

## 2.4 ELWHA RIVER AND TRIBUTARIES

### 2.4.1 Overview

The Elwha River is the largest watershed in the EMMT area and it constitutes the westernmost watershed within the planning area (Figure 2.4-1). The Elwha mainstem is approximately 45 miles long, has 100 miles of tributary streams, has a basin averaging approximately ten miles wide in an east-west direction, and drains 321 square miles of the Olympic Peninsula. Eighty-three percent of the drainage, including the upper 35 miles of the mainstem, lies within Olympic National Park, and is therefore protected from timber harvest, agriculture, and other land-use disturbances. The river flows in a northerly direction into the Strait of Juan de Fuca, entering the strait five miles west of Port Angeles. The Elwha is the fourth largest river, by drainage area, among all Olympic Peninsula streams, with a watershed area smaller only than those of the Quillayute, Queets, and Quinault rivers.

Two major hydroelectric developments have altered the historic condition of the Elwha River. The Elwha Dam, built at RM 4.9 beginning in 1910, now impounds the 2.5-mile long Lake Aldwell reservoir, and the Glines Canyon Dam, built at RM 13.4, now impounds the 2.8-mile long Lake Mills reservoir. Originally built and operated to produce electricity for Port Angeles and beyond (supplying power as far away as Bremerton and Port Townsend prior to 1921), the dams have been fully allocated to supplying power to the pulp mill now operated by Nippon Paper Industries USA since the early 1920s. The dams were acquired by the federal government in 2000 and are scheduled for removal by 2007, as part of a comprehensive restoration of the watershed's ecosystem and its fisheries.

This dam removal and restoration project is guided by a federally-managed planning process encompassing a series of three primary documents developed under the provisions of the National Environmental Policy Act (NEPA). These primary documents consist of an initial "programmatic" EIS, which examined options for achieving "full" restoration of the river and its fisheries (USDI et al. 1995); the ensuing "implementation" EIS, which examined various removal and restoration alternatives (USDI et al. 1996); and a "supplemental" EIS, draft due in mid 2003, which update and modify the proposed actions presented in the previous EISs. In addition, there is a wealth of related technical information derived from numerous studies associated with this restoration/removal process. All of these documents are available through the website <http://www.nps.gov/olym/elwha/documents.htm>. In total, these documents provide extensive additional information on the mainstem Elwha River that is well beyond the scope of this plan.

For the purposes of this plan, adopting the EIS approach--especially with regard to fisheries issues, the river is divided into three "reaches". The upper reach of the river is defined as upstream of Glines Canyon Dam; the middle reach is that portion between the two dams, and the lower reach is the length below Elwha Dam. The Elwha River has 15 tributaries greater than 4 miles in length (Table 2.4-1). Most of these tributaries have extremely steep gradients. Two of the tributaries, Boulder Creek and Cat Creek, drain into Lake Mills. Four other streams are located along the middle reach: Indian Creek drains Lake Sutherland; Little River is a larger tributary that drains a watershed highly disturbed by logging; and Hughes and Griff creeks are very steep, originating at approximately 4,000 feet.

**Table 2.4-1. Major Elwha River Tributaries**

	<b>Location Of Mouth (River Mile)</b>	<b>Tributary Length (miles)</b>
Indian Creek	7.5	5.7
Little River	7.8	7.5
Hughes Creek	11.3	4.6
Griff Creek	11.4	4.1
Boulder Creek	15.1	7.6
Wolf Creek	15.8	4.0
Cat Creek	15.9	6.7
Long Creek	18.5	8.0
Lillian River	20.9	11.1
Lost River	27.7	7.7
Goldie River	29.4	8.6
Hayes River	31.9	9.0
Godkin Creek	36.1	7.2
Buckinghorse Creek	37.5	4.1
Delabarre Creek	40.4	4.3

Note: All the above tributaries other than Indian Creek and Little River are within Olympic National Park.

More relevantly, this plan divides the full Elwha watershed into three separate subwatersheds that are treated individually. The first is the main Elwha River corridor (including all its tributaries within ONP), the second is the Indian Creek subwatershed, and the third is the Little River subwatershed. This separation is made because the latter two subwatersheds are substantially outside the boundaries of ONP and are therefore more directly subject to the interests and management of the Elwha Morse Management Team. To further focus this plan on the areas outside the national park, the mainstem of the Elwha River is examined in two sections. The “upper watershed” is the portion of the river upstream of the park boundary at RM 9.7 (roughly equivalent to the junction of the Madison Creek drainage with the river), and the “lower watershed” is the portion of the river below RM 9.7. This lower watershed is emphasized here because there is a greater potential for local determination of water resources goals and actions through the watershed planning process.

## **2.4.2 ELWHA RIVER (Upper & Lower mainstem) (WRIA # 18-0272)**

### **Geography**

#### **Upper Elwha Watershed**

The upper river originates in headwaters in the heart of the Olympic Mountains, with the mainstem draining the southeast slopes of Mount Olympus, and with initial elevations in the upper Elwha Basin between 2100’ and 2500’. It crosses the national park boundary and transitions to the lower river at an elevation of about 250’. This results in an overall average gradient (between RM 42, at 2500’ and RM 9.7, at 250’) of about 1.3%. As noted above, 83% (or ~266 sq. mi.) of the entire 321 sq. mi. watershed is in this upper watershed.

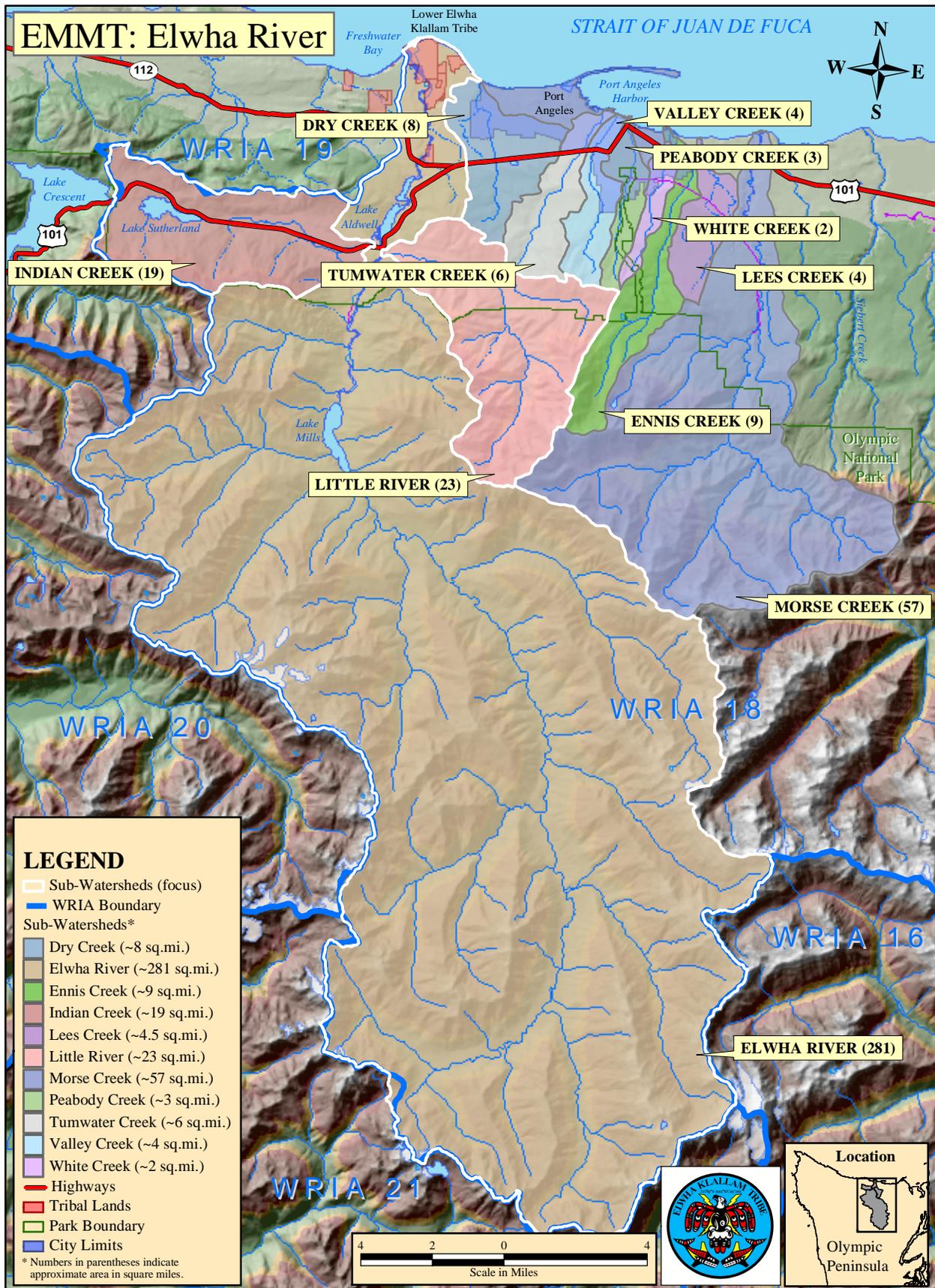


Figure 2.4-1. Elwha River and Tributaries Area Map

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This Upper Elwha watershed is bounded by the Sol Duc, Hoh, and Queets watersheds to the west, the Quinault watershed to the south and southeast, and the Dungeness watershed to the east. With its long-standing protection within the national park, the upper watershed retains its natural, old growth vegetation (cedar, fir, hemlock) and the bulk of its wildlife (though the loss of the fisheries caused by the dams has had extensive secondary wildlife impacts).

The most noticeable feature of the upper watershed is the Glines Canyon dam and the Lake Mills reservoir. Once the dam and reservoir are removed, several other notable features will be more prominent, including Elwha Basin, Press Valley, Grand Canyon, Geyser Valley, Rica Canyon, and Glines Canyon (now inundated by the reservoir).

### **Lower Elwha River**

The Lower Elwha watershed, beginning (by the definition in this plan) at the national park boundary at RM 9.7, encompasses the remaining 17% (~55 square miles) of the entire Elwha watershed. Setting aside the Indian Creek (~20 sq. mi.) and Little River (~23 sq. mi.) tributary watersheds (which are described in separate sections below), the lower mainstem watershed consists of the remaining ~12 sq. mi. The 9.7 miles of mainstem descend the final 250' to sea level, resulting in an average gradient of ~0.5%.

To the west, this Lower Elwha watershed is bounded by the Lake Crescent/Lyre River watershed (adjacent to the Indian Creek tributary watershed) and by the Coville Creek watershed, both of which are in WRIA 19. To the east, it is bounded by the headwaters of all the urban Port Angeles streams from Morse Creek west to Dry Creek (all of which are adjacent to the Little River tributary watershed). The lower portions of Dry Creek also represent the eastern boundary of the lower portion (below Hwy. 101 at RM 7.7) of the Lower Elwha watershed.

The entire Lower Elwha watershed, including the Indian Creek and Little River tributary watersheds, has experienced extensive logging in decades past. Today the area is largely second growth conifer forest with significant intermittent agricultural and rural residential use. Similarly, wildlife has been heavily impacted by changes to the landscape and the levels of continuing human activity.

As in the upper watershed, the presence of a dam, the Elwha dam, and its associated Lake Aldwell reservoir, are the dominant current features. Following dam removal and reservoir restoration, the exposed canyon under the reservoir and the 2-mile long Elwha Canyon will become prominent.

### **Soils**

The *Soil Survey of Clallam County Area, Washington* (SCS 1987) characterizes the soils of the Elwha River below the park boundary. Of the 11 soil units that SCS describes for Clallam County, three are found in the Lower Elwha watershed.

The soils of the watershed outside the riparian areas are Terbies-Louella. These gravelly loams, including Neilton loams, and very gravelly sandy loams are deep to very deep and well-drained on moderately to extremely steep slopes and mountainsides. The SCS found these soils suitable for forestland but not for most other uses, due to steep slopes. They

have high erosion potential due to the large amount of precipitation common to the area and the steepness of the slopes. Disturbance, such as logging and development, can greatly increase the chances of slides, which have occurred in various locations here over time. Though soils within the park have not been specifically investigated, these Terbies-Louella soils are likely to be present extensively in the upper watershed, above the park boundary.

Much of the lower elevation soils in the watershed below Hwy. 101 are of the Neilton-Lyre-Casey unit. These soils are characterized as very deep, poorly to excessively drained, on gradients from level to very steep, and generally with moderate to high susceptibility to erosion. The SCS (1987) considers these soils suitable for development only with caution as to construction techniques and septic design.

The riparian zone and floodplain of the lower four miles of the watershed, below Lake Aldwell, are of the Carlsborg-Puget-Dungeness Unit, which are characterized as very deep, with broadly variable drainage capability, and on level or gentle slopes. The SCS (1987) considers these soils suitable for low-density residential use and marginal for agricultural use.

## **Fluvial Geomorphology**

### **Upper Elwha Watershed**

The 1996 EIS (USDI et al. 1996) describes the overall picture of the Elwha River valley as consisting of a series of relatively narrow bedrock canyons and wide lower-gradient, flat alluvial sections referred to as bottomlands (or bottoms). Alpine glaciers carved out the wide bottomlands in weaker rock units, whereas canyon sections represent stronger rock units that could not be as easily eroded. The basin topography was influenced both by alpine glaciers flowing from the high Olympic Mountains, where remnants still remain, and the Juan De Fuca lobe of the great Vashon continental glacier, which covered the lower Elwha River.

The Elwha River has a steep slope, steepest at the headwaters (16% average gradient) and generally decreasing in the downstream direction. The river flows through several steep, narrow, bedrock canyons. Between these canyons, the channel is less steep and has wider reaches within its broad floodplains. At the outlet of the canyons, the channel widens, the streamflow slows, and sand, gravel, cobbles, and LWD are left behind by the slower-flowing river, creating deltas. In the floodplains, the river typically meanders, in some cases undercutting alluvial terrace and valley wall deposits.

