South Fork Nooksack River, known as "Pine Creek," were determined to be Dolly Varden (Young, pers. comm. 2003).

Similar to the Chilliwack River basin, comprehensive spawning surveys have not been conducted within the Nooksack core area, although limited survey data were very recently collected by the Washington Department of Fish and Wildlife and U.S. Forest Service in a small number of streams. Data are not yet sufficient to estimate spawner abundances for the core area, but this and past observational data have helped define current local populations. A total of 10 local populations (Upper North Fork Nooksack River, Glacier Creek, Middle North Fork Nooksack River, Lower Canyon Creek, Lower North Fork Nooksack River, Upper Middle Fork Nooksack River, Lower Middle Fork Nooksack River, Upper South Fork Nooksack River, Wanlick Creek, and Lower South Fork Nooksack River) have currently been identified in this core area. While tributaries with known spawning and rearing are described, other unsurveyed, adjacent and accessible tributaries are probably utilized as well.

The North Fork Nooksack River provides approximately 45 kilometers (28 miles) of accessible habitat, ending at Nooksack Falls, which is located just upstream from the confluence with Wells Creek. The Upper North Fork Nooksack River local population includes the upper most accessible 11.9 kilometers (7.4 miles) of the North Fork Nooksack River, from Nooksack Falls to the confluence with Glacier Creek. Also included are the short, accessible portions of tributaries to the North Fork Nooksack River including Wells, "Powerhouse", Deadhorse, Cascade, "Ditch", Boyd, "Chain-up", and Deerhorn Creeks. Wells Creek is the only tributary that is glacially influenced. This reach of the river and these tributaries support bull trout spawning and rearing; short reaches of other tributaries may also be used, but this has not been confirmed. There is a single report from the mid 1980's of native char in the North Fork Nooksack River upstream from Nooksack Falls, above and below the confluence with White Salmon Creek, and within the lower part of this creek (Green, pers. comm. 2003). However, at this time no local population is designated above Nooksack Falls. Additional information is needed to determine if native char still persist above the falls, whether these are bull trout, and if so, their geographic distribution.

Intensive bull trout spawning surveys have not been conducted in the mainstem of the upper North Fork Nooksack River, however, it is considered to support some spawning and rearing based on a number of observations reported during irregular survey efforts. Large adult native char, believed to be bull trout, have been caught in the North Fork within a mile of the falls (D. Sahlfeld, Washington Department of Fish and Wildlife, pers. comm. 2002). It is currently unclear to what extent these fish are spawning in this relatively steep portion of the mainstem, or whether these fish are moving into Wells Creek to spawn. Pre-spawn staging adults were also observed nearly to Nooksack Falls in the 1970's (C. Kraemer, Washington Department of Fish and Wildlife, pers. comm. 2002). Norgore and Anderson (1921) caught a 305-millimeter (12-inch) native char 0.40 kilometer (0.25 mile) downstream of Nooksack Falls, and also caught advanced fry in backwater areas 2.4 kilometers (1.5 miles) downstream from the falls on June 27, 1921, indicating nearby spawning. In October of 2003, an adult bull trout in spawning coloration was caught immediately downstream from the confluence of Deadhorse Creek (N. Currence, Nooksack Tribe, pers. comm. 2003c).

Wells Creek is steep near its mouth, but is considered accessible to river mile 0.9, where a steep boulder cascades is present. Two bull trout redds were recorded during surveys conducted by the U.S. Forest Service and Washington Department of Fish and Wildlife between river mile 0.5 and 0.9 in 1993 (Huddle, *in litt*. 1995). Native char less than 305 millimeters (12 inches) in length were observed in lower Wells Creek in the early 1990's during surveys conducted by small hydropower applicants (FERC 1997). A Federal Energy Regulatory Commission report describes the lower Wells Creek as a sequence of alternating steep and low gradient (2 to 5 percent) reaches (FERC 1997) . Anecdotal information suggests that migratory size native char may have historically utilized Wells Creek upstream from river mile 0.9, prior to inner gorge landsliding, but recent surveys have only detected brook trout in the reaches upstream of this point (D. Huddle, Washington Department of Fish and Wildlife, pers. comm. 2002a; Zyskowski, pers. comm. 2002a). There is a 3.6-meter (12-foot) vertical falls that spills onto a mid-channel boulder at approximately river mile 1.7 (Huddle, pers. comm. 2002b), and it is considered unlikely that former anadromous use extended upstream from this point. "Powerhouse Creek" is a

small, low gradient tributary which enters the river just downstream from the Excelsior hydroelectric powerhouse located below Nooksack Falls. Adult bull trout have been observed in the short 0.16- kilometer (0.1-mile) accessible portion of this creek, downstream of the impassible culvert that underlies the road leading to this facility (Huddle, pers. comm. 2002b). The creek gradient rapidly increases a short distance upstream of this road, presumably limiting available habitat above this point. Deadhorse Creek is accessible up to a steep cascade located at approximately river mile 0.1. Large bull trout adults and/or redds have been recorded in Deadhorse Creek during surveys conducted in 1982, 1992, 1993, 1994, 2001, and 2002, with a single day peak adult count of 8, and peak redd count of 14, both recorded in 1993 (Huddle, *in litt*. 1995; WDFW and USFS, *in litt*. 2001, 2002). Adult coho were also present during these surveys. The North Fork Nooksack River has recently recaptured the lower gradient, downstream portion of this creek, significantly reducing the amount of available spawning habitat. Cascade Creek is accessible to bull trout up to a falls located at approximately river mile 0.1. A large adult bull trout was observed downstream of the falls during fish surveys in 2001 (WDFW and USFS, *in litt*. 2001). "Ditch Creek" enters the North Fork Nooksack River downstream of Cascade Creek, and provides approximately 0.16 kilometer (0.1 mile) of accessible habitat. While adults or redds were not recorded during surveys in 2000 or 2001, adults and juveniles have been observed in past years at these locations (Huddle, pers. comm. 2002a, 2002b). Two age classes[†] of juvenile bull trout have also been observed in a river side channel immediately downstream of this creek, referred to as the Ditch Creek side channel (Huddle, pers. comm. 2002b). Spawning has also been observed in this side channel, upstream and downstream of "Ditch Creek", and this appears to correspond to periods when the creek's discharge is low (Huddle, pers. comm. 2002b). "Chainup Creek" has 0.2 kilometers (0.1 mile) of currently accessible habitat, and anadromous size bull trout have been observed spawning downstream of an impassible culvert on State Route 542 in the late 1990's (Sahlfeld, pers. comm. 2002). There is likely 0.40 to 0.80 kilometer (0.25 to 0.50 mile) of formerly accessible, suitable habitat upstream from this culvert (R. Nichols, U.S. Forest Service, pers. comm. 2002). This creek has year-round flow (Huddle, pers. comm. 2002b). Deerhorn Creek (stream catalog no. 0491) also has 0.16 kilometer (0.1 mile) of currently accessible habitat, and young-of-year juveniles have been observed downstream of the impassible culvert under

State Route 542 (Huddle, pers. comm. 2002b). This creek frequently goes subsurface during the summer, and the length of available habitat upstream of the culvert is thought to be short (Huddle, pers. comm. 2002b). Boyd Creek has approximately 0.48 kilometer (0.30 mile) of low gradient habitat, downstream of a falls. Anadromous size adults are recorded in this creek most survey years, with a single day peak of 5 adults counted in 1992, and a peak redd count of 16 in 1994 (Huddle, *in litt*. 1995). Adult coho were also present in the area during these surveys.

The Glacier Creek local population is heavily influenced by glacial runoff, but it has a number of non-glacial tributaries that support spawning and rearing for anadromous bull trout. The full extent to which spawning occurs in the Glacier Creek system is unknown, but anadromous size bull trout have been recorded spawning in Falls Creek, Coal Creek, and in small spring-fed tributaries, Thompson Creek, and Little Creek. Spawning probably occurs in Glacier Creek and several additional tributaries are considered likely to support bull trout spawning and rearing. These include an unnamed tributary (stream catalog no. 0476) which enters Glacier Creek at river mile 4.3, and Deep Creek (Huddle, pers. comm. 2002b; Nichols, pers. comm. 2002). Use is considered possible in Grouse Creek as well (Huddle, pers. comm. 2002b), and the presence of juveniles in Davis Creek (described below) indicates spawning here as well.

In 1982 and 1984, native char were the most common species collected in a proposed hydropower bypass[†] reach in Glacier Creek from approximately river mile 3.5 to 5.6 (FERC 1997). There is a falls on Glacier Creek at approximately river mile 3.4 where adult native char were observed jumping in 1981 (J. Schuett-Hames, Washington Department of Ecology, pers. comm. 1999). This potential barrier has now been determined to be passable, as a dead adult migratory-sized bull trout was recorded about 1.6 kilometers (1 mile) upstream of the falls following a flood event in 1989 (Zyskowski, *in litt*. 1989), and more recent observations of large adults and redds recorded in tributaries upstream. Falls Creek enters Glacier Creek at river mile 5.0, with spawning observed in the lower 0.32 kilometer (0.2 mile) (Huddle, pers. comm. 2002a; Zyskowski, pers. comm. 2002a). Two adults, 305 and 406 millimeters (12 and 16 inches) in length, and four redds were recorded from the mouth of Falls Creek up to river mile 0.2 in

1993 (Huddle, *in litt*. 1995), and one redd and two adults (518 and 569 millimeters; 20.4 and 22.4 inches) were recorded in 2002 (WDFW and USFS, *in litt*. 2002). Coal Creek enters Glacier Creek at river mile 4.7, and spawning adults have occasionally been observed in the lower portion of this creek, not far upstream of its confluence with Glacier Creek (Huddle, pers. comm. 2002b). A series of left bank, groundwater fed springs enter the Glacier Creek floodplain downstream of Coal Creek. Spawning has occasionally been observed in this area, including one redd located upstream from the U.S. Forest Service road crossing (Huddle, pers. comm. 2002b). Historical tractor logging resulted in skid trails which altered the surface hydrology in this area, eventually causing the road in this location to wash out. Rock groins (instream structures built to deflect flows and increase deposition[†] of sediment along stream banks), installed to protect the road, now impair access to this habitat (Huddle, pers. comm. 2002b).

Thompson Creek enters Glacier Creek at river mile 1.8, and it provides at least 2.7 kilometers (1.7 miles) of spawning and rearing habitat, with consistent records of anadromous adult bull trout and redds. Approximately 10 to 15 migratory size adults (11 to 13 kilograms; 5 to 6 pounds) were observed spawning in the lower 1.4 kilometers (0.9 mile) in the mid-1980's (Barclay, pers. comm. 2003). A single day peak count of 22 adults and 9 redds were recorded during spawn surveys in 2002 (WDFW and USFS, *in litt*. 2002). Bull trout use is presumed upstream from the passable cascade located at river mile 1.7 up to about mile 2.2 where a large waterfall blocks further passage (Zyskowski, pers. comm. 2003b). Spawning is presumed to occur in lower Davis Creek to approximately river mile 0.2 (Nichols, pers. comm. 2002). While spawn surveys have not been conducted, a substantial number of juvenile bull trout mostly 76 to 127 millimeters (3 to 5 inches) in length were observed in the mid-1980's during fish relocation efforts associated with a habitat improvement project. These bull trout were observed in lower Davis Creek where spring-fed waters enter an overflow channel in the Glacier Creek floodplain (Green, pers. comm. 2003). Little Creek is also believed to support spawning and rearing, as spawning bull trout were observed at river mile 0.1 in 1981 (Schuett-Hames, pers. comm. 1999).

The Middle North Fork Nooksack River local population includes the mainstem Nooksack River and associated tributaries between Glacier Creek and

Canyon Creek. Spawning information in the North Fork Nooksack River downstream of Glacier Creek is very limited. There is an anecdotal report of bull trout spawning in a side channel downstream of Glacier Creek (G. Dunphy, Lummi Nation, pers. comm. 2002). Bull trout redds have also been recorded in Cornell Slough. Tributaries that support bull trout spawning and rearing include Gallop Creek, an unnamed tributary to Gallop Creek, Cornell Creek, and Hedrick Creek.

Gallop Creek enters the North Fork approximately 0.3 kilometers (0.2 mile) downstream of Glacier Creek. An adult bull trout was recorded in 1993 and redds recorded in 1994 during spawning surveys to river mile 0.7 (Huddle, *in litt*. 1995). Additionally, large adults have been recorded during hook and line sampling at the base of the cascades at river mile 0.9 (Sahlfeld, pers. comm. 2002). A tributary referred to as "Son of Gallop" enters Gallop Creek upstream of State Route 542. Bull trout spawning was observed in the lower 0.1 mile of this creek in 1999 (Huddle, pers. comm. 2002a). Cornell Creek does not have recent records of bull trout, although native char were historically reported to use it (Norgore and Anderson 1921). Available habitat in Cornell Creek is limited by a 3.6-meter (12-foot) falls at about river mile 1.0 (Pautzke 1943). Mass wasting[†] has built up this creek's alluvial fan[†], and in late summer, adult salmon enter on freshets then die when the creek becomes subsurface (Huddle, pers. comm. 2002a). The Cornell Slough complex includes the outlet of Bottiger's Pond, Mink Farm Spring Creek, and lower Hedrick Creek. A dead adult bull trout and bull trout redds were recorded in this main slough in 1994 (Huddle, *in litt*. 1995). Adult bull trout have also been recorded in Hedrick Creek downstream of an impassible, double box culvert under State Route 542 (Huddle, pers. comm. 2002a). An examination of topographic maps suggests 1.6 kilometers (1 mile) of habitat may exist upstream of this culvert.

The Lower Canyon Creek local population consists of one of the largest known bull trout spawning tributaries in the North Fork Nooksack River. Canyon Creek is a very large, non-glacially influenced tributary, and with the exception of Glacier Creek, provides the greatest length of accessible habitat of all the North Fork bull trout spawning tributaries. Canyon Creek is used by stronger migrating salmonids including bull trout to about river mile 4.0. Spawning surveys for bull

trout have generally not been conducted in this creek since it is difficult to survey, particularly in the upper reaches. However, U.S. Forest Service snorkel surveys recorded 12 adults (up to 610 millimeters; 24 inches) as well as juveniles in a 1989 survey of the 7.1-kilometer (4.4-mile) anadromous reach. All were observed upstream of a cascade located at river mile 1.3, with the largest adult located near the top of the reach (Zyskowski, *in litt*. 1991). Counts are believed to be incomplete since only 20 percent of pools and 10 percent of riffles were sampled during this survey. Pre-spawn staging adult bull trout have also been observed holding in a gorge pool downstream of a second cascade (river mile 2.0) during spring Chinook spawn surveys (Huddle, pers. comm. 2002a). Both pre-spawning and post-spawning adults were reported in lower Canyon Creek in the 1970's (Kraemer, pers. comm. 2002). Genetic analysis of native char in Canyon Creek, upstream from the complete barrier, determined the samples to be from Dolly Varden.

The Lower North Fork Nooksack River local population consists of the North Fork Nooksack River and tributaries between Canyon Creek and Maple Creek. Boulder Creek is likely the most important spawning tributary in the local population. Survey data are generally lacking, but known or presumed spawning areas are based on the geographic settings and the limited data that are available. Boulder Creek is a large non-glacially influenced stream, with anadromous access up to a falls located at approximately river mile 1.3. Eleven adult bull trout, believed to be staging prior to spawning, were observed in two pools near the upper extent of accessible habitat in 1987 (Johnston, *in litt*. 2000). These fish appeared to be between 432 to 559 millimeters (17 to 22 inches) in size. Two juveniles, 127 and 171 millimeters (5 and 6.75 inches) in length, were also caught near the upper extent of accessible habitat. No adult or juvenile bull trout were observed further downstream in the creek. Norgore and Anderson (1921) also listed native char among the salmonids that reportedly used lower Boulder Creek. While not surveyed, the accessible reaches of several north-facing tributaries including Wildcat, "McDonald", and "Aldrich" Creeks are presumed to support spawning and rearing (DaPaul, Inc. 1994). Adult bull trout have been observed in "McDonald Creek" (Huddle, pers. comm. 2002a). In Maple Creek, mature bull trout up to 457 millimeters (18 inches) in size have been observed, (Huddle, pers. comm. 2002a), and what are believed to be subadults were recorded in snorkel

surveys in 2002 (Ecotrust, *in litt*. 2002). These observations are thought to be of foraging fish, attracted to the highly productive portion of Maple Creek downstream from the falls at river mile 0.8. Maple Creek is extensively surveyed for salmon, and consistent bull trout spawning would most likely have been observed incidental to these surveys. Other highly productive tributaries that are believed to support foraging for subadult and adult bull trout including the accessible reaches of Racehorse Creek, Bells Creek and its sloughs, and the "Bear Creek" slough complex and accessible portions of its tributary streams.

Similarly, adult bull trout have been observed at the Washington Department of Fish and Wildlife hatchery weir located near the mouth of Kendall Creek (Huddle, pers. comm. 2002a). This facility was constructed in 1899, and while anadromous fish are not passed upstream into Kendall Creek, this watershed is comparatively low elevation and may not have historically supported bull trout spawning. Adults have also been observed in Kenny Creek in 1994 or 1995 (Huddle, pers. comm. 2002a). It is unknown whether these are pre-spawning or foraging individuals, but an impassible road culvert at river mile 1.7 blocks access to habitat in the upper creek. There is also a baffled structure and perched culvert at the mouth of Kenny Creek that is a velocity barrier to all fish at high flows, and likely for smaller fish at normal discharges.

The Middle Fork Nooksack River is glacially influenced, with the lowest 10.9 kilometers (6.8 miles) transitioning upstream from a very low gradient braided channel to a more moderate gradient channel. The Middle Fork Nooksack River's average gradient is 2.4 percent over its lower 28 kilometers (17.4 miles), with no natural barriers to adult migration to at least river mile 17.8 (STS Heislers Creek Hydro 1994). At approximately river mile 6.8, the river exits from a 0.8-kilometer (0.5-mile) long bedrock gorge called Box Canyon. At its narrowest, the river is 2.7 meters (9 feet) wide in the gorge (Barclay, *in litt*. 1989). In 1987, a landslide temporarily blocked fish passage, although it was restored in a subsequent flood. No permanent features block passage through the gorge (Barclay, *in litt*. 1989). Norgore and Anderson (1921) also reported no falls greater than 0.9 meter (2.9 feet) high, and concluded there were no passage barriers. The City of Bellingham has an unladdered diversion dam located approximately 76 meters (250 feet) above the upstream entrance to the gorge.

Constructed around 1960, this dam is 3.6 to 4.3 meters (12 to14 feet) high and diverts water from the Middle Fork Nooksack River to Lake Whatcom. Salmon and trout, including bull trout, have been incidentally observed jumping at or over the diversion dam in 1986, 1992, and 1993 (STS Heislers Creek Hydro L.P. 1994; Currence 2000), and also in 2001 (Corral, *in litt*. 2001; E. Zapel, Northwest Hydraulics Consultants, pers. comm. 2001). A fisherman reported catching a 483 millimeter (19 inch) bull trout downstream of the Sven Larson Bridge (located upstream of the diversion dam) in the early 1990's (Huddle, pers. comm. 2002b). The size of this fish suggests it was anadromous. In October of 2000, two bull trout approximately 229 and 305 millimeters (9 and 12 inches) were caught less than 1.6 kilometers (1 mile) upstream from the mouth of its major tributary Clearwater Creek (J. Lee, Whatcom County, pers. comm. 2003). Since the diversion dam appears to stop most, but not all, migratory bull trout, the Middle Fork Nooksack River is presently separated into two local populations (Upper and Lower Middle Fork Nooksack River). When unimpeded anadromous passage is restored at the diversion dam, and as more information is collected, local populations may be revised (combined and/or subdivided). Several of these creeks such as Sisters Creek and Clearwater Creek contain substantial low gradient habitat upstream from steeper cascades that are probably only passable to anadromous bull trout, and abundances and usage is expected to change when full passage is restored. Comprehensive surveys have not been conducted in this fairly remote area.

The Upper Middle Fork Nooksack River local population includes more than 16.6 kilometers (10.3 miles) of mainstem and accessible tributary reaches above the diversion dam. The mainstem habitat is accessible to river mile 17.5, approximately 0.4 kilometer (0.25 mile) upstream of Ridley Creek. The reach between Wallace and Clearwater Creeks is the lowest gradient portion above the diversion dam, averaging 2 to 3 percent (STS Heislers Creek Hydro 1994). Spawning and rearing is reported or presumed in the Middle Fork mainstem, Ridley Creek, Rankin Creek, Green Creek, an unnamed tributary immediately upstream of Wallace Creek, Wallace Creek, Warm Creek, Sisters Creek, an unnamed tributary 1.6 kilometers (1 mile) downstream of Warm Creek, an unnamed tributary 0.3 kilometer (0.2 mile) upstream from Seymour Creek, Galbraith Creek, Clearwater Creek and Rocky Creek. Once anadromous access is

restored and additional information collected, this local population may be further subdivided.

In 1993, five bull trout (98 to179 millimeters; 4 to 7 inches) were caught in the Middle Fork Nooksack River mainstem and side channels near river mile 13 during juvenile sampling efforts (STS Heislers Creek Hydro 1994). They were described as relatively common in the upper Middle Fork Nooksack River and apparently more abundant in upstream reaches. Two of these fish were submitted for morphometric and meristic analysis and were determined to be bull trout (STS Heislers Creek Hydro 1994; Barclay, pers. comm. 2003). Ridley Creek enters the Middle Fork Nooksack River near the upper limit of migratory access, and while unsurveyed, this creek is presumed to be used by bull trout for spawning and rearing. It is accessible and affords substantial low gradient, high quality habitat (Green, pers. comm. 2003). Rankin Creek has cascades located at about river mile 0.3, which were likely passable at high flows (WDF 1978). Topographic maps indicate 0.4 to 0.8 kilometer (0.25 to 0.5 mile) of usable habitat upstream from the cascades, which may be used presently or in the future by anadromous bull trout. Norgore and Anderson (1921) also reported advanced fry in a tributary between Green and Ridley Creeks, which they referred to as “Ward Creek,” indicating nearby spawning. This creek was most likely Rankin Creek. Green Creek has accessible habitat up to a three-meter (10-foot) falls located at river mile 0.5 (Norgore and Anderson 1921). A small number of resident size native char were observed spawning in the mid-1970’s in the lower reach of Green Creek which paralleled the Middle Fork Nooksack River (Kraemer, pers. comm. 2002). Spawning and rearing is also presumed in a low gradient tributary entering upstream of Wallace Creek that was described as paralleling the mainstem of the river for 0.6 kilometer (0.4 mile) (WDF 1978). Juvenile native char were also observed during electrofishing in the mid-1970’s in lower Wallace Creek (Kraemer, pers. comm. 2002), which has accessible habitat up to a falls located at river mile 0.2 (Nooksack Tribe, *in litt*. 2001).

