.2-1. An early photograph depicting logging up to the shores of Chester Morse Lake.

3.2.3 Life Cycle of Salmon, Trout, Char, and Whitefish

A variety of species of fish are present in the Cedar River Basin (King County 1993), including species from the family Salmonidae. The status of many of the salmonids - which include salmon, trout, char, and whitefish - is of particular concern in the region (WDFW 1997a, b; Washington Fish and Wildlife Commission 1997). Eight species of salmonids are known to occur in the basin, including chinook salmon *(Oncorhynchus tshawytscha*), sockeye salmon (*O. nerka),* coho salmon (*O. kisutch*), steelhead/rainbow trout (*O. mykiss*), cutthroat trout (*O. clarki*), bull trout (*Salvelinus confluentus*), pygmy whitefish (*Prosopium coulteri*), and mountain whitefish (*P. williamsoni*).

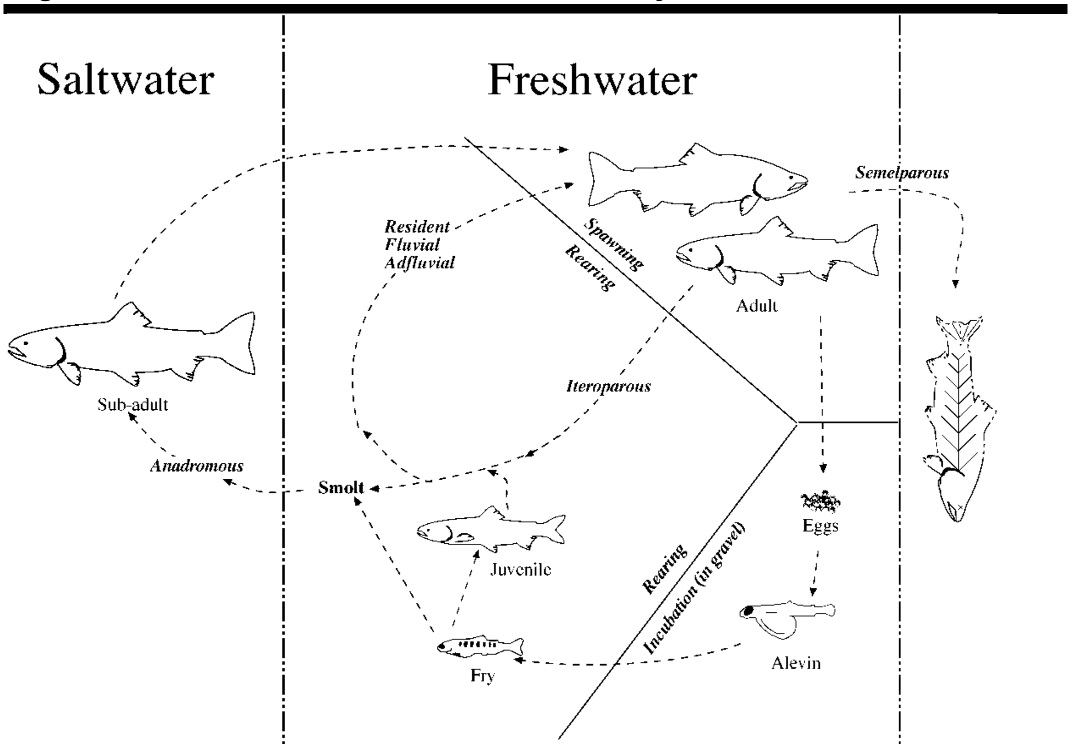
Although pink salmon (*O. gorbuscha*) and chum salmon (*O. keta*) are believed to have been historically present in large numbers in the Cedar River Basin, these species have been extinct since the Cedar River was rerouted into Lake Washington and the Lake Washington Ship Canal was constructed as the new outlet to the lake. This major engineering project was completed in 1916, and was the "most important human factor to ever affect the lake and its shorelands, [and] inflowing and outflowing streams . . . ." (Chrzastowski 1983).

Because salmonids spend all or a portion of their lives in freshwater streams or lakes, they are subject to the impact of both land management and water resource management in the basin. Information is given below to provide background on the different life history stages of salmonids and their potential susceptibility to anthropogenic impacts, which is important to understanding the mitigation and conservation strategies included in this HCP. The basic life cycle of salmonids, with many of the variations that occur among species, is shown in Figure 3.2-2, below.

THE REDD

Most members of the family Salmonidae begin their life cycle in streams, and sometimes lakes, when eggs and sperm are released into clean gravel (Wydoski and Whitney 1979). Over the course of several days, female salmon, char, and trout typically dig several egg pockets, each a little upstream of the last. Shortly after digging each egg pocket, the female will release a portion of her eggs as the male releases sperm. The eggs settle onto the gravel and after a short interval, the female will move upstream to repeat the process. As she digs the next egg pocket, the excavated gravel covers the previously deposited eggs. The combined group of egg pockets is called a redd. The pygmy whitefish presumably does not build a redd, but instead broadcasts its eggs over clean gravels (Wydoski and Whitney 1979).