Perry (2001) describes the upper valley of the Elwha as forming a very large crenulated basin with a series of deep glacial valleys, interspersed with steep canyons. The drainage of this watershed is very well integrated through this series of valleys. The valley floor at the upper end of the Elwha valley, just east of Low Divide between Mt. Seattle and Mt. Christie, has an elevation just under 2300 feet. This eastward-facing valley turns north, and then northwest, through Press Valley, Grand Canyon, Geyser Valley, Rica Canyon, and into Glines Canyon. From Glines Canyon, the streamcourse turns north and northeastward, continuing to the sea. The headwaters area is glacially fed which, in

combination with the many substantial tributaries arising in the upper watershed, provides a constant supply of gravel material to the entire system.

The 1996 EIS (USDI et al. 1996) describes that the sediments in the Elwha River drainage basin are dominated by glacial deposits and recent alluvium. These sediments range in size from clay to boulders and provide much of the material available for transport by the Elwha River and its tributaries. Upstream from Lake Mills, the riverbed material consists of sand, gravel, cobbles, boulders, and, in some places, bedrock outcrops. In the vicinity of Lake Mills, the river is cut into at least 600 feet of sediments that were deposited in a glacial lake impounded by the Vashon ice sheet. A set of eroding cliffs comprised of glacial deposits on the west side of Lake Mills supports the presence of glacial lake Elwha during the Vashon glaciation, 13,000 to 20,000 years ago. The lower 3.5 miles of the Elwha River is cut into a thick deposit of erodible, unconsolidated glacial outwash and till deposited by the same ice sheet.

The EIS goes on to describe that river alluvium deposited since the retreat of the glacier typically consists of sandy gravel, cobbles, and boulders. Sediment eroded from the valley walls is transported by the Elwha River and tributaries. Considerable amounts of recent alluvium are stored along the river channel, particularly in the wide terraces outside the floodplain that make up the bottoms and river mouth.

Fluvial processes here (above the Lake Mills reservoir) are fully intact, providing pristine habitat for resident fish and offering outstanding potential habitat for salmonids and other stocks expected to return following dam removal and river restoration downstream.

### **Lower Elwha Watershed**

From the Lake Mills reservoir downstream, past the park boundary and on to the river's mouth, the channel has been heavily impacted. The 1996 EIS (USDI et al. 1996) describes the reach between the Glines Canyon Dam and the Lake Aldwell reservoir as being constrained in a narrow bedrock canyon 80-250 feet wide. From the Altaire bridge on Olympic Hot Springs Road (RM 12.5) to the McDonald stream gage (RM 8.5), the river channel is 200-400 feet wide. Just downstream of the gage, a spur dike approximately 400 feet long provides some flood protection to properties adjacent to the river. Overall channel slope of the middle reach is 0.7%. Different from the river processes that occurred before the dams were built, there is now little reworking of valley alluvium by lateral channel migration in the middle reach. Also, the amount of sand and gravel in the riverbed is noticeably lacking compared to the river upstream from Lake Mills. Downstream of the Glines Canyon dam there has been noticeable scouring of fine sediment from channel edges and the floodplain. Sediment in this reach is only available from tributaries when they are in active flood stage and from sediment stored along the channel in bars and terraces.

At the Lake Aldwell reservoir, as at the upper reservoir of Lake Mills, substantial accumulation of these alluvial sediments has created sediment deltas and other deposits (~14 million cu. yd. in Lake Mills and ~4 million cu. yd. in Lake Aldwell). The handling of this accumulation of sediments is one of the major components of the overall dam removal and river restoration process and is treated extensively in the EIS and other documents prepared by the National Park Service (NPS) (USDI et al.).

Below the Lake Aldwell reservoir, the EIS describes the segment of the river down to RM 4 as being constrained by the steep bedrock walls of Elwha Canyon. In the next half mile of the river below Elwha Canyon, the stream gradient is less steep and the channel floodway widens to approximately 1,500 feet. The city of Port Angeles Ranney collector (adjacent to the channel) and the surface water intake that supplies water to the Nippon Paper Industries pulp mill and the state rearing channel are located between RM 2.8 and RM 3.0. At RM 2.8, the river channel is constrained by bedrock on the right bank and narrows through this area. Between RM 2.8 and the river mouth, the floodplain widens and is bound on the west side by steep cliffs of glacial deposits more than 150 feet high. The pre-dam river migrated throughout its entire floodplain; below the Elwha Bridge (RM 3.2), it moved laterally over an area up to 1.2 miles wide. Construction of flood controls, beginning in the early 30s, and reaching a peak in the late 40s and early 50s, had substantial impact on the dynamics of the floodplain. The Lower Elwha Federal Flood Control Set-back Levee, situated on the east side of the floodplain, limits the eastward migration of the river. A 900-foot-long county-constructed levee extending downstream from the high river bluffs on the west side of the river near its mouth currently restricts the movement of the river mouth westward, restricts the floodplain on it's the river's west side, and has reduced the extent of available estuary.

Haring (1999) notes that channel conditions in the lower Elwha have been dramatically affected by the construction of the two dams. The dams created upstream reservoirs that together inundate approximately six miles of free-flowing riverine habitat. Additionally, the dams truncate the recruitment of alluvium (riverbed sands and gravels) to channel reaches downstream of each dam, intercepting and storing the sediment in the delta at the upper end of each reservoir and elsewhere within the reservoirs. If the Elwha were free flowing, this material would have been transported downstream to nourish the channel, floodplain, and estuary with gravel and fine-grained sediments. Construction of the dams has nearly eliminated this supply of material for some 85 years. Over time, the channel below Elwha and Glines Canyon dams has decreased horizontally, incised vertically, and the bed has coarsened. Present estimates, based on interpretation of visual evidence of terraces downstream of the dams, are that the riverbed downstream of the dams may be up to as much as 10 feet lower and more channelized because of the dams (USDI et al. 1995). These changes have profound implications for salmon. The average substrate size in the lower river is now dominated by large cobble--substrate that is generally too large to provide spawning habitat for salmon. Historic side-channel and other offchannel refuge areas critical for over-wintering species such as coho are now largely isolated from the mainstem. These effects have been exacerbated by human activities such as diking. Attempts to control flooding by modification of channel meander patterns have also occurred, with limited success.

Perry (2001) noted that the dams and reservoirs are very efficient sediment traps. The lack of sediment has had dire consequences in the form of increased beach erosion along the coast east of the mouth of the Elwha, and serious erosion of Ediz Hook farther along the coast to the east. However, to an even greater degree, these dams have eliminated viable anadromous fish spawning runs, and the access of anadromous salmonids to spawning and rearing habitat within the Elwha River drainage. Presently remaining habitat below Elwha Dam has degraded to the extent that it has greatly weakened several anadromous stocks.

## Hydrology & Geohydrology (Natural Water Balance)

### Hydrology

#### Precipitation

Perry (2001) describes precipitation of 220 inches in the headwaters of the Elwha, declining to roughly 35 inches at the coast of the Strait. For the Lower Elwha watershed, precipitation at the upper end (park boundary, which also roughly corresponds to the mouths of the Indian Creek and Little River tributary watersheds) is approximately 50 inches.

#### Interception And Evapotranspiration

In his report (Perry 2001), Perry provides a generalized picture of the role of interception and evapotranspiration losses which have yet to be applied to specific watersheds.

#### Annual Hydrograph

Perry (2001) has presented the most current depiction of the Elwha River hydrograph (Figure 2.4-2) at a point slightly downstream from the park boundary (at the McDonald Bridge gage, named for a long-removed bridge crossing the river at RM 8.5). The hydrograph shows the expected bi-modal annual graph with a winter peak (79% exceedance) of ~2800 cfs and a late spring peak of ~3000 cfs. These are interspersed with a summer/fall low flow of ~800 cfs and a spring low flow of ~1400 cfs.

In considering this hydrograph, which is taken from a point below the Glines Canyon Dam and above the Elwha Dam, it is important to understand that though the two dams historically were manipulated to maximize generating capacity, they are no longer operated in this fashion. The upper dam has occasionally manipulated reservoir levels slightly to supplement low flows, enable dam/powerplant maintenance, or (prior to federal ownership) provide modest generating increases. The lower dam has operated as run-of-the-river since 1975, meaning that it passes through the dam the same amount of outflow as is coming in at the upper end of the reservoir. However, the timing and behavior of those flows (especially given the significant changes to the historic channel configuration), is significantly altered from what would be expected in the natural state.

#### Peak Flows

The Elwha hydrograph, above, incorporates, but masks, periodic true peak (flood) flows. The Elwha Restoration EIS (USDI et al. 1996) describes a daily peak flow range from 3320 cfs in August to 24,400 cfs in November. The all-time high recorded flow (post dam construction) is ~30,000 cfs for a day in 1950 and a peak instantaneous flow of ~40,000 cfs.

#### Stormwater Runoff And Flood Hazard

In the upper watershed, there is barely a trace of stormwater runoff of any sort. This comes from the very limited development occurring along the road corridor, which consists of ~2.5 miles of paved road from the park boundary up to the Elwha bridge at the Altaire campground (RM 12.5), an additional ~5 miles of unpaved road from the Altaire

campground to the road's end, and the unpaved Whiskey Bend road (~ 6 miles) along the east side of the Lake Mills reservoir. In addition to the road itself, development in this limited portion of the upper watershed consists of the Elwha and Altaire campgrounds, the Elwha Ranger Station and nearby maintenance areas (including pack animal stables), and the power plant, housing, and associated facilities at the Glines Canyon Dam site.

For all intents and purposes, flood hazards are non-existent in this upper watershed, and, to the extent that there may be hazards, addressing them is outside the jurisdiction of the EMMT partners.

The lower watershed does experience modest stormwater runoff in certain areas—mostly attributed to the impervious surface of roads and residences scattered throughout. This lower watershed also experiences altered and consequential flood flows—which have prompted a variety of flood control structures. The 1996 EIS (USDI et al. 1996) thoroughly documents the current flood hazards along the lower river. In addition to itemizing the structures susceptible to flooding (currently and post-removal) and modeling the anticipated aggradation of the river bottom (post-removal), the EIS prescribes how flood protection modifications will retain the current level of protection for all the structures that will remain following dam removal (homes, facilities, etc.).

Haring (1999) describes the overall modification of floodplains in the lower river as being diked in several places, with the most significant being the Army Corps dike on the Lower Elwha Klallam Tribe's reservation. This dike is set back approximately 1000' from the current active channel, and beyond the limits of the current meander belt. However, if the meander belt were to widen with restoration of the lower Elwha floodplain, the dike would prevent channel migration toward the eastern portions of the valley, which have been developed for housing. However, it is not considered structurally capable of constraining channel migration if the meander belt is widened, as it may be when the dams are removed (ACOE 1994, as referenced in USDI et al. 1995). Dikes have also been constructed to protect the City of Port Angeles industrial water line at RM 3.5, and on the west side of the estuary. The latter has severely impacted estuary processes and is responsible for eliminating all flow through one of the historic distributaries. Other constrictions include the industrial water supply intake structure at RM 3.7, and the spur dike below the one-way bridge (~RM 3.6). The spur dike has had an impact on channel meander patterns and is at least partially responsible for a loss of meander in the river over time.

The current plans to upgrade flood protection equivalent to the increased flood potential arising from dam removal and river restoration will result in perpetuation of the current status of a floodplain substantially altered from its historic condition, especially from the area of the city's Ranney collector and the WDFW hatchery at RM 3 downstream to the mouth of the river.

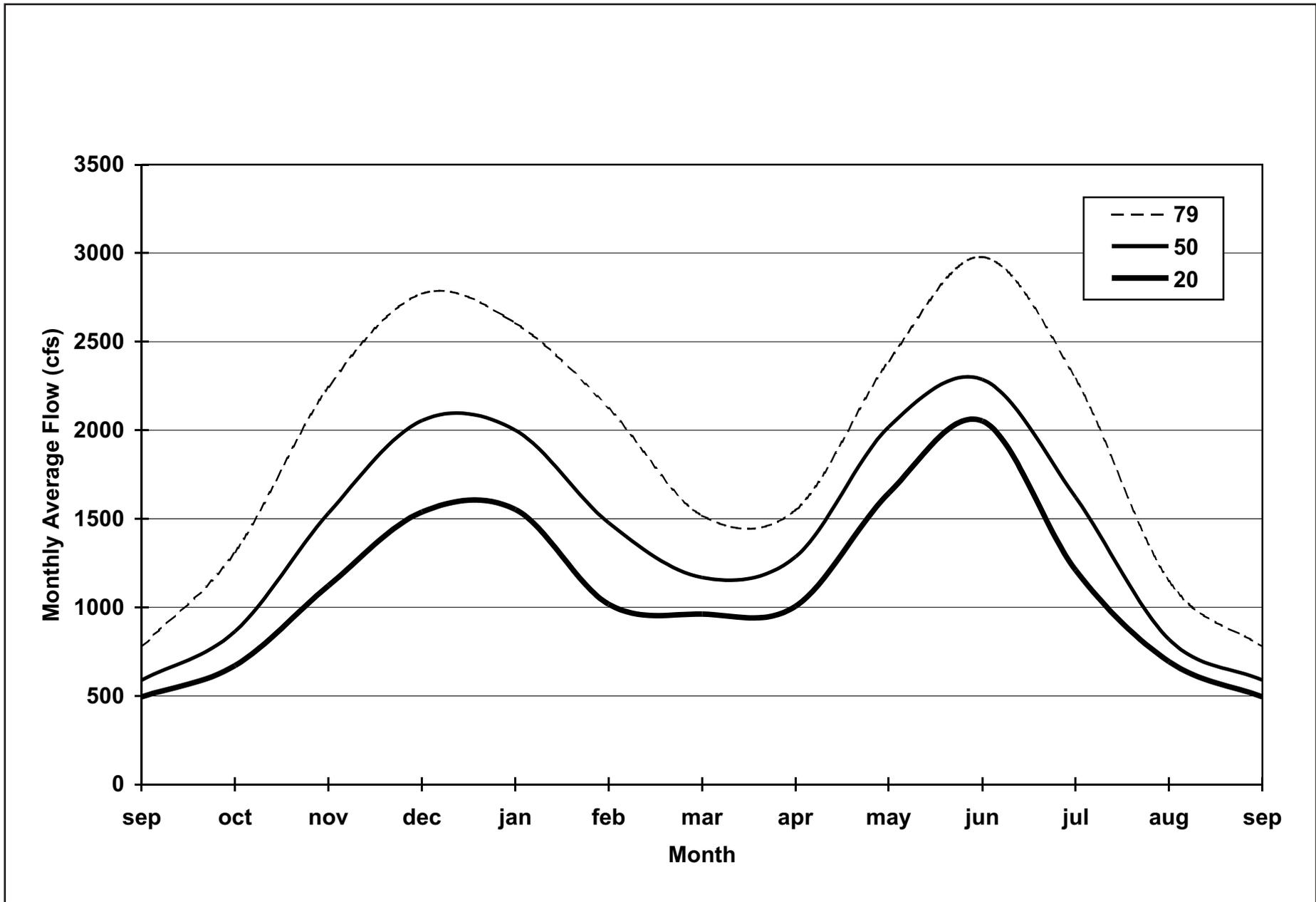


Figure 2.4-2. Elwha River at McDonald Bridge near Port Angeles 1952-76. Recent data indicate flows are overestimated. Exceedence Flow Duration Curves at less than or equal to 79, 50, and 20 percent.