A number of observations indicate spawning and rearing in Warm Creek below the falls located at about river mile 0.4. Norgore and Anderson (1921) reported catching advance native char fry, and Johnston (Washington Department of Fish and Wildlife, pers. comm. 1999a) found native char of all age classes in

lower Warm Creek in 1991. Juvenile native char were also observed during electrofishing efforts in the mid-1970's in lower Warm Creek (Kraemer, pers. comm. 2002), and during surveys conducted in pursuit of development of a small hydroelectric facility (FERC 2002a). The lowest 0.16 kilometer (0.1 mile) of Warm Creek parallels the Middle Fork Nooksack River, occupying a former mainstem channel (Nooksack Tribe, *in litt*. 2001). Norgore and Anderson (1921) also reported native char in Sisters Creek. This creek has cascades near the mouth that are considered passable to large anadromous fish at higher flows, with accessible habitat up to a falls located at river mile 1.0 (Nooksack Tribe, *in litt*. 2001). Bull trout are presumed to use the lower 0.6 mile of an unnamed tributary entering about a mile downstream of Warm Creek. This unnamed creek provides good low gradient habitat for bull trout spawning and rearing. Another unnamed tributary entering the river 0.3 kilometer (0.2 mile) upstream of Seymour Creek has 0.48 kilometer (0.3 mile) of low gradient habitat (CES 1992), and has presumed use by spawning and rearing bull trout. An accessible unnamed low gradient tributary enters just upstream of Middle Fork road bridge at river mile 10, and spawning and rearing is presumed in approximately the lower 0.5 kilometer (0.3 mile).

In 1986, resident-sized native char were reported spawning in Clearwater Creek at about river mile 2.5 (Johnston, pers. comm. 1999a), with a total of 13 individuals hook and line sampled (13.3 to 28 centimeters; 5.25 to 11 inches) in the lower 5.6 kilometers (3.5 miles) of the creek. The lower reach of Clearwater Creek is low gradient, becoming relatively steep with several cascades upstream of river mile 0.3. The cascades are considered passable by anadromous fish (FERC 2002a). The lower 2.9 kilometers (1.8 miles) of Clearwater Creek average 5.3 percent gradient, diminishing to 3.8 percent up to river mile 3.6 with an impassible falls located just upstream of the confluence with Rocky Creek (Nooksack Tribe, *in litt*. 2001). Access continues up Rocky Creek, with additional low gradient habitat, the lower kilometer (0.6 mile) averaging 3.2 percent gradient.

The Lower Middle Fork Nooksack River local population includes spawning that occurs in the Middle Fork Nooksack River and accessible tributaries downstream of the diversion dam to the confluence with the North

Fork Nooksack River. Anadromous size pre-spawning and post-spawning adults were observed in the 1970's at the outlet of Box Canyon, and adults have been captured just downstream from the canyon (Kraemer, pers. comm. 2002). Spawning is presumed to occur in and downstream of the gorge. While not a complete barrier to anadromous fish, the diversion dam significantly impedes bull trout migration to upstream habitats. Juveniles were recently captured at approximately river mile 2.5 (Anchor Environmental, L.L.C., *in litt*. 2002). It is unknown whether these are progeny from local spawning or from the Upper Middle Fork Nooksack River local population. Norgore and Anderson (1921) mentioned that native char were reported to use Canyon Lake Creek. This creek is accessible up to a falls at river mile 1.25, but spawning or rearing has not been confirmed. Porter Creek has 1.6 kilometers (1.0 mile) of accessible habitat and frequently becomes subsurface across its alluvial fan during late summer. It is believed to currently provide only subadult and adult foraging habitat. Although similar to Canyon Lake Creek, spawning and rearing are considered possible in this tributary. Channel migration by the Middle Fork varies the length of available habitat, and in recent years the river has recaptured the lower portion of Porter Creek. "Peat Bog Creek" (stream catalog no. 0352) and "Bear Creek" (stream catalog no. 0353) that enters just downstream are productive, low gradient systems discharging into a mainstem side channel complex. It is believed that these areas provide habitat for foraging and potentially spawning and rearing. The unnamed tributary (stream catalog no. 0347) that enters just upstream of Canyon Lake Creek is also a low gradient and productive salmon stream, and bull trout are presumed to use the lower 3.2 kilometers (2 miles) for foraging.

The South Fork is non-glacial, and predominately very low gradient, although is has confined reaches at Dyes Canyon (river mile 16 to17), Sylvesters Canyon (river mile 25), and near river mile 30.5. Although Sylvesters Falls (river mile 25) is approximately 3.4 meters (11 feet) tall, the presence of very large adult bull trout and summer-run steelhead in the upper South Fork indicate that these falls, and the cascades at river mile 30.4, are passable to anadromous bull trout. Upstream from river mile 30.4 the river is again unconfined and low gradient up to its headwaters above Elbow Creek. The upper South Fork, while

non-glacial, is fed from snowpack on Twin Sisters Mountain. Comprehensive bull trout spawning surveys have not been conducted in the South Fork.

The Upper South Fork Nooksack River local population includes the mainstem between river mile 34 and 39, the major unnamed tributary upstream of "Elbow Creek," Bell Creek, and the accessible reaches of small tributaries between Bell and Wanlick Creeks. The upper limits of bull trout distribution have not been determined for most of these tributaries with the exception of "Pine" and Bell Creeks. Spawning and/or rearing is presumed to occur in all accessible areas of the mainstem and tributaries. Large adults have been observed up to about river mile 38 in the mainstem near the confluence with Elbow Creek (Zyskowski, pers. comm. 2003b). Norgore and Anderson (1921) caught native char in the same general area, 2.5 miles downstream from Elbow Lake. The South Fork is accessible to at least the confluence of the major unnamed tributary that lies upstream of Elbow Creek (Huddle, pers. comm. 2002b), and topographic maps indicate that the river and this tributary are both low gradient and unconfined for 0.8 kilometer (0.5 mile) or more. Spawning and rearing are presumed in these areas, and in the accessible portion of Elbow Creek. Large adults, presumed to be anadromous, were observed spawning in the South Fork near Bell Creek in the 1970's (Kraemer, pers. comm. 2002). In the 1990's tissue was collected from two fish (both approximately 200 mm) captured upstream of the 1260 bridge (approximately river mile 36) during night surveys (S. McGrath, Washington Department of Fish and Wildlife, pers. comm. 2003). Genetic analysis determined that these were bull trout, while the samples from an isolated population of resident char in a nearby tributary commonly referred to as "Pine Creek" were determined to be Dolly Varden (Young, pers. comm. 2003). Bell Creek has an impassible falls located at approximately river mile 0.25 (Green, pers. comm. 2003). Norgore and Anderson (1921) caught native char in Bell Creek, presumably downstream of these falls. Tissue samples from the resident native char population above the falls were determined to be Dolly Varden (Spruell and Maxwell 2002). Bull trout to 610 millimeters (24 inches) have also been observed during mainstem snorkel surveys at about river mile 36 (Zyskowski, pers. comm. 2003b), and two adult bull trout were observed during recent spawner surveys conducted from river mile 34.0 to 34.3 (WDFW and USFS, *in litt*. 2002).

The Wanlick Creek local population consists of Wanlick Creek and its accessible tributaries. Wanlick Creek is a major tributary to the upper South Fork Nooksack River. It is believed to support spawning and rearing to approximately river mile 4, and in Loomis and "Monument" Creeks. Three anadromous size bull trout were caught in Wanlick Creek, downstream of "Monument Creek," during hook and line surveys (Huddle, pers. comm. 2002b). In 2002, an adult bull trout (approximately 711 millimeters; 28 inches) as well as multiple age classes of juveniles were observed during a snorkel survey of a small portion of the stream reach downstream of "Monument Creek" (Ecotrust, *in litt*. 2002). Loomis Creek has known use to approximately river mile 0.5, with presumed use up to river mile 1. Bull trout up to approximately 355 millimeters (14 inches) have been observed in Loomis Creek upstream from the U.S. Forest Service 12 road, with about a dozen adults (406 to 457 millimeters;16 to18 inches) observed in a single pool downstream of the road crossing (Zyskowski, pers. comm. 2002a, 2003b). A partial passage barrier exists under the U.S. Forest Service 12 road crossing. Age 0+ juveniles have been recently observed in lower Loomis Creek (Huddle, pers. comm. 2003a). "Monument Creek" also supports spawning and rearing, as juvenile age classes were observed during 2002 snorkel surveys (Ecotrust, *in litt*. 2002). The lower reaches of other tributaries to Wanlick Creek are presumed to also support bull trout spawning and rearing.

The Lower South Fork Nooksack River local population includes the mainstem and all tributaries downstream of Wanlick Creek, with Hutchinson Creek considered the downstream limit of spawning. Most streams have not been surveyed, and with more data this local population may be divided. A potential bull trout redd was observed in the first small stream that enters the South Fork Nooksack River downstream from Wanlick Creek (Salhfeld, pers. comm. 2002). Spawning bull trout have also been observed in the short accessible reach of the stream draining Bear Lake (Huddle, pers. comm. 2002a). Norgore and Anderson (1921) caught native char in lower Howard Creek downstream from the 1.8-meter (6-foot) falls at river mile 0.25. Bull trout can likely migrate past this falls to about river mile 1.0. Spawning is presumed in the other short accessible reaches of the other streams between Wanlick and Howard Creeks. It is undetermined how far downstream in the South Fork Nooksack River bull trout spawn, but temperatures elevate progressively downstream, with spawning likely limited to

cooler tributaries. In 1994, a single juvenile was captured in the mainstem during minnow trapping efforts near river mile 30 (WDFW, *in litt*. 1994). Adult bull trout were observed in this same reach September 1990 and in September and October 1992, suggesting spawning occurs nearby (Huddle, *in litt*. 1995). A newly emergent young-of-year juvenile was caught near river mile 20, off the mouth of Deer Creek around spring of 2001 (Dunphy, pers. comm. 2002). Bull trout between 150 to 300 millimeters (6 to 12 inches) have been observed in the same general area, and in the Teather Hole side channel across from the mouth of Deer Creek. Deer Creek and Plumbago Creek are accessible up to high falls, each located about 0.8 kilometer (0.5 mile) upstream from their mouths. The accessible portion of Fobes Creek also has presumed use for approximately 0.6 kilometer (0.4 mile). One dead adult bull trout was observed in lower Cavenaugh Creek in 2002 in the accessible reach below the falls located 0.8 kilometer (0.5 mile) upstream (Ecotrust, *in litt*. 2002). Edfro Creek is accessible to bull trout for about 0.5 kilometer (0.3 mile). A single juvenile was observed during electrofishing near the mouth of Edfro Creek in the late 1970's (Kraemer, pers. comm. 2002). Around 1990, a bull trout approximately 380 millimeters (15 inches) in length was observed in Skookum Creek at about river mile 0.3 during the fall (Dunphy, pers. comm. 2002). In August of 2003, a subadult bull trout was observed in lower Skookum Creek, and two other subadults were observed immediately downstream of the confluence in the mainstem of the South Fork Nooksack River (Currence, pers. comm. 2003b). Potential habitat in Skookum Creek extends up to the barrier located at approximately river mile 2, and while spawning has not been confirmed, it is presumed based on water temperature profiles similar to lower Hutchinson Creek (Watershed Sciences, LLC 2002).

Hutchinson Creek is a large tributary with abundant, accessible, low gradient habitat to a 2.4-meter (8-foot) falls at about river mile 6. Pautzke (1943) reported that Hutchinson Creek supported a fair population of native char. Small juveniles have been captured in lower Hutchinson Creek below the cascades at river mile 0.8 (Maudlin *et al*. 2002). A subadult bull trout was also recorded in this reach in the 1970's (Kraemer, pers. comm. 2002). Recent snorkel surveys recorded juvenile bull trout upstream of river mile 5 (Ecotrust, *in litt*. 2002). These observations indicate migratory bull trout also spawn in upper Hutchinson Creek, as these juveniles are unlikely to ascend the cascades at river mile 0.8.

There are several low gradient tributaries in this area draining Bowman Mountain, and spawning and rearing is also presumed to occur in these systems. The tributaries downstream from Hutchinson Creek are considered unlikely to support spawning and rearing as they are smaller, have lower elevation settings more subject to thermal heating, and have relatively short accessible reaches. Snorkel surveys, minnow trapping, and screw trapping have caught bull trout in areas of the South Fork Nooksack River downstream from Hutchinson Creek, including Black Slough and a slough near river mile 12, but only smolts, foraging subadults, and adults (WDFW, *in litt*. 1994; Maudlin *et al*. 2002).

Lower Skagit core area. The Lower Skagit core area includes all of the Skagit basin downstream of Seattle City Light's Diablo Dam (Figure 5). This encompasses all of the mainstem Skagit River downstream of Diablo Dam (including Gorge Lake), Cascade River, Sauk River, Suiattle River, White Chuck River, and Baker River (including that lake systems above Shannon and Baker Dams). Limited genetic work indicates that the native char within the lower Skagit River drainage are all bull trout while past meristic and morphological data have suggested that some may be Dolly Varden (WDFW *et al*. 1997; Spruell and Maxwell 2002). Bull trout can be found throughout these waters and their tributaries expressing various life histories and behaviors. In addition to these freshwater areas, many bull trout make extensive use of the lower estuary and near shore marine areas (*e.g.*, Skagit Bay, Port Susan) for extended rearing and subadult and adult foraging. In the lower Skagit core area, the key spawning and early rearing habitat is found in the upper portion of much of the basin. Typically this habitat is found between the 305 to 914 meter (1,000 to 3,000 feet) elevation range and often 129 kilometers (80 miles) or more upstream from the mouth of the river. Fortunately, much of this essential spawning and rearing habitat is found on Federally protected lands, either North Cascade National Park, North Cascade Recreation Area, Glacier Peak Wilderness and Henry M. Jackson Wilderness Areas.

The Lower Skagit core area supports all four life forms of bull trout: resident, fluvial, adfluvial, and anadromous. Rearing and foraging individuals may be found in nearly all anadromous reaches of the basin as well as several isolated areas above the typical anadromous zone. Bull trout are currently known

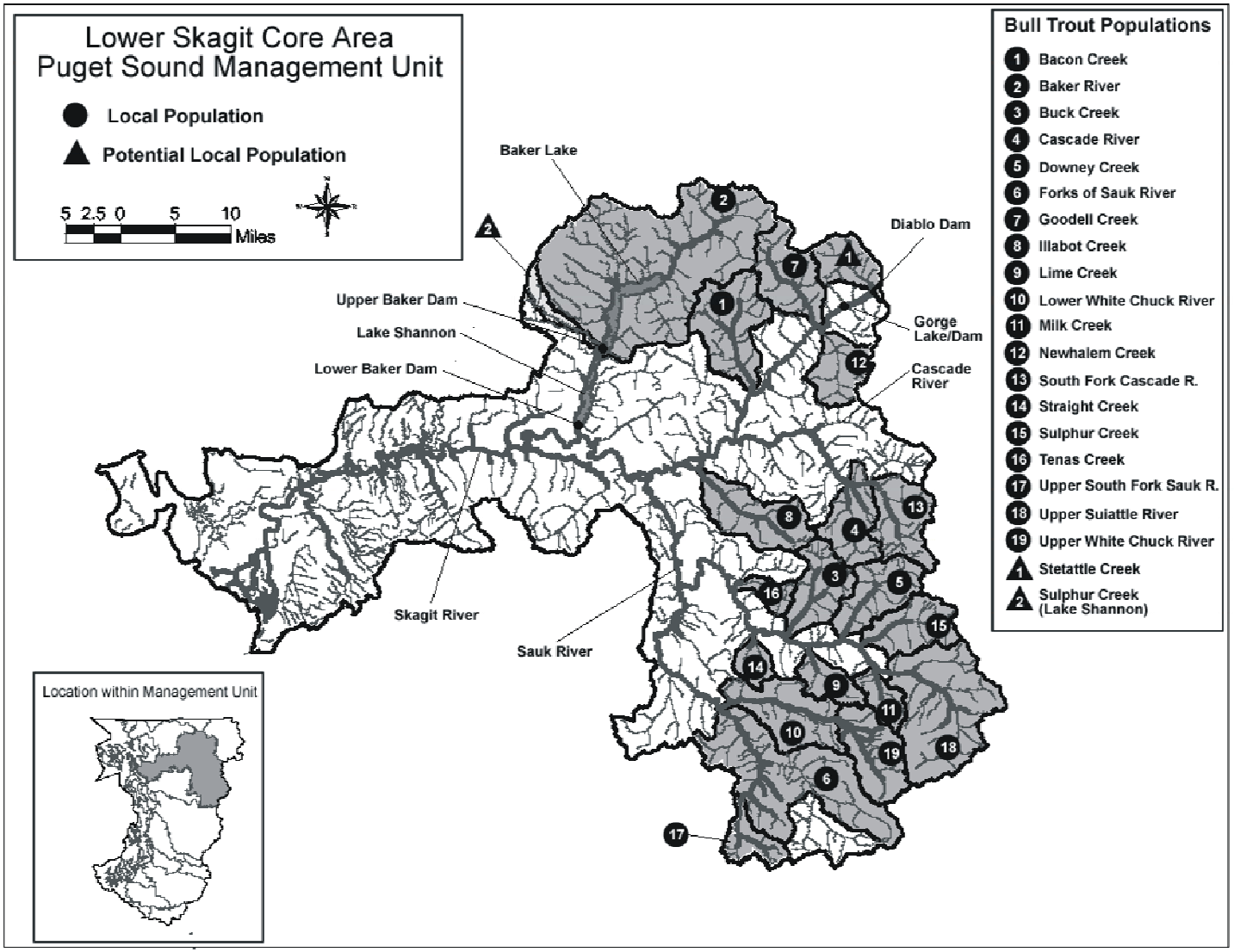

Figure 5. Lower Skagit core area for bull trout. Highlighted streams are key freshwater habitat for recovery.

to spawn and rear in at least 19 streams or stream complexes (*i.e.*, local populations). These local populations include Upper South Fork Sauk River, Forks of Sauk River, Lower White Chuck River, Upper White Chuck River, Tenas Creek, Buck Creek, Downey Creek, Sulphur Creek (Suiattle River), Straight Creek, Lime Creek, Milk Creek, Upper Suiattle River, Illabot Creek, South Fork Cascade River, Cascade River, Bacon Creek, Goodell Creek, Newhalem Creek, and Baker Lake. The resident life history form is found in a number of these areas as well as a number of additional small tributaries. These resident life history forms often coexist with migratory life history forms within the same local populations (Kraemer, *in litt*. 2003). Adfluvial fish are found only in the Baker Lake local population. Historically, the Baker River system likely supported both fluvial and anadromous bull trout. Prior to dam construction, bull trout were reported migrating in "great quantities" up from the Skagit River into Baker Lake (U.S. Fish Commission 1901). The two hydroelectric dams, Lower and Upper Baker Dams, have greatly limited fish movement in the Baker River system, and have generally excluded the anadromous life history form from this system. A large reservoir and regulated natural lake have been created by the lower and upper dams, Lake Shannon and Baker Lake, respectively. Upper Baker River, Bald Eagle Creek, Pass Creek, Crystal Creek, Sulfide Creek, and Swift Creek are the known spawning and/or rearing areas for the Baker Lake system, while Baker Lake provides the primary habitat for foraging and overwintering. Small numbers of bull trout are collected at the adult trap and haul[†] facility at the Lower Baker Dam and transported above the dams to Baker Lake each year. Bull trout smolts have been captured at an outmigrant trap on the Baker River located below the dams, however it has not been determined whether these are smolts originating from the Baker River system or from other parts of the Lower Skagit core area (WDFW 1998). Lake Shannon, formed by the lower Baker Dam, also contains bull trout with one potential spawning tributary, Sulphur Creek. Sulphur Creek is currently identified only as a potential local population given limited information. With the collection of additional bull trout use information, Sulphur Creek may be identified as a local population in the future.

It is thought that the Lower Skagit core area supports a spawning population of migratory bull trout that numbers in the thousands, likely making it the largest population in Washington (Kraemer, *in litt*. 2001a). The resident form

may be nearly as abundant. It is believed that the diverse and connected habitats found in this core area have allowed for the continued expression of the diverse life forms and behaviors that would have been typically found in robust coastal bull trout populations. Connectivity among most local populations and foraging areas is good to excellent, although some habitat diversity has been lost in the mainstem Skagit River due to channel simplification, impassable culverts, and diking and leveeing of the mainstem and estuary areas. For much of the basin, the migration corridors connecting the spawning and early rearing areas to essential downstream foraging and overwintering areas remain intact. The exceptions are the reach of the Baker River modified by the Baker River Hydroelectric Project (described previously), and the reach modified by the City of Seattle's Skagit Hydroelectric Project in the upper section of this system. The City of Seattle hydroelectric facilities on the upper river include three major dams: Gorge, Diablo, and Ross. Historical accounts by early settlers to the upper Skagit River indicate that native char and rainbow trout were present in a 13.7-kilometer (8.5-mile) reach of the river located between the present location of Gorge Powerhouse at river mile 96.5 and Ross Dam at river mile 105 (Envirosphere 1988). This reach, which is located in a steep narrow canyon, contains numerous boulder cascades, bedrock falls, and velocity barriers. Historical records indicate that salmon were not able to migrate upstream through this reach, but steelhead trout were able to migrate as far upstream as Stetattle Creek, located upstream from Gorge Dam at river mile 100. A steep and narrow bedrock gorge located at the current location of Diablo Dam probably blocked upstream migration of all migratory fish, including bull trout. Thus it may have been that genetic exchange between the upper river populations and the lower river were primarily one-way (downstream). It is possible that on rare occasions fish may have gained access beyond the barriers to the upper watershed, but it is not known for certain and likely occurred only during low flow conditions. A genetic comparison of bull trout located upstream and downstream of the project will be conducted by Seattle City Light in 2003. Currently, bull trout in the Lower Skagit core area can migrate upstream only as far as Gorge Dam.

