APPENDIX E

The City's Natural Environment

The City's Environmental Setting

General Characteristics

Portland is situated at 20 feet above sea level, near the confluence of the Columbia and Willamette rivers, about 65 miles inland from the Pacific Ocean. It lies midway between the lower Coast Range to the west and the high Cascades Range to the east, each about 30 miles distant. Portland's varied topography includes steep hills, isolated volcanic cones, low rolling hills and extensive flat areas. The area is composed primarily of alluvial deposits and Columbia River basalts. Much of the city is located in the Willamette Valley Plains ecoregion, although steeper portions of the Tualatin Hills on the west side are characteristic of Willamette Valley Hills and Coastal Mountains ecoregions (Clarke and others 1991).

Portland has a mild marine climate that is heavily influenced by the mountain ranges east and west of the city. The Coast Range protects the Portland area from Pacific storms, while the Cascades prevent colder continental air masses from invading western Oregon. In winter, the average temperature is 40°F and the average minimum temperature is 34°F. In summer the average temperature is 65°F with an average daily maximum of 74 to 78°F (Rockey 2002).

The Cascades also lift moisture-laden westerly winds from the Pacific, driving local rainfall patterns. Average annual rainfall in the Portland area is approximately 37 inches. Nearly 90 percent of the annual rainfall occurs from October through May. Only 9 percent of the annual rainfall occurs between June and September, with 3 percent in July and August. Precipitation falls predominantly as rain, with an average of only five days per year recording measurable snow.

The City of Portland's estimated 2000 population was nearly 530,000, and the City's population is expected to be approximately 589,000 by 2017. Land uses in the Portland area include industrial, commercial, low- and high-density residential and open space.

Portland's Watersheds and Waterways and Their Current Conditions

A number of tributaries to the Willamette River pass through the City of Portland, including Johnson Creek, Tryon Creek, Fanno Creek (via the Tualatin River), the Columbia Slough and a series of small tributaries draining the Tualatin Hills and Forest Park. A general overview of existing conditions within these watersheds is provided below. Detailed watershed characterizations will be completed as part of the watershed management process (watershed characterizations are described in Chapter 3 of the *Framework*). The City's watersheds are depicted in Figure E-1 and described in the following sections.

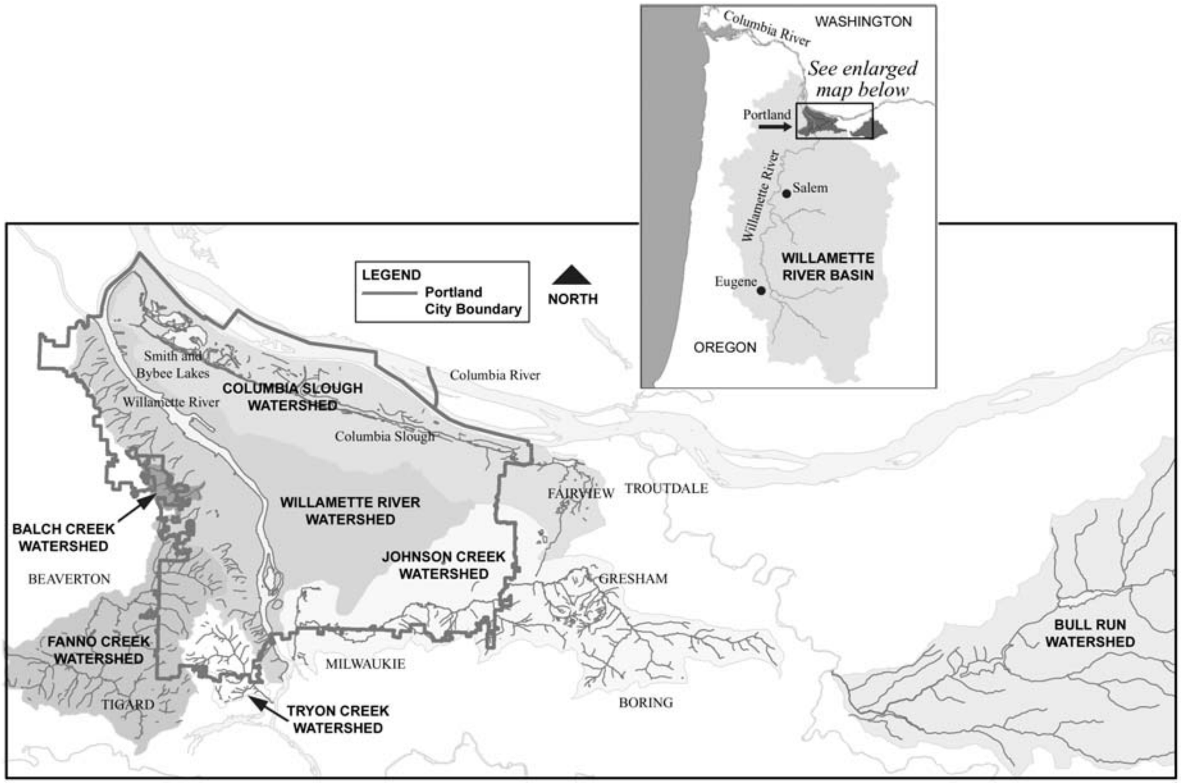

FIGURE E-1
City of Portland Watersheds

Lower Columbia River

The Columbia River is the second largest river in the contiguous United States in terms of stream flow. Land uses within the lower Columbia River watershed are urban/industrial, residential and rural/agricultural. Many of the region's heaviest industrial users are present in the lower Columbia watershed. Land uses in the basin upstream of Portland include timber production, grazing, irrigated and dryland agricultural and urban areas. The lower Columbia watershed has been heavily urbanized and industrialized in the vicinity of Portland for decades and has had many point source and nonpoint source pollution problems. The south bank of the Columbia River in this area of Portland is moderately urbanized. The banks are a mixture of steep natural cobble and sandbanks and riprap; riparian vegetation is generally sparse to absent and consists mostly of invasive plants and shrubs.

The lower Columbia watershed is degraded relative to historical conditions. River flow in the project area has been significantly altered from historical conditions as a result of the upstream storage reservoir releases and hydropower operations. The channel has been diked and dredged, and steep, riprapped shorelines along the river have reduced growth of riparian areas and recruitment of large wood (that is, wood deposited through natural processes). Most of the historical off-channel habitats (side channels, oxbow lakes and marshes) have long since been cut off from the channel and filled. Silt and sand dominate the river substrate.

Water quality in the lower Columbia River is fair to poor in summer. Mainstem temperatures often exceed 20°C (68°F), and maximum temperatures can reach 26°C (79°F). The Oregon

Department of Environmental Quality (DEQ) has listed the lower Columbia River, from the Willamette to the Bonneville Dam, as water quality limited for total dissolved gases and arsenic under the 303(d) process. This reach was also listed as water quality limited for temperature (summer), pH (spring) and toxics (tissue PCB and DDE, DDT).

The current biological conditions in the lower Columbia River have been degraded as a result of extensive changes in flow, habitat and water quality. Many nonnative fish species have been introduced into the Columbia Basin. This has resulted in increased competition and extirpation (that is, local extinction) of some native species and reduction of the biotic integrity of the system.

Lower Willamette River

The Willamette River is a tributary to the Columbia River at approximately river kilometer (Rkm) 164 (river mile [RM] 102). It is the 10th largest river in the contiguous United States in terms of streamflow. The Willamette Basin is 11,460 square miles in size and constitutes 12 percent of the land area of Oregon (Willamette Restoration Initiative 1999). In 1990, about 70 percent of Oregon's population lived in the Willamette Basin. The Willamette Basin is divided into 12 subbasins. The lower reach of the Willamette—the subbasin which includes the City of Portland—extends from the mouth upstream to the falls at Oregon City (RM 26.5, Rkm 42 of the Willamette River).

Land uses within the lower Willamette River watershed in the vicinity of Portland and its suburbs are urban/industrial, residential and rural/agricultural. Many of the state's heaviest industrial users are present in the lower Willamette watershed. Land uses in the basin upstream of Portland include timber production, grazing, irrigated and dryland agricultural and urban areas.