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### Low Flows

As with peak flows, low flows are masked within the generalized hydrograph shown above. Minimum daily discharges from 1898 to 1993 have ranged from 10 cubic feet per second in October to 746 in June. These minimum flows were largely influenced by storage in Lake Mills during drought periods—especially the extremely low minimums that occurred decades ago, during manipulations of the Elwha Dam and prior to operating the dams as run-of-the-river. Average monthly data provide a more realistic description of minimum flow conditions under present run-of-the-river operation of Lake Mills and Lake Aldwell. Minimum values for monthly average discharges are lowest during September (330 cubic feet per second (cfs)), October (241 cfs), and November (219 cfs). Instantaneous low flows drop as low as ~200 cfs.

Haring (1999) summarized an extensive low flow study that was conducted in the summer of 1998, a low snow pack year (Orsborn and Orsborn 1999). The objectives of this study were to assess the effects of water diversions on the current channel morphology and fish habitat. The results showed that the lowest measured flows were between 260-310 cfs depending upon location within the lower river. Based upon the current river morphology, the authors found that, for flows in the wetted mainstem declining toward 300 cfs, habitat loss begins to occur and that at flows less than about 300 cfs the loss of surface area of the wetted channel will cause significant habitat loss. The authors emphasized that their study did not fully investigate the effects of flow reductions on habitat loss in side channels, did not evaluate effects of flow reductions on elimination of bank cover habitat, and did not examine the further potential impacts of the dynamics between reduced flow and increased water temperature. The potential for these aggregate impacts resulting from reduced flows has prompted the state, the Lower Elwha Klallam Tribe, the National Park Service, and the Bureau of Reclamation (which operates the dams, following federal acquisition) to agree that at flows less than 400 cfs, the Bureau will take action to augment flows, even at the expense of power generation.

### **Geohydrology and Hydraulic Continuity**

The geology of the Elwha River watershed establishes the framework of its hydrology. As noted in the Elwha restoration EIS (USDI et al. 1996), in the Elwha basin from Lake Aldwell into the upper portions of the drainage, bedrock has been folded and faulted by the geologic events that formed the Olympic Mountains. At RM 14, approximately one-half mile upstream of Glines Canyon Dam, the Hurricane Ridge Fault crosses the Elwha River valley (see Figure 12: USDI et al. 1996). Farther downstream, in the Lake Mills area, the bedrock dips at an 80-degree angle to the south. The presence and alignment of this bedrock material prevents groundwater, or surface water from Lake Mills, from flowing north into downstream aquifers. In the lower Elwha River basin, the bedrock is overlain by younger unconsolidated deposits. Since the bedrock impedes flow, the groundwater is primarily contained in the overlying unconsolidated deposits. This results in comparatively limited aquifer formations and a high degree of hydraulic connectivity.

### Subsurface Inflow

Perry (2001) notes the close relationship between the river's surface water and the closely associated groundwater found in these aquifers in the unconsolidated deposits. He explains that within the lower Elwha valley, below Elwha Dam, domestic and municipal

water uses are supplied, in part, by an alluvial aquifer that is associated with the river. This aquifer is comprised of valley-fill alluvium deposited by the Elwha River following the Fraser glaciation. Because this aquifer is in hydraulic connection with the Elwha, water in the aquifer is derived from the river, and is, with the river, part of a single source of supply. As such, water pumped from the aquifer will be replaced by the stream, and water recharging the aquifer will become an accrual to the stream. Groundwater underflow from this aquifer, that discharges to the sea, has been estimated to be about 6.0 cubic feet per second (Walters et. al. 1979). Saturated thickness of this aquifer ranges between 30 and 70 feet.

The Elwha EIS (USDI et al. 1996) supplies much detail on this subsurface hydrology. A sequence of alluvial, glacial, and non-glacial deposits comprises the unconsolidated hydrogeologic system in the lower basin. The older glacial and non-glacial units were deposited first, covering the bedrock surface that slopes downward toward the north. The Elwha River valley is cut into these deposits. Recently deposited alluvial sediment (i.e., carried by the river) partially fills the valley floor. The width of the alluvium is restricted by relatively steep bedrock and glacial deposit bluffs. The glacial deposits yield water at rates generally less than 20 gallons per minute. Deposits of sand and gravel found at the top of the bluffs are unsaturated and do not serve as a water supply source.

Above Elwha Dam, the alluvial aquifer is restricted to the river channel and narrow floodplain within the valley and is bounded primarily by bedrock. The alluvium thickens and laterally extends into the lower Indian Creek valley.

Below Elwha Dam, the Elwha River valley is divided into three distinct alluvium-filled groundwater sub-basins separated by bedrock outcrops or constrictions in the surrounding glacial deposits. The upper sub-basin lies between RMs 4.0 and 3.1, where the river emerges from narrow, bedrock-walled Elwha Canyon downstream of the dam. The thickness of the 60-acre upper sub-basin is estimated to be as much as 75 feet. Dry Creek Water Association wells are located at the lower end of the upper sub-basin.

The middle groundwater sub-basin is approximately 70 acres between RMs 3.1 and 2.8 and includes the Port Angeles Ranney collector. The lower sub-basin, approximately 1,100 acres, extends downstream of RM 2.8 to the river mouth. It includes the Elwha Place Homeowners' Association wells and the Lower Elwha Klallam Reservation. Drilling in the middle and lower sub-basins showed alluvium thickness of 55 feet to 125 feet, respectively.

The yield of the aquifer varies according to local soil conditions. Large wells completed in the alluvium typically yield more than 100 gallons per minute, with maximum reported yields in excess of 1,000 gallons per minute. The hydraulic properties of the alluvium aquifer were tested during development of public water supply wells. Capacities of the wells vary from 10 gallons per minute per foot of well drawdown to more than 100 gallons per minute per foot. The transmissivity of the aquifer increases from upstream to downstream. In the upper sub-basin, the transmissivity is estimated to be 75,000 gallons per day per foot of aquifer; in the middle, 100,000; and, in the lower basin, approximately 400,000 gallons per day per foot of aquifer.

### Leakage From Streams

As noted in the discussion just above, there is widespread interaction, throughout the lower watershed, between the Elwha and its many small tributary streams and the associated aquifers.

### Septic Recharge

There are very few septic systems within the upper Elwha watershed and it is unlikely that they result in any measurable recharge to the river.

In the lower watershed, septic systems are not too numerous and are generally widely distributed, with the exception of some concentrations just above and below Hwy. 101, and in the area of the Lower Elwha Klallam Reservation on both sides of the river below RM 0.5. The degree to which there might be some recharge of the river coming from local septic systems has not specifically been investigated. However, given that the water supplying these household and commercial septic systems is coming from the same aquifer into which the septic recharge (if any) is released, it is likely that septic recharge plays little, if any, role in alteration of the localized hydrology.

### **Water Quality Constraints to Water Present and Available**

The Elwha EIS (USDI et al. 1996) illustrates that groundwater in the Elwha River watershed is of excellent quality overall, due largely to the fact that the entire headwater area is protected within Olympic National Park. The watershed land use is primarily rural, but non-point source pollution from agricultural and urban land use areas has a minor influence on groundwater quality. Low chloride levels (less than 1 milligram per liter (mg/L) to 8 mg/L) detected in wells near the mouth indicate that saltwater intrusion has not occurred to date. Private septic systems in the lower basin present a potential for groundwater contamination because of the poor filtering capability of the coarse-grained alluvial soils and the high water table.

Haring (1999) provides a thorough summary of the impact of water quality on the Elwha watershed, noting that the Elwha River is on the CWA 303(d) List of impaired water bodies, for temperature (resulting from thermal impacts associated with the operation of the dams) and for presence of PCBs (Ecology 1998). Otherwise, water quality in the Elwha is generally excellent. The Elwha provides domestic and industrial water to the City of Port Angeles, the Elwha Tribe, and several small community-based systems. Because most of the watershed is located within Olympic National Park, water quality impacts commonly associated with most streams on the Olympic Peninsula are uncommon. Little River and Lake Sutherland/Indian Creek, which have been developed for housing and commercial timber harvest, represent exceptions within the drainage. Increased sediment yield from logging has been noted in Little River (TAG observations of landslides from clearcuts). Runoff and septic systems from dense housing developments on the shores of Lake Sutherland may increase the potential for nutrient enrichment in the lake.

As noted, the biggest water quality problem on the Elwha is elevated summer stream temperature. Because the reservoirs act as thermal sinks in the summer, the upper layers stratify—with warm water on the surface and cooler water below. Water intakes to the hydroelectric generators were constructed so that only surface water can be drawn. As a result, warm water is delivered to downstream channel reaches. This effect is magnified in

low snowpack years. Summer water temperatures as high as 69<sup>o</sup> F have been measured in the lower river. In comparison, water temperatures rarely exceed 58<sup>o</sup> F in the river above Lake Mills (Lower Elwha Klallam Tribe, unpublished data). The heat storage effect of the dams is estimated to increase the temperature in the river below each dam by 2-4<sup>o</sup> C. Logging and agricultural activities conducted in the lower watershed outside the Park boundaries exacerbate the elevated water temperatures (USDI et al. 1994). Elevated temperatures are thought to be responsible for outbreaks of the gill parasite *Dermocystidium* which has caused pre-spawning mortality of up to 70% in some years for summer chinook salmon (WDF et al. 1993). This parasite may also be partially responsible for the decline of pink salmon in the Elwha River.

In sum, rather than having a situation in which water quality conditions are affecting the presence and availability of water, the Elwha River has an opposite condition. Here, limited quantities of water create a water quality problem, of high temperatures, that is compounded by the effects of the reservoirs and the operation of the dams. Other water quality indicators do not yet reach the level of having negative impacts on water presence or availability.

## **Factors of Change**

### **Human Influences/Major Projects**

The two major subwatersheds addressed in separate subsections, Indian Creek and Little River, have their separate human influences and impacts, which are addressed in those subsections. The consequences of those influences and impacts are, of course, combined with those of the main Elwha River. Figure 2.4-3 illustrates the location of the various capital facility improvements found along the Elwha River such as dikes, bridges, constricting roads, outtakes, and hatcheries.

### Dams

As discussed throughout this section, the Glines Canyon and Elwha dams and their associated reservoirs have had extensive and profound negative impacts on the watershed. However, the dams are scheduled for removal within the coming five years and their removal will be accompanied by extensive restoration of nearly all components of the ecosystem. Consequently, the expectation is that this particular major (negative) influence will be eliminated.

### Diversions

As described in the Elwha EIS (USDI et al. 1996), there are several significant water diversions in the lower watershed. The city of Port Angeles holds 200 of the 206 cfs of state-issued water rights on the Elwha River. These include a 50 cfs groundwater right for municipal purposes at a Ranney well next to the river at RM 2.8, and a 150 cfs surface right covering a diversion structure and canal approximately three miles upstream from the river mouth (Figure 10, USDI et al. 1996). This surface diversion provides water to two users – a large paper and pulp mill and the Washington Department of Fish and Wildlife fish rearing channel. Private landowners, the Dry Creek Water Association (0.6 cfs) and the Elwha Place Homeowners' Association (0.4 cfs) hold groundwater rights. The Lower Elwha Klallam Tribe and Lower Elwha Tribal Fish Hatchery withdraw