The fluvial population within the Lower Skagit core area typically forages and overwinters in the larger pools of the upper portion of the mainstem Skagit River and to a lesser degree the Sauk River (WDFW *et al*. 1997; Kraemer, *in litt*.

2003). Expression of this fluvial life history appears to be highly dependent upon availability of forage. The abundance of Pacific salmon (especially pink [*O. gorbuscha*] and chum salmon) appears to be key in supporting this life history form. In the fall of the year, fluvial bull trout gain considerable weight by feeding on the abundance of loose eggs from the large numbers of spawning salmon. In the spring, they forage heavily on the emerging fry and outmigrating smolts. Whitefish, sculpins and other fishes are important forage species for bull trout that are available throughout the year. The sockeye salmon and kokanee population within the Baker Lake complex supplies the forage base for the adfluvial population.

A significant portion of the migratory fish in the basin exhibit an anadromous life history and use the estuarine and nearshore marine areas in Skagit Bay and Port Susan with juvenile fish as small as 135 millimeters (5.3 inches) (Kraemer 1994; Yates 2001). The anadromous fish are typically found in nearshore marine waters from the early spring through the late fall. The maintenance of marine nearshore and estuary habitat is key to supporting this life history form. The anadromous fish forage primarily on salmon smolts and marine forage fish (*i.e.*, surf smelt, sandlance, and herring) while in the estuary and nearshore marine waters (see marine foraging, migration, and overwintering habitat). Surf smelt, sandlance, and herring become more and more important as forage as the summer growing season progresses. Protecting the spawning beaches for these forage fish in Skagit Bay and Port Susan are key to maintaining the current abundance of the anadromous life history form. While the anadromous fish are in the river, either as post-spawn adults or overwintering subadults, they rely on much the same forage base as the fluvial fish (Kraemer 1994).

The population status of bull trout in the Lower Skagit core area has been tracked in recent years using indices of abundance obtained at two locations. One is a spawning index area and the other is the smolt trap on the lower Skagit River located at river mile 14. The spawning index area is on the South Fork Sauk approximately 5.6 kilometers (3.5 miles) downstream of the old town site of Monte Cristo. The index area has been surveyed annually for spawner abundance beginning in 1988 (Table 2) (WDFW 1998; M. Downen, Washington Department

Table 2. Bull trout redd counts in the South Fork Sauk River spawning index area, and bull trout smolt counts at the lower Skagit River trap (representing entire core area), 1988 to 2002 (WDFW 1998; Downen, pers. comm. 2003a).

Year	Number of redds	Smolts captured
1988	16	--
1989	7	--
1990	4	130
1991	55	112
1992	46	132
1993	54	150
1994	34	452
1995	--	368
1996	56	244
1997	--	142
1998	--	359
1999	--	199
2000	--	247
2001	167	145
2002	221	--

of Fish and Wildlife, pers. comm. 2003a). The smolt traps have been in operation since 1990 (scoop trap prior to 1993, scoop and screw trap after 1993) monitoring out-migration of juvenile salmonids (Seiler *et al*. 2002). These traps are typically operated from the first of February through the end of September. Juvenile bull trout are typically captured throughout the trap period with peak captures in May and June. Recent work on adult bull trout found that nearly all the migratory (fluvial and anadromous) bull trout found in the Lower Skagit core area mature at age four with only the occasional fish maturing at age three or five. The size of first time fluvial spawners is typically 350 millimeters (13.8 inches), while the anadromous forms begin to spawn at about 425 to 450 millimeters (16.7

to 17.7 inches) in size. Multiple spawning adults are common in the population with half or more of the spawning population being repeat spawners. Repeat spawners as old as 8 (fluvial) and 10 (anadromous) years of age have been found. Once the fish reach sexual maturity, the fish spawn annually with no evidence of alternate year (skip) spawning. Based on growth patterns on scales, it appears that at least some fish within the Lower Skagit core area may on occasion change life histories. That is, following maturation, fish of one life history may adopt another life history or foraging strategy (*e.g.*, changing from anadromous to fluvial, resident to fluvial) (Kraemer, *in litt*. 2003).

The Upper South Fork Sauk River local population includes the South Fork upstream from Monte Cristo Lake located at river mile 4.5 and its tributaries Weeden Creek, Glacier Creek, and Seventysix Gulch. This area is thought to support fewer than 500 migratory adults, as well as numerous resident fish. Tagging data and scale analysis indicates that the migratory fish are both fluvial and anadromous (Kraemer 1994; Kraemer, *in litt*. 2003). The resident component of this local population is believed to be abundant and stable (likely near historical numbers), and the migratory component appears abundant and is increasing (Kraemer, *in litt*. 2001a). Spawning and early rearing habitat is believed to be in near pristine condition.

The Forks of the Sauk River local population includes the North Fork Sauk River downstream of the anadromous barrier at river mile 41 and the South Fork Sauk River downstream of Elliott Creek. In addition to these mainstem spawning areas, bull trout spawn and rear in several small tributary streams (Elliott, Chocwich, Bedal, Merry Brook and Martin Creeks) (WDFW *et al*. 1997; Kraemer *in litt*. 2001a). Typically fewer than 100 migratory adults use this area as well as a limited number of resident fish (Kraemer, *in litt*. 2001a). Status of the resident component of this local population is unknown, and the migratory component appears abundant and is increasing based on spawning ground counts (Kraemer, *in litt*. 2003).

The Lower White Chuck River local population includes the White Chuck River and several tributaries downstream of river mile 11. Spawning and rearing appears to be limited to the major tributaries, which include Pugh, Camp, and

Owl Creeks (WDFW 2002). This local population is thought to contain fewer than 500 migratory adults as well as resident adults (Kraemer, *in litt*. 2001a). Camp Creek is located in a Wilderness area and supports a number of resident bull trout above river mile 1.0. These are generally not fished. The status of the resident component is believed to be abundant and likely stable (near historical numbers), and the migratory component appears abundant and is increasing based on available spawning information in other parts of the basin.

The Upper White Chuck River local population includes the White Chuck River and tributaries upstream of river mile 12. Spawning is believed to occur in nearly all the mainstem reaches as well as the lower reaches of many of the tributary streams in this reach. Spawning bull trout have been observed in both the mainstem as well as in Fire, Pumice, Fourteen Mile, and Glacier Creeks (WDFW 2002). The population is known to contain both migratory and resident bull trout, though the total magnitude of the population is unknown. Glacial run-off limits the ability to monitor this system effectively, however it is believed to support one of the larger local populations in the Lower Skagit core area based on the available habitat. The resident component is believed to be abundant and stable (near historical numbers) since they are located in the Glacier Peak Wilderness. The migratory component appears abundant and is believed to be increasing based on available spawning information from other parts of the Skagit basin.

The Suiattle River system has documented spawning and rearing bull trout populations in seven tributaries: Tenas, Buck, Downey, Sulphur, Straight, Lime, and Milk Creeks (WDFW 2002). Spawning and rearing has also been documented in the upper mainstem above river mile 30 and in the tributaries associated with this reach. Both migratory (fluvial and anadromous) and resident bull trout are found throughout the Suiattle River system. Although a number of resident adult bull trout have been observed throughout this system, adequate data is generally unavailable at this time to estimate their abundance within each of the local populations.

Although Tenas Creek is used by migratory bull trout for spawning and rearing, no resident bull trout have been observed in this stream. The total

population is thought to be fewer than 100 adults (Kraemer, *in litt*. 2001a). The presence of spawning Chinook and pink salmon limits the opportunities to monitor this local population due to the superimposition of redds, especially in the lower reach. This local population is believed to be increasing in abundance.

Buck Creek is known to support both migratory and resident bull trout. Spawning and rearing in this subbasin is believed to extend upstream as far as river mile 6.0 and into its accessible tributary, Horse Creek. The Buck Creek local population is thought to currently contain fewer than 500 migratory adult bull trout based on the available habitat (Kraemer, *in litt*. 2001a). The resident component of this local population is believed to be abundant and stable (near historical numbers) since the majority of habitat lies within the Glacier Peak Wilderness. The migratory component is believed to be abundant and increasing.

Downey Creek is known to support both migratory and resident bull trout. Spawning and early rearing habitat for this local population is considered nearly pristine since the majority lies within the Glacier Peak Wilderness. Bull trout use in this basin extends upstream as far as river mile 6.2, and likely into its accessible tributary Goat Creek. This population is currently thought to contain fewer than 500 migratory adults based on the available habitat (Kraemer, *in litt*. 2001a). Tagging data indicates that migratory bull trout in this local population express both fluvial and anadromous behaviors (Kraemer, *in litt*. 2002). A cascade falls located at river mile 2.2 is an upstream migrational barrier to bull trout and anadromous salmon at most flows. However, during most years at peak run-off (June and early July), a limited number of adult bull trout are able to migrate past the falls and continue upstream of this point. The resident component of this local population is believed to be abundant and stable and the migratory component is believed to be abundant and increasing.

Sulphur Creek is known to support both migratory and resident bull trout. Spawning and early rearing habitat for this local population is also considered nearly pristine since the majority lies within the Glacier Peak Wilderness. Bull trout use in this basin is believed to extend upstream as far as river mile 6.0. This population is currently thought to contain fewer than 500 migratory adult bull trout based on the available habitat (Kraemer, *in litt*. 2001a). The resident

component of this local population is believed to be abundant and stable and the migratory component is believed to be abundant and increasing.

Straight Creek is known to support both migratory and resident bull trout. Bull trout spawning and rearing habitat in this basin is thought to extend upstream as far as river mile 2, and into its accessible tributary Black Creek. This population is thought to contain fewer than 100 migratory adult bull trout and an unknown number of resident adults (Kraemer, *in litt*. 2001a). The status of the resident component of this local population is unknown, however the migratory component is believed to be stable.

Lime Creek is known to support both migratory and resident bull trout. Bull trout spawning and rearing habitat in this basin is thought to extend upstream several miles. This population is thought to contain fewer than 100 migratory adult bull trout based on the presumed available habitat (Kraemer, *in litt*. 2001a). Migratory bull trout are typically confined to using the lower 0.8 kilometer (0.5 mile) of this stream below a steep cascade/falls, while resident forms can be found upstream of this point. The upper extent of this distribution is unknown. Both the resident and migratory components of this local population are believed to be abundant.

Milk Creek is known to support primarily resident bull trout, although it likely that a limited number of migratory fish regularly use the lower reach of the stream. Spawning and early rearing habitat for this local population is considered nearly pristine since it is completely within the Glacier Peak Wilderness. The resident component is believed to be abundant and stable (near historical numbers).

The upper Suiattle River local population includes the main Suiattle River upstream of river mile 30 and its associated tributaries (Dusty, Small, Miners, Vista, and Canyon Creeks). Both migratory and resident fish are found in this area with most spawning occurring in the lower reaches of the tributary streams. Spawning and early rearing habitat in this local population is currently in pristine condition. The adult abundance of all life history forms in this local population is currently unknown since only limited surveys have been conducted in this system.

Illabot Creek is a major tributary to the mainstem Skagit River and supports an abundant population of migratory and resident bull trout. Most spawning in this local population occurs upstream of river mile 8 and in Arrow Creek, with resident fish found primarily in the area near Illabot Lake. This local population is thought to contain fewer than 500 migratory adult bull trout (Kraemer, *in litt*. 2001a). Tagging data indicates that the migratory fish using this system express both fluvial and anadromous behaviors (Kraemer, *in litt*. 2002). The resident component of this local population is believed to be abundant and stable and the migratory component is believed to be abundant and increasing.

In the South Fork Cascade River bull trout have been observed as far upstream as river mile 23. Both resident and migratory fish are found in this reach, with tributary use limited to areas near the mouths of these tributary streams. Spawning and early rearing habitat in this local population is considered nearly pristine since the majority of habitat lies within the Glacier Peak Wilderness. The migratory component of this local population is thought to have fewer than 500 adults and is believed to be abundant and stable (Kraemer, *in litt*. 2001a). Although the abundance of the resident component is unknown, it is believed to be near historical numbers based on habitat conditions. The Cascade River local population consists of the mainstem reach between river mile 16 and the junction of the Cascade River forks, including the tributaries Kindy Creek and Sonny Boy Creek. Much of the spawning and rearing habitat in these two tributaries lies within Glacier Peak Wilderness. This area is thought to support a migratory population of bull trout of fewer than 100 adults (Kraemer, *in litt*. 2001a). The resident and migratory components of this population are considered stable.

In the Bacon Creek system, bull trout spawn and rear primarily in the East and West Forks of Bacon Creek with the East Fork being the most important of the two spawning areas. The total extent of use is unknown at this time, however it is believed that spawning may occur in 6.4 kilometers (4.0 miles) or more of the East Fork and only 3.2 kilometers (2.0 miles) of the West Fork. Spawning and early rearing habitat in the two forks is considered nearly pristine. Both resident and migratory fish have been observed in this population. The migratory population is thought to contain fewer than 500 adults (Kraemer, *in litt*. 2001a).

In Goodell Creek, bull trout spawning and rearing is confined to primarily the mainstem reaches. The upper limit of bull trout spawning and rearing is currently unknown, but may extend as far upstream as river mile 6.0. Spawning and early rearing habitat lie primarily in the North Cascades National Park. Both resident and migratory bull trout are found in this population. The migratory form is thought to currently number fewer than 500 adults, but is believed to be increasing (Kraemer, *in litt*. 2001a). The resident component of this local population is believed to be near historical numbers because of intact habitat conditions.

Prespawning adult bull trout have been reported staging in the lower reaches of Newhalem Creek, however the success of any spawning in the lower reaches is unknown (Kraemer, pers. comm. 2003b). The total adult abundance of this local population is currently unknown since no monitoring has occurred in this system.

The Baker Lake system contains the only adfluvial population in this core area. Bull trout are present in both Baker Lake and Lake Shannon. Spawning and rearing is known to occur in the Baker River above Baker Lake, as well as in Bald Eagle Creek, a tributary to the upper Baker River. Baker Lake is the primary foraging and overwintering habitat for subadult and adult life stages of the adfluvial form in the Baker Lake local population, however the Baker River likely also provides foraging and overwintering habitat. In 1986, 23 adult bull trout were observed staging in the Baker River within 0.8 kilometer (0.5 mile) of Bald Eagle Creek (WDFW *et al*. 1997). In the following year, 32 adult bull trout were observed actively spawning within 0.4 kilometer (0.25 mile) of the confluence. In 2001, adult bull trout were observed in Bald Eagle Creek at river mile 0.9 in the pool at the base of the migratory barrier (R2 Resource Consultants 2003). Adult and juvenile bull trout have also been observed within the Baker River tributaries, Sulphide, Crystal, and Pass Creeks (Glesne, *in litt*. 1993; R2 Resource Consultants 2003), and in the Baker Lake tributary, Swift Creek (Zyskowski, pers. comm. 2003d). Three adult and one subadult bull trout were recently observed in the Baker Lake tributary, Park Creek, during November 2003 surveys (Greenberg and Appy, *in litt*. 2003; M. Appy, R2 Resource Consultants, pers. comm. 2004). It is unknown if the upper reaches of the Baker River may

still support resident and fluvial forms of bull trout in addition to the adfluvial form. Their presence would be consistent with the apparent overlap of life history forms observed in other parts of the Lower Skagit core area. Spawning and early rearing habitat not modified by the placement of the dams is considered in nearly pristine condition, however the 9 miles of the Baker River mainstem and the lower portions of tributaries in the inundated reach between the dams no longer provide potential spawning habitat. The adult abundance in this population is currently unknown.

The bull trout observed in Lake Shannon are suspected to be fish that have dropped downstream past the Upper Baker Dam from Baker Lake and are no longer able to return upstream. Lake Shannon may currently act as a sink for those individuals that do not migrate past the Lower Baker Dam. Although Lake Shannon provides foraging and overwintering habitat, no bull trout spawning or rearing has been confirmed in any of the tributaries to the lake; however, spawning has recently been suspected in Sulphur Creek and bull trout might also be able to use Thunder Creek (Huddle, pers. comm. 2003b). In October 2002, four redds were identified in the lower reach of this system. They were believed to be bull trout redds based on their size and the time of year they were constructed (Huddle, pers. comm. 2003b). More recently, six adult sized bull trout were observed in Sulphur Creek during November 2003 surveys (Greenberg and Appy, *in litt*. 2003; Appy, pers. comm. 2004). In the early 1980's, bull trout were reported in the short (150 meter; 492 feet) accessible reach of Bear Creek (R2 Resource Consultants 2003). Although water temperatures in Bear Creek might be too warm for part of the year to support successful spawning and rearing (R2 Resource Consultants 2003), bull trout could use this system for seasonal foraging.

Currently one potential local population has been identified in the Gorge Lake system, Stetattle Creek. Bull trout in Gorge Lake are isolated from the other lower Skagit River local populations by Gorge Dam, although it is possible some one-way exchange may occur during spill events. There is a limited amount of available spawning and rearing habitat in the Gorge Lake system. Available spawning and primary rearing habitat would consist of the lower 2.7 kilometers (1.7 miles) of Stetattle Creek and potentially the lower portion of the Skagit River

mainstem from the reservoir up to Diablo Dam (less than 1.6 kilometers; 1 mile) (WDFW 1998). Spawning has not yet been confirmed in Stetattle Creek, although Gorge Lake does provide the foraging and overwintering habitat for bull trout residing in this system. If spawning does not occur within Stetattle Creek, Gorge Lake may be acting as a population sink for bull trout. These fish may have entered the system from the Upper Skagit core area through spill events at Diablo Dam. The adult abundance in the Gorge Lake system is currently unknown.

Upper Skagit core area. The Upper Skagit core area includes the Skagit basin upstream of Diablo Dam, including Diablo Lake and the majority of Ross Lake (Figure 6). A significant portion of the upper Skagit River drainage lies within British Columbia, Canada, and is functionally part of this core area. The upper Skagit River is a transboundary system that flows south from British Columbia into the United States. Much of the bull trout habitat in the upper Skagit River watershed is undisturbed, since a large portion of this watershed is located within North Cascades National Park, Pasayten Wilderness, and Skagit Valley Provincial Park. The Upper Skagit core area supports populations of both bull trout and Dolly Varden (McPhail and Taylor 1995). Adfluvial, fluvial, and potentially resident life history forms of bull trout are present in the upper Skagit drainage. Adfluvial bull trout are present in Ross Lake, while fluvial forms of bull trout are found in the upper Skagit River within British Columbia. Fluvial forms may also be present in Ruby Creek, a large tributary to Ross Lake. Resident bull trout are also found in several British Columbia tributaries to the upper Skagit River including Nepopekum and Snass Creeks, and the Klesilkwa, Sumallo, and Skaist Rivers.

Prior to dam construction, some tributaries to Ross Lake were inaccessible (including Big Beaver Creek) or had limited access by migratory forms (Smith and Anderson 1921). Resident bull trout are also believed to be present in the Lightning Creek drainage (S. Zyskowski, pers. comm. 2003c), and are likely to be present in the Big Beaver Creek, Little Beaver Creek, and Ruby Creek drainages as well as smaller tributaries to Ross Lake. Dolly Varden have been found in headwater tributaries of the Skagit River in British Columbia including Nepopekum Creek (McPhail and Taylor 1995), and are likely present in

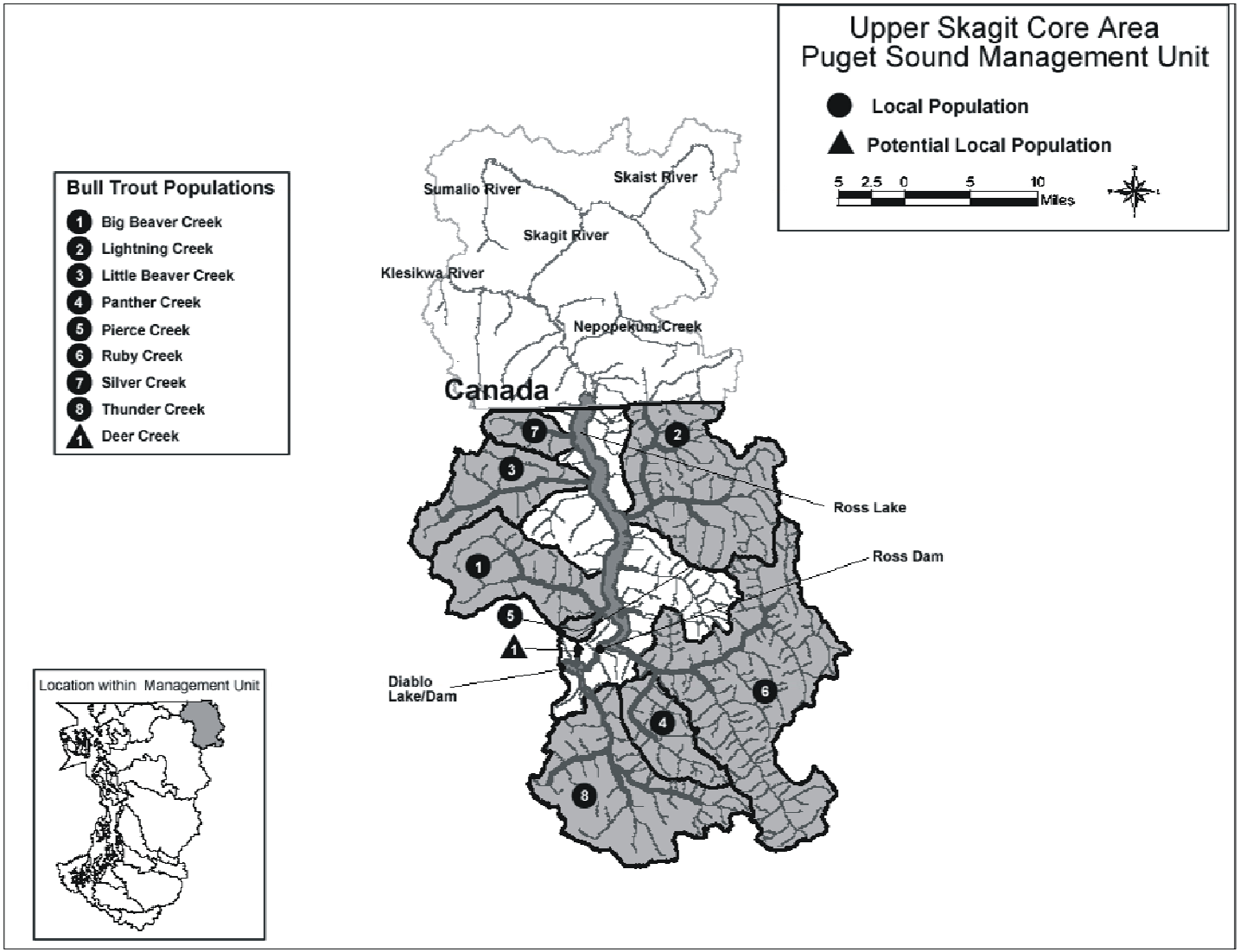

Figure 6. Upper Skagit core area for bull trout. Highlighted streams are key freshwater habitat for recovery.

tributaries of the Skagit in the United States as well. Recent genetics analysis of several yearling individuals captured in Diablo Lake near the mouth of Thunder Creek were determined to be Dolly Varden (Spruell and Maxwell 2002). Populations of Dolly Varden in the upper Skagit River drainage appear to be spatially segregated from bull trout, with Dolly Varden typically found above those areas possessing resident and migratory bull trout. Genetics analysis of native char in the upper Skagit River drainage in British Columbia indicates that there is an unusually high level of hybridization between bull trout and Dolly Varden in this system, with over 50 percent of Dolly Varden found to possess bull trout genetic markers (McPhail and Taylor 1995). This finding indicates that the distribution of bull trout and Dolly Varden have overlapped sometime in the past and may continue to overlap in some areas. It is possible that the filling of Ross Lake provided bull trout access to previously isolated Dolly Varden populations (D. McPhail, University of British Columbia, pers. comm. 1999).