The lower Willamette watershed has been heavily urbanized and industrialized for decades. Within the Portland downtown and harbor areas, the river's banks are typically steep and are primarily composed of bank stabilization and fill materials such as sheet pile, riprap, seawall and concrete fill. Riparian vegetation is generally sparse to absent and frequently consists of nonnative plants and shrubs.

The lower Willamette watershed is heavily degraded relative to historical conditions. Historically, the Willamette River in the Portland area comprised an extensive and interconnected system of active channels, open slack waters, emergent wetlands, riparian forest and adjacent upland forests on hill slopes and Missoula Flood terraces. Connectivity of habitat was high both longitudinally along the river and laterally from the vegetated riverbanks to the upland forests.

Gradually, habitats along the Willamette River have been destroyed, degraded or disconnected through construction of dams throughout the Willamette and Columbia rivers and from development along the Willamette. Large expanses of black cottonwood/Pacific willow forest and spirea/willow wetland have been filled and developed, leaving small strips of riparian forest, wetland and associated upland forests. These remnants are few or entirely lacking for large reaches through the downtown and industrial segments of the river. Most of the historical off-channel habitats (such as side channels, oxbow lakes and marshes) have long since been cut off from the channel and filled. Connectivity and maintenance of these habitats have been reduced or eliminated as a result of marked alteration of the seasonal hydrograph[1], particularly dramatic reduction of peak flows. Connection of many tributary habitats to the mainstem is eliminated or reduced by culverts.

The channel has been diked and dredged throughout the Portland Harbor. The channelized characteristics of the Portland Harbor and surrounding area have adversely modified the habitat types and the localized flow regime. The urban setting minimizes the presence of riparian vegetation and the input of new large wood from riparian areas.

A few small areas of higher quality habitat remain within the highly urbanized reaches of the Willamette. Remnant habitats of high quality—or with the potential to provide important functions if reconnected or restored—include Powers Marine Park, Ross Island, lower Stephens Creek, Oaks Bottom, Willamette Park, Kelley Point Park, the Forest Park watersheds and Smith and Bybee lakes.

Water quality in the lower Willamette River is fair to poor. In 2000, the Portland Harbor was placed on the National Priorities List ("Superfund") for elevated levels of DDT, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and heavy metals. The Lower Willamette River is listed on the 303(d) list for temperature, bacteria, biological criteria (fish skeletal deformities) and toxics (mercury; arsenic and pentachlorophenol near the McCormick and Baxter site). DEQ also identified lead and copper as potential water quality concerns in a 1997 analysis (Oregon Department of Environmental Quality 1997). These parameters are being investigated further to evaluate whether they should be included on the 303(d) list, using ultra-clean sampling and analysis methods and improved detection limits.

The aquatic biota of the lower Willamette River have changed significantly from historical conditions. Extirpations of sensitive species have occurred, and introductions of nonnative species have resulted in increased competition for food and habitat for native species. The existing fish community in the lower Willamette River consists of warm-water, cool-water and cold-water fish. There are several listed salmonid evolutionarily significant units (ESUs) that use the lower Willamette River. At least 33 other native and introduced species of both warm-water and cool-water fish inhabit the river (Oregon Department of Fish and Wildlife 1994).

Johnson Creek

Johnson Creek originates in the hills east of Portland and flows westward approximately 25 miles to its confluence with the Willamette River. The stream receives water from several major tributaries, including Crystal Springs Creek, Kelley Creek, Mitchell Creek, Butler Creek, Hogan Creek, Sunshine Creek and Badger Creek. Land use in the 34,560-acre Johnson Creek watershed ranges from heavily developed urban areas (the cities of Portland, Milwaukie and Gresham) to rural farm and nursery lands (headwaters).

Flow monitoring indicates that low-flow conditions in Johnson Creek may adversely impact aquatic life. The Oregon Department of Fish and Wildlife (ODFW) has set minimum flow targets to protect salmonids in Johnson Creek (Meross 2000). Flows in the middle and upper watershed frequently do not meet those minimum flows, particularly in spring and summer

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[1] A hydrograph is the annual and seasonal trend in flow in a stream or river.

months. Below Crystal Springs, which provides consistent and abundant groundwater flows, minimum instream flows are typically met.

There is also evidence of adverse impacts from excessive peak flows. The Sycamore gage provides the longest period of record with which to evaluate changes in flow over time that result from human activities.[2] Statistical evaluation of flow since 1940 indicates some increase in the flashiness of peak flows over the period of record (Clark 1999). Significant impacts on peak flows in Johnson Creek also appear to be affected by alterations in the stream channel and floodplain that change the way floods flow through Johnson Creek, as described below.

Johnson Creek has been substantially altered from its historical configuration. Diking, channelization and other alterations of the natural floodplain have eliminated many of the areas that once absorbed and conveyed floods through the watershed. One of the most significant alterations occurred in the 1930s when the Works Progress Administration widened, deepened, rock-lined and channelized 15 miles of the 25-mile stream in an attempt to control flooding. These alterations have had long-lasting and marked effects on the habitat and hydrology of the watershed. Most significantly, the historical floodplain of Johnson Creek is disconnected or minimally connected through much of the stream's length. The lack of floodplain connection means that flood flows cannot spread out and attenuate on the floodplain. Instead they are directed and concentrated into the main channel, where they increase scour and degrade instream habitat.

ODFW conducted habitat surveys throughout Johnson Creek (Oregon Department of Fish and Wildlife 2000). The department's findings indicate that Johnson Creek has extremely low wood volumes, a high percentage of hardened banks, lack of refugia through many reaches, channel incision and high levels of fine sediment. Riparian vegetation is minimal or lacking throughout much of the watershed. Interestingly, riparian vegetation is as lacking in the upper watershed as it is in the lower watershed.

Fish access to habitat is impaired by culverts throughout the watershed. Although there are no culverts on the mainstem until high in the watershed, they are present on nearly all the tributaries to Johnson Creek. Crystal Springs, an area used by local and migratory Willamette salmonids, has a series of partially impassable culverts along its length, and some of the least developed tributaries along the southern side of the middle watershed also have culverts along their confluences with the mainstem.

Water quality in Johnson Creek is rated as fair to poor. Johnson Creek was placed on the 303 (d) list by DEQ for bacteria, summer temperature and toxics (DDT and dieldrin). The 303 (d) listing includes the entire stream, from the mouth to headwaters. The numerous investigations of temperature in Johnson Creek over the years have consistently indicated that elevated temperatures are a problem throughout the watershed.

The fish community in Johnson Creek is dominated by redside shiners, reticulate sculpin and speckled dace (Johnson Creek Corridor Committee 1995). Large scale suckers are abundant in the lower reaches. Adult salmonids that have been observed in the stream include coho

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[2] The Sycamore gage is above the City of Portland and so does not reflect the impacts from the most intensely urbanized portion of the watershed. However, it does reflect impacts from Gresham and other changes within the middle and upper watershed since the 1940s.

salmon, chinook salmon, cutthroat trout and steelhead (ODFW unpublished data, as cited in Ellis 1994).

Tryon Creek

Tryon Creek is a seven-mile free-flowing stream located in a 4,237-acre watershed. The stream flows in a southeasterly direction from the West Hills of Portland to the Willamette River near Lake Oswego. It is primarily a moderate gradient stream with steep slopes. The upper watershed has undergone common impacts associated with urban development, including increased stream velocities and stream bank erosion (City of Portland Bureau of Environmental Services 1997). The increased impervious surface in the upper watershed has resulted in higher volume peak flows.

Channel condition is typical of a moderate-gradient Cascade stream with steep slopes. Approximately 60 to 75 percent of the slopes within the watershed exceed a 30 percent grade (City of Portland Bureau of Environmental Services 1997). This results in a high frequency of mass wasting and erosion. In addition, soils in the watershed are from a silt loam series (Cascade) that are underlain by a fragipan[3] that impedes water infiltration and root penetration. This results in a high incidence of wind throw, mass wasting, channel incision and bank erosion.