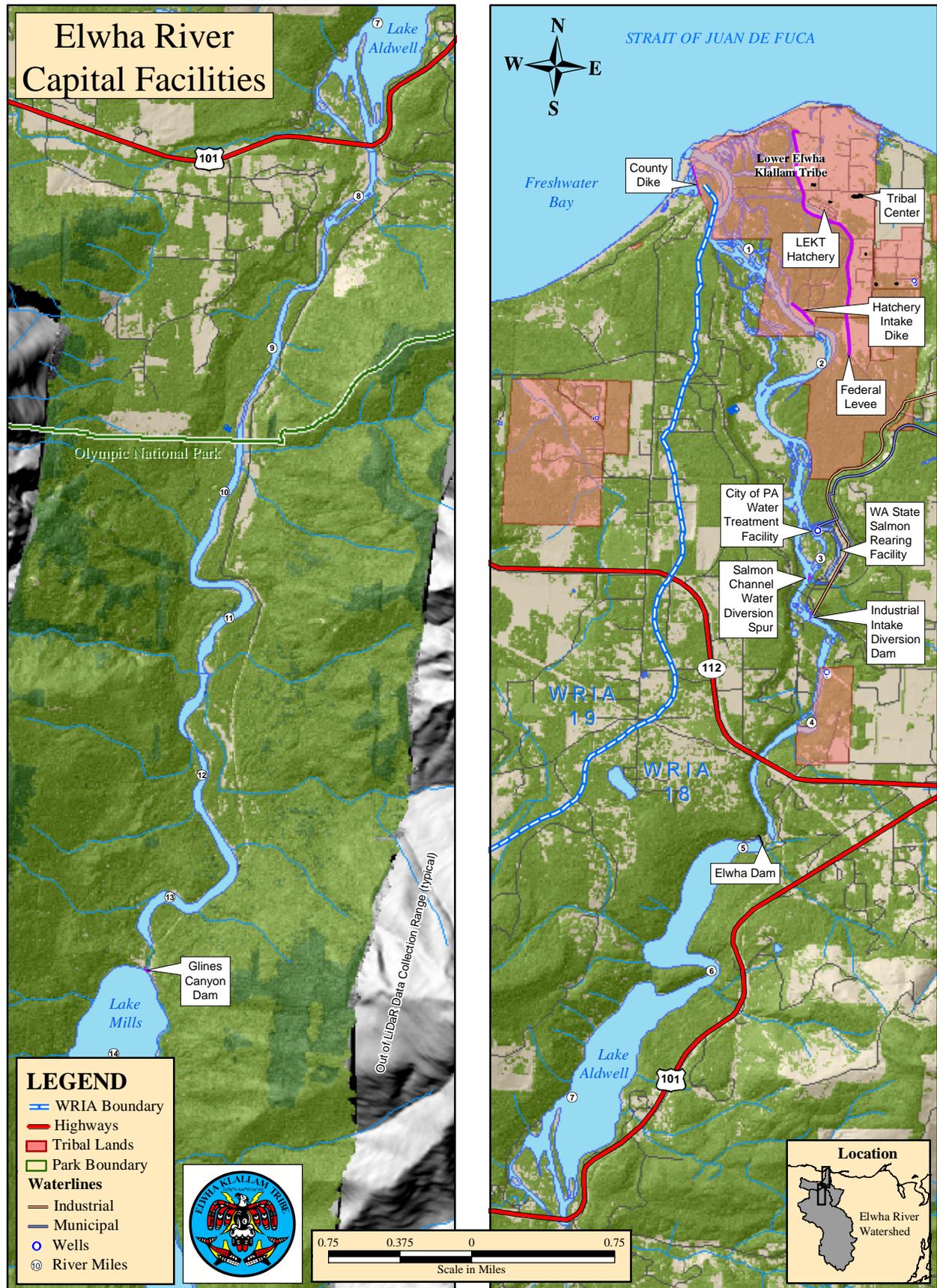


Figure 2.4-3 Elwha River Capital Facilities

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approximately 10 cfs. The United States holds unquantified additional water rights in trust for the tribe that are not issued by or registered with the state. These rights guarantee sufficient water to support treaty fisheries and the purposes of the Lower Elwha Klallam Reservation.

The Black Diamond Water District has a surface water right supplied from a surface diversion structure at approx. RM 0.5 of the South Branch of Little River.

### Dikes

The Elwha EIS (USDI et al. 1996) describes two major dikes present in the lower watershed. The 7640-foot-long Elwha flood control levee was constructed in 1988 by the US Army Corps of Engineers in the lower 1.5-mile floodplain of the river. Approximately 300 acres of Lower Elwha Klallam Reservation lands between the levee and the river are dedicated to flood abatement in this area. The levee, designed and constructed to withstand a 200-year flood, was built to protect structures in the 700-acre floodplain, including 305 acres east of the levee on Lower Elwha Klallam Reservation and private property. Operation and maintenance of the levee is the responsibility of the tribe, the local sponsor of the project. Structures within the floodplain now protected by this levee include approximately 60 houses, a community tribal center, two churches, a Head Start facility, dental clinic, tribal fish hatchery, and agricultural lands.

The 900-foot long privately owned and maintained levee on the west side of the Elwha extends downstream to near the mouth of the river from the high natural bluff line, preventing the river from migrating to the west beyond the shore zone. The design and construction criteria for this levee are unknown. Approximately 30 acres of residential development on the west side of the river are provided protection against 25- to 50-year floods. Flooding at the mouth of the river is also influenced by tidal conditions.

Two additional flood control structures exist on the river. The first is a spur dike just downstream of the one-lane bridge, which directs flow to the west side of the channel and away from the State Rearing Channel. The second structure is spur dike located immediately downstream of the McDonald Bridge Gage. This structure is about 400 feet long and provides nominal flood protection for properties west of the Olympic Hot Springs Road. Further, the Olympic Hot Springs Road itself lies within the floodplain in that same area, constricting flows while providing some unknown level of flood protection to several properties east of the road.

### Land Development

The Elwha EIS (USDI et al. 1996) provides the most recent and comprehensive description of land development along the lower Elwha River. In general, development has been confined to some forestry, a small agricultural component, and rural residential activity. In sum, these development activities do not represent a major impact to date. Further aspects of this land development are discussed under "Land Use and Demographics", below.

## **Modifications to Hydrograph/Fluvial Geomorphology**

### Channel Conditions

#### *Constrictions and Confinements*

The most significant alteration of channel conditions found along the Elwha River, by far, is the presence of the two reservoirs created by the Glines Canyon and Elwha dams, and their consequential channel effects. These channel effects include the inundation of ~6 miles of total channel length by the two reservoirs, the complete interception of sediment from its natural streambed maintenance function, and the reduction in channel-forming processes that result from the elimination of natural sediment routing through the system. Dam removal and river restoration are expected to fully restore these essential processes.

In addition to the dam/reservoir effects, the city's surface water diversion and the two flood control levees have significant impacts to channel conditions. Restoration of the Elwha incorporates a federal obligation to maintain the water supply that is currently routed through the diversion and to maintain the existing level of flood protection, even if the riverbed aggrades significantly. It remains to be seen whether or not the physical structures providing these benefits will be altered or replaced in ways that might reduce or eliminate their impacts on natural channel-forming process.

#### Log Jam and Large Woody Debris Removal

There has only been limited land development in the lower Elwha watershed. As was true on other rivers and streams throughout the west, there was a period of time during which there was extensive removal of log jams and large woody debris. The impacts of the loss of this channel component are compounded by the presence of the dams, which has virtually fully eliminated the natural delivery of new wood to the system. The overall riparian zone of the entire river is in very good condition, so there is a more than adequate supply of wood. However, as wood is recruited into the stream, it is intercepted at each reservoir and is then lost from its channel-related functions.

In recent years there has been a significant amount of effort to replace lost wood structure in the river. The effort has already achieved significant results and it will be continued as an integral part of the overall river restoration effort.

Woody debris currently trapped behind the two dams is under consideration for use in certain aspects of the overall river restoration plan. Because the volume and quality of the material won't be known until the reservoirs are drained, the extent and types of use for the wood will be determined during the course of restoration. At minimum, it is expected that some will be useful to include as part of the overall revegetation plan. There is also a possibility that some could be used for channel restoration, depending on how the restoration plan is finalized.

#### Substrate

There has been significant loss of substrate over the decades since the dams were constructed. This substrate loss is another of the very substantial impacts to fisheries. The dam removal and river restoration plan is being carefully designed to enable optimal

return to the streambed, the floodplain, the estuary, the coastal beaches, and the marine environment of the sediments and substrate material currently entrapped in the reservoirs.

### *Gravel Removal*

No specific info found. Presumably there has been occasional, incidental removal on a localized basis.

### Stormwater

As described above, the lower Elwha River watershed does experience modest stormwater impacts from the limited network of roads and the fairly sparse array of agricultural and residential properties. In sum, this probably does not represent a significant alteration to the hydrology or fluvial geomorphology of the river. In addition, the land ownership, land use, and zoning characteristics of the lower watershed (excluding the tributary subwatersheds of Indian Creek and Little River, addressed separately below) suggest that stormwater impacts should be able to be managed with little difficulty.

### Recharge

As discussed above, there is a high degree of hydraulic continuity between the surface water of the lower Elwha River and the associated aquifers, all of which are alluvial. As a consequence, recharge is more or less immediately and directly affected by any of the withdrawals from any of the major purveyors. To the extent that these withdrawals affect the adequacy of instream flow during low flow periods, it may be desirable to adjust the management of those withdrawals.

### **Soil Erosion and Sediment Load**

In the upper watershed, soil erosion and any resulting sediment load can be regarded as natural events occurring under acceptable conditions and requiring no management response. These sediments are intercepted and halted at the Lake Mills reservoir and from that point (RM 16) downstream, erosion and sediment load processes are significantly altered, having substantial impacts to channel processes.

From the sediment delta at the upriver end of the Lake Mills reservoir downstream to the mouth of the river and beyond, natural recruitment of sediment along the channel is virtually non-existent. With the exception of occasional erosion events occurring along the middle reach of the river (between the Glines Canyon Dam and the upper end of the Lake Aldwell reservoir—including the tributary watersheds of Indian Creek and Little River), and along the lower reach of the river (below Elwha Dam), there is no opportunity for sediment replenishment to the channel or the floodplain. At the same time, the lack of a continuous sediment source has resulted in the river cutting more deeply (degrading) into the streambed. This in turn leads to a more confined channel in some locations and creates areas of excessively eroded banks. It also results in the abandonment of some floodplain that is then only accessible during higher flows than would previously have been required, reducing the effectiveness of the floodplain functions.

Dam removal and restoration of the river corridor is intended to restore much of this natural erosion regime and the sediment processes associated with that erosion.

## Land Use and Demographics

### Areas Protected

The entire upper watershed of the Elwha River is in the permanent protection afforded by National Park status. This protection extends downstream to the park boundary at RM 9.7.

As part of the overall river restoration program, the lands surrounding and including the Lake Aldwell reservoir will also, following restoration, be managed in perpetuity in a fashion consistent with fisheries restoration and with the Wild and Scenic Rivers Act. At this time, ultimate management responsibility for these lands has not been determined, however, of four potential managing entities (NPS, USFWS, State of Washington, and Lower Elwha Klallam Tribe) only the Tribe has expressed an interest and put forward a proposed land use plan. The plan emphasizes compatibility with the overall restoration goals and also outlines upland areas proposed for residential, economic development, and resource management activities.

In addition, lands of the Lower Elwha Klallam Reservation are assured of a high degree of protection. The fisheries and natural resource management priorities of the Tribe result in significant long-term protection. Figure 2.4-4 shows the locations of restoration projects on the Elwha River, as identified by the Lower Elwha Klallam Tribe.

### Areas Most Affected

Within the Lower Elwha River watershed (excluding the Indian Creek and Little River subwatersheds), there is relatively little land use of significant current impact. Within that generally mild current condition, the areas most affected by existing land use (that will remain following dam removal and river restoration) would be those few pockets of comparatively aggregated residential use. There are five such areas sprinkled through the lower watershed:

- (1) Four residential properties on the east bank between RM 9.7 and RM 8.4.
- (2) Several residential and commercial properties in the northwest corner of the junction of Indian Creek and the river (currently the upstream end of the Lake Aldwell reservoir, just north of Hwy. 101).
- (3) The area incorporating Laird, Power Plant, and Seamit roads.
- (4) Several residential properties along the high bluff above the west bank of the river from ~RM 1.2 downstream to the mouth.
- (5) The Lower Elwha Klallam Reservation.

### Areas at Greatest Risk of Future Impacts

Within the Lower Elwha River watershed (excluding the Indian Creek and Little River subwatersheds), there are a few areas where potential future activities could have significant impacts if not managed effectively. These would predominantly be land development activities on existing large parcels found throughout the lower watershed.

The Elwha EIS (USDI et al. 1996) summarizes these circumstances, noting that timber companies and private individuals own tracts adjacent to and above the river shoreline



Figure 2.4-4. Restoration Projects, West WRIA 18

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below the Elwha Dam. Most of the lower five miles of the river valley, to the boundaries of the Lower Elwha Klallam Reservation, is privately owned and subject to county zoning and development regulations. The majority of the parcels in this section are 5- to 15-acre residential homesites. Eight private landowners hold a total of 849 acres in large lots (over 40 acres), several of which have development proposals pending.

### **Water Quality**

The EIS notes that the city of Port Angeles, Dry Creek Water Association, and Elwha Place Homeowners' Association groundwater withdrawals have been periodically tested for several contaminants as required by the Washington State Department of Health. Well water tested for turbidity, coliform bacteria, inorganic chemicals, trihalomethane, volatile organic chemicals, and pesticides was found to be of very high quality. Volatile organic chemicals were not detected in any samples. Inorganic maximum contaminant levels were not exceeded in any sample taken from Dry Creek Water Association (1990 to 1993) or Elwha Place Homeowners' Association wells (1985 to 1993). Trihalomethane concentrations were below the maximum contaminant levels in all Port Angeles (1988 to 1993) and Dry Creek (1989 to 1994) samples.

Only two constituents, iron and turbidity, were detected above maximum contaminant levels in the Port Angeles Ranney well samples taken from 1983 to 1993. Although the mean iron concentration of 0.2 mg/L was below state drinking water standards of 0.3, the maximum concentration detected was 1.0 milligram per liter. Samples of fine lake bottom sediment from Lake Mills were tested and found to contain high pore water concentrations of iron (average of three samples was 27.5 mg/L) and manganese (average of three samples was 4.67 mg/L). The dissolved iron and manganese concentrations could remain elevated with additional leaching from the sediment during dam removal, and cause iron fouling of groundwater delivery systems and mineral staining of fixtures and clothing.

Turbidity of the Ranney well water is lower than in the river because alluvial sands and gravels filter out a large portion of the particulate matter. The 1994 measured mean turbidity of 0.08 nephelometric turbidity units ((NTU) – a measure of how intensely light is scattered by particles in the water) does not exceed drinking water standards of 1.0 NTU. The maximum turbidity detected in the city's well from 1983 to 1993 was 4.8 NTU. All other inorganic constituents, including copper and lead, were detected at lower than state maximum contaminant levels.

The USGS tested water resources of the Lower Elwha Klallam Reservation in 1977 and found them to be of excellent chemical quality. The Lower Elwha Klallam Tribe has sampled two of their community wells for complete inorganic and organic analysis. All parameters tested were lower than state maximum contaminant levels.

### **Stream Channels**

With the exception of temperature and presence of PCBs, for which the Elwha River is on the 303(d) list of impaired water bodies, all other parameters are within acceptable ranges. It is expected that removal of the dams will eliminate the temperature impairment, while resolution of the PCB impairment remains an unaddressed question.