Figure 3.2-2. Salmon, trout, and char life cycle.



EGGS, ALEVINS, AND FRY

The eggs develop for variable lengths of time, depending on species, subspecies, individual variability, water temperature, and general incubation conditions. After 1-3 months, the eggs hatch into larval fish called alevins. Newly hatched alevins are negatively phototactic (i.e., they avoid light) and within 48 hours migrate downward further into the redd (Fast 1987). Here they remain in the gravel and gradually continue to develop using the energy stored in their attached yolk sacs. After 1- 3 months, depending primarily on the species and water temperature, the yolk sacs are absorbed. At this time, they become positively phototactic (i.e., they swim towards light) and positively rheotactic (i.e., they swim towards current) and move up through the gravel to emerge as free-swimming fry. As fry, most salmonids have rather large oval to circular dark markings on their sides called parr marks.

JUVENILE SALMONIDS

There is considerable variation in life history strategies among species and populations of salmonids during the juvenile stage (Groot and Margolis 1991). Variability occurs with respect to time spent in fresh water and where young fish grow (rear) to maturity. Sockeye salmon fry, like pink and chum salmon fry, leave their natal streams almost immediately after emerging from the gravel and migrate to rearing areas with significant plankton food resources. In the case of sockeye salmon, these rearing areas are freshwater lakes, whereas pink and chum salmon migrate to near-shore saltwater areas. Juveniles of these three salmon species do not grow up and compete for food and territories in their relatively less productive natal streams, but instead migrate to and rear in more productive lake or salt-water environments. This life history strategy can result in large runs of returning adults that spawn at very high densities in their home streams.

Sockeye, pink, and chum are often called mass spawners for this reason, and it is known that this mass spawning results in a net gain of nutrients from the marine environment into the freshwater environment (Bilby et al. 1996). The exception to this is the landlocked form of sockeye called kokanee, in which the fish remain in fresh water for their entire lives.

Juvenile chinook, coho, and steelheads typically remain in their natal streams for extended periods and produce relatively smaller runs of adults. The time spent by juvenile salmonids in natal streams or associated lakes and wetlands varies by species.

LIFE HISTORIES

Salmonids that spend their entire lives within a fairly limited stream range are said to exhibit a *resident* life history. A second freshwater life history variation is *fluvial*, in which fish spawn and perhaps rear for a period in a smaller tributary but move into larger rivers later in their life. A third life history variation is *adfluvial*, in which fish spawn and sometimes rear in a stream then move into a lake where they mature.

Fish that leave fresh water to grow and mature in the sea before returning to spawn are said to be *anadromous*. This life history strategy is exhibited by chinook, coho, chum, pink, and sockeye salmon, as well as by sea-run cutthroat trout, steelhead trout, and some populations of bull trout. As the individual fish physiologically prepare to leave fresh water and enter salt water, they lose their parr marks. At this stage they are called *smolts*. Salmon and steelhead spend from one to several years at sea, depending on species, sub-species, and individual variability. Sea-run cutthroat may only spend a few days at a time foraging in salt water.

SPAWNING

As salmon, trout, and char approach sexual maturity they begin a spawning migration, homing to their natal stream, although a small percentage do stray to other streams (Hasler 1966; Groot and Margolis 1991). The maturing adults exhibit changes in body form and color. Females choose the site of the redd and defend it from other females. Males fight over the females, aggressively chasing off other males after being accepted by a female. In some species, a few males (and occasionally females) in a population will return to spawn a full year earlier than the great majority of the population. These precocious males (jacks) can successfully fertilize some of the eggs during the act of spawning by the full size pair. The five species of Pacific salmon in Washington State waters are *semelparous*, meaning that individuals breed only once and die after spawning. One important consequence of semelparity in anadromous fish is the net flow of nutrients in their bodies from the sea to the natal streams. This has been shown to contribute to aquatic and riparian productivity (Bilby et al. 1996). The trout species are *iteroparous*, which means that individuals breed more than once and may live to spawn in several years.

SENSITIVITIES TO IMPACTS

In the Cedar River Basin, stream habitat for salmonids can be impacted in a variety of ways from urbanization, water resource management, and forestland management (King County 1993). Urbanization can seriously damage streams. The amount of impervious surface is typically increased in a basin, which results in increased peak flows (Booth 1991), and streamside vegetation is often removed, leading to bank instability, erosion, water temperature increases, and loss of coarse woody debris in the stream (Booth and Reinelt 1993; Booth and Jackson 1994). In addition, the loading of chemical pollutants into water bodies is increased (King County 1993).