Historically, Tryon Creek provided habitat for sea-run cutthroat, steelhead, coho and possibly chinook salmon. However, development activities, particularly culvert and road crossings, have resulted in degraded habitat and migration barriers. Habitat in Tryon Creek has been evaluated in ODFW stream surveys (Oregon Department of Fish and Wildlife 2000) and a City of Portland corridor assessment (City of Portland Bureau of Environmental Services 1997). Instream habitat ranged from marginal to optimal in a few areas, with most of the marginal habitat within the more heavily urbanized upper watershed. Highest quality habitats were located within Tryon Creek State Park, which had wide and relatively undisturbed riparian buffers. Even within this protected area, however, wood volume was low and channel incision was evident. Above the park the stream becomes highly segmented by road crossings and their associated culverts, and it is affected by intensive urban development.

Arnold Creek, one of the larger tributaries to Tryon, has good instream habitat within the lower section, with suboptimal percentages of fines, bank erosion and incision being the primary forms of degradation within the lower reaches. However, Arnold Creek is highly segmented by culverts from road and driveway crossings. In addition, invasions of nonnative plants are evident even within the higher quality areas of Arnold Creek and Tryon Creek State Park. Falling Creek, another major tributary to Tryon, has poor to marginal instream habitat, with a lack of instream cover, poor bank and riparian structure and excessive fine sediments.

Water quality in Tryon Creek is good to fair. Tryon Creek is on the DEQ 303(d) list for summer temperature. The City of Portland is currently monitoring the concentrations of 13 water quality parameters, but no modeling or analyses have been completed to date (City of Portland Bureau of Environmental Services 2000). A preliminary examination of the data indicates that with the exception of temperature, water quality generally meets water quality standards.

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[3] A soil layer, often composed of clays, that can act to slow or impede infiltration of water.

Impairment of fish access to habitat by culverts is a significant issue throughout the Tryon Creek watershed. A large culvert is present at the mouth of Tryon Creek just above its confluence with the Willamette River (at RM 19.9). Although baffles are present within this culvert, it is likely that the culvert impairs salmonid movements into and out of the watershed. An impassable culvert is present at Boones Ferry Road. Above this, there are many additional impassable culverts on Tryon and Arnold creeks that limit movements of resident fish through the watershed. A series of waterfalls and rapids at Marshall Park (at RM 2.7) that are considered a natural barrier would have limited anadromous fish access prior to the presence of culverts.

Fanno Creek

Fanno Creek is a tributary to the Tualatin River Basin, which drains about 20,500 acres (City of Portland Bureau of Environmental Services 1997). Land use in Fanno Creek is dominated by residential and commercial activities. Impervious areas, which are connected to a stormwater drainage system, make up 28 percent of the watershed, and 12 percent of the watershed consists of impervious areas that are not connected to the storm drain system.

Instream habitat quality in Fanno Creek and in two tributaries—Vermont and Woods creeks—was rated as extremely impaired or threatened, primarily as a result of adverse effects from excessive amounts of fine sediment (City of Portland Bureau of Environmental Services 1997). High channel erosion is present through much of the watershed within the city as a result of lack of bank vegetation, large wood and rock. These factors result in limited habitat complexity and instream cover. Channel morphology is generally poor and dominated by pools or glides with very few riffle areas. Isolated areas with comparably higher habitat values are present in some reaches in relatively undeveloped areas or in headwater reaches.

As a tributary to the Tualatin River, Fanno Creek has total maximum daily loads (TMDLs) for temperature, chlorophyll *a*, dissolved oxygen and bacteria. Urban and suburban development within the watershed has contributed to these water quality problems as a result of reduced riparian vegetation and increased nutrient loading and stream temperatures.

Most of Fanno Creek within the City of Portland is inaccessible to anadromous fish because of impassable culverts downstream of City limits. The City of Portland sampled fish populations in 1993 and found reticulate sculpin, redshide shiner, cutthroat trout and peamouth present in the upper reaches.

Forest Park Streams (Balch Creek, Miller Creek and Other Tributaries)

The Forest Park streams contain a number of small watersheds such as Balch and Miller creeks. Land use within these subbasins is largely open space, although there are also residential, industrial and transportation uses.

Because of the extensive protection provided by Forest Park, the Forest Park watersheds are probably among the least altered watersheds within Portland when compared with their historical conditions. The exception to this is in the lower reaches, where each stream must pass under Highway 30 and through the heavily industrialized port and industrial areas along the banks of the Willamette. The streams typically pass through pipes for considerable lengths through this section and receive stormwater and combined sewer overflow discharges before discharging to the Willamette.

The hydrographs in these small watersheds are probably reasonably comparable to historical conditions because of the low overall percentages of imperviousness and small amounts of stormwater drainage to them. Channel conditions range from mature forested stands with good bank stability in the middle and upper sections to underground pipes that carry the streamflow through industrial areas and then out to the Willamette River via a pipe outlet in the lower sections.

Limited water quality data are available for these streams. Based on our knowledge of these streams, water quality is probably generally good, except in the lower sections, which receive stormwater and CSO discharges. Excessive amounts of fine sediment may occur in sections of these streams near residential or industrial development. Summer temperatures may be unsuitable in certain areas, as a result of reduced and unvegetated riparian areas. Toxic contamination may be an issue in reaches receiving CSO and stormwater discharges.

The biota of the Forest Park streams are likely altered relative to historical conditions. The piping of streams and installation of culverts have blocked habitat access for anadromous fish; this has resulted in the extirpation of native anadromous fish species. Resident cutthroat trout are still present in many of these watersheds.

Columbia Slough

The Columbia Slough extends 18 miles from Fairview Lake on the east to the Willamette River at Kelley Point Park on the west. The slough drains 51 square miles, or 33,000 acres, of residential neighborhoods, vegetable farms, industrial areas and transportation corridors. The Columbia Slough is the remnant system of marshes, wetlands, lakes and side channels that historically formed the floodplain of the Columbia River between the mouths of the Willamette and Sandy rivers. However, the Columbia Slough has been severely altered from this historical condition. It is now a highly managed water conveyance system with dikes and pumps that provide watershed drainage and flood control and maintain a highly artificial hydrograph. Over the years extensive urban, agricultural and industrial development have profoundly altered the watershed and have resulted in a contaminated watershed that has lost a vast percentage of its upland, wetland and aquatic habitat.

The slough's channel configuration and flow regime have been altered significantly from historical conditions. Large amounts of open water areas and wetlands have been eliminated as a result of urban development, and the hydrologic connectivity of the entire system has been greatly reduced. The creation of the levee on which Marine Drive is located has blocked the direct connection between the Columbia Slough and the Columbia River system. A levee and pump station at NE 18th Avenue blocks passage of fish into the upper parts of the slough. Consequently, juvenile salmonids from the lower Willamette River that are seeking out rearing habitats have access only to the lower section of the slough.

Water quality in the Columbia Slough watershed is highly degraded. DEQ has placed the Columbia Slough on the 303(d) list for 10 parameters (four toxics, bacteria, nutrients, pH, dissolved oxygen, chlorophyll *a* and temperature).

The biological communities in the Columbia Slough are degraded as a result of the extensive degradation of flow, habitat and water quality conditions. Fish communities are dominated by nonnative warm-water fish species such as common carp and bluegill. Benthic macroinvertebrate communities are extremely sparse.

Biological Communities and Habitats in the City

Three broad classes of habitat are present in the Portland area that support fish and wildlife: aquatic, riparian and upland. The type, distribution and quantity of these habitats in Portland's watersheds and waterways are highly variable as a result of the diversity of environmental factors (topography, soils, geomorphology, climate, vegetation, etc.) and human-related factors (land use activities, habitat disturbance, etc.).

Habitat attributes can be used as valuable indicators of the composition and condition of the biological community. For example, the composition of biological communities can be tied in very predictable fashion to their preferred habitat associations. The health of biological communities is directly affected by the types and condition of specific habitat features. For example, salmonids prefer not only cold, clean and clear water but also specific physical habitat features, such as a diversity of depths, velocities and substrates.

Aquatic Habitats

Aquatic habitats can be broadly classified as running-water or slack-water systems. In the mainstem Columbia and Willamette rivers running-water habitats and the processes that form them differ substantially from running-water habitats in the much smaller tributaries. More than size and flow volume distinguish large, low-gradient streams from small tributaries. Elements such as flood frequency, channel characteristics, disturbance regimes and productivity all vary, creating unique habitats.