The Elwha EIS (USDI et al. 1996) states that the Elwha River, its tributaries, and Lake Mills and Lake Aldwell are classified by the Washington Department of Ecology as Class AA waters, signifying "extraordinary" quality. It also provides statistical results of water quality sampling activities conducted in 1985-86. Overall, the Elwha has relatively low concentrations of dissolved and suspended sediment loads, nutrients, and organics. Changes in natural water quality occur in the lower part of the watershed, mostly as a result of reduced sediment load and elevated water temperatures during the summer. Suspended sediment concentrations and turbidity of the lower river are related to reservoir trapping efficiency, flood flows, logging, agricultural practices, and bank erosion.

Water temperatures in the Elwha River are lowest during January and February and highest during August and September. Seasonal patterns in water temperature are highly influenced by yearly discharge, climatic conditions, and the presence of the dams. Dams have caused water temperatures to be elevated during critical summer months, sometimes severely degrading water quality for fish and other aquatic life in the river.

Values for pH and alkalinity indicate neutral to slightly alkaline conditions typical of oligotrophic (low biological productivity) waters (Wetzel 1975). Dissolved oxygen values are very close to saturation at all times of the year; these are excellent conditions for cold water fish (EPA 1976). Most water quality parameters vary little with time except for turbidity and suspended sediments, which increase during high discharge periods.

Nutrient concentrations in the Elwha River are relatively low. Nitrate, ammonia, total phosphorous, and ortho phosphorous concentrations are below those known to limit algal production (Wetzel 1975; Vollenweider 1968). Total phosphorous concentrations for most uncontaminated lakes range from 0.01 to 0.03 mg/L as elemental phosphorous (P) (Hutchinson 1957). The Elwha has an average total phosphorous concentration (as P) of 0.01 mg/L. As a result of these low nutrient concentrations, Lake Mills has very low phytoplankton production and can be considered oligotrophic (Mausolf and Sundvick 1976). Because of low algae production, Lake Mills and Lake Aldwell do not reduce downstream dissolved oxygen or increase turbidity and temperature as a result of biological activity.

### Nonpoint Sources

Though present only in moderate density and intensity, there is an array of typical nonpoint sources throughout the lower watershed. Forest practices, agricultural activities, road runoff, and septic systems are found throughout the watershed. Given the generally good quality of both surface and subsurface waters, it appears that these nonpoint sources are not currently a significant impact on water quality.

### *TMDLs*

There are no TMDLs in place for the Elwha River. However, PCBs were found in two water samples taken by the USGS from the river between the two dams in 1980. Subsequent fish tissue samples taken by DOE in 1999 have confirmed the presence of low levels of PCBs, but have been unable to locate any plausible source. This suggests either natural background levels or a source that is yet to be identified. These circumstances have led to a situation in which there is a reluctance to develop a TMDL. In lieu of a TMDL, some alternative response may ultimately be recommended. (Serdar

1999). The removal of the dams is not expected to remove this water quality problem because studies to date have not pointed to the dams as a likely source. The presence of these PCBs leads to the retention of the lower river on the 303(d) list until the matter is resolved.

### Point Sources

There are no point sources in the upper or lower Elwha watershed.

### **Groundwater**

Given the high degree of hydraulic continuity between the lower Elwha River and the associated alluvial aquifers, groundwater quality is of more or less equivalent importance as is surface water quality. The Elwha EIS (USDI et al. 1996) provides a thorough description of groundwater quality, describing it as being excellent overall. With the above noted exceptions of temperature and PCBs, surface water quality samples taken over the years, showing generally good to excellent water quality tends to confirm this level of quality for the groundwater as well. The EIS notes that the city of Port Angeles, Dry Creek Water Association, and Elwha Place Homeowners' Association groundwater withdrawals have been periodically tested for several contaminants as required by the Washington State Department of Health. Well water tested for turbidity, coliform bacteria, inorganic chemicals, trihalomethane, volatile organic chemicals, and pesticides was found to be of very high quality. Volatile organic chemicals were not detected in any samples. Inorganic maximum contaminant levels were not exceeded in any sample taken from Dry Creek Water Association (1990 to 1993) or Elwha Place Homeowners' Association wells (1985 to 1993); trihalomethane concentrations were below the maximum contaminant levels in all Port Angeles (1988 to 1993) and Dry Creek (1989 to 1994) samples.

Only two constituents, iron and turbidity, were detected above maximum contaminant levels in the Port Angeles Ranney well samples taken from 1983 to 1993. Although the mean iron concentration of 0.2 mg/L was below state drinking water standards of 0.3, the maximum concentration detected was 1.0 milligram per liter. Samples of fine lake bottom sediment from Lake Mills were tested and found to contain high pore water concentrations of iron (average of three samples was 27.5 mg/L) and manganese (average of three samples was 4.67 mg/L). The dissolved iron and manganese concentrations could remain elevated with additional leaching from the sediment during dam removal, and cause iron fouling of groundwater delivery systems and mineral staining of fixtures and clothing.

Turbidity of the Ranney well water is lower than in the river because alluvial sands and gravels filter out a large portion of the particulate matter, the 1994 measured mean turbidity of 0.08 NTU (nephelometric turbidity units – a measure of how intensely light is scattered by particles in the water) does not exceed drinking water standards of 1.0 NTU. The maximum turbidity detected in the city's well from 1983 to 1993 was 4.8 NTU. All other inorganic constituents, including copper and lead, were detected at lower than state maximum contaminant levels.

USGS tested water resources of the Lower Elwha Klallam Reservation in 1977 and found them to be of excellent chemical quality. The Lower Elwha Klallam Tribe has sampled two of their community wells for complete inorganic and organic analysis. All parameters tested were lower than state maximum contaminant levels.

Though groundwater sampling has not been done, the close hydraulic continuity between ground and surface water in this area permits consideration of surface water quality sampling results as an approximation of groundwater quality. As part of its Elwha EIS (USDI et al. 1996), the NPS took surface water quality readings from October 1985 to September 1986. These data are reported in the following sub-sections.

### Nitrates

Nitrates have been detected at low levels in surface water. The NPS results indicate a maximum of 0.1 mg/L, and an overall mean of 0.1 mg/L. This is well within the State standard.

### pH

pH ranged from 7.2 to 7.9, with a mean of 7.7.

### Iron

Iron has been detected above maximum contaminant levels (MCL), at up to 1.0 mg/L, with an MCL of 0.3 mg/L. The Elwha EIS (USDI et al. 1996) also noted that samples of fine lake bottom sediment from Lake Mills were tested and found to contain high pore water concentrations of iron (average of three samples was 27.5 mg/L) and manganese (average of three samples was 4.67 mg/L). The dissolved iron and manganese concentrations could remain elevated with additional leaching from the sediment during dam removal, and cause iron fouling of groundwater delivery systems and mineral staining of fixtures and clothing.

### Dissolved Oxygen

DO ranged from 9.8 to 13.3 mg/L, with a mean of 11.8 mg/L.

### Specific Conductance

Conductance ranged from 80 to 108 umhos/cm, with a mean of 93 umhos/cm.

## **Fish and Habitat**

Given the extensive and comprehensive attention given to fisheries and habitat issues in the entire Elwha River watershed, including the Indian Creek and Little River subwatersheds, this subject is addressed here for the entire ecosystem.

## **Salmon Distribution, Abundance & Stock Status**

The Elwha EIS (USDI et al. 1996) is largely directed toward the full restoration of all historic stocks in the watershed. It provides the majority of the information provided below.

### Natural Productivity

The natural productivity of the Elwha can be thought of in terms of what its historic productivity (prior to dam construction in 1910) might have been. However, accurate figures for that time are not available. As a substitute, the best available estimation is the

work done in the Elwha EIS (USDI et al. 1996) to project future salmonid productivity and the time period expected. This is summarized in Table 2.4-2 below.

**Table 2.4-2. New Wild Salmonid Production and Recovery Time (number of fish/year).**

	Action Alternatives (full restoration)		No Action <sup>a</sup> (existing conditions)
	Number of Fish	Years to Recovery	Number of Fish
Chinook	31,000	21-25	1,500-2,000 <sup>b</sup>
Coho	35,000	15-18	<500
Pink	274,000	16-20	0
Chum	36,000	18-21	<200
Steelhead	10,000	15-18	<500
Sockeye	6,500	12-20	0

Source: Elwha EIS USDI et al. 1996.

<sup>a</sup> No Action (existing conditions) would not result in any new wild salmon or steelhead. These figures are estimates of current production of wild anadromous fish in the Elwha River. Wild chum would likely decline to zero in time.

<sup>b</sup> All Elwha chinook are considered a composite of wild and hatchery stocks.

### Indigenous Fish Distribution, Abundance & Status

The Elwha EIS (USDI et al. 1996) describes ten stocks of anadromous salmon and trout that are either now present in the Elwha River or, based on data from neighboring rivers or other information were present before the dams were built. The ten stocks are winter and summer steelhead trout, coho, summer/fall and spring chinook, pink, chum and sockeye salmon, cutthroat trout, and native char (Dolly Varden and bull trout). In addition to these anadromous species, the Elwha harbors many non-migrating fish, including threespine sticklebacks, sculpins, resident cutthroat, rainbow, and native char. Marine species such as flounder are found in the estuary. White sturgeon and smelt also have been observed in this river in the past.

The Elwha River was legendary for its production of huge chinook; fish in excess of 100 pounds were recorded as late as 1930, 18 years after the closure of Elwha Dam (Brannon 1930). The river also was known as a producer of large quantities of pink and chum salmon. Although pink salmon were numerous through the 1960s, they appear to have died out by the late 1980s.

Approximately 70 miles of the mainstem river and its tributaries are estimated to have been available to anadromous species before the dams were built. Steelhead and possibly other species could have traveled as far as 43 miles up the 45-mile mainstem channel before encountering impassible stretches. Carlson Canyon Falls at RM 34 may have blocked some species, depending on timing and condition of the fish. It is unknown but widely speculated that the relatively poor jumping ability of pink and chum salmon may have restricted them to the region below Rica Canyon (RM 16).

The Elwha River is currently the largest producer of steelhead and chinook salmon on the Strait of Juan de Fuca and is second only to the Dungeness River for coho. Though salmon and steelhead run sizes in the Elwha appear minor in relation to Washington State's total production, they are significant contributors to the Strait of Juan de Fuca and

Vancouver Island fisheries, with the exception of chum salmon production which is small compared with other strait streams. Nearly all chinook, coho, and steelhead are hatchery-produced. A chum hatchery program operated for 10 years, but was abandoned in 1986.

Resident sport fish in the river system are dominated by rainbow trout and, to a lesser degree, native char. Very small numbers of cutthroat trout and brook trout are also present. The Elwha drainage is a major wild trout producer on the Olympic Peninsula. Its ranking to other regional streams is not known, but a creel survey conducted on Lake Aldwell, Lake Mills, and the middle reach indicated a high fishing effort (approximately 22,000 hours seasonally).

### Salmonid Stocks, Status and Life Histories

The Elwha EIS (USDI et al. 1996) provides the following descriptions of the various stocks.

#### *Chinook Salmon*

Chinook salmon are described by the season in which they enter their natal streams to spawn. Spring chinook enter fresh water several months earlier than summer/fall chinook. Before the dams were built, it is believed that chinook entering the river in the spring swam farther upriver and spawned upstream of Carlson Canyon Falls at RM 34. Fish entering in the late summer or fall spawned downstream of RM 34.

Chinook enter the Elwha River primarily from June through September. Adults require cool water (below 14°C) and medium-size spawning gravel, usually laying their eggs in a main channel of the river rather than its side channels or tributaries. Peak spawning occurs from September through mid-October, and adults die within days or weeks of spawning. Juveniles either migrate out their first spring or rear in the river and leave the following May and June as yearlings (Williams et al. 1985). All spend some time in the estuary as they grow and adapt to salt water. Native Elwha underyearlings move into the offshore marine environment in late July and early August.

Records show that chinook have been regularly stocked for many years. As early as 1930, E.M. Brannon, supervisor of the Dungeness Fish Hatchery, proposed the stocking of chinook in the Elwha. By 1945, the program was in full implementation. The major stock has been Elwha River summer/fall chinook. Spring chinook planted in 1973 and 1977 were from Dungeness and Sol Duc hatchery stocks. For the period 1985-1995, approximately 775,000 chinook yearlings were released annually, with fry and fingerlings totaling 2.6 million fish per year.

#### *Coho Salmon*

Coho salmon are another highly prized sport and commercial salmon species in Washington. The Elwha River, because of its hatchery program, is currently one of the largest producers of coho on the Strait of Juan de Fuca. Run size is a small portion (less than 1%) of the total Puget Sound coho production, but accounts for approximately 35% of the runs returning to the North Olympic Peninsula.

Adults enter the river from mid-August through early December, with some arriving as late as January. Spawning takes place from October into December, typically in gently sloping

(1-3%) tributary habitats, although adults can use main or side channel habitat. Coho adults die shortly after spawning. Most juveniles emerge from the gravel from late winter through mid-spring. Juveniles live for over a year in the system before migrating to the ocean from late March through mid-June; peak outmigration occurs in May. Overwintering habitat, which is critical for survival, is often associated with wooded off-channel areas such as ponds and side channels, though main channel pools also are used.

Coho are typically released from the hatchery into the river as yearling fish in April and May. Recent releases (1990-94) ranged from 0.4 to 0.8 million smolts per year. Since 1977, coho returns to the Elwha have varied from as high as 16,000 to as low as 1,100 fish per year, with the majority being hatchery fish. For the 1990-1994 period, the average return to the river was just under 3,000 coho per year.

### *Chum Salmon*

Chum salmon are a major commercial species in Puget Sound, infrequently captured by sport anglers. The historic Elwha River chum run, like the Elwha pink run, was considered abundant. Since the mid-1970s, though, the Elwha River has been a small contributor to total strait chum production and a very small portion to Puget Sound—with runs to the Elwha River typically less than 1,000 fish, and peaking in 1980 at 1500.

Native chum salmon migrate to the Elwha from September through early December with the majority entering in October and November. Spawning occurs from October into January in smaller sized gravels in low gradient channels and tributaries. Rearing and outmigration is very similar to pink salmon. Fry emerge from the gravel from March through early June and migrate directly to the estuary or ocean. Puget Sound chum spend their first few weeks in the marine environment in shallow water (less than 1 meter) before gradually moving offshore.