The population status of bull trout and Dolly Varden in the upper Skagit River drainage is generally unknown. In British Columbia, the status of the Skagit River stock of bull trout is categorized as "presumed healthy" (*i.e.*, viable for at least 20 years if no new threats are added to watershed and data are available for populations in the watershed, or absence of significant threats and there was a known occurrence of bull trout in watershed) (BCMWLAP 2002). Bull trout are known to spawn and rear in at least eight streams (*i.e.*, local populations) in the United States; these are Ruby Creek (including Canyon and Granite Creeks), Panther, Lightning, Big Beaver, Little Beaver, Silver, Pierce, and Thunder Creeks (WDFW 1998; Ed Connor, Seattle City Light, pers. comm. 2003a). Recent spawning surveys indicate the majority of bull trout in the Upper Skagit River core area spawn in the mainstem Skagit River and in a number of its tributaries within British Columbia. Bull trout spawn and rear in at least six streams in the Skagit River drainage north of the United States-Canada border, including the mainstem Skagit, upper (East Fork) Skagit, Klesilkwa, Skaist, and Sumallo Rivers, and Nepopekum Creek (McPhail and Taylor 1995). Bull trout spawning and rearing may also occur in McNaught, St. Alice Creek, Maselpanik, and Snass Creeks (McPhail and Taylor 1995). No spawning index areas have been established in this drainage within either Washington or British Columbia, so only rough estimates of abundance are available for a few local populations.

Adfluvial bull trout have been observed staging and migrating into many of these tributaries of Ross Lake to spawn, including Ruby Creek, Lightning Creek, Big Beaver Creek, Little Beaver Creek, and Silver Creek. The largest runs of adfluvial fish south of the United States-Canada border are in Lightning Creek and Ruby Creek (Hopkins, *in litt*. 2002; Connor, in *litt*. 2003). Up to several dozen fish at a time can be observed staging at the mouths of these tributaries from mid-September through mid-November. Relatively large numbers of adfluvial bull trout (more than 100) can be observed holding in the upper Skagit River just north of the border by the end of September. These staging adults are known to spawn in the upper Skagit River and tributaries including the Sumallo River, Klesilkwa River, and Nepopekum Creek.

Although large juvenile or subadult bull trout (150 to 200 millimeters; 5.9 to 7.8 inches) have been observed at the mouth of Devil Creek, this system is similar to Little Beaver Creek in that it is located in an extremely steep and narrow canyon (Connor, pers. comm. 2003a). The lower 0.8 kilometer (0.5 mile) of this stream is also inundated by Ross Lake when it is near full pool elevation. However, this stream is dominated by large boulders and bedrock, so upstream migration beyond the lake inundation zone is unlikely due to numerous boulder and bedrock cascades and waterfalls in this stream. Areas surveyed upstream of these barriers were found to be inhabited only by cutthroat trout. Roland Creek supports a significant spawning run of adfluvial rainbow trout, however spawning use by bull trout has not been determined (Connor, pers. comm. 2003b). Roland Creek is likely an important foraging area for bull trout due to its productivity. A single subadult bull trout was observed in 2002 during rainbow trout broodstock collection efforts (Connor, pers. comm. 2003d).

Ruby Creek is the largest tributary entering Ross Lake within the United States. Ruby Creek has a relatively low gradient where it enters Ross Lake, providing good access for bull trout migrating into this stream from the lake. Early biological surveys conducted prior to the construction of the three Seattle City Light dams reported that native char were abundant in Ruby Creek, with these fish reaching 3.6 to 4.5 kilograms (8.0 to 10.0 pounds) in weight (Smith and Anderson 1921). U.S. Forest Service and Seattle City Light biologists have observed bull trout spawning within the lower 3.2-kilometer (2-mile) section of

Ruby Creek. The two major tributaries in this system are Canyon and Granite Creeks. Canyon Creek is believed to provide spawning and rearing habitat for this system based on recent habitat surveys (Hopkins, *in litt*. 2002). Pre-spawning bull trout appear to arrive in mid-August and hold in cold groundwater-fed pools in the upper reach of Canyon Creek above the confluence with Slate Creek (D. Hopkins, U.S. Forest Service, pers. comm. 2002). Granite Creek also supports some bull trout use, however current habitat conditions are believed to be limiting for spawning and rearing. Based upon snorkeling and electrofishing surveys conducted by the U.S. Forest Service, bull trout do not appear to use more than a few miles of lower Granite Creek (J. Molesworth, U.S. Forest Service, pers. comm. 2002). Although in the past bull trout were captured in the Ruby Creek tributary, Crater Creek (Glesne, *in litt*. 1993), it is not known whether this is still part of their current distribution within the system. Panther Creek is a tributary to the lower reach of Ruby Creek. The lower section of Panther Creek is steep and it is currently unknown if migratory bull trout are able to use this tributary. Bull trout in this stream appear to be primarily the resident form (Connor, pers. comm. 2003a). The upper limit to the distribution of bull trout in this stream is currently unknown.

Big Beaver Creek is the second largest tributary to Ross Lake. Spawning and rearing habitat for bull trout is believed to occur primarily in the upper reaches of Big Beaver Creek based on habitat surveys. Snorkeling surveys suggest that juvenile rearing in the lower reaches of Big Beaver Creek is mainly limited to a large complex of beaver ponds situated along this stream. Spawning and rearing surveys have not yet been conducted in the upper Big Beaver Creek drainage. However, the best spawning and rearing habitat for bull trout may be located in upper reaches of this stream (Johnston, pers. comm. 1999b). The distribution within Big Beaver Creek is thought to extend to about the confluence of Luna Creek. Spawning and rearing is also presumed to occur in its accessible tributary, McMillan Creek.

Little Beaver Creek is located in an extremely steep and narrow canyon. The lower 0.8 kilometer (0.5 mile) reach of Little Beaver Creek is annually inundated by Ross Lake when it is near full pool, which usually occurs between mid-July through mid-November. Upstream passage by migrating bull trout may

be difficult due to numerous boulder and bedrock cascades and waterfalls within this system.

Lightning Creek probably has the best habitat conditions for bull trout of all the Ross Lake tributaries. Like Little Beaver Creek and Devil Creek, the lower end of this stream is located in a steep and narrow canyon section which is inundated by the reservoir when it is near full pool. Lightning Creek is less confined by bedrock and lower in gradient than Little Beaver and Devil Creek upstream of Ross Lake, and consequently provided much better upstream passage conditions for migrating fish. Spawning bull trout have been observed in the lowest 3 kilometers (2 miles) of Lightning Creek, however, since spawning surveys have not been conducted above this section, the complete distribution is unknown. Given the near pristine habitat conditions, bull trout are presumed to use all the accessible reaches and tributaries in this system, including upper Three Fools Creek, Cinnamon Creek, and Freezeout Creek. High densities of juvenile and resident bull trout have been observed in the upper reaches of Lightning Creek, including lower Three Fools Creek, during snorkeling surveys conducted by the National Park Service and U.S. Forest Service (Hopkins, pers. comm. 2002).

Silver Creek is a moderate gradient stream, which currently appears to have a highly unstable channel and banks. These channel characteristics suggest that a recent mass wasting event or other type of natural watershed disturbance has occurred in the upper watershed of this stream. Both bull trout and brook trout have been documented spawning in this system (Connor, *in litt*. 2003).

Hozemeen Creek is located immediately south of the United States-Canada border, and is believed to support few bull trout due to relatively poor habitat conditions caused by high sediment loads, debris barriers, and warm water temperatures originating from historical logging in the upper watershed and the presence of nonnative brook trout (Connor, *in litt*. 2003).

Although no spawning has been observed in Pierce Creek, young-of-year bull trout were observed in this system during snorkel surveys conducted in the fall of 1999 (Connor, pers. comm. 2003a). Adfluvial bull trout kelts (surviving

post-spawning adults) were also observed at the mouth of Pierce Creek during this same survey period. A 24.4-meter (80-foot) waterfall located approximately 0.8 kilometer (0.5 mile) upstream from the mouth of this stream is a total barrier to the upstream migration of adfluvial fish.

Ross Lake is a 38.6-kilometer (24-mile) long reservoir impounded by Ross Dam, which is operated by Seattle City Light. This reservoir provides foraging, migration, and overwintering habitat for the adfluvial bull trout that spawn and rear in tributaries to Ross Lake, the upper Skagit River in Canada, and tributaries to the upper Skagit River. Large numbers of juvenile bull trout typically greater than 200 millimeters (7.9 inches) have been observed to congregate in Ross Lake at the mouth of Big Beaver Creek, Devil Creek, and in Ruby Creek, Lightning Creek, and the upper Skagit River immediately above the reservoir (Connor, *in litt*. 2003). These areas likely provide important foraging for larger juvenile bull trout, which feed on small rainbow trout, as well as provide coldwater refuge for juvenile and adult bull trout. The upper Skagit River also provides important bull trout foraging habitat for this core area, with the main prey reported to be Dolly Varden and rainbow trout (McPhail and Taylor 1995). Ross Dam is currently a passage barrier to the upstream and downstream migration of bull trout and Dolly Varden between Ross Lake and Diablo Lake. Bull trout may move downstream during periods of spill at Ross Dam, though spill events at this dam are rare. Studies are presently being initiated to determine whether there are genetic differences between populations of bull trout and Dolly Varden in Ross Lake and Diablo Lake.

Immediately downstream of Ross Dam is Diablo Lake, a 6.4-kilometer (4.0-mile) long reservoir with a limited number of spawning and rearing tributaries. This reservoir, formed after the construction of the Diablo Dam, provides foraging, migration, and overwintering habitat for bull trout and Dolly Varden. Prior to the construction of Diablo Dam, this section of the Skagit River flowed into Thunder Lake. Biological surveys conducted by University of Washington researchers prior to the construction of Diablo Dam reported that trout transplanted[†] from the Lake Chelan system were present in Thunder Lake, presumably rainbow or cutthroat trout (Smith and Anderson 1921). Thunder Creek is the largest tributary to Diablo Lake, and is believed to provide the

primary spawning and rearing habitat today. Spawning conditions are considered to be excellent in this stream due to abundant gravels situated within long runs and glides having depths and velocities which were well suited for spawning by bull trout, however flows are extremely "flashy" in this stream due to glacial runoff (Glesne, pers. comm. 2003). Egg and fry survival may be low in the mainstem sections of Thunder Creek due to the extreme variability of flows in this stream and scour† by fine sediments mobilized during these events. Spawning and early juvenile rearing are more likely to be successful in "clear running" tributaries to Thunder Creek (P. Castle, Washington Department of Fish and Wildlife, pers. comm. 2003a). Juvenile char have been observed in the lower reaches of Thunder Creek (Craig, *in litt*. 2000a; Zyskowski, pers. comm. 2002b). Very limited genetic sampling of juvenile char in the Diablo system has identified only Dolly Varden, however, bull trout are also likely present. Large native char are frequently captured by anglers in this lake, strongly suggesting that bull trout are also present in this system (Downen, pers. comm. 2002; Zyskowski, pers. comm. 2003a). There are two additional tributaries to the Diablo Lake system where bull trout or Dolly Varden were observed in the past. In 1976, spawning bull trout or Dolly Varden were documented in Deer Creek, which is located near the Diablo Lake Resort (Glesne, *in litt*. 1993). This is a small creek system with limited habitat. It has not been determined whether spawning and rearing may still occur here. During this same time period, bull trout or Dolly Varden were also observed in the lower reaches of Colonial Creek, a tributary to the Thunder Arm of Diablo Lake (Glesne, *in litt*. 1993).

Stillaguamish core area. The Stillaguamish River basin, including both the North and South Forks, comprises the Stillaguamish core area (Figure 7). Major tributaries to the North Fork include the Boulder River, Deer Creek, and its tributary, Higgins Creek. Canyon Creek constitutes the only major tributary to the South Fork, which also receives water from several minor tributaries including Palmer, Perry, and Beaver Creeks. Spawning habitat is believed to be somewhat limited, where in most cases only the extreme upper reaches of these waters appear to provide adequate spawning conditions. This is believed to have been the case historically due to the lack of accessible high elevation stream habitat and instability of soils found in the basin, but has been further reduced from the effects of land management activities. In some cases, access to these

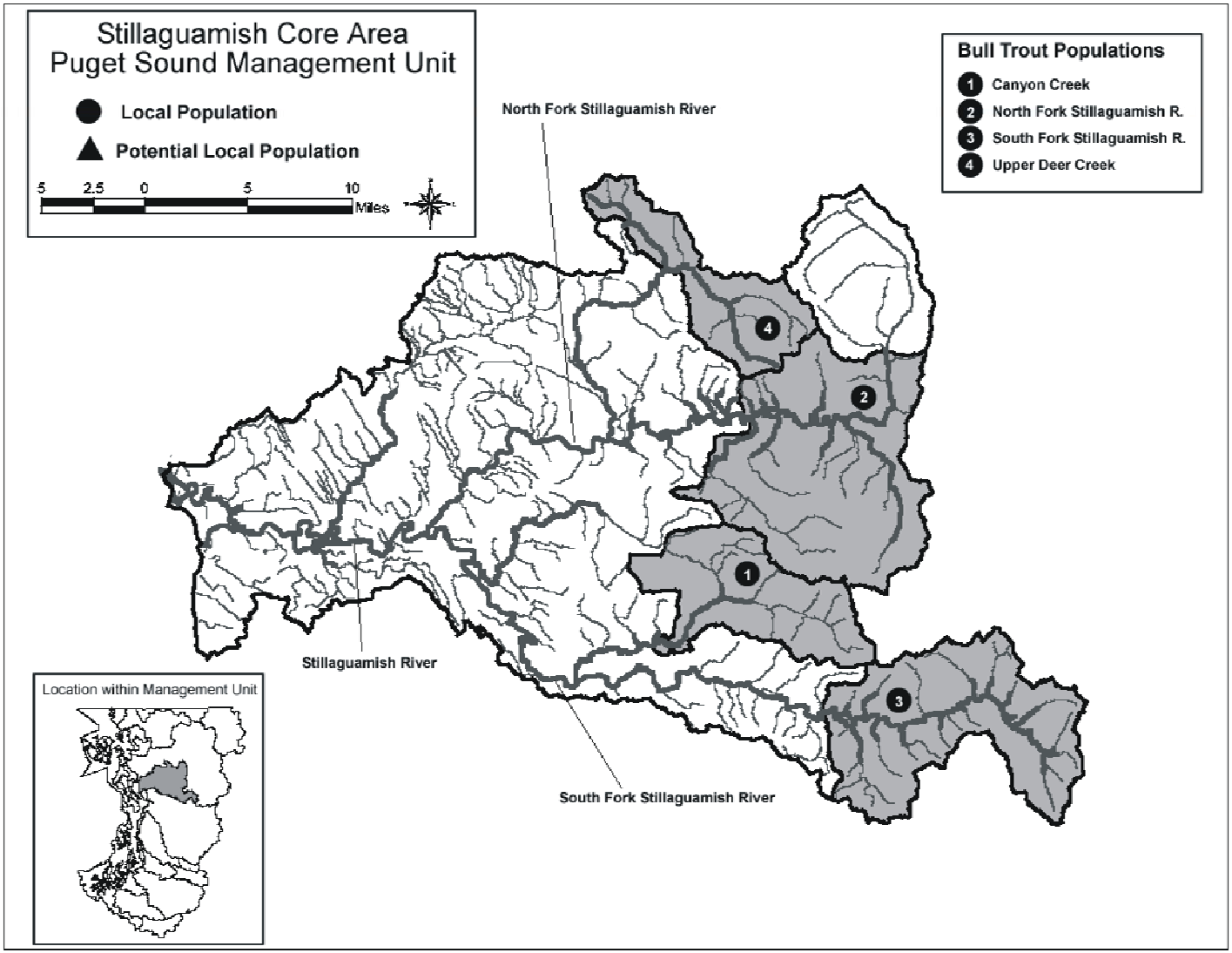

Figure 7. Stillaguamish core area for bull trout. Highlighted streams are key freshwater habitat for recovery.

reaches are blocked by natural barriers. Rearing and foraging habitat does exist downstream of these areas. For example, large juvenile or subadult bull trout have been observed or captured in Big Four Creek (K. Nelson, Tulalip Tribe, pers. comm. 2003; Chang, *in litt*. 2003), a short tributary to the South Fork Stillaguamish River which enters just downstream of Perry Creek. This core area is believed to support primarily anadromous and fluvial life history forms. No exclusively resident populations have been identified in this core area, but the South Fork population does have a strong resident component which coexists with migratory forms.

The paucity and spatial isolation of available spawning habitat suggest that only four local populations likely exist in the Stillaguamish core area: Upper Deer Creek (including Higgins Creek); the North Fork Stillaguamish River (including a major tributary, the Boulder River, and potentially Squire Creek); the South Fork Stillaguamish River (including its upper minor tributaries); and Canyon Creek (major tributary to the South Fork Stillaguamish River). These local populations are somewhat isolated from one another, therefore maintaining connectivity between each of these within the core area will be critical.

In the Upper Deer Creek local population, bull trout have been observed spawning in Higgins Creek and are suspected in upper Little Deer Creek as well. Juvenile bull trout sampled in low numbers during U.S. Forest Service stream surveys in Higgins Creek provide further evidence for successful reproduction. In October 1983, two pairs of adult bull trout and eight redds were incidentally observed between river mile 1.0 and 1.5 during stream surveys (Doyle, pers. comm. 2003). No resident populations have been found above any of the natural migratory barriers on Deer or Higgins Creeks. Spawning and early rearing habitat in this local population is currently believed to be in poor condition resulting from past forest management (Deer and Higgins Creeks currently violate State water quality standards for temperature), but is believed to be recovering. Current population abundance is believed to be low.

In the North Fork Stillaguamish River local population, upwards of 100 adult bull trout have been observed holding in the mainstem of the North Fork Stillaguamish River below the mouth of the Boulder River. Fall snorkel surveys

conducted between 1996 and 2003 counted close to 300 adult char in the reach between river mile 21 and 25 during fall 2001, although counts were fewer than 100 adults for the remaining sample years (Pess, *in litt*. 2003). Other limited snorkel survey efforts have made similar observations (Downen, pers. comm. 2003b). Due to limited information on spawning distribution within this part of the system and the presence of other fall-spawning species, adult counts of staging bull trout appear to be the best monitoring tool for this local population. These staging adult bull trout are assumed to spawn somewhere in the North Fork. Bull trout have been observed spawning in the extreme accessible portion of the upper North Fork and in the Boulder River below the impassible falls at river mile 3. Currently no extensive juvenile sampling or evaluation of spawning success has occurred in the North Fork. There are no known populations in the North Fork above the anadromous barrier at river mile 37.5 (Kraemer, *in litt*. 1999a). In addition, no resident populations have been identified above the barrier on the Boulder River. Spawning and early rearing habitat is limited primarily due to natural barriers on the Boulder River and lack of headwater habitat with suitably cold water temperatures. Warmer water temperatures in the summer may also limit movement of juvenile bull trout. Current population abundance in the Boulder River is believed to be low, fewer than 100 adults. While unconfirmed, spawning and rearing is also suspected in the Squire Creek system, which is similar in size to Boulder River, and also influenced by snowmelt from Whitehorse and Three Fingers mountains. In the late 1980's, bull trout approximately 457 millimeters (18 inches) in length were observed holding in Squire Creek just downstream of the mouth of Aston Creek (Castle, pers. comm. 2003b). The natural anadromous barrier in Squire Creek is reported to be at river mile 7.9. As better distribution information is collected, Boulder River may be separated from the rest of the North Fork Stillaguamish River into its own local population.

