SUMMARY AND CONCLUSIONS

Although the Snoqualmie Watershed has healthy aquatic habitat compared to the more urbanized watersheds of King County, recent habitat inventories and temperature surveys conducted on the mainstem Snoqualmie River and several tributaries showed that there are impaired habitat conditions at many locations. In the summer of 2000, only a few reaches of the mainstem Snoqualmie were found to have simultaneous good conditions for a suite of habitat features (i.e., little or no bank hardening, erosion, and cattle access; presence of side channels and back channels; few channel modifications and other artificial structures; mostly native vegetation; relatively mature trees; and presence of LWD). These good habitat conditions were found at approximately RM 8-9 (RB), 10-11 (both banks), 19.3-21.3 (LB), 22-22.5 (RB), 24-25 (LB), and 37-38 (both banks). Large pools were also found in these reaches in the summer of 2001 (the presence of pools in RM 37-38 is unknown because the pool survey ended at RM 35).

A total of 8.5 river miles on the mainstem Snoqualmie (i.e., 13% of the 32 river miles that were inventoried on each bank of the river for a total of 64 river miles) exhibited good habitat conditions for all habitat features. The remaining 87% of river miles had one or more habitat problems (i.e., extensive bank hardening and erosion; many cattle access points; few or no side channels and back channels; many channel modifications and other artificial structures; sparse or mostly nonnative vegetation; and limited or no LWD).

In the summer of 2000, bank hardening was observed on 35.5% of river miles on the toe of the LB, 29.5% of river miles on the upper LB, 30.4% of river miles on the toe of the RB, and 29.4% of river miles on the upper RB of the mainstem Snoqualmie River. By disconnecting the main channel of the river from its side channels and inhibiting natural channel migration, bank hardening limits the creation of summer rearing habitat and winter refuge habitat for salmonids and restricts fish access to off-channel habitat. Bank hardening also accelerates the natural process of bank erosion on adjacent or opposite unprotected banks; excessive erosion can degrade habitat conditions by contributing excessive fine sediment to the river, aggrading the channel bed, or filling pools. Scours, slumps, and other erosional features were observed at many locations directly downstream or on the opposite bank from revetments.

Riverbank erosion also correlated with human or cattle access to the Snoqualmie River. Although there were locations throughout the mainstem Snoqualmie where cattle could access the river, most of the cattle access points were concentrated in the APD between RM 10-19. In addition to causing excessive erosion of riverbanks and loss of riparian vegetation, cattle access can degrade water quality for fish and for people by contributing nutrients, sediments, and fecal coliform bacteria to the river. King County WLRD staff are working cooperatively with landowners to identify and develop defined access points that will allow regrowth of trampled riparian vegetation, help to prevent excessive erosion of riverbanks, and benefit water quality, thereby contributing to improved salmonid habitat conditions at affected locations.

Several types of floodplain features were observed in the mainstem Snoqualmie including the mouths of several major tributaries, 46 small, unnamed tributaries, and 26 back channels. Tributaries and back channels can provide good edge habitat for summer rearing and winter refuge for salmonids. On the other hand, other types of floodplain features such as water diversion pumps, flap gates, and culverts can be barriers to fish habitat. Banks and pilings were the most frequently noted channel modification structures on the mainstem Snoqualmie. These

structures can adversely impact salmonid habitat quality by increasing habitat quantity for predatory and invasive species and by altering the river's natural scour pattern, thereby affecting sediment transport.

Several shrub species that are not native to the Pacific Northwest were observed on the banks of the mainstem Snoqualmie River in the summer of 2000. These invasive species included Himalayan blackberry, Japanese knotweed, virgin's bauer, English ivy, butterfly bush, yellow tansy, and purple loosestrife. Native shrub species that were present included willow, snowberry, salmonberry, red osier dogwood, Oregon grape, elderberry, and Indian plum. Most of the riparian trees were deciduous, with red alder, vine maple, and black cottonwood found most frequently. Conifers such as western redcedar, Sitka spruce, grand fir, and western hemlock were found at some locations. Riparian tree species in 2000 were similar to historic species (those noted in the 1870s), but the percentage of conifers is now lower and the trees are now smaller. Mature trees (i.e., trees with an average stem diameter greater than 50 cm) are now found along only 1.8% of river miles on the LB and 9% of river miles on the RB of the mainstem Snoqualmie.

Although more LWD was found in the mainstem Snoqualmie River than expected, there was still an overall dearth of wood in the river (i.e., less than one piece per 20 meters of river channel). There were a few locations where large alder and cedar trees were leaning over the river (e.g. immediately downstream of the Tokul Creek confluence) and were potential near-term sources of LWD. However, the generally degraded riparian vegetation results in low recruitment of LWD to the river.

River segments with one or more of the above habitat problems lack the floodplain connectivity and complex structure that is important for forming and sustaining high quality salmonid habitat. Furthermore, data from the temperature loggers showed that the temperature of the Snoqualmie River is not low enough to provide good rearing and pre-spawning holding habitat for salmon during summer and early fall low flow conditions. However, future efforts will explore the potential for localized cool temperature refuge (such as from springs or cold water tributaries) that may not be obvious from the sampling to date.

Data from the University of Washington temperature survey that was conducted during the hottest part of the summer (the middle of the first week of August) in 1999 to 2001 showed that the temperature of the Raging River, and Griffin, Harris, and Patterson Creeks at that time was not low enough to provide optimal rearing conditions for salmonids (Bjornn and Reiser, 1991). Some temperature measurements in the Raging River, Griffin Creek, and Harris Creek exceeded 18°C, thereby violating the State of Washington water quality standard for temperature in Class A waterbodies. If sustained, temperatures that are this high can be lethal to salmonids and can have sublethal physiological and behavioral effects as well (Berman, 1998). High summer water temperatures in tributaries to the Snoqualmie River contribute to high summer water temperatures in the mainstem Snoqualmie. To reduce water temperatures, solutions must be found starting in the headwaters to ensure that feeder tributaries are well shaded and riparian canopy is protected and restored to the maximum extent practicable throughout the watershed.