Floods are a driving force in large rivers such as the Columbia and Willamette. In these rivers, floods are often slow to rise, extensive and can last for several months, but they generally occur during predictable seasons. Plants and animals found in the floodplain environment have responded to this regime of predictable flooding by developing adaptations suited to the wetter location. In contrast, smaller tributaries tend to have irregular flood patterns that are strongly influenced by local precipitation events.

Tributary streams generally have smaller channels and narrower floodplains. The channel and the floodplain, when there is one, consist of larger rocks and boulders and poorly sorted gravels (Gurnell 1995). Pools, riffles and glides are common habitat features. Wood may be large enough to span the channel and is not easily dislodged in headwater streams. Where tributaries are wide enough and have flow volume that allows the downstream movement of logs and stumps, logs can accumulate in jams spaced several channel-widths apart. In large, low-gradient streams, sediments are sorted by size and generally include abundant fine particles of silt and clay. The pool, riffle and glide sequence common in the tributary streams is no longer the dominant feature of the habitat. Instead, channel roughness, shallow-water areas and deep pools define aquatic habitats. Logjams are scattered along the shoreline near the high-water line, at the end of islands and bars and submerged in the channel.

Disturbance regimes also can differ. In tributary streams, the more direct contact between the river and adjacent hillsides results in more frequent landslides, debris flows, dam-break floods and bank erosion. In turn, channel form is more likely to be influenced by mass wasting and alluvial processes (Naiman and others 1992). However, mass wasting is less common along large rivers because the river's terraces and floodplains generally insulate adjacent hillsides from the river's erosive forces. However, floods, tree falls and bank erosion are common forms of disturbance along large rivers.

Tributary streams typically have narrow tree canopy openings, which reduce the amount sunlight reaching the stream. In headwater streams as little as 1 to 3 percent of the total available solar radiation reaches the stream. This reduced sunlight helps maintain relatively cool and stable daily temperatures (Naiman and others 1992). As stream size increases, solar input increases. For large rivers, most of the solar input reaches the river, although penetration can be limited by river depth.

The amount of sunlight reaching large river waters supports the production of phytoplankton, periphyton and rooted vascular plants that are dominant in large river food webs. Fine particulate matter from upstream and from floodplains also plays a critical role in supporting the tropic structure of large river aquatic communities. Zooplankton and benthic detritivores are considered important invertebrate consumers. However, floodplain inundation is critical to providing the organic inputs necessary to support productivity. In smaller tributary streams primary production is lower. Invertebrates consume algae or organic material derived from riparian vegetation.

Riparian Habitat

Riparian areas are the environments adjacent to streams and rivers, a zone of direct interaction between terrestrial and aquatic ecosystems. An intact riparian area serves a multitude of functions vital to aquatic ecosystem health. More specifically, a healthy riparian and aquatic ecosystem provides the functions discussed below.

Organic Materials. Riparian vegetation influences adjacent aquatic systems by providing important components of the food web (Hachmoller and others 1991, Forest Ecosystem Management Assessment Team 1993), and it plays a significant role in the structure of aquatic communities. Litterfall, such as leaves, twigs, bark and needles, can fall to the ground or directly into the stream, providing an important food source for insects and invertebrates.

Channel Dynamics. Stream channels are dynamic systems. Water velocities and levels fluctuate, submerging and exposing the riparian zone and floodplain (Swanson and others 1982) through time. Meanders can slowly shift downstream or across the floodplain as erosion wears at stream banks, or they can migrate suddenly when a flood cuts a new channel that captures the bulk of a stream's flow. Wood entering the stream channel from the riparian area influences channel dynamics by diverting flow, creating channel roughness and stabilizing banks (Forest Ecosystem Management Assessment Team 1993, May and others 1997, Gregory and others 1991, Sedell and others 1988). Such processes help create a variety of habitats in the floodplain and maintain channel complexity. Annual flooding allows for the interchange of organic material and nutrients (in the form of wood, leaf litter and invertebrates) between the riparian and aquatic environments.

Water Quality. The roots, wood and soils in the riparian area contribute to water quality (Forest Ecosystem Management Assessment Team 1993). Roots and wood help limit sediments entering the stream by moderating the erosive power of floodwaters and holding soils in place (Budd and others 1987). Riparian vegetation acts as a barrier that reduces sediment and debris transport (Swanson and others 1982, Gregory and others 1991), slows surface flows and encourages infiltration (Budd and others 1987, Knutson and Naef 1997). Riparian areas also filter (from groundwater and surface flows) sediments (Forest Ecosystem Management Assessment Team 1993), pollutants (Knutson and Naef 1997), metals and excess nutrients (Castelle and others 1994). Riparian vegetation absorbs and stores nutrients and other dissolved materials as they are transported through the riparian zone (Spence and others 1996).

Water Quantity. In a watershed, a variety of characteristics, such as climate, topography, geology, geomorphology and vegetation, all interact to determine the amount and velocity of water flowing in a stream (Spence and others 1996). In riparian areas, and throughout a watershed, water can be stored and transported in the atmosphere, vegetation, stream channel, floodplain, soil and shallow or deep groundwater aquifers. Riparian features and functions are a critical part of this storage and transport system.

Riparian plants intercept, store and transpire water. Water stored in the atmosphere can be intercepted by vegetation or other structures. The leaves, needles and branches in the canopy and on the ground can absorb precipitation and prevent it from reaching the ground, or they slow its progress, thus reducing the amount of erosion and runoff (Black 1990).

Microclimate. The diverse structure and composition of the riparian zone create microclimates, multi-layered canopies and off-channel areas that provide fish and wildlife habitat. Riparian vegetation creates a microclimate that influences both the riparian area and stream environment by affecting soil moisture and temperature, air temperature, water temperature, wind speed and relative humidity (Forest Ecosystem Management Assessment Team 1993).

Wildlife Habitat. Budd and others (1987) claims that, regarding riparian habitat, "there is no other habitat type upon which wildlife is more dependent." This statement is supported by Kauffman and others (2001), who report that although riparian zones cover only an estimated one to two percent of the landscape, 53 percent (319 out of 593) of wildlife species that occur in Oregon and Washington use these areas. The Forest Ecosystem Management Assessment Team (1993) reports that most vertebrates regularly use the riparian zone for some part of their activity and that the zone also provides wet micro-sites, seeps and springs that are important for maintaining arthropods, mollusks, bryophytes, vascular plants and riparian-associated amphibians. Riparian vegetation also is known to influence benthic communities (Erman and others 1977), birds and mammals (Castelle and others 1994, Kauffman and others 2001) and herpetofauna (Kauffman and others 2001).

Intact riparian areas are important to fish and wildlife because they do the following:

- Have a high diversity of vegetation species and structure
- Often have unique vegetation assemblages relative to the upland area
- Exhibit high edge-to-area ratios because of their linear nature
- Influence the environment-microclimate, chemistry, structure
- Provide corridors and migration routes
- Provide habitat features necessary for the survival of many species, including water, forage, nesting and breeding habitat, resting areas and cover (Kauffman and others 2001)

Upland Habitats

Upland habitat refers to all areas that are not riparian, wetland or open water habitats. (It should be noted, however, that wetlands may be found within upland areas). Although most wildlife species associated with upland habitats also use riparian areas, they are dependent on upland areas for key aspects of their life history such as breeding, food or shelter. Habitat types found in upland areas include grassland or meadow, shrubs, coniferous or deciduous forests and rocky slopes.

Johnson and O'Neil (2001) describe five upland habitat types present in significant amounts in the Portland area. These include Westside Lowlands Conifer-Hardwood Forest, Westside Oak and Dry Douglas-fir Forest and Woodlands, Westside Grasslands, Agriculture Pasture and Mixed Environs, and Urban and Mixed Environs. These five make up the majority of upland habitats available to native wildlife in this region. Eighty-nine percent of all terrestrial species in the Portland area are associated with upland habitats, with at least 28 percent depending on these habitats to meet their life history requirements.

Westside Lowlands Conifer-Hardwood Forest

This habitat is widespread and prevalent in the Portland area. Historically and currently the most extensive of all natural habitats west of the Cascade Mountains, it often forms the matrix within which other habitats occur as patches and is very important to wildlife in this region. This habitat may be dominated by conifers, deciduous trees or both and tends to have structurally diverse understories. In nutrient-poor soil conditions evergreen shrubs dominate the understory, while nutrient-rich or moist sites contain more deciduous shrubs, ferns and grasslike plants. Mosses are a major ground cover component, and older stands are rich with lichens.