In the South Fork Stillaguamish River, bull trout are currently known to use Palmer, Perry, and Buck Creeks and the upper South Fork mainstem above Palmer Creek for spawning and rearing. It is uncertain whether bull trout were present in the South Fork above Granite Falls prior to construction of the fishway facility in the 1950's, but anecdotal information from fish surveys in the 1920's and 1930's suggest bull trout may have existed here prior to the construction

(WDFW 1998). Recently initiated spawning surveys have identified a major spawning area above the Palmer Creek confluence. Between 50 and 100 bull trout have been observed using this reach to spawn, and electrofishing surveys conducted by Washington Department of Fish and Wildlife personnel have also documented high densities of juveniles (Downen, *in litt*. 2003). Fish believed to be resident bull trout have also been sampled in Palmer Creek. Spawning and early rearing habitat in this local population is currently believed to be in fair condition. Although fish have been observed spawning in the upper South Fork and other tributaries, available habitat is likely partially limited by gradient and competition with coho salmon. Upstream movement of bull trout from the lower river is currently dependent upon proper functioning of the fish ladder at Granite Falls. There has been no evaluation of bull trout passage past this facility. Current population abundance is believed to be low. Migratory and resident fish are both present and commingle on the spawning grounds. Conservative estimates of current population size based on spawning and electrofishing surveys suggest that between 50 and 100 adult spawners are present in this population (Downen, *in litt*. 2003).

In the Canyon Creek local population, bull trout are known to use the upper South Fork of this system for spawning and rearing. Both Washington Department of Fish and Wildlife and U.S. Forest Service staff have made isolated and incidental observations of spawning by migratory size bull trout. However, recent electrofishing surveys by the Washington Department of Fish and Wildlife have been unable to locate any juvenile or resident bull trout from this population. Spawning and early rearing habitat in this local population is currently believed to be in poor condition. Logging and the low elevation of this tributary put both natural and anthropogenic constraints on spawning and rearing habitats. Warmer summer temperatures and low water resulting from habitat problems associated with logging and mass wasting issues likely limit suitable juvenile rearing habitat. Current population abundance is believed to be low. Difficulty in locating individuals from this population despite repeated survey efforts suggests this population currently exists in very low numbers.

During some years, juvenile and subadult bull trout have been captured by smolt trapping efforts conducted in the lower Stillaguamish River. In 2002, a

single bull trout was captured each month between March and June (Griffith, *in litt*. 2002). Fish captured were 50, 130, 142, and 345 millimeters (2, 5.1, 5.6, and 13.6 inches) in length, indicating that some level of juvenile rearing may take place within the mainstem.

Primary foraging, migration, and overwintering areas in this river basin include the mainstem areas of the North and South Forks, and the Stillaguamish River to the estuary. Foraging subadults and adults may be found in nearly all anadromous reaches of the basin, while rearing individuals may utilize nearly all accessible reaches in higher elevation and coldwater portions of the basin. Like anadromous populations in the Lower Skagit and Snohomish-Skykomish core areas, anadromous forms in the Stillaguamish core area are presumed to use nearshore marine areas in Skagit Bay, Port Susan, and Possession Sound.

Snohomish-Skykomish core area. The Snohomish-Skykomish core area includes the Snohomish, Skykomish and Snoqualmie Rivers and all their tributaries (Figure 8). Bull trout can be found throughout these waters, generally downstream of anadromous barriers. They are not known to be present upstream of Snoqualmie Falls, upstream of Spada Lake on the Sultan River, upstream of the lower reaches of the forks of the Tolt River, upstream of Deer Falls on the North Fork Skykomish River, or upstream of Alpine Falls on the Tye River (Kraemer, *in litt*. 1999b). Fluvial, resident and anadromous life histories are all found within the basin. There are no lake systems within the basin that support typical adfluvial populations, however anadromous and fluvial forms occasionally forage in a number of lowland lakes having connectivity to the mainstem rivers. A large portion of the migratory segment of this population is anadromous, and these forms make extensive use of the lower estuary and nearshore marine areas for extended rearing.

Rearing bull trout can be found throughout the anadromous portions of the Snohomish, Skykomish, North Skykomish and South Fork Skykomish with occasional use in the other portions of the anadromous reaches of the basin. A population containing only resident forms is found in Troublesome Creek on the North Fork Skykomish River. This resident bull trout population is upstream of a migration barrier at river mile 0.5. Infrequent access to Troublesome Creek

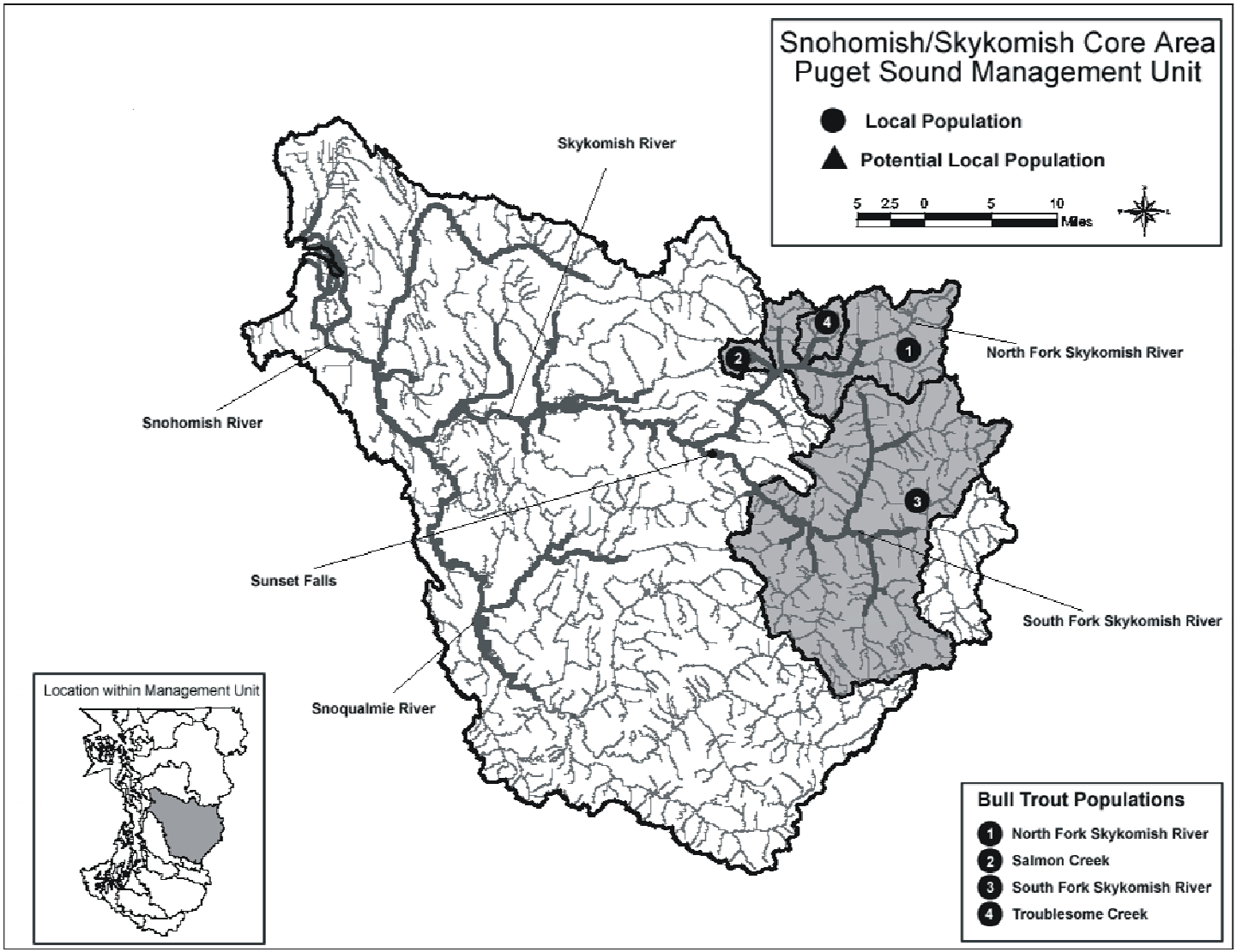

Figure 8. Snohomish/Skykomish core area for bull trout. Highlighted streams are key freshwater habitat for recovery.

above the barrier by summer steelhead has been documented at least once in the last 15 years (Kraemer, pers. comm. 2003b). It is possible that migratory bull trout may occasionally migrate to the upper basin under the same conditions that allow steelhead access upstream of this barrier. The known spawning and early rearing areas of the Skykomish River basin are all found at an elevation of 305 to 457 meters (1,000 to 1,500 feet). Because of the topography of the basin, the amount of key spawning and early rearing habitat available is more limited than in some basins. Primary spawning and early rearing habitat for bull trout is found in the upper North Fork Skykomish River drainage. The major areas of production include the North Fork Skykomish River between Bear Creek Falls and Deer Falls, Goblin Creek, Troublesome Creek, and Salmon Creek. In addition, in the last several decades a migratory bull trout population has become established in the East Fork Foss and Beckler Rivers on the South Fork Skykomish River. This group of fish gained access to the area upstream of the historical anadromous barrier in 1958 when the Washington Department of Fish and Wildlife (then the Department of Fisheries) instituted a trap and haul operation to move fish over Sunset Falls (Kraemer, *in litt*. 1999b). Currently four local populations have been defined for this core area: North Fork Skykomish River (includes Goblin Creek and West Cady Creek); Troublesome Creek; Salmon Creek; and South Fork Skykomish River. Information gathered through ongoing and future bull trout research within the basin may result in the need to reevaluate these local populations.

Bull trout spawn in the North Fork Skykomish River local population upstream of Bear Creek Falls to Deer Falls, as well as in Goblin Creek and West Cady Creek. This area supports as many as 500 migratory adults based on redd counts as well as a small number of resident fish (only occasionally observed). The migratory fish are thought to be primarily the anadromous life history form. Recent genetic work (DNA) indicates that these fish are all bull trout, while prior meristic and morphological data has indicated that some may be Dolly Varden (WDFW 1998; Kraemer 1994). Spawning and early rearing habitat is generally in good condition. The abundance of the resident component of this local population is currently unknown.

The Troublesome Creek local population is primarily a resident population with typically only resident fish found upstream of the natural barrier located approximately 0.4 kilometer (0.25 mile) upstream from the mouth. The abundance of the resident population is currently unknown, but is believed to be stable due to intact habitat conditions. Spawning and early rearing habitat is believed to be in good to excellent condition given the upper reaches of this system are within the Henry M. Jackson Wilderness. A few migratory fish are seen annually spawning downstream of the barrier, and migratory fish may rarely gain access to the upper creek under unusual conditions. It is believed that only a few migratory adults use the section of Troublesome Creek downstream of the barrier, since there is a limited amount of spawning and rearing habitat. Although connectivity with other local populations within the system is considered poor, this is the natural condition of this particular local population. Recent genetic work indicates that the native char in this system are all bull trout (Young, pers. comm. 2004), while prior meristic and morphological data suggested that some were potentially Dolly Varden (Kraemer 1994).

In Salmon Creek, migratory-sized adult bull trout have been observed in the mainstem near the confluence with South Fork Salmon Creek during the spawning period (David Evans and Associates and R2 Resources Consultants 1998b). Juveniles have also been observed in the lower reach of the mainstem (David Evans and Associates and R2 Resources Consultants 1998b). Specific spawning areas in this system have not yet been identified, however available spawning and early rearing habitat is considered to be in good to excellent condition. The spawner abundance within this local population is currently unknown.

In the South Fork Skykomish River, an increasing number of migratory adult bull trout are trucked around Sunset Falls annually. The only known spawning areas are the lower East Fork of the Foss where tagged adults were tracked in 1993 (WDFW 1998), and more recently the Beckler River between river miles 2.0 and 5.0. The presence of resident fish is unknown, however, the migratory population of adult spawners currently numbers about 50 fish a year (Table 3). This population represents an expansion of the historical range of migratory bull trout in the Snohomish-Skykomish basin, with colonization

Table 3. Bull trout redd counts in the North Fork Skykomish River spawning index area, and bull trout adult counts at the Sunset Falls trap on the South Fork Skykomish River, 1988 to 2002 (Kraemer, *in litt*. 2001c).

Year	Number of Redds	Number of Adults
1988	21	--
1989	49	--
1990	67	--
1991	156	--
1992	82	--
1993	159	--
1994	*	18
1995	75	40
1996	60	45
1997	170	42
1998	177	47
1999	110	45
2000	236	51
2001	319	62
2002	538	90

*** incomplete survey**

occurring within the last few decades. Continued use of this area by migratory fish is dependent upon the ongoing operation of the trap and haul facility at Sunset Falls. Genetic samples from these returning adults have been collected and are awaiting analysis. Spawning and early rearing habitat is considered to be in good to excellent condition based on assessments from local biologists.

The mainstem corridors on the Snohomish, North Fork Skykomish, South Fork Skykomish, and Snoqualmie Rivers, and many of their accessible tributaries, provide important foraging, migration, and overwintering habitat for subadult and adult bull trout in this system. The anadromous component within this core area

appears to be much more abundant than the fluvial component. Fluvial fish are generally confined to a few large pools found in the middle portion of the mainstem Skykomish River. In contrast, anadromous bull trout can be found throughout the anadromous reaches of the Snohomish-Skykomish River system. Juvenile and subadult life stages forage throughout the mainstem, but occasionally may be found using tributary streams. For example, a juvenile bull trout was observed in Trout Creek during 1998 stream surveys (David Evans and Associates and R2 Resource Consultants 1998c), while two adults were observed in Trout Creek' confluence pool with the North Fork Skykomish River (David Evans and Associates and R2 Resource Consultants 1998a). Subadults are believed to typically overwinter in the mainstem reaches of the Snohomish River. Recent tagging information indicates that subadults observed in the mainstem reaches may include fish from populations outside of the Snohomish core area (Goetz, pers. comm. 2002). The anadromous subadult and adult life stages spend much of the growing season (late winter to fall) in the estuary and nearshore marine waters of Possession Sound and Port Susan.

A spawning index, established by the Washington Department of Fish and Wildlife, has been used to track the overall status of bull trout in the Snohomish-Skykomish system. This index reach encompasses the upper North Fork Skykomish River from river mile 15 to 18.5, including Goblin Creek up to river mile 0.5 and the lower portion of West Cady Creek. Spawner abundance (number of redds) have been tracked annually since 1988 (WDFW 1998) (Table 3). Assuming an intermediate value of 2.5 spawners per redd based on sex ratios reported in other systems (Goetz 1989; Brown 1994; McPhail and Baxter 1996; James and Sexauer 1997), the average number of redds counted over the last six years (258), when counts exceeded 100 redds annually, suggest the average annual spawner abundance in the North Fork Skykomish index reach is around 650 individuals. The average number of redds counted for the past 10 years of record is 188, which would suggest a 10-year average of 470 individuals. Population monitoring also occurs at the trap and haul facility at Sunset Falls. All adult bull trout entering the trap are counted and released above the falls (Table 3). Numbers of adult bull trout passed into the South Fork continue to increase, and new spawning and rearing areas are being colonized. It is believed that this local population will exceed 100 adult spawners in the near future. Based on

increasing abundances (approximately a three-fold increase in spawner abundance since 1990), the Washington Department of Fish and Wildlife has rated this population as healthy. With this increase in abundance, fishing continues to be allowed in this system (two fish limit with a 508 millimeter (20 inch) minimum size limit).

Chester Morse Lake core area. The Chester Morse Lake core area is located within the Cedar River Municipal Watershed in the upper reaches of the Cedar River drainage, upstream of a natural migration barrier at Lower Cedar Falls (river mile 34.4) (Figure 9). The municipal watershed serves as the major source of water for the City of Seattle and surrounding communities, and has had restricted public access since 1908 to maintain high water quality. The Chester Morse Lake core area has a drainage area of 214 square kilometers (83 square miles). The largest water body in the upper Cedar River watershed is the Chester Morse Lake/Masonry Pool reservoir complex, which is approximately 10.7 kilometers (6.6 miles) in length. Chester Morse Lake (originally Cedar Lake) was naturally formed by glaciers and is approximately 8.4 kilometers (5.2 miles) long and 1 kilometer (0.6 mile) wide. The water elevation of the lake was raised 9.8 meters (32 feet) following the construction of Masonry Dam to provide storage for the City of Seattle's municipal water supply and hydroelectric power generation.

Chester Morse Lake currently has a maximum depth of approximately 41.1 meters (135 feet) at full pool. The western end of the reservoir complex, Masonry Pool, is connected to Chester Morse Lake by a narrow channel flowing through a lateral glacial moraine. Masonry Pool is physically separated from Chester Morse Lake during periods of drawdown by a small concrete dam (Overflow Dike). The two major tributaries flowing into Chester Morse Lake are the upper Cedar River and the Rex River. Although the ‘canyon reach’ between Lower Cedar Falls and the Masonry Dam is included in the core area, it is not considered to be suitable bull trout habitat or capable of supporting a sustainable population because it is dominated by a series of waterfalls, bedrock chutes, and large plunge pools that severely restrict any appreciable upstream movement and/or interchange within the reach.

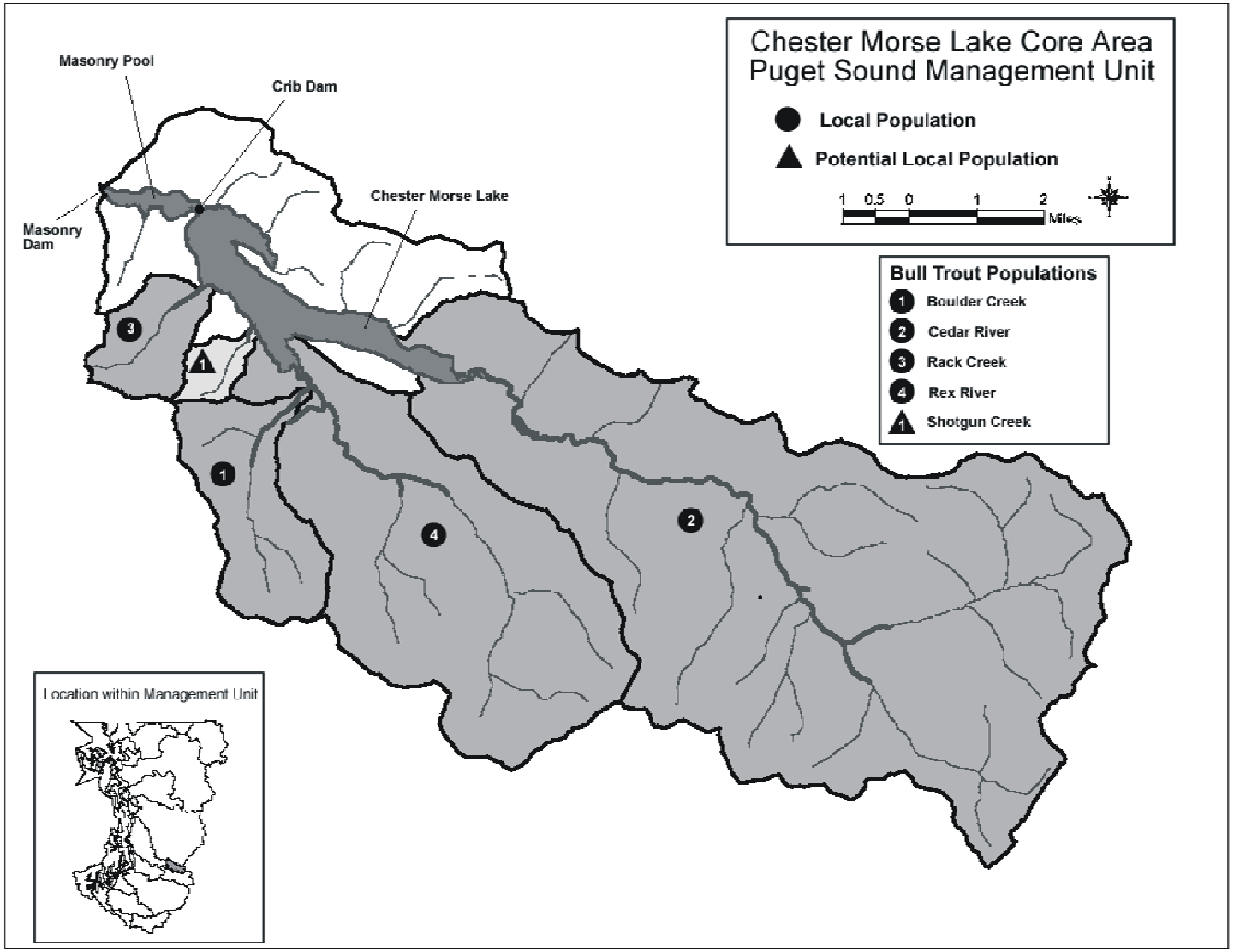

Figure 9. Chester Morse Lake core area for bull trout. Highlighted streams are key freshwater habitat for recovery.

The Cedar River watershed upstream of the Masonry Dam supports the only known self-sustaining population of bull trout in the Lake Washington basin. Identification of char in this core area to date has been based on morphometric and meristic measurements that strongly indicate they are bull trout (City of Seattle 2000a). Genetic samples were collected from juvenile fish (1+ year class[†]) rearing in the Cedar and Rex River mainstems, selected tributaries to these streams, and a tributary to Chester Morse Lake, Rack Creek, during the 2002 field season and will be submitted for analysis (Paige, *in litt*. 2003).

The presence of bull trout in the Chester Morse Lake core area has been documented in Chester Morse Lake and Masonry Pool and in some tributaries to Chester Morse Lake, including the Cedar and Rex Rivers (City of Seattle 2000a). In addition, Seattle Public Utilities staff have documented the presence of bull trout in Rack and Shotgun Creeks, tributaries to Chester Morse Lake; in Boulder, Cabin, and Morse Creeks, one unnamed side channel to the Rex River (upstream of the 300 Road), and in the lowermost reach of Lindsay Creek (Boulder Creek tributary); in Eagle Ridge Creek and several floodplain channels of the Cedar River, and one small, unnamed northside tributary of the upper Cedar River downstream of the North and South Forks and the 600 Road bridge (Paige, *in litt*. 2003). The upstream terminus of the documented bull trout distribution in most of these streams has been established up to natural passage barriers (*e.g.*, Rex River, Lindsay Creek, North Fork Cedar), but has not been definitively established in several others (*e.g.*, South Fork Cedar, Boulder Creek) (Paige, *in litt*. 2003). In addition, the presence of bull trout has not been detected in several streams thought to exhibit habitat characteristics suitable to support them (*e.g.*, Bear Creek, upper South Fork Cedar, Bridge Creek) (Paige, *in litt*. 2003). Field surveys to expand the documented range of bull trout within the Chester Morse Lake core area will be continued by Seattle Public Utilities staff under elements of the City of Seattle's Habitat Conservation Plan (see Appendix 4 for a definition of habitat conservation plan) for the Cedar River Watershed (City of Seattle 2000b; Paige, *in litt*. 2003).