Management of water resources by dams and diversions can have impacts of several kinds. Adequate stream flows are needed by salmonids for migration, spawning, incubation, rearing, and holding of adults. Dams can impede fish migrations, and flood control by dams can reduce peak flows during flood events. Flood control over the long term can result in decreased connectivity of a river with its floodplain. In the short term, however, flood control can reduce flood scour of gravels with redds and, thus, egg mortality. Channelization, development, and diking along a river, such as is the case along most of the Cedar River below Landsburg, exacerbates peak flow damage in the channel and further reduces the connectivity of a river with its floodplain (King County 1993).

Forestland management activities, including timber harvest and associated roads, can impact stream habitat in several ways (Meehan 1991; Section 4.2.3). Timber harvest activities have often resulted in removal of streamside vegetation, and large-scale clearcutting and poorly designed forest roads have resulted in high levels of sediment delivery into many stream channels from increased erosion and landslides (Franklin 1992).

Because eggs and alevins need oxygen during incubation, they can be impacted by deposition of sediment, which can fill the interstitial spaces between the pieces of rock and reduce the flow of oxygen-bearing water. Sedimentation can also hinder the movement of alevins in the gravel. Juveniles that rear in streams are sensitive to a variety of impacts on their habitat that can result from forest management activities. Increased sediment inputs can fill pools, and the loss of streamside forests can result in loss of coarse woody debris. This can result in a loss of habitat complexity and a change in sediment dynamics in the stream.

3.2.4 Fish Habitat and Distribution in the Cedar River Watershed

The Cedar River and its tributary network provide abundant and varied habitat for a number of species of fish. The Cedar River Municipal Watershed, which encompasses all waters upstream of the Landsburg Dam and the Walsh Lake system, contains approximately 90 miles of fish-bearing streams; associated floodplain channels and wetlands; a large high-elevation reservoir (Chester Morse Lake); and a productive lowland lake (Walsh Lake).

A separate discussion of fish habitat in the mainstem Cedar River downstream of the Landsburg Diversion Dam is provided in Section 3.2.5, and sections 3.5.8 - 3.5.11 contain descriptions of the fish species. For the purpose of discussion in this section, the terms upper, middle, and lower are applied only to the Cedar River within the *municipal* watershed.

FISH DISTRIBUTION

Geographic Regions

There are four main geographic regions within the municipal watershed, each with a unique fish assemblage. The upper region above the Masonry Dam contains all of the streams that drain to the Chester Morse Lake and Masonry Pool reservoir system. These include the subbasins of the North and South Fork Cedar rivers, the Upper Cedar River (between the reservoir and the forks), the Rex River, and the smaller tributaries to Chester Morse Lake (Map 1). This region is primarily mountainous, high-relief land, and is geographically separated from the lower region along the front range of the Cascade Mountains. Two waterfalls in the Cedar River located downstream of Masonry Dam are natural barriers to upstream fish migration into this upper region (Map 8).

The lower watershed region drains to the Cedar River between Masonry Dam and Landsburg Diversion Dam. This area includes the Lower Cedar River subbasin and the Taylor Creek subbasin (Map 1). The landscape in this region is characterized by rolling foothills with low to moderate relief in the western portion, but moderate to high relief terrain as it merges on its eastern boundary with the mountainous upper watershed.

The third region is the Walsh Lake subbasin, which contains Walsh Lake (Figure 3.2-3), Webster and Hotel creeks, and the Walsh Lake Diversion Ditch, which is the outlet for the lake. The waters from this low-relief basin drain to a point in the Cedar River downstream of the Landsburg diversion and outside the administrative boundaries of the watershed (Map 1).

The fourth region is the smallest and contains only Taylor Ditch and a portion of Carey Creek. Waters in this region do not flow to the Cedar River. Carey Creek eventually connects to Issaquah Creek, which empties into Lake Sammamish. Taylor Ditch receives surface drainage from the old Taylor town site, passes under Webster Creek in a siphon, and empties into Carey Creek (Map 1).

Fish Studies

Information on fish distribution was gathered from several studies of fish in the watershed (see Appendix 23 ; R2 Resource Consultants, in preparation; Congleton et al. 1977; Wyman 1975). The variety of sampling techniques used in these studies included spawning surveys, angling, electrofishing, gill netting, and snorkeling. Additional data on fish distribution was gathered during minnow trapping, road-crossing construction activities, bull trout spawning surveys, and from recent observations of pygmy whitefish in the watershed by City biologists. Most field efforts were focused on collecting data on fish in the family Salmonidae. These results are summarized on Map 8 and in Table 3.2-2.

The fish family Salmonidae is represented within the municipal watershed by bull trout, pygmy whitefish, rainbow trout, cutthroat trout, kokanee (landlocked sockeye salmon), and coho salmon. The greatest uncertainty regarding the distribution of salmonid fish in the municipal watershed is associated with a lack of information on fish distribution in the smaller tributaries. Additional surveys of the upper portions of these tributary streams are needed to fully describe the fish habitat and fish distribution within the watershed.