Several wildlife species dependent on this habitat are at risk at the state and/or federal level. This includes one amphibian, the northern red-legged frog. At-risk bird species dependent on this habitat include band-tailed pigeon, northern pygmy-owl and olive-sided flycatcher. Mammals include two bat species (long-legged myotis and silver-haired bat) and a tree-dwelling rodent, the red tree vole.

Westside Oak and Dry Douglas-Fir Forest and Woodlands

This habitat is limited in area and declining in extent and condition in the Willamette Valley. Conifers, deciduous trees or some combination of the two may dominate these typically dry woodlands. Canopy and understory structures are variable, ranging from single- to multi-storied, with large conifers sometimes emerging above deciduous trees in mixed stands. This habitat is too dry for western hemlock and western red cedar; lack of shade-tolerant tree regeneration, along with understory indicators such as tall Oregon grape, help distinguish oak woodlands from Westside Lowlands Coniferous-Hardwood forests. Large woody debris and snags are less abundant than in other westside forested habitats. Sweet cherry (*Prunus avium*) and English hawthorn (*Crataegus monogyna*) have invaded and sometimes dominate this habitat's subcanopy in the Metro region.

Several wildlife species dependent on this habitat are considered at risk at state and/or federal levels. These include band-tailed pigeon, Lewis' woodpecker (extirpated as a breeding species), acorn woodpecker and western bluebird. At-risk mammals include western gray squirrel and red tree vole.

Westside Grasslands

Once widespread in the Willamette Valley, Westside Grasslands are now rare and declining because of fire suppression, conversion to agriculture and urban habitats and invasion by nonnative species. In the Metro region, this habitat has virtually disappeared.

Agriculture, Pasture and Mixed Environs

Occurring within a matrix of other habitat types, agricultural lands often dominate the landscape in flat or gently rolling terrain, on well-developed soils and in areas with access to irrigation water. This habitat can be diverse, ranging from hayfields and grazed lands to multiple crop types, including low-stature annual grasses to row crops to mature orchards. Hedges, windbreaks, irrigation ditches and fencerows provide especially important habitat for wildlife (Demers and others 1995). The U.S. Department of Agriculture (USDA) Conservation Reserve Program lands are included in this category and may provide valuable wildlife habitat. Agricultural lands are subject to exposed soils and harvesting at various times during the year and receive regular inputs of fertilizer and pesticides, thus influencing the quality of water-associated habitats.

The greatest conversion of native habitats to agricultural production occurred between 1950 and 1985, primarily as a function of U.S. agricultural policy (Gerard 1995). Since the 1985 Farm Bill and the economic downturn of the early to mid 1980s, the amount of land in agricultural habitat has stabilized and begun to decline (National Research Council 1989). The 1985 and subsequent farm bills contained conservation provisions encouraging farmers to convert agricultural land to native habitats (Gerard 1995, McKenzie and Riley 1995). Clean farming practices and single-product farms have become prevalent since the 1960s, resulting in larger farms and widespread removal of fencerows, field borders, roadsides and shelterbelts (National Research Council 1989, Gerard 1995, McKenzie and Riley 1995). In Oregon, land-use planning laws adopted in 1973 prevent or slow urban encroachment and subdivisions into areas zoned as agriculture.

Twenty-nine percent of birds and 25 percent of mammals native to Oregon use croplands and pasturelands to meet their habitat needs (Puchy and Marshall 1993). Agricultural fields left fallow for the winter often provide wintering habitat for migratory birds (Puchy and Marshall 1993). Many of the species that use this habitat require the nearby associated aquatic habitats to meet their needs. Bird species at risk that depend on this habitat include Oregon vesper sparrow and western meadowlark. One mammal, the Camas pocket gopher, is at risk at the federal level.

Urban and Mixed Environs

These areas are widely distributed but patchy. Urbanization encompasses all habitats with impervious surfaces covering at least 10 percent of the land's surface (less than 10 percent is considered rural). Characterized by buildings and other structures, impervious surfaces and plantings of nonnative species, urban environments provide habitat to some species requiring structures such as cavities, caves, cliffs and rocky outcrops and ledges. This habitat is subdivided into low-density (10 to 29 percent impervious surfaces), medium-density (30 to 59 percent impervious) and high-density (60+ percent impervious) areas, described in detail in

Johnson and O'Neil (2001). Many human-induced changes in urban areas are essentially irreversible; for example, building a house requires removing vegetation, scraping and leveling topsoil, building driveways and roads and running sewers and utilities both above and underground. Canopy cover is reduced in these habitats, and structural features present in historical vegetation, such as snags and dead wood, are rare.

Frequent human disturbance is normal in urban habitats, and species that are disturbance-sensitive tend to be absent or reduced in numbers (Marzluff and others 1998). Historical natural disturbance patterns are largely absent in urban habitats, although flooding, ice, wind or fire still occur. Flooding and pollution are more frequent and more severe in areas with significant impervious surface cover and/or modified stream systems. Temperatures are elevated, background lighting is increased and wind velocities are altered by the urban landscape (often they are reduced, except around the tallest structures downtown, where high-velocity winds are funneled around the skyscrapers). Urban development often occurs in areas with little or no slope and frequently includes wetland habitats. The urban and mixed environs habitat type is expected to increase at an accelerating pace locally and nationally (Parlange 1998).

Studies in the Pacific Northwest document declining wildlife diversity with increasing urbanization (Penland 1984, Puchy and Marshall 1993). Nonnative species and generalists are most common in urban habitats. Few sensitive species are associated with this habitat, because sensitive species are often habitat specialists that are quickly out-competed by nonnatives and generalists. The only closely associated mammal of concern is big brown bat (genus, spp.), also known by the common name "house bat." This nonmigratory species often lives in a variety of artificial structures, eating termites and beetles (Csuti and others 1997).

Artificial structures provide key habitat for some wildlife species in the urban area (Puchy and Marshall 1993). For example, bridges provide important bat habitat. Fences, power lines and poles provide perches from which hawks and falcons search for prey. Ledges of several tall buildings in the urban area provide perching sites for wintering peregrines, from which they can chase prey (Puchy, personal communication, 2001). Nest boxes and bird feeders provide valuable resources, as the continuing recovery of western bluebirds within the Metro area demonstrates. Chapman Elementary School in Portland is renowned for the annual roosting of thousands of Vaux's swifts in the furnace chimney, and the school community is working to conserve these long-distance migrants (Robertson 1999). Since 1993 peregrine falcons have chosen the Fremont Bridge, the St. Johns Bridge and other structures in the Portland area as a nesting place, as these structures have characteristics similar to the high cliffs that would be attractive in the wild (Sallinger 2000; Puchy, personal communication, 2001). The bridges provide three important functions for the peregrine falcons: a high nesting spot inaccessible to humans, updrafts and proximity to a constant food supply, in the form of nonnative pigeons, starlings and other birds.

There are no species at risk dependent upon this habitat, although the purple martin population in Portland appears to be dependent on artificial nest boxes along Marine Drive (Puchy, personal communication, 2004).

Salmonid Populations in Portland's Waterways

Life History of Salmonids in the Lower Willamette River

The Independent Scientific Group (2000)[4] recognized that multiple life histories have been observed in populations of salmonids. Life history diversity in the Willamette River ecosystem should be substantial, given the size of the watershed, number of tributaries, highly variable flow regime, complex geomorphology and complex oceanic circulation patterns.

Spatial and temporal habitat diversity are critical for the expression of life history diversity (Independent Scientific Group 2000). Habitat degradation and the loss of connectivity among habitats have suppressed much of this expression, contributing to the loss of different life history strategies. Historically, adaptation of individual populations to specific habitats (and life history pathways) across a mosaic of different landscapes created an abundant diversity that characterized salmonids in the Willamette watershed. Today much of that diversity has been lost as a result of degradation of both the mainstem and tributary habitats. This loss is difficult to verify because of a host of factors, including altered and lost habitat conditions that have resulted from the many changes imposed on the river (such as changes to flows and the loss of side channels and floodplains as a result of diking and filling).