Within the Chester Morse Lake core area, in addition to Chester Morse Lake and Masonry Pool, the presence of bull trout has been confirmed in a total of 36.6 kilometers (22.7 miles) of streams. Of that total, 15.9 kilometers (9.9

miles) are in the mainstem of the Cedar River, 6.0 kilometers (3.7 miles) are in the mainstem of the Rex River, 1.3 kilometers (0.8 mile) are in the North Fork Cedar, and 1.1 kilometers (0.7 mile) are in the South Fork Cedar (upper limit not determined). The remaining bull trout habitat is found in smaller tributaries of the Cedar (8.8 kilometers; 5.4 miles) and Rex (5.5 kilometers; 3.3 miles) systems and in tributaries of Chester Morse Lake (0.6 kilometer; 0.4 mile).

The level of emigration of bull trout occurring from Chester Morse Lake to the lower Cedar River is unknown. The only means for bull trout to leave the reservoir complex and pass to the lower Cedar River is during use of the emergency spill gates and/or the smaller spillway† near the south end of the Masonry Dam. These gates are rarely opened except under emergency conditions of high reservoir elevation (*e.g.*, 1990 flood) or for special operational purposes. It is presumed impossible for live fish to pass through the other structure used to release water from Masonry Pool (Masonry Dam spill valve/Howell-Bunger Valve) at the base of the Masonry Dam. It is possible, however, and in fact probable, that bull trout do successfully pass through the spill gates when water is released and thereby gain access to the 'canyon reach' and the lower Cedar River, but no accurate estimate of numbers of fish passing the dam can be determined.

As of 2000, no substantive evidence has indicated that either a self-sustaining population of bull trout or any significant number of individuals exists in the approximate 20 kilometers (12.5 miles) of mainstem, or additional tributary habitat, between the Masonry Dam and the Landsburg Diversion Dam. Although passage over the Masonry Dam, and subsequent downstream movement, of a limited number of bull trout is expected to occasionally occur during seasonal spillway releases of water from Masonry Pool as indicated above, it apparently has not been sufficient to support establishment of bull trout populations under the ecological conditions existing in downstream reaches (City of Seattle 2000b). One incidental sighting of a single adult char (assumed to be a bull trout) immediately upstream of the powerhouse at Cedar Falls was reported during September 1997 (K. Binkley, Seattle City Light, pers. comm. 1997). A second sighting of three adult char (assumed to be bull trout) was reported during July 2000 in one of the powerhouse tailraces† at Cedar Falls (E. Ablow, Seattle City Light, pers. comm. 2000). These individuals were estimated to be approximately

254 to 305 millimeters (10 to 12 inches) in length and exhibited some signs of recent, non-lethal injury on their heads and dorsal surfaces (Paige, *in litt*. 2003). A third sighting of three adult char (assumed to be bull trout) was reported during August 2003 in the powerhouse tailrace at Cedar Falls (E. Ablow, Seattle City Light, pers. comm. 2000), but these may have been the same individuals as observed previously in July. No other sightings of bull trout are currently known from the Cedar River between Cedar Falls and Landsburg. A few incidental sightings, however, have been reported from the Landsburg to Lake Washington reach of the lower river (see Lake Washington foraging, migration, and overwintering habitat).

The only sexually mature bull trout that have been observed to date in the Cedar and Rex Rivers are spawning adults that have migrated upstream from Chester Morse Lake. Consequently, local populations of bull trout in this core area appear to be primarily, if not completely, composed of adfluvial life history forms. There remains, however, the possibility that resident and/or fluvial life history forms may be present in some upper reaches of the North and/or South Fork of the Cedar River downstream of natural passage barriers.

Bull trout in the Chester Morse Lake core area have exhibited a consistent pattern of spawning habitat use since studies were initiated during the early 1990's (Paige, *in litt*. 2003). The most densely and consistently utilized bull trout spawning reaches during the last decade are located in mainstem reaches of the Cedar and Rex Rivers, within approximately 2.9 kilometers (1.8 miles) and 1.1 kilometers (0.7 mile) of the reservoir, respectively, and in several floodplain channels of the Cedar River upstream of the Camp 18 bridge (City of Seattle 2000a; Paige, *in litt*. 2003). Each of these reaches contains large concentrations of gravel relative to other upstream reaches of the Cedar and Rex River systems; both substrate size, and in most cases gradient, increase immediately upstream of these ‘core’ survey reaches (Paige, *in litt*. 2003). Redds are distributed throughout these reaches in varying density and patterns of distribution from year to year, however, the vast majority of observed use has been concentrated in these same areas during all years of survey (Paige, *in litt*. 2003).

A relatively low level of bull trout spawning activity has been detected in several limited reaches of the Cedar River upstream of the 'core' survey reaches near Chester Morse Lake. Between Roaring Creek and Seattle Creek, spawning was discovered by redd surveys (City of Seattle 2000a). Fry trapping (fyke nets) conducted between the confluences of Seattle and Bear Creeks indicates that some relatively low level of bull trout spawning activity has taken place upstream of that point (Paige, *in litt*. 2003). Limited evidence (unconfirmed redds) has suggested some potential for isolated spawning activity (in pocket gravels) a short distance downstream of the 600 Road bridge located at river mile 51.4. This area is 1.4 kilometers (0.9 mile) downstream of the confluence of the North and South Fork of the Cedar River. No indications of bull trout spawning activity upstream of this reach (upstream of the 600 Road bridge) have been observed. The river upstream of this location is dominated by large cobbles and boulders, while spawning gravels upstream of this location are scarce (City of Seattle 2000a). Bull trout spawning in the Rex River has been observed upstream only as far as 122 meters (400 feet) downstream from the confluence of Morse Creek. Upstream of Morse Creek, the reach of the Rex River that extends approximately 2,921 meters (9,582 feet) upstream to Lindsay Creek becomes narrow and substantially higher in gradient and is dominated by large cobbles and boulders. Most reaches of the Rex River within a short distance upstream of the confluence of Lindsay Creek are dominated by bedrock substrates and bedrock intrusions that result in a series of barriers which are impassable to fish. The first barrier is a large falls 354 meters (1,160 feet) upstream of the confluence of Lindsay Creek (Paige, *in litt*. 2003).

Based upon spawning surveys conducted in the upper Cedar River watershed since 1992, it appears that the population of bull trout spawners in this core area may vary considerably from year to year, although both environmental conditions (*e.g.*, high stream flows) and field logistics (*e.g.*, lack of field staff, organizational priorities, documenting extent of habitat usage, etc.) have substantially influenced at least some of the redd counts, especially those conducted prior to the 2000 season. The level of effort (repeated surveys) invested in redd surveys during years prior to 2000 was typically several magnitudes (2 to 5 times) less than the effort expended during and after 2000. Prior to 2000, surveys were not typically conducted on a regular (weekly or bi-

weekly) schedule and in several years were concentrated in only one month (*e.g.*, October, November) of the spawning season as it is now defined (September to January). In several of these years, the majority or all of the surveys were conducted during October, presumably prior to the peak activity period (early November) as indicated by data from more extensive survey years. For example, the highest number of bull trout redds observed (110) prior to year 2000 was in 1993 when all surveys were conducted during the period November 1 through November 21 (City of Seattle 2000a). Because surveys were not conducted prior to November, nor during December and January, it is possible that a substantial number of redds may not have been detected and counted, even though all surveys were conducted during the month of peak spawning activity.

Total redd counts for the core area including the major tributaries, Cedar and Rex Rivers, and all mainstem and lake tributaries from 1992 to 2002 have ranged from 6 to 504 redds per year (WDFW 1998; City of Seattle 2000a; City of Seattle 2000b; Paige, *in litt*. 2003). The lowest redd counts were recorded in 1995 and 1996 with fewer than 10 redds recorded per year, however these particular counts are considered incomplete survey years due to lack of access to streams and substantial periods of marginal survey conditions during high flows and late season floods. Emigrant fry trapping, however, following each of these low spawning count years (1996 – 0 fry captured; 1997 – 15 fry captured) were not inconsistent with low levels of spawning activity (City of Seattle 2000b). Low levels of fry capture are potentially an indication of low spawning activity and/or loss of redds due to extensive substrate scour, as was probably the case in 1996 after extended periods of peak flows (Paige, *in litt*. 2003). Not capturing fry in 1996 with levels of effort similar to years in which fry were readily captured suggests that the entire year class may have been lost due to the extent of substrate scour incurred during peak flow events in the system. Such complete production losses (or low production years) in any given year have presumably occurred periodically as the result of natural causes as bull trout have evolved in this core area. Their persistence despite such catastrophic losses (*e.g.*, of an entire age class) is at least some indication of the stability of this core population[†].

In comparison, surveys documented totals of 236 bull trout redds in both fall 2000 and fall 2001, and 504 bull trout redds in year 2002 in the Chester

Morse Lake core area (Paige, *in litt*. 2003). These 3 years of survey data were collected under nearly ideal field survey conditions with sufficient field staff to provide complete coverage of 'core' spawning reaches on a consistent (*i.e.*, weekly) basis throughout the spawning season and between successive years. These more recent data may therefore present a much more valid picture of the capacity of the bull trout population than that presented by much of the early survey data. This is believed to be the case considering that in a year (2002) with some of the lowest recorded stream flows for the system and near record low lake levels in the reservoir, bull trout were able to access typical spawning reaches in both the Cedar and Rex Rivers throughout the spawning season and spawn in record numbers.

Based on earlier gill net data (Wyman 1975) and more recent hydroacoustic data collected from 1993 to 1994, the minimum bull trout population in Chester Morse Lake was estimated to be about 3,100 adult fish, and one half of these fish were considered to be sexually mature (City of Seattle 2000a). Based on these population estimates and data from Flathead Lake indicating an average of 57 percent (range 38 to 69 percent) of the adult-sized bull trout in Flathead Lake spawn annually, and that there are 3.2 fish per redd (Fraley and Shepard 1989), it is estimated that 884 (range 589 to 1,070) bull trout could be expected to move into tributaries of Chester Morse Lake to spawn (City of Seattle 2000b). From this estimate of potential bull trout spawners, a prediction of 276 (range 184 to 334) bull trout redds could be expected in the Chester Morse Lake core area. Although earlier redd counts fell well below this range, recent redd counts during the period 2000 to 2002 (236 redds in 2000, 236 redds in 2001, and 504 redds in 2002) fall either in the middle or significantly exceed the predicted range (Paige, *in litt*. 2003). If it is assumed that there are 2.5 fish per redd (Goetz 1989; Brown 1994; McPhail and Baxter 1996; James and Sexauer 1997), the estimated number of potential redds would be 353 (range 235 to 428) and as above, the recent redd survey counts for the core area fall within the predicted range, or in the case of year 2002, substantially exceed the highest predicted count.

Bull trout redds located in lower portions of areas of concentrated bull trout spawning activity, especially in the Cedar and Rex Rivers, as well as

extreme lower reaches of Boulder Creek and Cabin Creek (tributaries to Rex River) and smaller lake tributaries (*e.g.*, Shotgun Creek, Rack Creek), are subject to varying degrees of inundation (*i.e.*, depth and duration of inundation) during periods of late winter/early spring reservoir refill. It is currently unknown, however, whether redd inundation causes any mortality, or otherwise causes any significant effects to eggs and/or alevins[†] in either the Cedar or Rex systems. It is significant to note, however, that adults have consistently returned to traditional spawning reaches in both the Cedar and Rex systems on an annual basis and persisted in the Chester Morse Lake core area over a period of 100 years of widely variable reservoir fill and drawdown regimes. The City of Seattle plans to evaluate the potential impact of redd inundation in studies planned as part of their habitat conservation plan (City of Seattle 2000b).

Bull trout have also been documented to spawn in small numbers (*i.e.*, usually fewer than 10 redds per year) in Boulder Creek, a tributary to the Rex River, and in Rack Creek, Shotgun Creek, and Damburat Creek (single redd; early 1990's), which are tributaries to Chester Morse Lake (Paige, *in litt*. 2003). Spawning activity in Rack Creek and Shotgun Creek has been limited to within a few hundred meters/yards of their confluence with the reservoir, only downstream of the perimeter forest road (200 Road) in the case of Shotgun Creek and up to 270 meters (885 feet) upstream of the road in the case of Rack Creek. A natural passage barrier is present in Rack Creek approximately 457 meters (1,500 feet) upstream of the perimeter forest road. Although limited spawning activity in Rack Creek has been consistent from year to year, activity in Shotgun Creek has been somewhat sporadic. Both of these creeks consistently experience one or more periods of subsurface flow each year, typically during the hottest and/or driest summer periods.

Such subsurface flow can also be influenced and/or caused by low reservoir levels in that flows are subsurface at the confluences with the reservoir and therefore present barriers to fish either entering or exiting the upstream reaches. Subsurface flow conditions are most commonly and consistently observed in reaches downstream of the perimeter forest road (200 Road), but have routinely been observed to extend to upstream reaches of Rack Creek as much as 76 to 91 meters (250 to 300 feet) upstream of the road. Subsurface flow

conditions have not been observed in Shotgun Creek upstream of the perimeter forest road (200 Road) in more than two decades (Paige, *in litt*. 2003). Similar subsurface flow conditions are consistently observed and exaggerated in Lost Creek, the only tributary to Masonry Pool, downstream of the 202 Road, and no bull trout spawning or rearing has been observed in the tributary (Paige, *in litt*. 2003). Such annual subsurface flow conditions may be problematic to both adult and/or juvenile bull trout in that flow conditions can present conditions that prevent both ingress and/or egress by either adults and/or juveniles or that isolate individuals of any age class within barriers, which in many cases may result in mortality. Other southside tributaries to Chester Morse Lake have natural gradient barriers at their confluences with the reservoir and are not accessible to fish (*e.g.*, Echo Creek, Snowshoe Creek).

Prior to 1992, bull trout were restricted to the lowermost reaches of Rack Creek. These reaches experienced subsurface flow conditions annually, and may have resulted in mortality of a substantial number, if not all, of the bull trout fry and juveniles produced in the drainage. In 1992, fish passage was restored to the upper reaches by removal of blocking culverts. Currently, despite experiencing subsurface flow conditions in the lowermost reaches, juvenile bull trout utilizing Rack Creek appear to be able to consistently pass upstream of the bridge and access and persist in wetted refuges upstream of portions of the channel that become dewatered. Fish surviving in these reaches are subsequently able to reoccupy downstream reaches and migrate to Chester Morse Lake under favorable flow conditions (Paige, *in litt*. 2003). Similarly, bull trout rearing in Shotgun Creek have for decades been confined to lower reaches that dewater annually at a passage barrier (perched culverts) at the perimeter road (200 Road). Similar to the historical condition in Rack Creek, many, if not all, of the bull trout fry and/or juveniles produced in those reaches may have perished, at least in some years. However, this barrier was removed in 2001 and a concrete box culvert (bridge) was installed to restore fish passage. It has not yet been confirmed whether bull trout have recolonized reaches upstream of the forest road (200 Road), but it is expected that juvenile bull trout produced in this system will soon be able to access upstream reaches of Shotgun Creek, rear in reaches that retain flow year-round, and be able to migrate to Chester Morse Lake under favorable flow conditions as is currently the case in Rack Creek (Paige, *in litt*. 2003).

Incidental observations of juvenile bull trout captured and released during efforts to collect genetic samples in 2002 indicated they are surprisingly mobile in small tributary streams, with one individual moving a minimum of 152 meters (500 feet) upstream during a 1- to 2-day period (Paige, *in litt*. 2003). Large woody debris restoration projects were completed in the lowermost reaches of Shotgun Creek and Lost Creek during 2002 to improve both hydraulic stream function and instream habitat (Paige, *in litt*. 2003).

Similar to the conditions described above for southside creeks, tributaries entering Chester Morse Lake on the north side (including Otter Creek, Bridge Creek, Green Point Creek, and McClellan Creek) all experience similar subsurface flow conditions over some portion of their length, especially after they reach the valley bottom floor. In addition, each creek is similarly influenced by low reservoir levels on a seasonal basis. Habitat in these streams is severely limited, especially by steep gradient, aggradation† of substrates in some of their reaches, and substantial bedload† movement in others. The presence of bull trout has not been established in any of these tributary streams (Paige, *in litt*. 2003). Damburat Creek also experiences subsurface flow conditions, especially at low lake levels, and access may also be frequently limited by extensive beaver activity in its reaches near the confluence with the reservoir. Observation of bull trout activity in Damburat Creek is limited to one potential redd in an early 1990's survey (City of Seattle 2000a).

Based on the spatial distribution of spawners observed in the Chester Morse Lake core area in the Cedar River Municipal Watershed, the Cedar and Rex Rivers are currently identified as the primary local populations for this core area. Small local populations are presumed to be present in Boulder Creek (a major tributary to the Rex River), Rack Creek, and possibly Shotgun Creek, based upon the relatively limited amount of spawning and rearing activity (see below) observed in these lake tributaries and their degree of spatial separation from other local populations. Although in recent years most bull trout redds observed in Boulder Creek have been located within 30 meters (100 feet) of the confluence with the Rex River and in close proximity to the reach of highest concentration of redds observed in the Rex system, some redds documented in earlier surveys (1992) were located as far as 976 meters (3,200 feet) upstream of the confluence

(226 meters [738 feet] upstream of the 200 Road). The overall distribution of redds observed in Boulder Creek is a preliminary indication that bull trout spawning in this creek may constitute a local population. A restoration project is being evaluated by Seattle Public Utilities staff for potential implementation during 2003 to 2005. This project would return the lower reaches of Boulder Creek back to a channel occupied prior to the peak flow events of the 1990's. This historical channel is thought to be of better habitat quality and less susceptible to reservoir inundation.

This core area appears to have one of the most extended spawning periods within the Puget Sound Management Unit, and potentially within the entire range of the species. The spawning period of bull trout in the upper Cedar River watershed extends from mid-September through December, with some fish observed spawning as late as mid-January (Paige, *in litt*. 2003). Spawning is typically observed from mid-October through mid-November, but peaked the first week of November in 2001 and 2002 (Paige, *in litt*. 2003). Spawning typically commences following the first major storms in the fall, and appears to be initiated by rapidly declining water temperatures and significant increases in streamflow.

Juvenile bull trout have been observed in the upper Cedar River drainage in the mainstem as far upstream as the natural passage barrier (*i.e.*, falls) on the North Fork Cedar River just upstream of the 500/530 Road Junction at river mile 52.2 (City of Seattle 2000a) and in the South Fork Cedar River drainage to the 500/600 Access Road, at the abandoned USGS weir that constitutes a seasonal fish passage barrier (no bull trout documented upstream of this reach) at river mile 52.1 (Paige, *in litt*. 2003). Seattle Public Utilities is investigating the feasibility of breaching and/or removing this structure under restoration elements of the Cedar River Habitat Conservation Plan. Juvenile bull trout have also been observed in the Rex River immediately upstream of the confluence of Lindsay Creek and in the lowest reach of Lindsay Creek (downstream of natural barrier) (Paige, *in litt*. 2003). In addition, juvenile bull trout have been documented in several wetlands and tributary streams fed from wetland systems including Eagle Ridge Creek and floodplain channels (Camp 18 area) on the Cedar system, and Cabin Creek and Morse Creek on the Rex system. Water temperatures in some of

these floodplain channels range between 1 and 10 degrees Celsius (34 to 50 degrees Fahrenheit) on an annual basis (Paige, *in litt*. 2003).

Boulder Creek, although not fed from a wetland system, also supports juvenile bull trout rearing in the Rex River drainage. Juvenile bull trout are likely present in major tributaries to the Cedar and Rex Rivers that are accessible, but their presence has not yet been confirmed in some (*e.g.*, Bear Creek). The presence of juvenile bull trout has been confirmed consistently in Rack Creek but only sporadically in Shotgun Creek. Both of these streams are tributaries to Chester Morse Lake and are subject to the seasonal subsurface flow conditions described above. The observed variability in the presence/absence of juvenile bull trout may, at least to some degree, be a function of the need to 'recolonize' these streams after certain flow conditions create barriers to adult access and/or mortality of fry and juveniles rearing in these systems. Juvenile bull trout may also be present in other tributaries to Chester Morse Lake that are accessible to these life stages, but both habitat and seasonal flow conditions may be limiting factors in these types of streams (*e.g.*, Otter, Green Point, McClellan Creeks) where bull trout presence has not yet been confirmed (Paige, *in litt*. 2003).

The majority of bull trout in the upper Cedar and Rex River drainages are juveniles up to 3 years of age. Most juveniles captured in tributaries during electrofishing surveys are between 0 and 2 years of age (City of Seattle 2000b). Size distribution plots of bull trout captured (minnow traps) during 2002 in both the Cedar and Rex mainstems and several tributary streams demonstrated the presence of two distinct age classes (young-of-year and age 1+ fish)(H. Barnett, pers. comm. 2003).

Bull trout fry are typically evident throughout 'core' spawning survey reaches in both the Cedar and Rex River mainstems, as well as smaller tributaries (*e.g.*, floodplain channels) throughout late-winter and early spring. Based on visual observations, fry begin to emerge during a period that begins as early as February 22 and extends until late May (W. Belknap, Seattle Public Utilities, pers. comm. 2003). Some bull trout fry may emerge subsequent to this period, but are difficult to effectively detect after rainbow trout fry also begin to emerge at the end of May or in early June. Although a few bull trout fry as small as 23

millimeters (0.9 inch) have been observed, the smallest individuals that are captured most frequently are 25 millimeters (1 inch) in length, which should approximate typical total length of fry at or soon after emergence (Paige, *in litt*. 2003). Newly-emerged fry are typically observed in, and appear to favor, areas of low velocity flow, especially in mainstem reaches where they occupy habitat exhibiting a variety of substrate types including fine sediment, sand, and small to medium size gravel. At this stage, bull trout fry experiencing disturbance tend to seek refuge in channel substrates and channel margins and rarely retreat to deeper and faster flowing water (Belknap, pers. comm. 2003). Bull trout fry and rearing juveniles have been observed to extensively use small groundwater channels in the Cedar River floodplain, especially in the reach located upstream of the Camp 18 Bridge (100-300 Access Road) (Paige, *in litt*. 2003). These small streams may provide important refuge habitats to bull trout fry from peak flows and predators, as well as possess the cold water temperatures required by fry (Goetz 1997). Bull trout fry appear to be most mobile in mainstem reaches of the Cedar River in mid- to late April with a peak of activity around the 24th day (City of Seattle 2000b). The activity peak in the Rex River system appears to occur from 1 to 2 weeks later relative to the Cedar system (in early May) (City of Seattle 2000b), and may be related to differences in basin size, aspect, timing of snow melt, resultant flow levels, and water temperature differences. Bull trout fry have been observed in the mainstem Cedar River as far upstream as the reach between the confluences of Seattle Creek and Bear Creek (river mile 48.8).