The Upper Watershed Subbasins

The fish in the upper watershed region are separated from the populations in the lower watershed by the two impassable falls in the Cedar River downstream of Masonry Dam (Map 8). The fish assemblage in this upper region is distinct from the lower basins by the presence of bull trout and pygmy whitefish and the absence of cutthroat trout. Both bull trout and pygmy whitefish are found in Chester Morse Lake and Masonry Pool. Rainbow trout are also widely distributed in the upper watershed.

Bull trout occur in the Cedar River upstream of Chester Morse Lake; the lower sections of the North Fork and South Fork Cedar rivers; the streams of the broad Cedar River floodplain above Camp 18; Eagle Ridge Creek; the lower half of the Rex River; lower Lindsay, Boulder, and Rack creeks; and Morse and Cabin creeks (Map 7 and Table 3.2-2). There was one observation of a bull trout redd in Damburat Creek.

Pygmy whitefish have been observed during their spawning migration in the lower reaches of the Cedar and Rex rivers, as well as in Boulder Creek.

Rainbow trout are found throughout the range of bull trout in the watershed, as well as further upstream in the North Fork and South Fork Cedar rivers, Rex River, and Boulder Creek. Rainbow trout are also found in the lower reaches of the following Chester Morse Lake tributaries: McClellan, Green Point, Bridge, Otter, Damburat, and Lost (historic) creeks. Cutthroat trout have not been observed in the upper watershed region.

The only other fish species found in this region of the watershed are sculpin (*Cottus* spp.) in the family Cottidae. Sculpin have been found in all of the waters mentioned above, in lower Pine Creek, and also in the Rex River below Pine Creek.

Lower Cedar River and Taylor Creek Subbasins

The Lower Cedar River and Taylor Creek subbasins in the lower watershed contain two salmonid species: rainbow and cutthroat trout (Map 8 and Table 3.2-2). Rainbow trout have been found in the Cedar River, Rock Creek, and Taylor Creek. Cutthroat trout have been found in the Cedar River, and in Rock, Steele, Williams, and Taylor creeks. Rainbow trout are predominant in the Cedar River, while cutthroat trout are predominant in Rock Creek. Some hybridization between the two species has likely occurred in the Taylor Creek drainage. These subbasins also contain sculpin.

Walsh Lake Subbasin

The Walsh Lake subbasin contains the largest diversity of fish in the watershed (Table 3.2-2). Because the Walsh Lake Diversion Ditch joins the Cedar River downstream of the Landsburg Dam, this subbasin is accessible to some anadromous fish. The lower reach of this channel is reported to support anadromous coho, sockeye, and chinook salmon, and steelhead trout (King County 1993). A partial fish barrier in the Walsh Lake Diversion Ditch downstream of the Cedar River Municipal Watershed's western administrative border is a barrier to migrating sockeye salmon, although coho salmon are able to pass and have been observed in the Walsh Lake Diversion Ditch and Webster Creek (see Appendix 23).

Figure 3.2-3. Walsh Lake.

A recent study has also confirmed the presence of kokanee, a form of landlocked sockeye salmon, in Walsh Lake (see Appendix 23 and sections 3.5.8 and 3.6). The kokanee population spawns in lower Webster Creek and matures in Walsh Lake. Cutthroat trout are found throughout the waters of the Walsh Lake subbasin, and rainbow trout have been observed in the upper Walsh Lake Diversion Ditch (Map 8).

Other fish species in this subbasin include speckled dace (*Rhinichthys osculus*), redside shiner (*Richardsonius balteatus*), and western brook lamprey (*Lampetra richardsoni*), which have all been observed in the Walsh Lake Diversion Ditch. Walsh Lake also supports northern squawfish (*Ptychocheilus oregonensis*), a native fish, and largemouth bass (*Micropterus salmoides*) and yellow perch (*Perca flavescens*), both non-native species.

Issaquah Creek Subbasin

The portion of Carey Creek within the municipal watershed and the waters of the Taylor Ditch have not been sampled for fish. The lower reaches of Carey Creek, outside of the watershed, is a known salmon-bearing stream. The portion of the stream within the watershed may support trout and coho salmon. This reach of Carey Creek may also support common fish such as speckled dace and western brook lamprey.

FISH HABITAT

Chester Morse Lake and Masonry Pool

Chester Morse Lake is an approximately 1,500-acre reservoir with a maximum depth of approximately 125 ft. Current management of Chester Morse Lake can result in a maximum elevation change of 38 ft between full pool and the gravity-flow drawdown limit. Normal annual fluctuations are between 28 and 30 ft (sections 2.2.4 and 3.2.5). Masonry Pool, approximately 190 acres, is located downstream of Chester Morse Lake, and can fluctuate 70 ft in elevation, although the normal annual fluctuation is about 30 ft. At the higher lake levels, Masonry Pool and Chester Morse Lake join to form a single water body. At its lowest level, Masonry Pool is essentially a flowing channel.