Hypotheses of current use in the lower Willamette River by listed migratory salmonids were formulated and discussed in a workshop sponsored by the City of Portland and NOAA Fisheries (formerly the National Marine Fisheries Service, or NMFS) in June of 1999. Workshop attendees were asked to consider three hypotheses covering the range of possible strategies of adult and juvenile salmonids in the lower Willamette River. Each of the hypotheses explored the different possible spatial and temporal strategies for each of the species. These included consideration of adult migration, spawning, juvenile rearing and smolt migration for winter steelhead (*Oncorhynchus mykiss*) and spring and fall chinook (*Oncorhynchus tshawytscha*).

The choice to focus on life history strategies at the workshop was due to the recognition by some members of the scientific community that these strategies should be considered in the development of salmonid conservation efforts (Carl and Healey 1984, Lichatowich and others 1995, Spence and others 1996). This reflects the widely held view that the historically high abundance of salmonids in the Pacific Northwest was due to the diversity of life history patterns that evolved over time.

The workshop participants considered the following hypotheses:

- **Hypothesis One:** Adult and juvenile salmon migrate quickly through the lower reach of the river without any use of habitat in the vicinity of the City of Portland. This hypothesis assumed that there was no adult spawning and/or holding and no rearing by juveniles.
- **Hypothesis Two:** Adult salmonids move quickly through the lower reach of river while juveniles use this reach for some or all of their freshwater life history phases.
- **Hypothesis Three:** Both adult and juvenile salmonids use this reach for some or all of their life history phases.

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[4] This was a group of independent scientists that developed a conceptual foundation and review and synthesis of science underlying the Columbia River Basin Fish and Wildlife Program of the Northwest Power and Conservation Council.

The workshop concluded that the third hypothesis provided the best explanation for both winter steelhead and spring chinook (adult and juvenile) behaviors in the lower river, while the second hypothesis provided a better explanation of fall chinook (adult and juvenile).

This produced the following key hypotheses of salmonid use in the lower Willamette River:

- Spring chinook and winter steelhead (adults and juveniles) use the reach of the Willamette River within the vicinity of Portland for some or all of their life history phases.
- Fall chinook juveniles exhibit similar near-shore and off-channel behaviors as spring chinook and steelhead juveniles with a series of migrating and rearing strategies as they move down the Willamette River in the vicinity of Portland.

Juveniles of winter steelhead and spring chinook are expected to use habitats available in the shallower margins of the river or off-channel sites where available for rearing as they out-migrate through the lower river.

The importance of off-channel and near-shore environments as habitat for juvenile salmon was explored in depth by the workshop participants. Depending on conditions in the main channel, juveniles seek out these areas either for shelter from high-velocity events and protection from predators or because they offer optimal rearing conditions (such as a steady supply of food particles).

Adult steelhead and spring chinook have been documented holding up in the lower mainstem for a period of time before moving upriver (City of Portland 1999). Adult spring chinook come in as late as December and hold in the main river before crossing over the Willamette Falls. Adult steelhead have been documented entering the mouth of the Clackamas River with a darkened coloration, indicating that they have been in freshwater for some time (City of Portland 1999).

Fall chinook are believed to exhibit more of the traits of the second hypothesis because of the lack of reliable information on the behaviors of the adults. Juvenile fall chinook exhibit similar near- and off-shore behaviors as spring chinook, with a series of migrating and rearing strategies as they move down the river.

Life History of Salmonids in the City of Portland Tributaries

Since the 1999 workshop, the City of Portland's Endangered Species Act Program has investigated further information that currently exists regarding salmon and trout presence and their use of the tributary streams that flow through Portland into the Willamette River. In some cases, studies or observations have documented salmon and/or trout presence. In other cases, no documentation exists but there are reasons why salmon or trout are believed to be present in a given tributary. The following are the current hypotheses regarding salmonids in tributaries to the Willamette River in Portland:

- Chinook juveniles that have emerged from spawning sites in the upper Willamette River watershed are using the lower reaches of watersheds and other, off-channel sites in Portland for temporary rearing as they migrate through the area to reach the ocean.
- Two groups of steelhead exist in Portland: self-sustaining independent populations in Johnson and Tryon creeks and juveniles seeking temporary rearing opportunities as they

migrate from areas in the upper watershed to the ocean. Under NOAA Fisheries' definition of viable salmonid populations, Johnson and Tryon creeks support independent populations of steelhead.

- Cutthroat trout are found throughout Portland in watersheds such as Johnson and Tryon creeks, where access to habitat is unimpeded by culverts, as well as in Fanno Creek, Stephens Creek and Balch Creek in Forest Park — creeks that have been cut off from the Willamette River by culverts.

There has been little documentation of the extended presence of chinook in tributary streams under the City of Portland's jurisdiction and little evidence to suggest that these streams supported self-sustaining populations of chinook. Adult chinook have been documented spawning in lower Johnson Creek over the years but in such small numbers as to prompt Ellis (1994) to speculate that these fish may be strays.

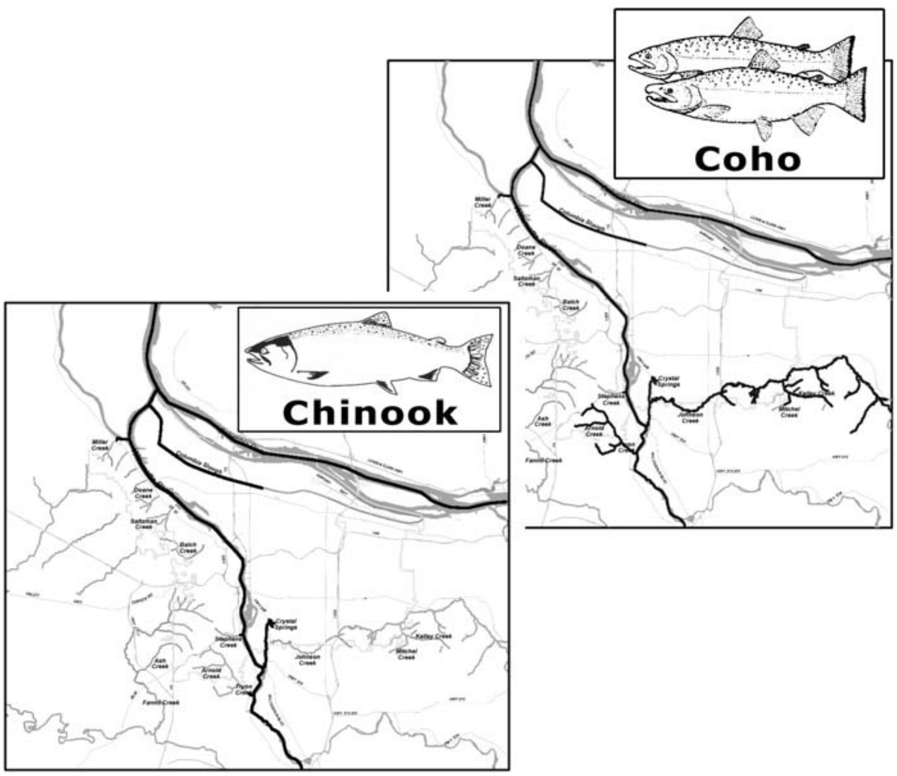

FIGURE E-2
Distribution of Chinook and Coho Salmon In Portland's Waterways

Juvenile chinook have been documented in the lowest reaches of Johnson Creek and Crystal Springs Creek (Ellis 1994, Reed and Smith 2000) and in Smith and Bybee Lakes (Fishman Environmental Services 1987). Given the limited information that is available regarding the number of adult chinook that have returned to spawn, the evidence suggests the possibility that juveniles that have spawned in other watersheds may be using these areas as temporary off-channel sites as they migrate through the area. This hypothesis would be consistent with the observations of the Independent Scientific Group (2000) of chinook juvenile out-migration strategies that consist of movement from upriver tributary spawning sites into mainstem areas downstream where they can rear over the winter (Healey 1991).