Most bull trout in Chester Morse Lake and Masonry Pool are subadults and mature adults, based upon age analysis using otoliths[†]. Approximately one half of the fish sampled in the lake system were subadults (3 and 4 years of age), and the other half were sexually mature adults, generally 5 years of age and older (City of Seattle 2000a). Adult bull trout in Chester Morse Lake can exceed 12 years in age, but generally do not exceed 650 millimeters (25.6 inches) in total length. The age-structure of bull trout in this lake may be influenced by the absence of fishing pressure, since public access to this lake has been restricted for over 90 years. Juvenile bull trout have been observed in Chester Morse Lake during snorkel surveys, but appear to be restricted to the shallow margins of the lake (City of Seattle 2000a).

Chester Morse Lake and Masonry Pool provide the foraging, migration, and overwintering habitat for subadult and adult adfluvial bull trout in the Chester Morse Lake core area. Reservoir levels vary both between and within seasons, although the most substantial differences are exhibited between major seasons (*e.g.*, spring refill and fall drawdown). Seasonally fluctuating reservoir levels alter the surface area of the lake, exposing or inundating varying degrees of the littoral zone[†], especially in low gradient delta areas. The type and relative amount of habitat available to bull trout therefore change constantly and the type and availability of food resources vary accordingly and are dependent upon the integrated effects of all prevailing environmental conditions. Bull trout in Chester Morse Lake and Masonry Pool forage on a wide variety of food items, including invertebrates, salamanders, sculpin, juvenile rainbow trout, and pygmy whitefish. The most important food item to the largest bull trout in this lake system is pygmy whitefish. Chester Morse Lake possesses the largest population of pygmy whitefish in western Washington (City of Seattle 2000a).

Puyallup core area. The Puyallup core area contains the southernmost population of bull trout in the Puget Sound Management Unit. This core area is critical to maintaining the overall distribution of migratory bull trout within the management unit, since it is the only anadromous bull trout population in south Puget Sound. The Puyallup core area consists of several major watersheds draining the north and west sides of Mount Rainier. This glacial source significantly influences both water and substrate conditions in the mainstem reaches of this drainage. The core area includes the Puyallup, Mowich, and Carbon Rivers and their tributaries, and the White River including the Clearwater, Greenwater, and West Fork White Rivers, as well as Huckleberry Creek (Figure 10). Both anadromous and fluvial/resident bull trout local populations have been identified in the White River and Puyallup River systems, which converge in the lower basin at river mile 10.4 of the Puyallup River. Limited information is available regarding the distribution and abundance of bull trout in this core area. Observations of bull trout have generally been incidental to other fish survey work. Glacial turbidity creates limited opportunities and sites to survey for bull trout in this system. Five local populations have currently been identified for this core area: the upper Puyallup and Mowich Rivers; Carbon River; upper White River; West Fork White River; and Greenwater River. In addition, one potential

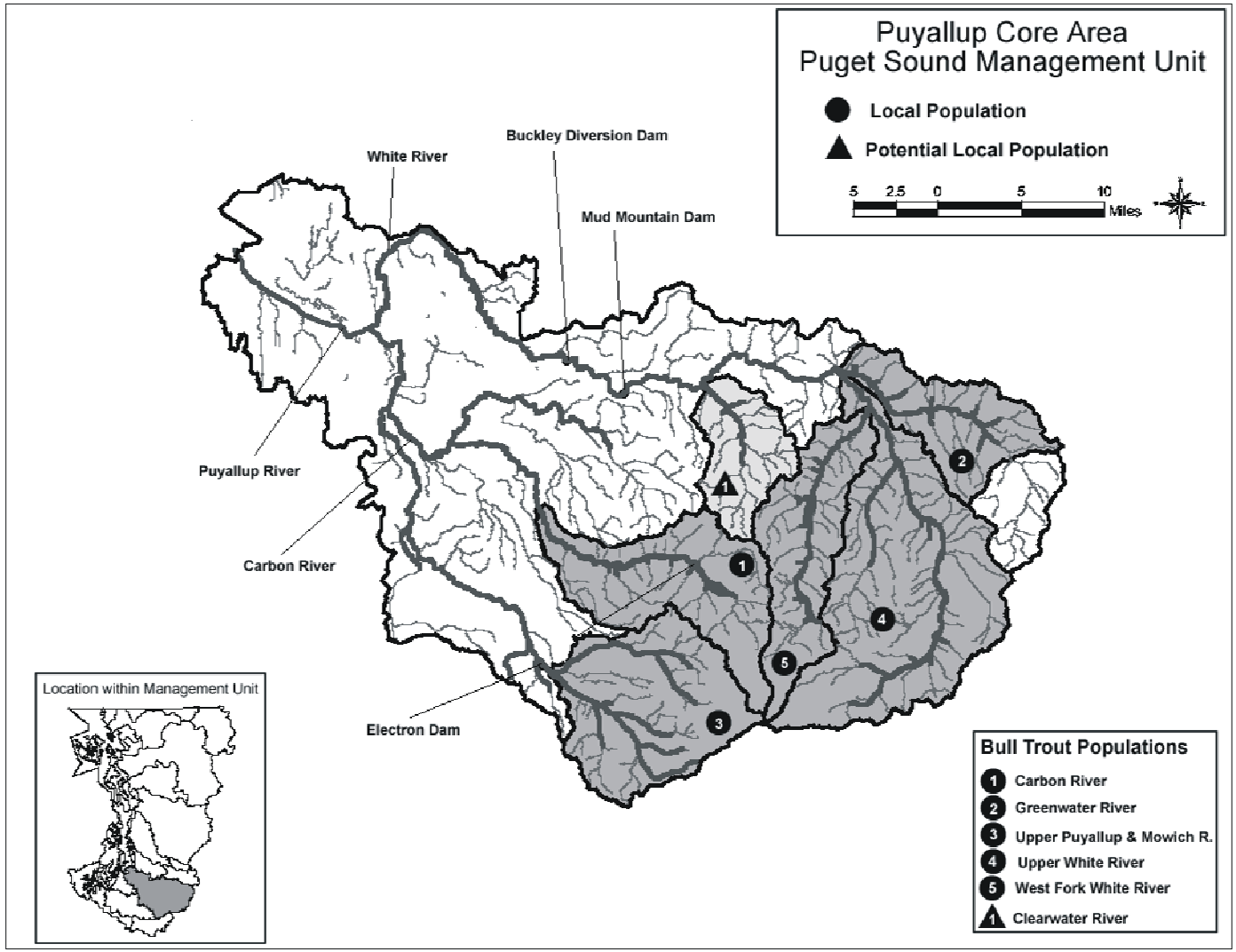

Figure 10. Puyallup core area for bull trout. Highlighted streams are key freshwater habitat for recovery.

local population, Clearwater River, has also been identified; although part of the current bull trout distribution, there is currently insufficient information to determine if reproduction is occurring here.

Spawning occurs in the upper reaches of this basin where higher elevations produce the cool temperatures required by bull trout. Based on current survey data, bull trout spawning in the Puyallup core area appears to occur earlier (September) than what has typically been observed within other Puget Sound core areas (Marks *et al*. 2002). Rearing is believed to occur throughout the rivers listed above, however sampling indicates that a majority of the rearing is confined to the upper reaches of the basin. The Puyallup Tribal fisheries in the lower Puyallup River and the U.S. Army Corps of Engineer's Buckley trap commonly intercept large migratory bull trout, indicating that an anadromous life history is present in this system (Hunter, *in litt*. 2001). In addition, bull trout have been confirmed in tidewater areas of the lower Puyallup River (Baker and Moran 2002; Puyallup Tribe, *in litt*. 2003). Primary foraging, migration, and overwintering habitat for migratory bull trout within the core area is believed to be the mainstem reaches of the White, Carbon, and Puyallup Rivers. The anadromous life history form is believed to use Commencement Bay and likely other marine nearshore habitats along Puget Sound. Many of the headwater reaches of the basin are within either Mount Rainier National Park or designated Wilderness areas (Clearwater Wilderness, Norse Peak Wilderness) providing pristine habitat conditions. However, a majority of the basin has been significantly altered by a variety of anthropogenic factors including extensive timber harvest and associated road construction; conversion of landscape to residential, commercial, and agricultural use; substantial channelization of lower mainstem reaches; and total commercial development of the estuarine habitat. These factors have undoubtedly reduced the overall productivity of bull trout and salmon populations in the basin.

The Puyallup River drains from Tahoma and the Puyallup glaciers on Mount Rainier and flows generally northwest to Commencement Bay. The Mowich River drains the North and South Mowich and Flett Glaciers and enters the upper Puyallup River at river mile 42.3. The Puyallup River diversion at river mile 41.7, which serves Puget Sound Energy's Electron facility, impacts bull trout

through interception of downstream migrants. The Carbon River is the other major tributary draining the Carbon and Russel Glaciers, flowing generally westerly to join the mainstem Puyallup River.

The upper Puyallup and Mowich Rivers are located upstream from Puget Sound Energy's Electron Diversion Dam. The upstream impasse created by the dam has effectively isolated these fish from the rest of the basin for nearly 100 years (WSCC 1999b). Baker and Moran's (2002) analysis of six tissue samples collected at the Electron Diversion Dam confirmed all native char sampled to be bull trout. Due to their close proximity and the shared effects from the diversion dam, bull trout residing in these two reaches are considered a single local population. A recently constructed fishway has been in operation since October 2000 and is expected to significantly improve connectivity and genetic interaction with other local populations in other parts of the core area. However, there are still concerns regarding the downstream interception of bull trout at the diversion facility (G. Ging, U.S. Fish and Wildlife Service, pers. comm. 2003). The Puyallup River mainstem and upper South Puyallup River upstream of the diversion is an unconfined channel incising through ancient mudflow terraces. This reach is characterized by moderate to moderately steep gradient and generally fast riffle waters and dominated by boulder to rubble/gravel substrate. Downstream of the diversion the stream channel becomes generally more confined with moderate gradient and contains a significant canyon feature. The Mowich River is generally characterized as unconfined and braided with fast rapid/riffle areas and a few shallow pools. Substrate is largely rubble and gravels with a few boulder areas. Tributaries of both rivers are generally steep with fast riffles and cascades with larger boulder and rubble substrates. Specific locations of spawning populations have not been identified in this area. However, the lower portions of the South Puyallup River and St. Andrews Creek are known to be currently occupied. Upstream portions of those streams and Kellogg, Swift, Deer, Niesson and Kapowsin Creeks are presumed to be occupied, excluding upper Swift Creek. The lower South Fork Mowich River and mainstem Mowich River are currently occupied, and the North Mowich River is presumed occupied. Juvenile bull trout were observed during fish surveys conducted in 2000 (MRNP, *in litt*. 2001). As additional information is gathered on this complex of streams, this local population may be further subdivided in the future. The overall

condition of available spawning and rearing habitat in this local population is currently unknown, although pristine conditions within Mount Rainier National Park provide some quality habitat. The overall abundance of this system is currently unknown.

The Carbon River drains the Carbon and Russel Glaciers flowing generally westerly to join the mainstem Puyallup River near river mile 18. All known reports of spawning bull trout in this watershed are confined to the upper Carbon River above the canyon at river mile 11 to 15, indicating a spatial separation from other populations in the core area. Therefore, the Carbon River is currently considered a local population. The upper river is characterized as unconfined, heavily braided channel with moderate gradient and dominated by cobble and gravel substrate. The lower Carbon River has moderate gradient with riffle/pool habitats and gravels suitable for spawning by salmonids. Most upper river tributaries are steep in nature with cascades and rubble substrate. Two lower river tributaries, South Prairie Creek and Wilkeson Creek, have steep headwaters and moderate gradient with productive fish habitat characteristics throughout their lower sections. Spawning populations have been identified in the Carbon River near river miles 20, 22 and 28. The presence of juvenile and subadult bull trout has been documented in the mainstem, lower Ipsut Creek, lower Chenuis Creek, and Ranger Creek (Samora, *in litt*. 1998; MRNP, *in litt*. 2001). In 1994, 16 bull trout were sampled incidentally to steelhead parr (juvenile fish) surveys, between river mile 18.6 and 22 on the Carbon River (WDFW 1998). These bull trout ranged from 112 to 310 millimeters (4.4 to 12.2 inches) in length. In 2000, Puyallup Tribal Fisheries conducted spawning surveys for the first time in Ranger Creek. Several redds, presumed by their size and timing to be from bull trout, were observed that year, however, no redds were observed in 2001 (Marks *et al*. 2002). Accessible upstream reaches of these creeks are presumed to be occupied.

The other accessible Carbon River tributaries located within Mount Rainier National Park (*e.g.*, June Creek, Falls Creek) provide near pristine and excellent conditions with ideal spawning and early rearing habitat. Unfortunately, this favorable habitat is limited to the park boundary, whereas tributaries downstream from the park do not provide the same favorable habitat. Tributaries immediately outside of the park in Snoqualmie National Forest (e.g., Poch Creek,

Tolmie Creek) also provide potential spawning and/or rearing habitat. Bull trout have not been found in South Prairie Creek and Wilkeson Creek, however due to the relatively high salmonid production in these particular streams, they likely contribute significant forage for bull trout in the lower Puyallup River and Carbon River systems. Subadult and adult size bull trout have been caught by salmon anglers in the lower reaches of the Carbon River to its confluence with the Puyallup River (K. Reynolds, U.S. Fish and Wildlife Service, pers. comm. 2003). In March 2000, night snorkel surveys in the mainstem Carbon River between the top of the canyon reach (Fairfax Bridge) to the Mount Rainier Park entrance detected four bull trout between 305 to 457 millimeters (12 and 18 inches) in length, and six brook trout near the park entrance (Craig, *in litt*. 2000b). The overall abundance of the Carbon River local population is currently unknown. Connectivity to other local populations and forage areas is believed to be good, although the canyon reach in the Carbon River may present some short-term upstream migration delays. Some habitat diversity has been lost in the lower mainstem Carbon and Puyallup Rivers due to channel simplification, impassable culverts, and estuarine fill.

The major lower Puyallup tributary, the White River, drains the northeast portion of Mount Rainier and has extensive bull trout use in several tributaries: the Greenwater River, Clearwater River, and the West Fork White River. Mud Mountain Dam, completed in 1948, is a flood control structure in the lower White River located at river mile 29.6 and Puget Sound Energy's Buckley diversion dam forms a barrier at river mile 24.2 just downstream. These two structures have historically been a problem for both downstream and upstream fish passage, but new fish screens installed in 1996 have helped improve passage. Storage of peak flows behind Mud Mountain Dam still results in a disruption of sediment routing and ultimate delivery to downstream reaches, however. This, in turn, results in prolonged high turbidity and increased concentrations of fine sediment in the substrate. Recent operational modifications of the Puget Sound Energy diversion system have increased base flows in the bypass reach, thereby increasing rearing habitat quantity and quality.

The upper White River drains Emmons, Inter, Winthrop and Frying Pan Glaciers on the northeast flank of Mount Rainier located in Mount Rainier

National Park. The White River then flows through the Mount Baker-Snoqualmie National Forest providing some suitable habitats. Similarly, the West Fork White River and Huckleberry Creek originate in Mount Rainier National Park and flow through the Mount Baker-Snoqualmie National Forest. The channels are generally steep, braided, and unstable. Cascades and fast riffles are dominant with a few pools and the substrate is largely boulder and rubble/gravel. Spawning in the upper White River has been documented near river mile 61 at Silver Springs Creek and in lower Klickitat Creek. Silver Springs Creek is a lower tributary to Silver Creek and parallels the White River. This short tributary (approximately 0.5 kilometer [0.3 mile] in length) runs directly through the Silver Springs campground, with spawning occurring throughout this reach. Only two redds were observed in 2001 (Marks *et al*. 2002). A peak count of 11 adults and 4 redds were recorded in Klickitat Creek on September 2001 downstream of the anadromous barrier located at approximately river mile 0.3 (Marks *et al*. 2002). Juvenile bull trout have also been observed in the pools and lateral habitats of this lower reach during surveys. A large adult migratory bull trout, approximately 508 millimeters (20 inches) in length, was observed in Huckleberry Creek in July of 1989 (E. Stagner, U.S. Fish and Wildlife Service, pers. comm. 2003). Spawning is presumed to occur in many of the accessible small tributaries within Mount Rainier National Park, since bull trout rearing has already been documented in a number of surveyed park tributaries including Sunrise Creek, Fryingpan Creek, Crystal Creek, and an unnamed tributary (stream catalog no. 0364) upstream of Klickitat Creek (MRNP, *in litt*. 2001).

The West Fork White River is generally steep, braided, and unstable. Cascades and fast riffles are dominant with a few pools and the substrate is largely boulder and rubble/gravel. Tributaries are steep and fast flowing with narrow channels and boulder to rubble/gravel substrate. Juvenile bull trout have been observed in Cripple Creek, Lodi Creek, and several other unnamed tributaries (stream catalog nos. 0226 and 0217) within Mount Rainier National Park (USFS, *in litt*. 1982; MRNP, *in litt*. 2001). Bull trout are presumed to also spawn and rear in lower Pinochle Creek, lower Hazzard Creek, and Viola Creek.

The Greenwater River enters the White River below river mile 46 and does not directly drain the glaciers off of Mount Rainier. Flowing from Castle

Mountain, the river drops rapidly for about 16 kilometers (10 miles) through a series of lakes within the Norse Peak Wilderness to near Pyramid Creek. Below Pyramid Creek to Burns Creek, cascades and fast riffles are dominant with a few pools and the substrate is largely boulder and rubble/gravel. The lower Greenwater River has reduced gradient producing good riffle pool characteristics with gravel substrates despite the obvious lack of large wood. The Greenwater River mainstem (Section 25), lower Pyramid, lower Slide, and "Midnight" (stream catalog no. 0126) Creeks are known to be used by bull trout (Stagner, pers. comm. 2003; USFS, *in litt*. 1990; USFS, *in litt*. 1991). George, Twenty-eight, Lower Foss, upper Pyramid Creeks, and two other unnamed tributaries (stream catalog No. 0124 and 0125) are presumed to support bull trout due to their accessibility. Steep-sided valley characteristics prohibit fish use of several other tributaries.

The Clearwater River flows from springs and runoff from Bear Head Mountain within the Clearwater Wilderness and flows northerly 16.9 kilometers (10.5 miles) to the White River at river mile 35.3. Upper sections of the Clearwater are characterized by steep gradients with cascades and fast riffles dominant with a few pools, substrate is largely boulder and rubble/gravel. Lower valley sections have a moderate to low gradient with gravel substrate. Bull trout have been identified in lower mainstem areas of the Clearwater system. In fall of 1998, a single adult bull trout approximately 400 to 450 millimeters (15.8 to 17.7 inches) in length was observed in the mainstem in close proximity to a redd (T. Nelson, Washington Department of Fish and Wildlife, pers. comm. 2003). However, it could not be determined whether this fish was spawning or foraging. Tributaries to the Clearwater River are steep and generally have impassable cascades a short distance upstream of their mouths. Bull trout are presumed to use the upper mainstem Clearwater to the natural barrier at river mile 6.2, as well as accessible tributaries such as lower Lyle Creek.

Connectivity of the White River local populations to other local populations and foraging and overwintering areas is fair to good depending upon trapping success and/or delays associated with the upstream migrant fishway at the Buckley diversion and the downstream migrant trap located in the Buckley diversion flowway. In fact, subadults are not typically trapped for upstream haul

at the Buckley diversion due to the design of the trap. The U.S. Army Corps of Engineers operates the adult fish trap on the White River near Buckley as part of the Mud Mountain Flood Control Project. Records for bull trout that are trapped at the facility have been kept since 1987. These records show that numbers of bull trout trapped ranged from a low of 5 fish in 1992 to a high of 48 fish in 2000 (Table 4). The average for the years from 1990 to 2002 is 26 fish. Monthly counts at the trap show two peak counts, one occurring in August and the other in October. This information shows that bull trout migrate upstream in most months, but generally from May to early January. The Washington Department of Fisheries operated a downstream migrant trap in 1953, located on the bypass leading from the screens to the White River. Downstream juvenile/subadult bull trout migration, corrected for fish using the main channel, was estimated to be 693 bull trout between May and July of that year (Heg *et al*. 1953).

Table 4. Summary of annual counts of bull trout at the adult fish trap at Buckley Diversion Dam, 1990 to 2002 (USACOE 2003).

Year	‘90	‘91	‘92	‘93	‘94	‘95	‘96	‘97	‘98	‘99	‘00	‘01	‘02
Total	19	20	5	23	40	15	15	16	44	18	48	39	41

The Puyallup Indian Tribe recorded some length information for bull trout when they took scale and genetic samples at the Buckley fish trap. The information collected in 2000 found that bull trout lengths ranged from 340 to 560 millimeters, with a mean of 442 millimeters (13.0 to 22.0. inches; n = 56) (Marks *et al.* 2002). These lengths would be within the size range of anadromous bull trout as indicated by three bull trout caught in Commencement Bay with recorded lengths of 425, 508 and 565 millimeters (16.7, 20.0, and 22.2 inches) (Pacific International Engineering 1999). Young’s (1999) genetic analysis of 12 tissue samples provided by the Puyallup Tribe confirmed 11 of these fish to be bull trout, while Baker and Moran’s (2002) analysis of 104 tissue samples collected at the fish trap confirmed all sampled native char to be bull trout.