The potential impacts of fluctuating lake levels in Chester Morse Lake on fish habitat include seasonal changes in the quantity and availability of lake volume and associated lake habitats, diminished productivity in the littoral zone (see Lindstrom 1973), inundation of tributary habitats used by spawning and incubating fish, and possible creation of physical obstructions to the upstream migration of spawning fish in the fall, when reservoir level is at its lowest, during dry years. Inundation is caused by high lake levels that cover areas with still water that are otherwise usually dry or covered by flowing water. Inundation of the lower reaches of streams during spring reservoir refill can cause diminished flow velocities, which could cause suffocation of some developing bull trout embryos, unless upwelling occurs in the spawning gravels (Section 3.5.6). Physical obstructions by exposed deltas can delay or prevent spawning migrations. These changes in lake habitat can affect the availability of food resources and influence competition and predation (sections 3.5.6 and 3.5.7).

A more detailed description of the results of reservoir operations on lake habitat is provided in sections 3.4.1 and 4.4.3 of the Revised NEPA EA/ final SEPA EIS for the Cedar River Watershed HCP, and the potential impacts of the changes in reservoir operations associated with the proposed instream flow regime are discussed in Section 4.5.6 of this HCP.

Stream Habitat

Fish-bearing Streams

Of the almost 400 miles of stream within the watershed, approximately one-fourth (90 miles) are classified by the state as fish-bearing waters (fish-bearing streams). These 90 miles include streams classified as Type I, II, and III waters (based on WDNR's water typing system) (Table 3.2-3; Map 8). Additional fish habitat in the municipal watershed includes Chester Morse Lake, Masonry Pool, Walsh Lake, and a number of smaller lakes and ponds.

Table 3.2-2. Fish distribution within the Cedar River Watershed.

Upper Watershed	Chester Morse Lake	Cedar River	North Fork Cedar River	South Fork Cedar Rive	Rex River	Camp 18 floodplain	Eagle Ridge Creek	Pine Creek	Lindsay Creek	Morse Creek	Cabin Creek	Boulder Creek	Rack Creek	Lost Creek (historic)	Damburat Creek	Otter Creek	Bridge Creek	Green Point Creek	McClellan Creek
Pygmy Whitefish	x	x			x							x							
Bull Trout	x	x	x	x	x	x	x		x	x	x	x	x		x				
Rainbow Trout	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
Sculpin	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Lower Watershed	Cedar River	Rock Creek	Williams Creek	Steele Creek	Taylor Creek
Rainbow Trout	x	x			x
Cutthroat Trout	x	x	x	x	x
Sculpin	x	x	x	x	x

Walsh Lake System	Walsh Lk Diversior	Walsh Lake	Webster Creek	Hotel Creek
Coho Salmon	x		x	
Kokanee		x	x	
Rainbow Trout	x			
Cutthroat Trout		x	x	x
Sculpin	x		x	
Speckled Dace	x			
Northern Squawfish		x		
Redside Shiner	x			
Western Brook Lamprey	x			
Largemouth Bass		x		
Yellow Perch		x		

Table 3.2-3. Summary of Cedar River Watershed stream miles by stream type, based on 1994-1997 WDNR data. Note that miles do not reflect the new Emergency Water Type Rule (WAC 222-16-030).

BASIN Subbasin	Stream Miles					
	Type I	**Type II**	**Type III**	**Type IV**	**Type V**	**Total**
NORTH FORK CEDAR RIVER North Fork Cedar River	1.5	1.4	3.7	7.2	20.0	33.9