Steelhead. Steelhead and/or rainbow trout have been documented in the Crystal Springs Creek tributary to Johnson Creek, the lower 9.6 miles of Johnson Creek (from roughly SE 145th to the confluence with the Willamette River) (Ellis 1994), the Kelley Creek tributary of Johnson Creek

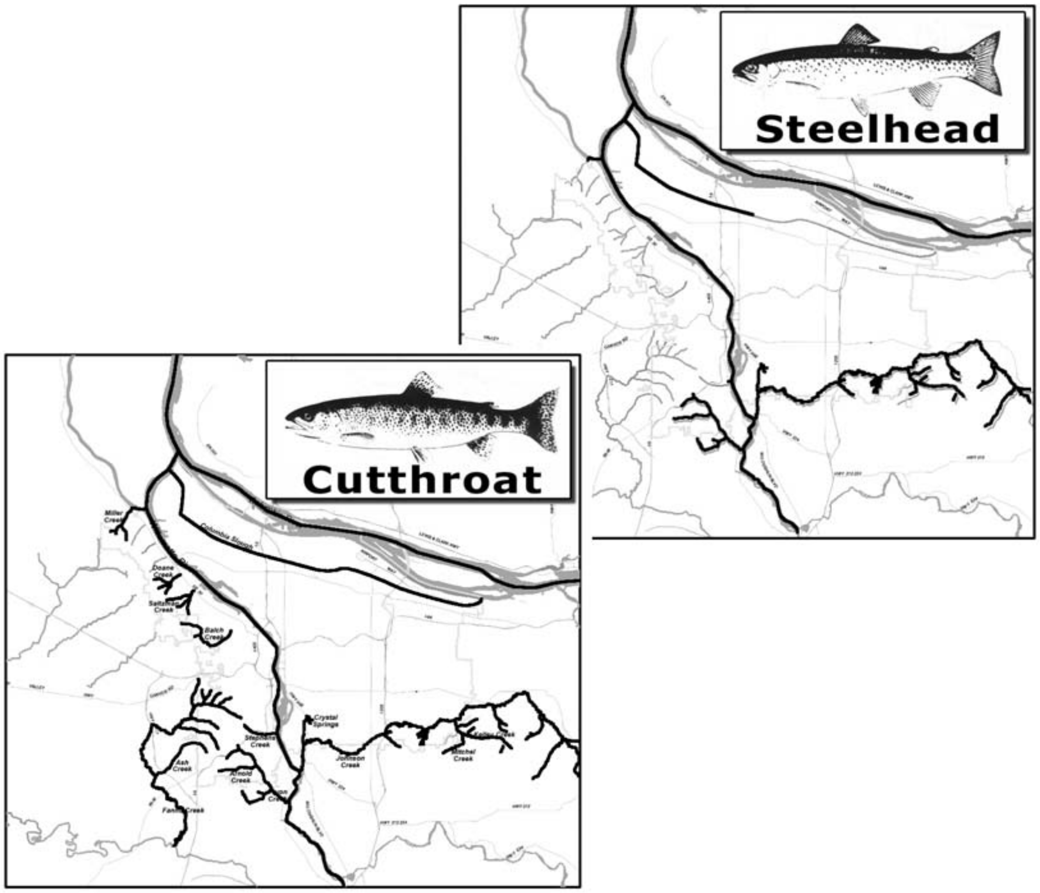

FIGURE E-3
Distribution of Steelhead and Cutthroat Trout in Portland's Waterways

(Ellis 1994, Reed and Smith 2000), the Tualatin Basin (Friesen and Ward 1996), the lower portion of Miller Creek below St. Helens Road (City of Portland 1992) and Tryon Creek (City of Portland 1992, Pacific Habitat Services 1997, Reed and Smith 2000).

Given the extensive culverting of streams emptying into the Willamette within Portland, there is very little stream habitat that is accessible to salmonids for spawning and rearing in the tributaries. Johnson and Tryon creeks are the only watersheds within the metropolitan area that are accessible to migrating steelhead.[5]

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[5] A culvert under Highway 43 near the mouth of Tryon Creek has been determined to be passable by an Oregon Department of Fish and Wildlife inventory. However, there has been speculation that the culvert is impassable at certain times of the year, depending on water levels (personal communication, Chris Prescott, City of Portland).

There are several small streams where temporary off-channel rearing of out-migrating juvenile steelhead may be occurring where habitat exists between the culvert and the river. For example, there is documentation of off-channel rearing of steelhead in the lower reaches of Miller Creek. When conditions are appropriate, the lower reaches of Stephens, Tryon, and Johnson creeks may offer temporary rearing opportunities to out-migrating juvenile steelhead spawned in tributaries upstream in the Willamette watershed. This hypothesis is consistent with the Independent Scientific Group's findings that steelhead juveniles in the Columbia Basin appear to move downstream to more productive areas as they grow and require more sustenance. Eventually, they move into the ocean when they reach a suitable size (Independent Scientific Group 2000).

The City of Portland's Endangered Species Act Program has determined that Johnson and Tryon creeks hold independent populations of steelhead. The documented findings of spawning and rearing steelhead suggest that these are more than strays. Determining their population status will not be easy. Nonetheless, because the purpose of the Endangered Species Act is to "provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved and to provide a program for conserving such species " (McElhany and others 2000), this determination must be made.

A viable salmonid population (VSP) is an independent population of any Pacific salmonid that has a negligible risk of extinction as a result of threats from demographic variation, local environmental variation or changes in genetic diversity over a 100-year time frame (McElhany and others 1999). The crux of this population definition is what is meant by "independent." According to NOAA Fisheries, an independent population is any collection of one or more local breeding units whose population dynamics or extinction risk over a 100-year time period are not substantially altered by exchanges of individuals with other populations (McElhany and others 2000).

The definition that NOAA Fisheries uses for an independent population is taken from Ricker's (1972) definition of a "stock." Ricker states that "an independent population is a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other groups spawning in a different place or in the same place at a different season."

Not interbreeding to a "substantial degree" means that two groups are considered to be independent populations if they are isolated to such an extent that exchanges of individuals among the populations do not substantially affect the population dynamics or extinction risk of the independent populations over a 100-year time frame.

The population defined here is not the only biologically logical grouping that may be encountered. Within a single population, for example, individual groups of fish are often reproductively isolated to some degree from other groups but not sufficiently isolated to be considered independent according to the criteria adopted here. These groups of fish are termed subpopulations.

Determining whether the City of Portland currently supports subpopulations or independent steelhead populations within the larger federally designated ESU (National Marine Fisheries Service 1996) will determine fish and habitat goals that the City of Portland will establish. Fish survey efforts conducted by the City of Portland's Endangered Species Act Program and a review of fish surveys and spot samples conducted in previous years have given some direction to this question. These findings suggest that the only two watersheds that have the potential to support an independent steelhead population are Johnson and Tryon creeks.

NOAA Fisheries admits that, given the paucity of information on the distribution, local abundance and migratory patterns of a species during its life cycle, it will be challenging to identify the appropriate groupings of salmon that are most useful for predicting the long-term persistence of populations (McElhany and others 2000). It is suggested that using direct observations of trends in abundance or productivity from groups of fish with known intergroup stray rates could determine the degree to which a population's dynamics are independent of those of any other group. It is likely that much of this information does not exist for urbanized areas such as Portland.

However, some information suggests that there are population dynamics occurring independently of those of any other group. The documentation of steelhead juveniles in surveys between 1992 and 1999 in the Kelley Creek subwatershed to Johnson Creek and documentation of possible overwintering juveniles (Reed and Smith 2000), combined with ongoing observations of spawning steelhead adults, suggest the continued presence of a small population and not just sightings of occasional strays.

It should be clear that a statement that the Johnson Creek watershed contains an independent steelhead population is a hypothesis based on preliminary evidence. The City of Portland would need to substantiate this with extensive survey work and other investigations (such as molecular genetic evidence) (Nielson and others 1994).

Coastal Cutthroat Trout. Given the potential for a coastal cutthroat trout listing by the U.S. Fish and Wildlife Service and the importance of improving the status of this species, the City of Portland's Endangered Species Act Program is determining the extent of cutthroat presence in streams within the City's jurisdiction.