In 1977, the tribal fish hatchery began stocking chum fry from the Quilcene hatchery (Walcott Slough stock) into the Elwha River and used returning fish for broodstock beginning in 1980. This continued until 1986, with releases averaging 0.8 million fry per year. Production was discontinued primarily due to poor adult returns and low market value.

The historical upstream distribution of chum salmon is not known. However, chum are the poorest jumpers of all Elwha River salmon, and it is assumed that they did not migrate above RM 16 (Rica Canyon). Habitat in the middle and lower river is therefore particularly important to this species.

### *Pink Salmon*

Pink salmon are a major commercial salmon species in Puget Sound, returning primarily every odd year. Elwha River pink salmon production has dramatically declined since 1979, and the stock may now be extinct. The 1979 decrease in pink salmon returns was a regional occurrence with similar large decreases in the Dungeness River, the other major pink salmon bearing river in the Strait. This crash corresponds to a year of heavy rains and flooding, though the lack of suitable riverine habitat caused a subsequent long-term decline.

Pink salmon adults enter the river from July through September, spawning in smaller sized gravels with low gradient channels and tributaries. Eggs deposited in the stream bed gravels incubate during the winter and hatch in early spring. Juveniles emerge from the gravels and move downstream toward the sea within hours or days of hatching. Because they are so small, they are not as strong swimmers as older juveniles of other species and are largely swept by the downstream current to the river mouth and estuary, where they grow and feed. Juveniles spend up to two months maturing in estuaries or nearshore marine habitat before moving into deeper water.

There has been no hatchery program for Elwha pink salmon since the failed hatchery program in the 1920s. Peak runs and escapement to the river since 1959 were nearly 40,000 (in 1963). Since 1979, however, estimated runs and escapement have been in the hundreds; since 1989, probably fewer than five fish annually.

The historical upstream distribution of pink salmon is not known. However, based on increasing stream gradient, it is assumed that they did not migrate above RM 16, about the upper end of Lake Mills. Therefore, habitat below that point, including the inundated reservoir areas, is critically important to pink salmon.

### *Steelhead*

Steelhead trout, an anadromous form of rainbow trout, are one of the most sought-after sport fish in the state and also support substantial tribal commercial harvest. Because of the tribal hatchery program, the Elwha River is the largest producer of steelhead in the Strait of Juan de Fuca. Although the Elwha ranked tenth highest among state streams for winter steelhead sport catch in 1987-1988, this ranking has declined in recent years.

Winter steelhead typically enter the Elwha from as early as November to as late as June, while summer steelhead migrate upstream from late April through September and occasionally into October. Summer steelhead reside in the river for up to six months before spawning, and both races spawn in the spring. Most juveniles rear in the river for two years before migrating to the ocean, although rearing ranges from one to three years. Approximately 5% of adults migrating upstream have spawned before. Adults that spawn and return to the ocean are called "kelts" on their trip out to sea.

Steelhead spawn in mainstem and tributary streams and use a wide range of substrate sizes from fine gravel to medium cobble. Rearing juveniles use both tributary and mainstem habitat. Moderate to high gradient habitat (0.5-5.0% slope) is generally the most productive for rearing steelhead.

As typical for other streams in the area, the winter run is larger, accounting for more than 80% of the total steelhead harvest. Beginning about 1979, the Lower Elwha Tribal Fish Hatchery began to rear winter steelhead and has continued to collect stock returning to the Elwha for rearing and release. This facility is now the primary source of winter steelhead for the river.

Approximately 3,100 winter adults enter the river from an average of 82,000 hatchery smolts released each year. The Lower Elwha Klallam Tribe operates a commercial in-river fishery for hatchery run winter steelhead; these harvests average 1,450 fish per year for

the tribe. Sport anglers additionally harvest an estimated 1,150 winter and 355 summer steelhead each year (PNPTC and WDFW 1994).

### *Sockeye Salmon*

Sockeye salmon are one of the most prized commercial salmon species in Washington, although state-originated runs are small. All major stocks of sockeye require a river system with a connected lake for spawning and rearing purposes. The only lake in the Elwha River drainage is Lake Sutherland, now inaccessible because of the Elwha Dam. Lake Sutherland drains into Indian Creek, which enters the Elwha at RM 7.5, between the two dams. Records (1982-1991) show an in-river harvest of only eight sockeye total over the ten-year period; these fish were probably strays, and could have come from coastal (Ozette or Quinault), Puget Sound (Baker or Lake Washington), or Fraser River runs. There are no hatchery operations for sockeye on the Elwha River.

Lake Sutherland currently supports a population of kokanee, generally recognized as lake-bound sockeye. It is anticipated that removal of the dams will enable these kokanee to become the founding population from which an anadromous sockeye run may be naturally re-established in the future.

### *Searun and Resident Cutthroat Trout*

Both resident and anadromous races of cutthroat trout were probably present in the pre-dam Elwha River. Searun cutthroat trout are a major sport species in the state although they are less abundant than steelhead in most areas. A regionwide decline in searun cutthroat populations has occurred in the past 15 to 20 years.

Searun cutthroat are not abundant in the lower river, though they are caught incidentally (fewer than five annually) during other in-river fisheries. Similarly, resident cutthroat trout are not numerous in the upper reaches of the Elwha, though small numbers were found in the middle reach, particularly in Indian Creek. In a 1981-82 creel survey of Lake Aldwell and Lake Mills, no cutthroat were observed. It is possible that more isolated populations may be present farther up tributary streams in this system, since cutthroat are often present in these areas in the state. Hatchery outplanting of cutthroat into nearby Lake Sutherland averaged 10,500 fish annually, for the period 1982-91, except 1984.

Adult anadromous cutthroat trout migrate upstream from July to January at least once before they are ready to spawn. Spawning occurs from December to March, most often in low-gradient tributaries of small or moderate-sized streams (<46 square miles), draining sloughs, or meadowlands. As many as 40% are repeat spawners. Fry emerge in late spring. Cutthroat juveniles mature in and live for several years in their natal streams before migrating as smolt. Generally, fish from coastal stocks leave later (age five) than do fish from inner Puget Sound (most at age two). Outmigration is from March to May. Adults in the marine environment stay within 30 miles of their stream of origin.

### *Bull Trout*

Bull trout and Dolly Varden (each also known as native char) populations in Washington are minor sport species because of their limited abundance. Little is known about the

species in Washington. They are widely distributed in the state, but not locally abundant. Like cutthroat, there are both anadromous and freshwater races.

Anadromous populations migrate from the sea upriver from May to December (usually August to September) with spawning occurring in the fall, usually October. Fry emerge in April to mid-May. Anadromous stocks migrate to sea at age three or four in the spring and return to the same river in the fall, spending only late spring to fall in the marine environment each year of their life. Like cutthroat, char migrate only a short distance from the river in the marine phase and spend the entire time in tidal water. In systems with lakes, resident fish may undergo similar migrations, spending summers in the lake and other times in the river.

### *Resident Rainbow Trout and Other Species*

Rainbow trout and small populations of brook trout (nonnative) occupy the upper Elwha, as well as the reservoirs and middle reach of the river. These are non-anadromous populations of trout, although the impulse for rainbow to migrate to sea may remain.

The life history of rainbow trout is similar to the steelhead. They spawn from April to June with fry emerging in early to mid-summer, depending on temperature. Rainbow trout are well adapted to Northwest streams, commonly residing in most regions of a watershed including lakes, mainstem rivers, and tributary streams.

The creel survey conducted by Collins in 1983 found slight differences between rainbow stocks in Lake Mills and those in the middle reach and Lake Aldwell. Rainbow trout in Lake Mills were generally larger and more abundant for the same age than those in the middle reach and Lake Aldwell. Collins concluded that the rainbow population characteristics (i.e., size, distribution, and abundance) in all areas sampled were probably controlled by angler harvest. Although fishing restrictions have been imposed since this study, some anglers still believe the fishing has not improved and that other factors (e.g., food availability, water quality, and habitat conditions) may be affecting populations.

There have been sporadic plantings of rainbow trout in the Elwha River, the two reservoirs, and Lake Sutherland. In the latter case, the most recent fish plants were 1982-84 and 1992, ranging from 1,300 to 17,000 fish annually (WDF et al. 1993). These fish were to supplement a recreational fishery on the lake, though some portion of the fish likely escape the lake and move downstream into the mainstem Elwha River and reservoir.

### *Other Stocks*

Other fish that may occur in the Elwha River include dace, peamouth, suckers, threespine stickleback, sculpins, whitefish, smelt, and sturgeon. Sturgeon are a major commercial and recreational species in Washington with the most important stocks utilizing the Columbia and Chehalis rivers. While resident populations occur in the largest Northwest rivers (i.e., the Columbia), most stocks are anadromous. They are occasionally taken in tribal net fisheries in the Elwha River.

### Reintroduction and Restoration Strategies

Reintroduction and restoration activities throughout the mainstem Elwha River will be guided by the comprehensive program managed by the NPS in conjunction with dam removal and ecosystem restoration.

Supplemental restoration activities in the lower Elwha watershed outside the areas encompassed by the NPS restoration program will need to be closely integrated with that larger effort. Haring (1999) summarized the recommended supplemental restoration work that might be contemplated, emphasizing that restoration of the Elwha is not confined to dam removal alone. Floodplain and channel conditions are currently severely altered, particularly in the floodplain downstream of Elwha Dam, and it is simplistic to believe that dam removal alone equates with ecosystem restoration in the Elwha River. The Technical Advisory Group (for the Limiting Factors Analysis) believes that significant restoration actions could and should occur in the lower Elwha River prior to dam removal. These actions can help prepare the lower river for the dramatic changes expected following dam removal. Specifically, the highest priorities for the Elwha include:

- Systematic restructuring of the lower and middle river with large wood
- Removal of selected dikes and other channel constrictions
- Riparian restoration
- Acquisition/conservation easement access and setback of structures constructed within the channel migration zone

In the Elwha EIS process, the cost of interim gravel supplementation downstream of Elwha Dam was evaluated and found to be cost prohibitive (on the order of \$300,000/year, not including a collection strategy from the deltas). In addition, the bulk of the sediment is located in Lake Mills, upstream of Glines Canyon Dam and within Olympic National Park.

### **2.4.3 Indian Creek (WRIA # 18-0283)**

#### **Geography**

Perry (2001) describes the Indian Creek watershed as lying within a very broad, east/west elongated valley. Lake Sutherland is found at the head of this valley. From its origin at the east end of Lake Sutherland to its outlet into the Elwha River at the upper end of the Lake Aldwell reservoir, Indian Creek flows a total length of 5.65 miles. Although the watershed covers an expansive area of about 20 square miles, the drainage network within the watershed is very poorly integrated. The southern boundary of the watershed attains elevations in excess of 4500 feet extending along Baldy Ridge, and to Mount Storm King. The highest elevation along this boundary is just under 5100 feet at the western end of Baldy Ridge. The western end of Indian Creek valley is essentially bounded by Olympic National Park, while the southern two-thirds of the valley lies within Olympic National Forest.

Elevations are somewhat lower along the northern boundary of the watershed. Although a maximum elevation of just over 2400 feet is found at the western end of the northern watershed boundary, elevations tend to remain somewhat below 2000 feet along the length of this segment of the watershed. At the head of the valley, a low divide separates

the Indian Creek valley, including Lake Sutherland, from the Lake Crescent valley, to the west. Indian Creek drains from the eastern end of Lake Sutherland, and flows eastward down the valley, to the southern end of Lake Aldwell on the Elwha River.

The eastward sloping valley floor of Indian Creek is typically somewhat broad and flat until the stream is within a mile and a half of its confluence with the Elwha River. In this lower reach, the valley narrows and the stream falls into a narrow, ravine-like valley until reaching the flood plain of the Elwha. Accrual of groundwater to the stream seems to progressively increase baseflow of the stream in a downstream direction along the streamcourse. This may be particularly evident within the lower reach of the stream where the stream flows in the deepened valley section.

Tributary inflow to Indian Creek is supported by several highland subwatersheds along the southern margin of the valley. These subwatersheds originate on Baldy Ridge, and appear to be poorly integrated. Within the western half of the valley, the lone watershed of Falls Creek is a highland subwatershed which shows this typically poor integrated characteristic of the highland drainage. Areas within the Indian Creek watershed that would be classified as upland subwatersheds do not show any drainage network with sufficient definition to be significant.

## Geology

Tabor and Cady (1978) have mapped the Indian Creek watershed, showing the entire southern side of the east-west oriented watershed (above the lower valley floor) being composed of basalt of the Crescent Formation. At the upper end of the watershed, Lake Sutherland is now separated from Lake Crescent by massive landslide deposits that occurred in prehistoric times. The northern side of the watershed consists of Crescent basalts along the lower elevations (above the valley floor) with the siltstone/sandstone/conglomerate of the Aldwell Formation at the higher elevations. The valley floor consists of glacial gravel deposits left by the continental ice sheet's withdrawal. These deposits widen downslope as the creek flows eastward to the Elwha, to a width of over one mile where the deposits join the Elwha River lobe of these same glacial materials.

## Soils

The USDA Soil Conservation Service (SCS) *Soil Survey of Clallam County Area, Washington* (SCS 1987) characterizes the soils of Indian Creek. The SCS describes 11 soil units for Clallam County, two of which are found in the Indian Creek watershed.

The soils of the mountain slopes of the entire Indian Creek watershed are of the Terbies-Louella group. These gravelly loams, including Neilton loams, and very gravelly sandy loams are deep to very deep and well-drained on moderately to extremely steep slopes and mountain sides. The SCS found these soils suitable for forest land but not for most other uses, due to steep slopes. They have a high erosion potential due to the large amount of precipitation common to the area and the steepness of the slopes. Disturbance, such as logging and development, can greatly increase the chances of slides.