BASIN Subbasin	Stream Miles Type I	Type II	Type III	Type IV	Type V	Total
SOUTH FORK CEDAR RIVER						
South Fork Cedar River	2.6	0.1	1.5	5.5	13.0	22.7
UPPER CEDAR RIVER [a]						
Bear Creek	NA	0.1	2.8	1.3	5.5	9.8
Goat Creek	NA	0.2	1.2	2.4	3.7	7.4
Seattle Creek	NA	NA	2.7	2.6	10.8	16.1
Findley Creek	0.3	0.1	2.3	0.3	4.5	7.5
Roaring Creek	NA	NA	0.7	0.8	3.0	4.5
Upper Cedar River	7.1	1.7	3.4	6.7	16.4	35.2
TOTAL	7.4	2.1	13.2	14.1	43.8	80.4
REX RIVER						
Pine Creek	NA	NA	0.6	1.9	3.2	5.7
Lindsay Creek	NA	NA	2.6	3.8	8.0	14.4
Boulder Creek	NA	1.1	1.6	5.5	13.2	21.4
Rex River	7.0	NA	2.2	6.9	26.2	42.3
TOTAL	7.0	1.1	7.1	18.0	50.6	83.81
CHESTER MORSE LAKE						
McClellan Creek	NA	NA	0.2	2.0	4.0	6.1
Rack Creek	NA	NA	0.2	2.1	7.5	9.8
Damburat Creek	NA	NA	0.1	0.8	0.9	1.8
Otter Creek	NA	NA	NA	0.5	2.1	2.6
Green Point Creek	NA	NA	NA	1.7	2.5	4.1
Chester Morse Lake	8.1	NA	NA	6.0	15.0	29.1
TOTAL	8.1	0.0	0.4	13.1	31.9	53.5
TAYLOR CREEK						
North Fork Taylor Creek	NA	1.3	NA	7.0	12.5	20.8
Middle Fork Taylor Creek	0.8	0.7	0.8	5.9	16.1	24.3
South Fork Taylor Creek	NA	1.7	1.0	1.2	5.7	9.7
Taylor Creek	4.0	NA	1.1	2.3	4.5	11.9
TOTAL	4.7	3.8	3.0	16.4	38.8	66.7
LOWER CEDAR RIVER [b]						
Steele Creek	NA	NA	1.7	0.6	1.0	3.3
Williams Creek	NA	2.9	NA	0.9	1.8	5.5
Rock Creek	1.6	2.2	3.3	2.8	4.0	13.9
Lower Cedar River	13.9	NA	NA	7.7	12.3	33.9
TOTAL	15.6	5.0	5.0	12.0	19.1	56.6
WALSH LAKE						
Webster Creek	NA	NA	2.5	2.0	5.0	9.5
Hotel Creek	NA	NA	0.3	0.7	1.2	2.2
Walsh Lake Diversion Ditch[c]	NA	NA	3.0	NA	NA	3.0
TOTAL	0.0	0.0	5.8	2.7	6.2	14.7
ISSAQUAH CREEK						
Carey Creek	NA	NA	0.8	0.3	NA	1.1
TOTALS	46.8	13.6	40.4	89.3	223.4	**413.5**

[a] Upstream of Chester Morse Lake to confluence of the North and South Fork Cedar rivers.
[b] Downstream of Masonry Dam to Landsburg Diversion Dam.
[c] Miles are for only the area within the municipal watershed property boundaries.
NA Not applicable.

Surveys of fish-bearing streams in other Washington State watersheds have indicated that many streams classified as Type IV (non-fish bearing) should actually be classified as Type II or III (fish-bearing) (Forest Practices Board 1997; Conroy 1997). Although this may be true for streams in the Cedar River Municipal Watershed, a systematic fish-habitat survey has not been conducted. Therefore, the full extent of streams in the watershed that can support fish is unknown.

In comparison to the quality and extent of fish habitat in the Cedar River Basin downstream of the Landsburg Dam, the municipal watershed contains some of the best fish habitat in the Lake Washington Basin (Seattle Water Department 1995; King County 1993; Williams et al. 1975). The lack of land development combined with an unharvested and naturally reproducing fishery has preserved a system that has relatively high quality habitat and is generally free of non-native species interactions. Nonetheless, as a result of past logging practices, some of the stream channels have been negatively affected by reduced volumes of large woody debris, and by increased sediment inputs, bedload movement, and segmentation from anthropogenic barriers.

Stream-crossing Structures and Effect on Fish Distribution

A survey of stream-crossing structures in the Cedar River Watershed was conducted by City biologists during the period 1994-1997 (Seattle Public Utilities 1998). Locations where forest roads cross streams were initially identified with the GIS system by overlaying the roads with the drainage network. Crossing locations were also identified in the field and marked with a comprehensive numbering system. The condition of each structure located on potential fish-bearing streams was assessed with visual observations and measurements of attributes affecting fish passage, such as structural gradient, structural alignment and size, water depth, and channel features.

Stream reaches were defined as potentially fish-bearing if they were designated as Type I, II, or III waters on WDNR maps, and also if the stream met the new Emergency Water Type Rule (WAC 222-16-030). The Emergency Water Type Rule, absent evidence that fish are not present, classifies as Type III any Type IV or higher type streams that are 2 ft wide or wider, and less than or equal to 20 percent gradient.

Many stream crossings (103 out of the total of 168 stream-crossing structures) were included for fish-passage evaluation because of the Emergency Water Type Rule. These stream locations will eventually need to be surveyed for fish habitat to assess if they can support fish life. Many of these reaches are located in headwater areas where fish habitat is minimal or likely absent, or in lower elevation streams that flow only for short periods during spring snow melt. Additionally, some of the reaches included as potentially fish-bearing are not expected to contain fish, because they are located above natural fish barriers, such as impassable waterfalls or chutes. A comprehensive inventory of fish habitat above and below each structure will be needed to finalize these survey results.