The individual status of each of these local populations within the White River system is currently unknown, however based on trap counts at the Puget

Sound Energy dam, at least the number of adult migratory bull trout transferred upstream into the White River system are known (Table 2). These numbers are extremely low relative to other anadromous core populations within the Puget Sound Management Unit. There is uncertainty as to whether these are primarily anadromous or fluvial migrants, however a number of the bull trout scale and length samples collected at the trap (Hunter, *in litt*. 2001) are comparable to that of anadromous forms sampled in the Lower Skagit River core area (Kraemer, *in litt*. 2003).

Samish River foraging, migration, and overwintering habitat. The Samish River foraging, migration, and overwintering habitat consists of the mainstem of the Samish River and Friday Creek. The Samish watershed is a relatively small drainage with approximately 46.7 kilometers (29 miles) of low gradient mainstem habitat and additional tributaries such as Ennis Creek which also provide accessible low gradient habitat. This is a productive river system supporting coho salmon, chum salmon, Chinook salmon, and steelhead and cutthroat trout which provide a forage base for anadromous bull trout. Adult and subadult bull trout have been caught on the mainstem Samish upstream of the confluence with Friday Creek as well as in the lower river, but potential use likely extends to the uppermost reaches of anadromous salmon use. In the past, most bull trout were observed during the winter steelhead season, primarily December through February (Kraemer, pers. comm. 2003c; D. Toba, Washington Department of Fish and Wildlife, pers. comm. 2003). This habitat is likely to be most heavily used by anadromous bull trout from the Nooksack and Skagit core areas due to their close proximity to this system. The Samish River enters Puget Sound at Samish Bay, between Bellingham Bay to the north and Padilla Bay to the south of Samish Island (which is no longer an island, as the former intertidal estuarine area was diked and drained in the late 1800's).

Lake Washington foraging, migration, and overwintering habitat. The Lake Washington foraging, migration, and overwintering habitat consists of the lower Cedar River below Cedar Falls, the Sammamish River, Lakes Washington, Sammamish and Union, the Lake Washington Ship Canal, and all accessible tributaries. The upper Cedar River Watershed above Cedar Falls, is a separate core area and not included in this description. Population status

information, extent of use, and complete recovery value of this area is currently unknown. Adult and subadult size individuals have been observed infrequently in the lower Cedar River (below Cedar Falls), Carey Creek (a tributary to Upper Issaquah Creek), Lake Washington, and at the Hiram H. Chittendon (Ballard) Locks. No spawning activity or juvenile rearing has been observed and no distinct spawning populations are known to exist in Lake Washington outside of the upper Cedar River above Lake Chester Morse (see Chester Morse Lake core area).

The potential for spawning in the Lake Washington basin is believed to be very low as a majority of accessible habitat is low elevation, below 152 meters (500 feet), and thus not expected to have the proper thermal regime to sustain successful spawning. There are, however, some coldwater springs and tributaries that may come close to suitable spawning temperatures and that may provide thermal refuge for rearing or foraging during warm summer periods. These include Rock Creek (tributary to the Cedar River below Landsburg Diversion) and Coldwater Creek, a tributary to Cottage Lake Creek immediately below Cottage Lake. Coldwater Creek is a major temperature modifier for both Cottage Lake and Big Bear Creeks. Cottage Lake Creek below Coldwater Creek exhibits a much lower temperature profile than any other tributary to Big Bear Creek. High temperatures in Big Bear Creek are moderated by this flow to its confluence with the Sammamish River. Both Coldwater and Rock Creeks are relatively short, 1.6 to 3.2 kilometers (1 to 2 miles) in length, have high quality riparian forest cover, and are formed by springs emanating from glacial outwash deposits.

The upper reaches of Holder and Carey Creeks, the two main branches of Issaquah Creek, have good to excellent habitat conditions and may hold potential for bull trout spawning due to their elevation and aspect. However, despite survey efforts by King County (Berge and Mavros 2001; KCDNRP 2002), no evidence of bull trout spawning or rearing has been found. Holder Creek drains the eastern slopes of Tiger Mountain, elevation 914 meters (3,000 feet), and the southwestern slopes of South Taylor Mountain. Coho are found in Holder Creek up to an elevation of about 360 meters (1,200 feet) and cutthroat trout occur up to 427 meters (1,400 feet) in elevation.

Carey Creek originates at an elevation of roughly 700 meters (2,300 feet) in a broad saddle on the southeastern slopes of South Taylor Mountain. It is the only stream in the north Lake Washington/Sammamish drainage with a relatively recent (within the past 10 years) char sighting. The single observation of a pair of native char in the fall of 1993 (WDFW 1998) was about 0.8 kilometer (0.5 mile) downstream from an impassable, approximately 12-meter (40-foot) high falls, which is at an elevation of approximately 256 meters (840 feet). Thus the habitat in which this pair of char was observed was potentially too low in elevation for successful spawning. Upstream of the falls, significant numbers of resident cutthroat trout exist up to an elevation of approximately 396 meters (1,300 feet).

Aside from spawning, the Lake Washington drainage has both potential benefits and challenges to adult and subadult bull trout. Two large lakes with high forage fish availability are dominant parts of the lower watershed, and provide significant foraging habitat. A number of observations of subadult and adult sized bull trout have been made in Lake Washington (Shepard and Dykeman 1977; KCDNR 2000; H. Berge, King County Department of Natural Resources and Parks, pers. comm. 2003a). The connection with the Chester Morse Lake core area (population located in the upper Cedar River) is one-way only, and currently the level of connectivity with other core areas is unknown. Observations of bull trout in the Ballard Locks suggest migrations from other watersheds is likely occurring.

Bull trout have been caught in Shilshole Bay and the Ballard Locks during late spring and early summer in both 2000 and 2001. In 2000, up to eight adult and subadult fish (mean size 370 millimeters; 14.5 inches) were caught in Shilshole Bay below the locks between May and July. These fish were found preying upon juvenile salmon (40 percent of diet) and marine forage fish (60 percent of diet) (Footen 2000, 2003). In 2001, five adult bull trout were captured in areas within the Ballard Locks and immediately below the locks. One bull trout was captured within the large locks in June, and in May one adult was captured while migrating upstream through the fish ladder in the adult steelhead trap at the head of the ladder. Three adult bull trout were also captured below the tailrace during the peak of juvenile salmon migration on June 18 (Goetz, pers. comm. 2003).

Lower Green River foraging, migration, and overwintering habitat. Historically, bull trout were reported to use the Duwamish River and lower Green River in "vast" numbers (Suckley and Cooper 1860). In contrast, bull trout are observed infrequently in this system today. Prior to the permanent redirection of the Stuck River (lower White River) into the Puyallup River system in 1906 (Williams *et al*. 1975), the lower Green River system provided habitat for the spawning populations from the White River. Another factor that may have diminished the Green-Duwamish River system's value for bull trout is the loss of the Black River due to construction of the Lake Washington Ship Canal in the mid-1910's. The Black River historically connected the Lake Washington Basin and Cedar River to the Green-Duwamish River system. Creation of the ship canal and Ballard Locks lowered Lake Washington by 2.7 meters (9 feet) and completely redirected flows of the Cedar River and Lake Washington tributaries to the canal (Warner 1996). The effect of these diversions was to leave the Green-Duwamish River system with only about a third of its original watershed (Parametrix and NRC 2000). Potentially this may have led to reducing its value for bull trout foraging and colonization.

Regardless, in recent times bull trout have been reported on the lower Green River as far upstream as the mouth of Newaukum Creek at approximately river mile 41, and are consistently reported in the lower Duwamish (KCDNR 2000; Berge and Mavros 2001; KCDNRP 2002). It is presumed that bull trout utilize the Green River up to the City of Tacoma's Headworks Diversion Dam at river mile 61, which has been a barrier to upstream migration since 1912 (KCDNR 2000). It is not known for certain whether the bull trout observed in the lower Green River basin are foraging individuals from other core areas or if natural reproduction may still persist somewhere within the basin. Based on observed behavior from other systems within the management unit and the size of individuals typically reported, there is a strong likelihood that bull trout in the lower Green River are anadromous migrants from other core areas. Reports of historical use of tributaries in the lower Green River are rare, and there have been no recent observations (KCDNR 2000). Given their size and potential as a foraging area, tributaries such as Newaukum and Soos Creeks may occasionally be used by bull trout.

Bull trout occurrence in the Duwamish River has been documented several times over the past few decades. In April 1978, Dennis Moore, Hatchery Manager for the Muckleshoot Tribe, talked with three fishermen in the vicinity of North Wind Weir, river mile 7 of the Duwamish, and identified four fish as adult char (Brunner, *in litt*. 1999a). One adult bull trout was observed near Pier 91 in May 1998 (Brunner, *in litt*. 1999b). In 2000, eight subadult bull trout were captured in the Duwamish River at the head of the navigation channel at the Turning Basin restoration site at river mile 5.3. These fish averaged 299 millimeters (11.8 inches) in length and were captured in August and September (Shannon, *in litt*. 2001). A single subadult char (222 millimeters; 8.7 inches) was caught at this same site in September of 2002 (J. Shannon, Taylor Associates, Inc., pers. comm. 2002). In May of 2003, a large adult bull trout (582 millimeters; 23 inches) was captured in the lower Duwamish River at Kellogg Island (Shannon, pers. comm. 2003).

It is not known whether bull trout historically occupied habitats in the upper Green River basin, however given their life history it is certainly possible. Various fish sampling efforts in the upper Green River (above Howard Hansen Dam) have not detected bull trout (KCDNR 2000). The City of Tacoma has proposed to construct a trap and haul facility at the Headworks Diversion Dam to allow fish passage to the upper watershed as part of their habitat conservation plan. Although uncertain, it is possible that a bull trout population may become established or reestablished in the upper watershed once this facility is constructed. Establishing a self-sustaining population in the Green River system would help maintain bull trout distribution within the southern portion of the Puget Sound Management Unit. The recovery team currently identifies the upper Green River, above the Headworks Diversion Dam, as a research needs area.

Lower Nisqually River foraging, migration, and overwintering habitat. As bull trout populations recover, the Nisqually River and McAllister Creek estuary and lower Nisqually River will provide significant foraging, migration, and overwintering habitat for bull trout in south Puget Sound. Although it is unknown whether a remnant bull trout population continues to persist in the lower Nisqually River drainage, it is believed that there is a high likelihood that recovered populations of bull trout from the Puyallup and other

Puget Sound Management Unit core areas will use this area in the future. Historically, anadromous bull trout were described entering the Nisqually River as early as the first of June (Suckley and Cooper 1860), which is the typical river entry timing of prespawning bull trout seen today. In addition to this observation, it was noted that larger individuals were generally caught during the summer versus the fall, further suggesting that rivers such as the Nisqually and Duwamish supported anadromous spawning populations of bull trout at that time. Although Suckley and Cooper (1860) described bull trout entering the Nisqually River in "vast numbers" starting in October, there have been only rare observations of bull trout in recent years. A single juvenile was collected during stream sampling in the lower reaches of the Nisqually in the mid-1980's (WDFW 1998). In the late 1990's, a single adult was observed at the Clear Creek Hatchery in mid-September (J. Barr, Nisqually Tribe, pers. comm. 2003). This fish was approximately 508 to 558 millimeters (20 to 22 inches) in size and presumed to be anadromous based on its "bright" coloration.

The Nisqually River originates from glaciers and streams on the south side of Mount Rainier in the National Park and flows westerly to Alder Reservoir created by Alder Dam. Downstream from Alder Dam is LaGrande Dam from which the river flows northerly to south Puget Sound. LaGrande Dam, located at river mile 42.5, limits potential upstream use by anadromous fish including bull trout. A natural barrier may have historically existed near the location of LaGrande Dam, naturally limiting migratory bull trout use. There is currently no evidence of a remnant bull trout population existing upstream of these two dams. The upper Nisqually watershed, upstream of LaGrande Dam, has currently been identified by the recovery team as a research needs area.

The Nisqually River estuary is the only major undeveloped delta in south Puget Sound, offering a variety of intact and restorable foraging habitat for anadromous subadult and adult bull trout. Significant portions of historical estuarine habitat are currently separated from the delta by dikes. The restoration potential of these areas is recognized as providing significant opportunity to improve habitat conditions of the Nisqually River estuary (Wiltermood Associates, Inc. 2000; USFWS 2002). McAllister Creek is a low gradient stream originating at McAllister Springs and flowing 8.8 kilometers (5.5 miles) to enter

the Nisqually River delta southwest of the mouth of the Nisqually River. McAllister Creek may also provide potential foraging habitat for bull trout. The estuary largely falls under the ownership of the Nisqually National Wildlife Refuge and the Nisqually Tribe, while much of the lower river falls under tribal and military ownership. The Nisqually River is bordered on the south bank by the Nisqually Tribal Reservation from approximately river mile 3.7 to 10.6. The Fort Lewis Military Reservation borders the Nisqually River on the north bank from river mile 2.4 upstream to approximately river mile 21. Development along the lower river is light with undisturbed riparian† habitat in most areas, which has helped maintain largely intact foraging habitat for bull trout.

There are a limited number of tributaries to the Nisqually River below LaGrande Dam with Muck Creek, Murray Creek, Toboton Creek, Tanwax Creek, Powell Creek, Ohop Creek and the Mashel River being the primary streams. Muck Creek is a significant chum salmon spawning stream and the Mashel River is utilized by both Chinook and coho salmon, providing potential habitat for foraging bull trout. Many of the remaining tributaries have only short useable reaches and mainstems with relatively poor salmonid habitat due to impacts from agricultural development. It is unknown whether these tributaries historically provided significant foraging habitat for bull trout.

Marine foraging, migration, and overwintering habitat. Within the Puget Sound Management Unit, anadromous bull trout require access to marine waters, estuaries, and lower reaches of rivers and lakes to forage and overwinter. It is generally believed that some level of mixing or interaction within marine waters occurs among anadromous individuals from the various core areas identified in Puget Sound. Although recent and past studies have documented bull trout from one major Puget Sound river basin moving into the downstream portions of another via marine waters (WDFW *et al.* 1997; Goetz, *in litt*. 2003b), there is currently insufficient information to understand the full extent to which bull trout express this behavior. Although some level of basin to basin movement has been observed, there is currently no information that indicates anadromous bull trout spawn in basins which do not contain their natal stream/watershed. Historically, anadromy could have played a role in establishing this species'

distribution within Puget Sound. Anadromy may potentially function as an important means for the natural reestablishment of extirpated populations.

Given that it is currently unclear to what degree this behavior actually influences population structuring within Puget Sound, we have chosen to define all marine and estuarine waters solely as important foraging, migration, and overwintering habitat at this time. These "common" marine habitats cannot be accurately linked with any specific core population(s) until additional information becomes available that can help further refine the migratory patterns of bull trout within core areas. The "marine" foraging, migration, and overwintering habitat currently includes Puget Sound and associated nearshore and estuarine areas. These areas are important for maintaining life history diversity and for providing marine foraging within the management unit.

The current distribution of bull trout within Puget Sound marine waters is not completely known, but has been documented from the Canadian border to at least Commencement Bay to the south (Kraemer 1994; McPhail and Baxter 1996; WDFW 1998; Pacific International Engineering 1999; Ballinger, *in litt*. 2000; KCDNRP 2002). As late as 1978, their marine distribution was still identified as far south as the Nisqually River Delta (Fresh *et al*. 1979). The more recent observation made at the Clear Creek Hatchery would indicate that bull trout still occasionally migrate in marine waters to at least the Nisqually River. It is unknown if individuals from Puget Sound populations migrate as far west as the Kitsap Peninsula and the Strait of Juan de Fuca, or to what extent they may migrate up the coast of British Columbia. One bull trout tagged in the Squamish River in British Columbia was recaptured in the Skagit River (McPhail and Baxter 1996), and another tagged in the Nooksack River was later recovered in the Lower Fraser River (Kraemer, pers. comm. 2003a). It is thought that bull trout primarily use the shallower nearshore waters along the eastern shore of Puget Sound, and occasionally use or cross deeper waters to access nearshore locations along the west side of the sound (*e.g*., Whidbey Island). Currently few observations of bull trout have been reported in nearshore areas around the small islands of eastern Puget Sound, however anadromous bull trout are presumed to use many of these nearshore areas based on their accessibility and the abundant forage fish populations they support. Although there has been only limited study

of their diet in marine waters, bull trout appear to utilize these productive shallow waters to forage on a variety of prey items. Bull trout appear to target juvenile salmonids and small marine fish such as herring, sandlance, and surf smelt, especially keying in on their spawning beaches (Kraemer 1994). Bull trout have also been noted to feed heavily on shiner perch (*Cymatogaster aggregata*) at some locations (Castle, pers. comm. 2003c; Berge, pers. comm. 2003b).

Bull trout use of the marine environment is thought to be similar to that of other species, such as anadromous Dolly Varden and cutthroat trout. Thorpe's (1994) review of salmonid estuarine use found that anadromous Dolly Varden have an affinity to the shoreline. He also found clear evidence of a trophic advantage to estuarine residency (abundant prey). Aitkin (1998) reviewed the estuarine habitat of anadromous salmon, including native char. His literature review found that Dolly Varden pass through estuaries while migrating, like steelhead, and inhabit coastal neritic waters (nearshore marine zone extending to a depth of 200 meters [656 feet], generally covering the continental shelf), like cutthroat trout. In Chignik, Alaska, Dolly Varden in the estuary preyed upon amphipods (81.1 percent), gastropods, and isopods, while sand lance were 1 percent of their diet (Roos 1959). From a sample of 145 Dolly Varden (121 to 490 mm; 4.7 to 19.3 inches), Armstrong (1965) found the principal foods by occurrence to be juvenile pink and chum salmon (21.6 percent), mysids (17.6 percent), amphipods (12.7 percent) and capelin (9.8 percent). Thorpe (1994) reported that Dolly Varden feed heavily on amphiphods, mysids, and various fish.

Bull trout may also use the estuaries and reaches of river systems that are historically or currently unlikely to support spawning populations of bull trout, such as the Samish River and Duwamish River. Bull trout are believed to be foraging on juvenile salmonid downstream migrants or other fish species while occupying these areas, and potentially overwintering there as well. The extent of past and current bull trout use of smaller independent creek drainages that discharge directly into Puget Sound is not well known, with only a few known reported observations. In Bellingham Bay, bull trout were observed in Squalicum Creek in the late 1970's and in lower Whatcom Creek more recently (Currence, pers. comm. 2003a). In 2002, three subadult bull trout approximately 203 to 229 millimeters (8 to 9 inches) in length entered the Maritime Heritage Fish Hatchery

pond. These were reported to be the first bull trout observed at the facility in more than a decade, although formerly one to two a year were said to be observed at the facility. In contrast, bull trout from coastal populations on the Olympic Peninsula have recently been documented using a number of small independent creek systems flowing into the Pacific Ocean (USFWS 2004). Even if it is determined that many of the small stream systems in Puget Sound are not commonly occupied by bull trout, these streams still provide an important contribution to the potential forage base for bull trout using adjacent nearshore marine waters or other parts of Puget Sound.

Importance of Identified Core Areas and Foraging, Migration, and Overwintering Habitats in the Puget Sound Management Unit.

The eight identified core areas (summarized in Table 5) all play a critical role in the recovery of bull trout in the Puget Sound Management Unit. Each core area is vital to maintaining the overall distribution of bull trout within the management unit; however, the Nooksack, Lower Skagit, Stillaguamish, Snohomish-Skykomish, and Puyallup core areas are particularly critical for maintaining the distribution of the anadromous life history form unique to the Coastal-Puget Sound Distinct Population Segment. The Puyallup core area plays a vital role in maintaining anadromous bull trout distribution in the management unit, because it is the only major watershed in south Puget Sound supporting a population with this life history form. Although the Lower Nisqually River, Lower Green River, and Lake Washington/Lower Cedar River are used by anadromous bull trout, currently no spawning populations have been detected in these systems. These areas, in addition to the Samish River and Puget Sound marine waters, are essential to support the unique migratory behaviors and requirements of anadromous bull trout. When comparing all core areas within the management unit, the Lower Skagit is unique in its geographic size and population abundance. This core area is believed to be central to maintaining anadromous bull trout within the Puget Sound Management Unit.

Table 5. Summary of core area status, Puget Sound Management Unit. Population trend status must be interpreted with caution, since the availability of consistent survey data is limited; the development of a standardized survey protocol to improve the quality of this data set is one of the identified research needs in this plan.

CORE AREA	EST. NUMBER OF LOCAL POPULATIONS IN U.S. (CANADA)	ESTIMATED ADULT ABUNDANCE	LIFE HISTORY FORMS PRESENT	POPULATION TREND	NOTES
Chilliwack[a]	3 (7)	> 1,000[c]	fluvial, adfluvial; possibly anadromous and resident	unknown	no long-term monitoring data available
Nooksack	10	< 1,000	anadromous, fluvial; possibly resident	unknown	no long-term monitoring data available; population numbers generally low
Lower Skagit	19	> 1,000[d]	anadromous, fluvial, adfluvial, resident	stable to increasing	based on limited monitoring data
Upper Skagit[a]	7[b] (6)	> 1,000[c]	fluvial, adfluvial; possibly resident	unknown	populations in Canada "presumed healthy"
Stillaguamish	4	< 1,000	anadramous, fluvial, resident	unknown	limited data; population numbers low

Table 5 (continued). Summary of core area status, Puget Sound Management Unit. Population trend status must be interpreted with caution, since the availability of consistent survey data is limited; the development of a standardized survey protocol to improve the quality of this data set is one of the identified research needs in this plan.

CORE AREA	EST. NUMBER OF LOCAL POPULATIONS IN U.S. (CANADA)	ESTIMATED ADULT ABUNDANCE	LIFE HISTORY FORMS PRESENT	POPULATION TREND	NOTES
Snohomish-Skykomish	3[b]	500 - 1,000	anadramous, fluvial, resident	increasing	based on limited monitoring data
Chester Morse Lake	4	500 - 1,000	adfluvial; possibly fluvial or resident	stable to increasing	based on limited monitoring data
Puyallup	5	< 1,000	anadromous, fluvial, resident	unknown	few monitoring data available; population numbers generally low

[a] these core areas share local populations with Canada (number of local populations in Canada shown in parentheses)
[b] does not include resident populations
[c] estimates of adult abundance for these core areas include the local populations in Canada, since those populations are functionally a part of the core area for the purpose of evaluating the risk of genetic drift
[d] adult abundance of this core area is estimated to be several thousand individuals, making it likely the largest population of bull trout in Washington