The valley bottom is covered by Neilton-Lyre-Casey soils. These very deep soils are poorly to excessively drained on nearly level to very steep (70%) slopes, terraces, and terrace escarpments. The SCS (1987) considers this soil suitable for woodland and limited homesite development. Limitations on the use of these soils for these purposes are steep slopes and the wetness of the Casey soil components. The Neilton and Lyre soils are marginal for support of septic systems due to poor filtration capabilities and steepness of slope, while the Casey soils are limited by wetness and poor permeability.

### **Fluvial Geomorphology**

The presence of Lake Sutherland as the source of Indian Creek, the moderate overall gradient, and the limited extent of human activity in the watershed (with the notable exception of the intensive residential activity surrounding Lake Sutherland itself), result in a stream channel that is generally very stable. There is little indication of significant channel migration or substantial sediment migration through the watershed.

Winter season snowpack within the well-forested higher elevation slopes of the steeper north-facing south valley wall, may slowly ablate during an extended snowmelt period lasting well into the summer. This valley wall appears to be well shaded due to its steep north facing aspect and dense vegetation, and hence the consequence for the extended period of snowmelt. This slow rate of melting may produce significant infiltration and result in considerable subsurface recharge. Therefore, because there is not a sufficiently developed drainage network in evidence resulting from such characteristically high precipitation, much of the higher elevation precipitation that remains as snow must produce significant recharge to a groundwater system that is drained through the Indian Creek valley. This groundwater flow may discharge into Indian Creek and appears to be the source supporting baseflow of the stream. However, in the lowermost segment of the stream near Elwha River, a substantial part of the groundwater underflow may discharge directly into the Elwha.

### **Hydrology & Geohydrology (Natural Water Balance)**

#### **Hydrology**

##### Precipitation

Perry (2001) describes that precipitation for the Indian Creek watersheds range from an average of about 55 inches annually in the lowermost segment of the valley near the Elwha River, to in excess of 80 inches annually in the vicinity of Mount Storm King at the western end of the valley.

##### Interception And Evapotranspiration

In his report (Perry 2001), Perry provides a generalized picture of the role of interception and evapotranspiration losses which have yet to be applied to specific watersheds.

##### Annual Hydrograph

Perry (2001) has developed an annual hydrograph for Indian Creek, at its mouth at the Elwha River, using a watershed characteristics methodology in a direct comparison with

the East Twin River gage near Pysht, about 16 miles to the west. The computed hydrograph (Figure 2.4-5) suggests typical annual monthly high flows at about 240 cfs and low flows at about 10 cfs.

Perry notes that there are some limitations to this method that should be acknowledged, explaining that, if the seasonal flow of Indian Creek is like that of East Twin River, the seasonal variability of the flow may be somewhat different than that of similar streams within the EMMT study area. Characteristically, the reconstructed record of this stream shows a seasonal flow maximum that occurs in response to the winter season precipitation maximum. Flow is noted to decline steadily throughout the summer. Minimum flow is indicated to occur in August, yet the minimum flow season is well defined and ends as fall begins.

### Peak Flows

Peak flows have not been directly measured on Indian Creek.

### Stormwater Runoff And Flood Hazard

The largest source of stormwater runoff is the length of US Hwy. 101, which extends along the entire length of the Indian Creek valley—a distance of ~8.5 miles before crossing the westward divide into the Lake Crescent watershed. The extent and nature of this highway-based stormwater has not been studied, but is likely to be of relative importance within this watershed.

Otherwise, given the sparse population and comparatively stable landscape conditions along the length of Indian Creek, the potential for significant stormwater runoff or flood hazards is small and probably of limited consequence. However, the population density and parcel development surrounding Lake Sutherland itself does represent a significant potential stormwater runoff impact to the watershed—though probably more in terms of water quality impacts than of stormwater volume.

### Low Flows

Low flows have not been directly measured on Indian Creek.

## **Geohydrology and Hydraulic Continuity**

### Subsurface Inflow

As noted above, Perry (2001) has described a high likelihood of a strong subsurface inflow connection due to the slow melting of annual snowpack into a watershed with a poorly defined drainage network (which, if present, would more quickly transport water through and out of the watershed).

### Leakage From Streams

With this poorly defined drainage network and a limited number of small tributaries, there is probably a fairly small component of leakage from streams (as distinguished from generalized subsurface inflow).

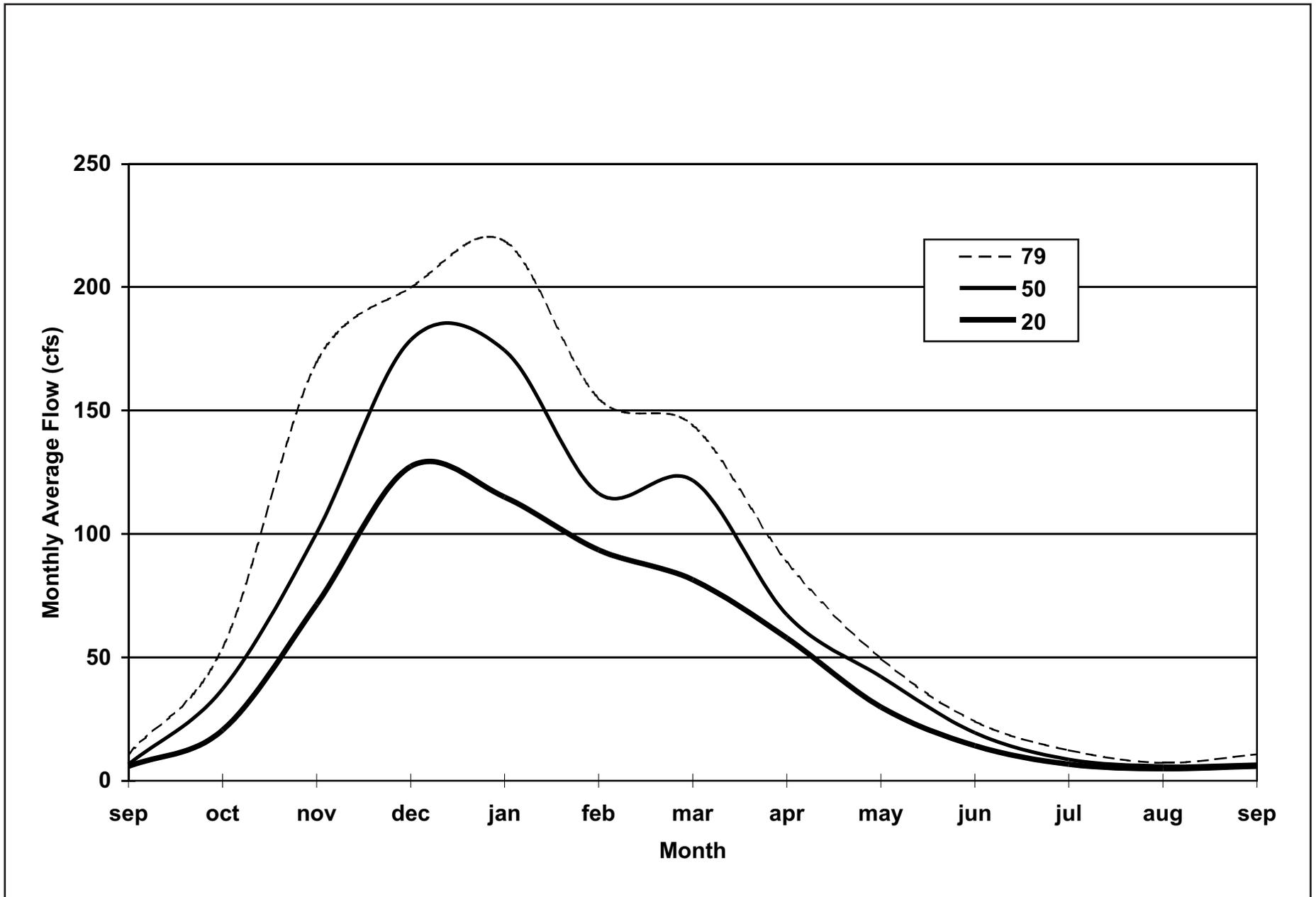


Figure 2.4-3. Indian Creek above the Confluence with the Elwha River 1952-76. Recent data indicate flows are overestimated. Exceedence Flow Duration Curves at less than or equal to 79, 50, and 20 percent.

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### Septic Recharge

With very few residences along the length of Indian Creek (even including the small residential aggregations in the Herrick Road neighborhood and the Lake Aldwell Road neighborhood, both in the lower mile of the creek), septic recharge is not likely to be a significant factor in the creek's hydrology. Any septic recharge implications resulting from the dense population surrounding Lake Sutherland is probably fully buffered by the volume of water represented by the lake itself.

### **Water Quality Constraints to Water Present and Available**

No such constraints have been identified, but continuing attention may be appropriate regarding potential water quality impacts from the comparatively dense residential population surrounding Lake Sutherland.

### **Factors of Change**

#### **Human Influences/Major Projects**

The presence of US Highway 101 is probably the most significant influence to the watershed at this time. As noted elsewhere in this subsection, future land use activities such as timber harvest, land conversion and development, and potential expansion of activities surrounding Lake Sutherland are activities that may require careful management in order to minimize impacts.

#### Dams

There are no dams in the Indian Creek watershed. There is a small outlet structure at the east end of Lake Sutherland as it feeds Indian Creek. The structure serves to retain fish stocks present in the lake and, to a limited extent, control and maintain the elevation of the lake—primarily to support recreational uses.

#### Land Development

The largest area of land development is surrounding Lake Sutherland. As noted above, there do not appear to be any current impacts or influences of significance. However, potential future land development activities such as conversions of timber lands and/or expansion of Lake Sutherland development may become consequential.

### **Modifications to Hydrograph/Fluvial Geomorphology**

#### Channel Conditions

Though the watershed experienced extensive logging in past decades, the forested areas are now largely composed of stable second growth. Channel conditions in this comparatively stable context appear to be more or less stable as well, though the size, location and character of the current channel is probably somewhat different from its historic form.

There is an important, though not fully understood, wetland complex in the lower portion of Indian Creek. Flow data taken by Streamkeepers volunteers in November of 2002 found that on one day, flow leaving Lake Sutherland was approximately 10cfs. This decreased to

3cfs in the wetlands complex and then increased to 20cfs at the outlet of the complex. Not only is the wetlands complex an important feature of Indian Creek, likely buffering both winter high flows and summer low flows, but it may also buffer temperatures in Indian Creek during the summer (an important fact, as the creek is lake-fed). However, the complex may also be a bottleneck for fish passage during the summer, potentially affecting the chances for restoration of sockeye to Lake Sutherland. Further, it is unclear if this wetland is naturally occurring or if it was created by construction of Highway 101, logging, or other anthropogenic cause(s).

### *Constrictions and Confinements*

None identified.

### Log Jam and Large Woody Debris Removal

The history of logging in the watershed, and especially along the riparian area, has resulted in a lack of truly large woody debris. However, there is ample and adequate woody debris throughout the length of the channel.

### Substrate

No significant changes to Indian Creek's streambed have been identified.

### *Gravel Removal*

No specific information was found. Presumably there has been occasional, incidental removal on a localized basis.

### Stormwater

Stormwater quantities do not currently appear to have any significant impact on hydrology or fluvial geomorphology.

### Recharge

Recharge appears to be operating at more or less natural levels and does not appear to have any significant impact.

### **Soil Erosion and Sediment Load**

Soil erosion and sediment load have not been identified as having any current significance. However, these sorts of impacts might accompany future land use activities in the watershed and therefore it may be useful to monitor this in the future.

### **Land Use and Demographics**

#### **Areas Protected**

The only areas of the Indian Creek watershed that are protected in any way are those covered by local ordinance or regulation such as the county critical areas ordinance.

**Areas Most Affected**

The areas most affected by current land use are the US Highway 101 corridor and the Lake Sutherland area.

**Areas at Greatest Risk of Future Impacts**

Future impacts are most likely to occur as land development occurs around Lake Sutherland, as conversions of timber lands are implemented, and/or as additional commercial or residential activities take place along the highway corridor

**Water Quality**

Water quality monitoring has generally not been conducted in the Indian Creek watershed. Consequently, characterization of water quality can only be made through inference and consideration of the typical impacts of activities and land uses present in the watershed.

**Stream Channels**Nonpoint Sources

Though present only in moderate density and intensity, there is an array of typical nonpoint sources throughout the watershed. Forest practices, agricultural/hobby farm activities, highway runoff, and septic systems are found throughout the watershed. Given the generally good quality of both surface and subsurface waters, it appears that these nonpoint sources are not currently a significant impact on water quality.

TMDLs

There are no TMDLs in place or proposed for the Indian Creek watershed.

Point Sources

There are no point sources in the Indian Creek watershed.

**Groundwater**Seawater Intrusion

Seawater intrusion is, in all likelihood, not present in the Indian Creek watershed given its nearly five mile distance from the saltwater of the Strait of Juan de Fuca.

**Stormwater**

Stormwater arising from the US Highway 101 corridor will likely be found to have water quality impacts typical of highway runoff, including hydrocarbons and heavy metals. It is difficult to estimate the degree of significance or insignificance of this stormwater source.

## **Fish and Habitat**

With the exception of certain watershed-specific fisheries and habitat information included below, this subject is addressed primarily in the Elwha River watershed subsection (2.4.2).

### **Salmon Distribution, Abundance & Stock Status**

#### Natural Productivity

Given the lengthy interruption of anadromy caused by the dams, natural productivity of the Indian Creek watershed is difficult to quantify. No historic records have been identified and no watershed-specific evaluations have been conducted.

#### Indigenous Fish Distribution, Abundance & Status

The current productivity of the watershed is limited to kokanee (nonanadromous salmon) and trout in Lake Sutherland, and some trout in Indian Creek.

#### Salmonid Stocks, Status and Life Histories

##### *Chinook Salmon*

Based on informal qualitative assessment of the Indian Creek watershed, tribal biologists infer that chinook would likely have been occasional occupants of some of the lower portions of the creek where flows and channel characteristics would have been consistent with their requirements (McHenry, pers. comm., 2002). The life history would be closely aligned with what is described in the Elwha River subsection.

##### *Coho Salmon*

Based on informal qualitative assessment of the watershed, tribal biologists infer that coho would likely have been common in the watershed (McHenry, pers. comm., 2002). The life history would be closely aligned with what is described in the Elwha River subsection.