A separate survey of crossing structures on Type V and Type IX streams is on-going. Several stream locations from this survey that meet the new Type III stream criteria have already been identified and have been included in this summary. However, the survey is not yet complete. It is estimated that this survey may result in the reclassification of reaches associated with up to 60 additional crossings as Type III (fish-bearing) stream reaches. As these additional stream-crossing structures are identified, they will be assessed for fish passage and the stream reaches surveyed for fish habitat.

Of the 168 stream-crossing structures currently identified on potential fish-bearing streams, 39 are bridges, 120 are culverts, and 9 are wood puncheons. None of the bridges obstruct fish passage, and all of the stream-crossing puncheons are scheduled for replacement or removal. Of the 120 culverts, 82 percent of them create water velocities or hydraulic drops that would be partial or total obstructions to migrating trout and salmon based on state criteria for installation of new culverts in fish-bearing streams (WAC 220-110-070).

The actual effect of the impassable culverts on fish distribution is uncertain, as many of the streams with these obstructions have not yet been surveyed for natural barriers, fish presence, or fish habitat. It is likely that many of these stream reaches were not used by fish prior to the culvert installations, and therefore many of these crossings probably do not influence fish migration. However, all of the impassable culverts will be assessed in the field for their influence on fish migration.

Surveys for fish presence or absence, fish habitat, and natural barriers will have to be conducted at each obstacle to accurately determine its impact on fish. Structures that limit fish distribution will be upgraded, replaced, or removed. This scheduled work will follow a prioritization that involves the consideration of the species of fish affected; the area, type, and quality of habitat available; and the immediacy of the problem and other integrated watershed restoration and maintenance activities. The surveys will be used to update fish distribution maps and other databases.

3.2.5 Fish Habitat in the Cedar River Downstream of the Landsburg Diversion Dam

There are 21.8 mainstem river miles in the Cedar River downstream of the Landsburg Diversion Dam. This section of the river, below the boundaries of the Cedar River Municipal Watershed, flows from the Landsburg Diversion Dam to the river’s outlet at Lake Washington (Map 2). The basin area of the Cedar River downstream of the watershed boundary is approximately 35 percent of the total Cedar River drainage basin (King County 1993). This area is predominantly within unincorporated King County, with only a small percent in the City of Renton and the newly incorporated City of Maple Valley. The remaining 65 percent of the total basin area is within the municipal watershed.

The following discussion on fish habitat in the Cedar River downstream of the Landsburg Diversion Dam is summarized primarily from a King County basin planning report, the Cedar River Current and Future Conditions Report (King County 1993). This document provides a comprehensive assessment of the condition of the river and the basin downstream of the Landsburg Dam. Included in this report are descriptions of current land use in the basin, hydrology, flooding, erosion and deposition, aquatic habitat, and water quality.

CHANNEL CONDITIONS

Prior to the early 1900s, the Cedar River flowed into the Black River, the original outlet of Lake Washington, and then into the Duwamish River before emptying into Puget Sound at Elliot Bay (Map 2). Only during flood events did water from the Cedar River flow north through the Black River and into Lake Washington (Chrzastowski 1983). In 1916, the Lake Washington ship canal was completed under the direction of the ACOE. As part of this project, the outlet of Lake Washington was rerouted through Lake Union, down to the Ballard Locks and into Salmon Bay (Chrzastowski 1983). The principle objective of this project was to aid the navigation of logs, coal, and farm produce. Flood control for the Renton area was an additional benefit. As a result of this project, the elevation of Lake Washington was lowered approximately 9 ft, and the 3.3-mile long Black River became a dry channel. Additionally, the Cedar River was extended 1 mile north to flow into the south end of Lake Washington. At the same time the lower 1 mile of the existing Cedar River channel was straightened and the banks stabilized with large rock (King County 1993).

In addition to rerouting and channelizing the mouth of the Cedar River, other influences have shaped the channel morphology since the mid-1850s. Since this time, the channel has been hardened to prevent lateral migration, diked to prevent flooding, and straightened to facilitate railroad construction. The City’s water management in the upper reaches has also contributed to changes in channel morphology. Flood management practices have to some degree decreased the magnitude and frequency of flood events (King County 1993). Water management has not eliminated all flood flow, however, as the water storage facilities at Masonry Dam have a limited storage capacity and only capture runoff from the uppermost 43 percent of the basin. The Cedar River still overtops the banks at some places, and creates potentially serious problems for almost 200 homes, downtown Renton, and Boeing Company aircraft assembly facilities situated within the 100-year floodplain (King County 1993).