Aside from high temperatures, habitat conditions were generally good in the summer of 2001 in the inventoried reaches of the Raging River, Griffin Creek, and Tolt River that were upstream of confinement levees, other bank hardening, and residential land uses. Between RM 1.3-8.2 of the Raging River, good habitat conditions included native riparian vegetation, some LWD, and cobble and gravel substrate. Between RM 2.7-3.1 of Griffin Creek, dense native riparian vegetation recruited a high frequency of LWD to the stream. Habitat conditions were good between RM 1.6-2.7 as well, with mostly high-density native riparian vegetation, pools, and a

gravel and cobble substrate. On the Tolt River (RM 2.9-5.8), instream habitat was generally good, with mature and dense native trees and shrubs, high frequency of LWD, pools, and side channels. The reaches with good habitat conditions in the mainstem Snoqualmie, Raging, and Tolt Rivers and Griffin Creek should be targeted for habitat protection actions in the Snoqualmie Watershed portion of the WRIA 7 salmonid conservation plan.

The results of the habitat inventories on the mainstem Snoqualmie River and several tributaries highlight four of the nine most important habitat problems that were identified by the WRIA 7 Technical Committee. These were loss of channel area and complexity resulting from bank protection, disconnecting the channel from its floodplain; dearth of LWD; increased sediment input to rivers and streams as a result of unnaturally high rates of erosion; and poor quality riparian forests.

Aquatic habitats critical to salmonids are the product of natural ecosystem processes acting throughout watersheds and particularly within riparian areas along rivers and streams. At the watershed level, the major processes that affect physical and chemical attributes of aquatic ecosystems are (Spence et al., 1996):

- hydrology - pertains to precipitation in the form of rain and snow and to migration of river and stream channels across their floodplains.
- sediment transport - pertains to redistribution and sorting of sediment based on energy gradients.
- heat energy transfer - pertains to river and stream temperatures.
- nutrient cycling - pertains to delivery of nutrients to rivers and streams from trees falling in the water and from decaying salmon carcasses.
- LWD recruitment - related to size and density of riparian vegetation.

Large-scale disruption and acceleration of natural ecosystem processes has occurred in WRIA 7 since the 1850s (i.e., beginning of Euro-American settlement). Human activities such as logging, road building, flood control actions, and conversion of forest land to agricultural and residential land have changed the way that water, sediment, and wood move through the Snoqualmie Watershed (Snohomish Basin Salmonid Recovery Technical Committee, 1999). Data from the habitat inventories and temperature surveys described in this report suggest that sediment transport, heat energy transfer, nutrient cycling, and LWD recruitment have been altered from natural conditions (hydrology was not examined in these field studies) and, in turn, have adversely affected aquatic habitat quality. For example, bank hardening on the mainstem Snoqualmie River and its tributaries is often related to erosional features on the opposite or adjacent banks. Excessive erosion alters the natural sediment regime of the river and can contribute fine sediments to the channel substrate. Lack of mature, native riparian vegetation along the mainstem Snoqualmie and its tributaries contributes to the dearth of LWD, and high summer and early fall temperatures in the river. Low LWD recruitment into the river will impact nutrient cycling in the river as well.

In order to be effective in the long-term, salmonid conservation and recovery efforts in the Snoqualmie Watershed need to assess and take into account the natural ecosystem processes that create instream habitat structure. Habitat protection, reconnection, and restoration projects need to focus on restoring these processes rather than just addressing the symptoms of observed impaired habitat conditions. For example, instream habitat would benefit from forest retention in headwaters areas of the Snoqualmie Watershed, native plant revegetation of riparian zones, and

removal of invasive plants along the mainstem Snoqualmie River and its tributaries. Historical data should be consulted on the composition of the mainstem riparian plant community in order to determine which species of native vegetation to plant along the banks. Healthy riparian buffers will provide LWD for the rivers and streams of the Snoqualmie Watershed, which will lead to more nutrient cycling and to more and better quality habitat for juvenile salmonid rearing and refuge and adult salmonid holding prior to spawning. The shade provided by riparian vegetation will help to moderate summer water temperatures (i.e. will help to restore a more natural heat energy transfer regime). The roots of riparian vegetation will reduce the amount of unnatural bank erosion, thereby helping to restore natural sediment transport. Because natural ecosystem processes are interrelated, restoring one process will help to restore others.

The 1999-2001 field studies provided qualitative information about baseline habitat conditions in the Snoqualmie Watershed. This is not a final or comprehensive picture of habitat conditions in the watershed. Before definitive conclusions can be drawn and a salmonid conservation plan can be developed, more in depth and quantitative research and habitat inventories need to be conducted. Some high priority information needs for the Snoqualmie Watershed include:

- Quantitative surveys of habitat conditions in specific reaches of rivers and streams.
- Snoqualmie River valley floor habitat assessments.
- Temperature stratification assessments in large pools of the mainstem Snoqualmie River.
- Wetland assessments, including location, functions, and values.
- Juvenile salmonid distribution mapping.
- Hydrologic mapping and modeling of stormwater catchment and subcatchment basins.
- Geologic interpretation of surficial geology maps.

Information that is obtained from the above investigations and from monitoring habitat quality trends over time will be included in updates to this report.