Cutthroat trout have been documented in several streams that drain into the Willamette River, including Johnson Creek and its tributaries (Crystal Springs, Kelley, Hogan, Badger, Sunshine and Mitchell creeks) (Ellis 1994, Reed and Smith 2000). Cutthroat trout have also been observed in Tryon Creek (Pacific Habitat Services 1997, Reed and Smith 2000, Gram and Ward 2002) and Miller Creek (Gram and Ward 2002). No documentation is available to confirm whether these populations are anadromous.

All of the Forest Park streams that historically flowed into the Willamette River have been blocked by culverts. Balch Creek was isolated in 1921 when the lower part of the creek was diverted and incorporated into the City of Portland's sewer system, yet a small population of resident cutthroat trout population has been documented[6] (Johnson 1993). This evidence suggests that similar isolated populations of cutthroat may exist in Forest Park streams where appropriate flows and habitat exist.

Independent Populations versus Subpopulations. There is no clear guidance for determining whether a group of fish is a marginally independent population or a significantly distinct subpopulation within a larger population. It follows that if there is reason to assume that the

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[6] The population has been estimated to contain between 2,000 and 4,000 individuals.

Johnson and Tryon Creek watersheds support subpopulations rather than independent populations, there are similar steps that would need to be followed to determine recovery goals for the species. Of course, watershed or habitat goals within a recovery plan might look very different for watersheds or subwatersheds that are supporting subpopulations. Viable salmonid population goals may not be as easily applied for subpopulations that are spread out over many subwatersheds and watersheds and across multiple jurisdictions.

Currently many areas of Portland are able to support only temporary rearing of individuals from populations of steelhead and chinook that are emigrating out of larger tributaries in the upper portion of the Willamette River watershed. Many Portland watersheds are blocked near the mouth by culverts that allow anadromous fish access to, at best, only a few hundred meters of stream. These areas offer opportunities for fish to temporarily move off the mainstem of the Willamette, and fish in these areas most likely are coming from more productive watersheds such as the Clackamas River.

Because these areas offer temporary but important rearing opportunities for populations of salmonids outside Portland, attention needs to be directed toward ensuring that these rearing opportunities continue to exist. Robin Waples of NOAA Fisheries stated at a workshop with the Northwest Science Center and City government staff that degraded areas are recognized as playing a role in salmon recovery by providing demographic linkages. That is, fish from other populations and watersheds need to be able to move between areas. These temporary refugia sites provide important linkages between spawning sites and the ocean in both space and time. In addition, there is recognition that degraded areas might provide some production in the future (McElhany and others 2000).

Wildlife in Portland's Watersheds

The Portland metro area is fortunate to have retained some important natural areas such as Forest Park, the East Buttes, Cooper Mountain and other habitat that is essential for maintaining a diversity of wildlife species within the urban area. While some wildlife species that once inhabited our region are no longer found, remaining natural areas still provide habitat for many wildlife species, as well as recreational opportunities for humans (Houck and Cody 2000).

Metro's Regional Urban Growth Goals and Objectives (RUGGOs), adopted in 1995 state that "a region-wide system of linked significant wildlife habitats should be developed. This system should be preserved, restored where appropriate, and managed to maintain the region's biodiversity." Also in 1995, citizens of the Portland metro area passed a $135.6 million bond measure to acquire natural areas within the Portland metropolitan region. Metro has since acquired more than 7,000 acres of key habitat.

Amphibians

There are sixteen extant native amphibian species in the Portland metro area, including twelve salamanders and five frogs (see Metro's species list in Appendix 1 of Metro's *Technical Report for Goal 5*, revised draft dated January 2002; see http://www.metro.dst.or.us/metro/habitat/habitat_fish_docs.html). An additional species, the bullfrog, is introduced and places considerable pressure on native species. Amphibians and birds are the two groups in the area most dependent on aquatic and riparian habitats. In the Portland area, 69 percent of native amphibian species (salamanders, toads and frogs) rely exclusively on stream- or wetland-related riparian habitat for foraging, cover, reproduction sites and habitat for aquatic larvae.

Another 25 percent use these habitats during their life cycle. Six Portland-area amphibian species are state-listed species at risk; four species are considered at risk at the federal level (see Metro's species list).

Because amphibians require both aquatic and terrestrial habitats to complete their life cycle, changes to either ecosystem may interfere with amphibians' success (Schueler 1995). Small non-fish-bearing streams and beaver ponds may be important because they are free from competition and predation by fish (Gomez 1998, Metts and others 2001). As with salmonids, amphibians have specific habitat requirements and are sensitive to environmental change. Clean, relatively sediment-free water, rocky stream beds and woody debris are important to amphibians in western Oregon (Bury and others 1991, Welsh and Lind 1991, Butts and McComb 2000).

Reptiles

Thirteen native reptile species inhabit the Portland area, including two turtle, four lizard and seven snake species (see Metro's species list). This is the least riparian-associated group; even so, 23 percent of native reptile species depend on water-related habitats and another 46 percent use water-related habitats during their lives. Although most lizards and snakes are associated with upland habitats, many species use riparian areas extensively for foraging because of the high density of prey species and vegetation. Both of the native turtle species — the Western pond turtle and the painted turtle — are riparian/wetland obligates and rely on large wood in streams and lakes for basking (Kauffman and others 2001). These two turtles are state and/or federal species at risk. Several nonnative turtle species have established breeding populations in Portland, and they compete with native turtle species.

Birds

Birds represent the majority of vertebrate diversity in this region, and 209 native bird species occur in the Portland area (see Metro's species list). An additional four nonnative species have established breeding populations in the area. In the Portland area, about half (49 percent) of native bird species depend on riparian habitats for their daily needs, and 94 percent of all native bird species use riparian habitats at various times during their lives. Twenty-two bird species are state or federal species at risk (see Metro's species list). Nineteen of these are riparian obligates or regularly use water-based habitats. An additional riparian obligate, the yellow-billed cuckoo, is extirpated in the Portland area.

Bird abundance, species richness and diversity are typically higher in riparian habitats compared to other habitat types (Stauffer and Best 1980, LaRoe and others 1995, Kauffman and others 2001). This reflects greater plant volume and structural diversity (birds are highly three-dimensional in their habitat use) and food, water and habitat resources associated with riparian vegetation (LaRoe and others 1995).

Mammals

Mammals are another diverse group of species in the Portland area, with 54 native species (see Metro's species list). This is the terrestrial group with the highest number of nonnative species (eight species, or 15 percent of total species; most are rodents). Of native species, 28 percent are closely associated with water-based habitats, with another 64 percent using these habitats at various points during their lives. Six out of nine bat species are state or federal species at risk. Three native rodent species are similarly listed.

Riparian resources are important to mammals for many of the same reasons they are important to amphibians and birds (i.e., diverse habitat structure, abundant coarse woody debris, good connectivity, access to water and a wealth of food resources) (Butts and McComb 2000, Kauffman and others 2001). In Pacific Northwest forests, multispecies canopies, coarse woody debris and well-developed understories (dominated by herbs, deciduous shrubs and shade-tolerant seedlings) are important to small mammal biodiversity across a broad spatial scale (Carey and Johnson 1995). Other Pacific Northwest studies have shown increased small mammal abundance and/or diversity with increasing coarse woody debris (McComb and others 1993, Butts and McComb 2000, Wilson and Carey 2000). Riparian forests contain high amounts of coarse woody debris, and this may be why some studies document higher small mammal abundance in riparian habitats than in uplands (Doyle 1990, Menzel and others 1999, Bellows and Mitchell 2000).

Mammals can profoundly influence habitat conditions for other animals, including fish. Beaver, a keystone species in riparian areas, play a critical role in the creation and maintenance of wetlands and stream complexity and may have broad effects on physical, chemical and biological characteristics within a watershed (Cirmo and Driscoll 1993, Snodgrass 1997, Schlosser and Kallemeyn 2000). Historically, beavers were nearly extirpated from the Willamette Valley as a result of trapping, but populations have rebounded (Oregon Department of Fish and Wildlife 2001). Large herbivores such as deer browse on herbs and shrubs, which can promote vigorous growth (Kauffman and others 2001). Medium-sized carnivores keep rodent and small predator populations in check, with important implications for bird nest success. Bats help regulate insect populations and may contribute to nutrient cycling, particularly in riparian areas (LaRoe and others 1995).