Between 1865 and 1989, the active river channel and channel width between Renton and Landsburg decreased significantly (King County 1993). The channel narrowing was predominately the result of reduced flood flows, the confinement of the channel within rock-hardened banks (revetments), and floodplain development (King County 1993). The Cedar River has been transformed from a braided river with multiple channels, to a sinuous, generally single-channel river, with 64 percent of the length of the river hardened with revetments on at least one bank.

In the Cedar River, two important ecological interactions have been dramatically altered. The natural upstream-downstream connection between salt water and fresh water has been permanently changed, and the connection between the channel and its floodplain has been reduced. These connections represent the longitudinal and lateral interactions that are two primary components of a river ecosystem (Ward 1989). These ecological interactions have been altered in the Cedar River by rerouting the outlet of the Cedar River, narrowing and simplifying the channel shape, and reducing flood flows and frequencies. The rerouted upstream-downstream connection between the river and the ocean has altered the ability of the Cedar River to support fish, such as pink and chum salmon (Section 3.5.8), and the reduced connection between the channel and its floodplain has altered the supply and stability of spawning habitat for many fish, as discussed below.

SEDIMENT

The substrate composition in the Cedar River downstream of the Landsburg Diversion Dam generally provides good spawning habitat for anadromous salmonids (sections 3.5.8 - 3.5.11). The river contains abundant cobble and gravel that provide habitat for developing salmonid embryos and larvae. However, the supply and stability of the substrate has changed as a result of channel realignments and reduced flood flows. Extensive hardening of the banks has reduced localized inputs of gravel and cobble. Movement of sediments within the channel during high flows has also changed because the river is mostly contained within its banks. As a result, floodwaters do not spread onto the floodplain where sediments would naturally drop out as the flood energy is dissipated. High flows are consequently contained predominantly within the banks of the river, which causes greater velocity and increased scour of the substrate habitat. Sediment transported by the river tends to aggrade near the mouth of the river in Renton instead of its natural pattern of incorporation into and storage in the floodplain further upstream (King County 1993). Maintenance dredging of this reach was discontinued around 1980, although in 1998 the ACOE completed a renewed dredging project in this reach.

WATER QUALITY

Because the upper basin is managed by the City for high quality drinking water, contaminant concentrations in the lower Cedar River are typically low as a result of dilution with the upper waters. Water quality is reported as excellent just below the Landsburg Dam, where the intake for the City's water supply is located However, at points further downstream heavy rainfall causes runoff of contaminants from animal pastures, roads, and commercial lots into the Cedar River, and contaminant concentrations periodically exceed established criteria to protect water quality (King County 1993). Water quality criteria exceedances occur most often near the river outlet (King County 1993).

FISH HABITAT

The mainstem Cedar River downstream of the Landsburg Dam supports a variety of fish populations, although habitat quality for many fishes has been negatively affected by the conditions described above. Much of the channel exhibits a low structural complexity, and a reduction in the supply and stability of spawning gravel. The revetments constructed along the majority of the channel length preclude the establishment of mature riparian trees that normally provide shade, cover, and inputs of large wood and nutrients. Approximately 45-67 percent of the riparian area along the river is devoid of large trees (King County 1993).

Because of the simplified channel shape, habitat in the river is dominated by riffles along much of its 21.8 miles. It is estimated that the river has approximately 70 percent fewer large pools than would be expected under unmanaged conditions (King County 1993). Most of the extant large pools are located at the bases of large bluffs. Smaller lateral-scour pools are typically located along banks artificially hardened with rock. The majority of these pools lack large woody debris and the structural complexity preferred by many fish species. The simplified channel configuration and lack of instream structure reduces the Cedar River's ability to diffuse the energy of flood flows, which makes the channel more susceptible to substrate scour. This is especially destructive to fish eggs and larvae, which develop in the substrate.

Fish habitat in the Cedar River downstream of the Landsburg Dam can be divided into three distinct reaches. The Renton reach, from river mile (RM) 0.0 to 1.6, is entirely artificial and is essentially one long riffle with relatively little habitat complexity (King County 1993). This depositional area for coarse sediments is used extensively by spawning sockeye salmon, although it provides poor rearing habitat for stream-dwelling salmonids.

The second reach, from RM 1.6 to 16.2, is also dominated by riffle habitat, and is confined and stabilized throughout most of its length. A 1-mile section between RM 9.6 and 10.7 retains a more natural channel pattern with braids and side channels. A habitat concern in this reach is the lack of gravel recruitment and pool formation resulting from efforts to stabilize steep banks to prevent catastrophic landslides (King County 1993).

The third reach, from RM 16.2 to the Landsburg Diversion Dam, contains 5.5 miles of mainstem habitat. The river valley in this area is more confined by high bluffs than in the lower reach, but the channel itself is less constrained by revetments and there is less development in this portion of the basin. The majority of large pools in the lower Cedar River occur in this reach, generally along the bases of high bluffs.