##### *Chum Salmon*

Though not currently found, Indian Creek is likely to have supported a chum population of moderate size. The life history would be closely aligned with what is described in the Elwha River subsection.

##### *Pink Salmon*

Though not currently found, Indian Creek is likely to have supported a pink population of moderate size. The life history here would be closely aligned with what is described in the Elwha River subsection.

##### *Kokanee (Sockeye) Salmon*

A significant population of these non-anadromous salmon is present in Lake Sutherland. Two spawning types are generally found among kokanee—lake (shore) spawners and river (lake tributary) spawners. The Lake Sutherland kokanee are thought to consist entirely of the shore spawning type.

## Harvest

There are no substantive records of harvest specific to the Indian Creek watershed.

## Reintroduction and Restoration Strategies

Within the framework of the Elwha restoration, Indian Creek and Lake Sutherland would be involved in the restoration of nearly all stocks. The details of the fisheries restoration plan component of the overall Elwha River restoration effort continue to evolve following the first “draft” provided as part of the Elwha EIS (USDI et al. 1996).

### *Chinook (Summer/Fall) Salmon*

The Elwha EIS (USDI et al. 1996) restoration plan offers an option for the use of Indian Creek (and Little River) as a low elevation outplant acclimation site for chinook fingerlings (120-150/lb.) for up to two months and ending no later than June 30, at which time they would be freed to volitionally emigrate.

### *Coho Salmon*

Tribal biologists have suggested that Indian Creek will be a particularly productive stream for coho, which will be attracted to the extensive wetland and other preferred habitat (McHenry, pers. comm., 2002). The watershed may be a candidate for active outplanting or may simply offer a fertile opportunity for natural recolonization.

### *Chum Salmon*

The restoration plan suggests use of Indian Creek as a site for smolt (450/lb.) outplants and egg outplants in remote incubators, with outplanting conducted in spring.

### *Pink Salmon*

Pink salmon would be “mass” outplants (to swamp predators) as smolts (1125/lb.) and as eggs in the lower river (below RM 16 on mainstem and principal tributaries such as Indian Creek).

### *Sockeye Salmon*

Indian Creek offers the only location in the entire Elwha River watershed where sockeye could be reestablished. Though this is a very uncertain possibility, the opportunity has been provided for in a more or less passive way. As explained in the Elwha EIS (USDI et al. 1996), the native lower river stock no longer exists because Elwha Dam blocks access to Lake Sutherland, which is needed to complete the freshwater phase of the sockeye life cycle.

The only option considered by the EIS is to rely on Lake Sutherland kokanee to reestablish a native sockeye run. Kokanee (non-anadromous sockeye) may retain the genetic drive for anadromy over a number of generations. Regaining unrestricted access to the sea by removal of screens in the Lake Sutherland outlet (after removal of the Elwha Dam) may, in time, permit reestablishment of a native sockeye run from the existing

kokanee population of Lake Sutherland. Indian Creek also would be surveyed to ensure that passage (adult and juvenile) is possible.

A key question is the uncertain parentage of Lake Sutherland kokanee. Washington State hatchery records indicate release of nonnative (Lake Whatcom stock) kokanee in Lake Sutherland from at least 1944 until 1964. The Lake Sutherland kokanee population has sustained itself to present, but the influence of nonnative kokanee releases on the native kokanee/sockeye population is uncertain.

To answer questions about Elwha sockeye restoration, an examination of the existing kokanee population was conducted in 1994 to determine the number and genetic makeup (by DNA testing) of Lake Sutherland kokanee, the lake's productive potential for sockeye, and whether smolt production presently occurs in the kokanee population. Results suggest that a historic sockeye population of at least several thousand beach spawners exist, but no evidence of anadromy (smolt production) in the lake's kokanee population was found.

The EIS concludes by explaining that presumptions of Elwha sockeye parentage and ability to stimulate anadromy may not be met, and prospects for successfully importing a nonnative stock are not optimistic. Reliance on natural reestablishment of sockeye is, therefore, the only proposal.

### *Steelhead Trout*

Tribal biologists have suggested that Indian Creek will be a potentially productive stream for steelhead, especially in the upper portion of the watershed (McHenry, pers. comm. 2002). The watershed may be a candidate for active outplanting or may simply offer a fertile opportunity for natural recolonization.

### **Instream Flows**

No instream flows have been established.

### **Habitat Connectivity**

For purposes of fisheries restoration, Indian Creek's habitat is more or less intact. There may be some passage constraints through the culvert at the lower highway crossing, and through some low-elevation wetlands during periods of low flow.

### **Habitat Use and Availability**

#### Spawning and Rearing Habitat

Existing riparian habitat is probably adequate to support restored stocks as intended. Some habitat improvements to enhance passage and to add larger pieces of LWD may be appropriate.

The most significant habitat issue is likely to be the long-term availability and protection of sufficient beach/shoreline habitat around Lake Sutherland to support kokanee/sockeye populations.

### **Introduced Species/Predation**

None reported.

### **Ecosystem Functions and Conditions**

While seeming to be in generally reasonable condition, little recent attention has been given to the Indian Creek watershed.

#### Riparian Corridor And Floodplain

The corridor and floodplain have been modified by logging and rural residential activities over the past decades. However, the overall condition of these ecosystem components is fairly intact and is probably adequate to support healthy populations of restored stocks.

#### Wetlands

The Indian Creek valley has several substantial wetland areas that appear to be more or less stable. Historic logging and other land use activities may well have altered and expanded some of these wetland areas (Pat Crain, Clallam County, pers. comm. 2003). The current distribution and form of these wetlands may create passage problems during low flow periods and is a question that calls for further investigation.

## **2.4.4 Little River (WRIA # 18-0297)**

### **Geography**

Perry (2001) observes that the Little River watershed (~23 square miles) is one of the most diverse watersheds of any of the small streams in West WRIA 18. The Little River watershed is comprised of two main tributary watersheds, and a confluence watershed. South Branch Little River is the principal tributary that joins Little River, and produces most of the flow in the stream. Above and below the confluence of South Branch with the mainstem of the Little River, lie the upper and lower segments of Little River, respectively. The upper Little River watershed contributes somewhat less flow than South Branch, and the combined flow of these two stream segments continues westward through the watershed below the confluence, which contains the mainstem of the lower Little River.

This diverse watershed contains each of the basic subwatershed types, except coastal lowland. Vegetative cover within the Little River watershed ranges from old-growth forest, to commercial forest, to other lands that have been cleared and partially developed. The elevation range for the Little River watershed extends from nearly 6500 feet at the summit of Mount Angeles, down to an elevation of just over 200 feet, at the confluence of Little River, with the Elwha River.

### **Lower and Upper Little River Watersheds**

The mainstem of Little River flows through, and defines, the lower and upper watersheds of the stream. The confluence of Little River with South Branch Little River separates the upper and lower watersheds. The crest of The Foothills defines the northern boundary of the upper watershed (~4.8 square miles), while the common boundary with the Ennis Creek drainage defines the eastern boundary of the upper watershed. Both of the upper and lower watersheds occupy somewhat more than one-third of the total Little River

watershed area. These watersheds lie within the northern half of the tributary area for Little River with the upper watershed being partially within Olympic National Park. Vegetative cover within the National Park is predominantly protected old-growth forest.

For the lower Little River watershed (~4.0 square miles), a small fragment of this watershed lies within the Park, yet a significant part of this watershed is within a block of Olympic National Forest, which is adjacent to the National Park and buffers the northern boundary of the Park. Clear-cuts within the National Forest are replanted and typically show young growth trees. All of the land exclusive of federally-managed land within both the upper and lower watersheds, is privately held. Much of this land is managed for commercial forestry, and these lands show evidence of managed clear-cutting. Although Olympic National Forest serves as a buffer along the common boundary with Olympic National Park, clear-cutting in areas outside of the National Forest has taken place up to the Park boundary. Lands that are privately held within the lower and upper watersheds, which are not used for commercial forestry, are minimally developed. These lands cover a minor area of the lower and upper watersheds, and are located in the vicinity of the stream. Cleared lands within this group, may typically include single residence wood-lots, or hobby farms.

Subwatershed areas within these two watershed areas range from lowland to highland. Most of the lower Little River watershed is a lowland subwatershed area. Along the southwestern boundary of the lower watershed, several small upland subwatershed areas are present. These upland sub-watersheds become progressively larger with increasing southeastward elevation along the southwestern boundary of the lower Little River watershed, and into the South Branch watershed. Along the northern margin of the lowland subwatershed area, the drainage network is well integrated and possesses upland characteristics. The lowland subwatershed area penetrates into the upper Little River watershed, which is predominantly an upland subwatershed area. The streamcourse within this upland subwatershed lies within a well-defined and deep valley where inflow to the stream is developed by a somewhat well integrated drainage network. Two well-defined northeast-facing highland subwatershed areas are found along the eastern boundary of the watershed area. These highland sub-watersheds are predominantly within Olympic National Park.

### **South Branch Little River Watershed**

Most of the watershed area of the South Branch (~13.9 square miles) lies within ONP and Olympic National Forest. Vegetative cover is predominantly protected old-growth forest. Clear-cutting within the National Forest has been replanted and shows young growth trees. A small area of clear-cut lands within the South Branch watershed lies predominantly within the National Forest.

Subwatershed areas of the South Branch watershed are progressive from the lower Little River watershed. The lowland subwatershed area is relatively small, with much larger upland subwatershed areas forming the lower portion of the South Branch watershed. The drainage network of these upland subwatershed areas ranges from moderately well integrated to very well integrated. Most of the South Branch watershed, however, is comprised of highland subwatershed areas that form a contiguous sequence along the southeastern boundary of the South Branch watershed area. The drainage network of

these areas is very well integrated. Highland valley areas having a northeast facing aspect, and that head against Hurricane Ridge, show typical glacial stepped-valley characteristics. These characteristics fade to a more typical mountain watershed character as valley aspect changes to face more northwest along the high western flank of Mount Angeles.

## Geology

Tabor and Cady (1978) have mapped the Little River watershed, showing the entire southern side of the east-west oriented watershed (above the lower valley floor) being composed of basalt of the Crescent Formation. Upstream of the confluence with the South Branch, the valley floor and the northern side of the watershed consist of Crescent basalt. Downstream of the confluence, the Crescent basalt is topped with the siltstone/sandstone/conglomerate of the Aldwell Formation at the higher elevations. The valley floor downstream of the confluence consists of glacial gravel deposits left by the continental ice sheet's withdrawal. These deposits maintain a width of  $\frac{1}{4}$  to  $\frac{1}{2}$  mile as the creek flows westward downslope to the Elwha, where the deposits join the Elwha River lobe of these same glacial materials.

## Soils

The USDA Soil Conservation Service (SCS) *Soil Survey of Clallam County Area, Washington* (SCS 1987) characterizes the soils of Little River. The SCS describes 11 soil units for Clallam County, one of which predominates throughout the Little River watershed. The soils of the watershed are of the Terbies-Louella group. These gravelly loams, including widespread Neilton loams, and very gravelly sandy loams are deep to very deep and well-drained on moderately to extremely steep slopes and mountain sides. The Neilton loams are present throughout the valley bottom. The SCS found these soils suitable for forest land but not for most other uses, due to steep slopes. They have a high erosion potential due to the large amount of precipitation common to the area and the steepness of the slopes. Disturbance, such as logging and development, can greatly increase the chances of slides.

## Hydrology

### Precipitation

Perry (2001) reports that the range of precipitation for this watershed ranges from about 70 inches annually in the highest elevations of the southern part of the South Branch watershed, to just more than 30 inches in the vicinity of Lake Dawn, within the upper Little River watershed.

### Interception and Evapotranspiration

In his report (Perry 2001), Perry provides a generalized picture of the role of interception and evapotranspiration losses which has yet to be applied to specific watersheds.

### Annual Hydrograph

Corresponding to his differentiation of the Little River watershed into three sub-watersheds, Perry (2001) determined flow at three locations within the watershed. These

locations are at the foot of the South Branch watershed, at the foot of the upper Little River watershed (just above the point where it joins the South Branch and transitions to the lower watershed), and at the outfall of the lower Little River watershed, just above the confluence of Little River with the Elwha River. Estimated streamflow used in this assessment was computed using the watershed characteristics method, and provides an illustrated view of the expected variation in naturally occurring streamflow that is contributed by runoff from the diverse combination of highland, upland, and lowland sub-watersheds within the total watershed of Little River.

#### *Upper Little River Watershed*

Flow of the upper Little River watershed shows a principal seasonal maximum in streamflow during the winter season precipitation maximum. Only in drier years, the spring to summer snowmelt will produce a much subdued seasonal maximum in streamflow. Evidently, when the total flow in April is at, or below, the probable flow expected 50 percent of the time, a subdued spring seasonal snowmelt maximum will be evidenced in the discharge of the stream. Flow from the upper Little River watershed is noted to decline to a seasonal minimum in late summer or early fall, with minimum expected variation in streamflow noted for August. During August, flow in the stream is primarily derived from baseflow that is supported by groundwater seepage into the stream. As with other streams, maximum expected variation of instream flow occurs in November.

#### *South Branch Little River Watershed*

Flow of the South Branch Little River watershed shows two seasonal maximum instream flows. These occur during the winter season precipitation maximum and during the spring-to-summer snowmelt season. Flow in the South Branch Little River is noted to decline to a seasonal minimum through late summer and into early fall. As with other streams, maximum expected variation of instream flow is indicated to occur in November.

#### Little River above Olympic Hot Springs Road

The combined flow of the upper Little River and South Branch, which includes flow contributed by the lower Little River watershed, produces the total flow of the stream at its confluence with the Elwha River. This flow is indicated at the outfall of the Little River watershed, which is at the location where the stream crosses the Olympic Hot Springs Road (Figure 2.4-6). The combined flow characteristics of the highland, upland, and lowland sub-watersheds within the Little River watershed, shape the distribution of flow that occurs throughout the year. This variability in flow shows the stream, at its mouth, has two seasonal maximums in flow. Minimum flow in the stream occurs during September and may extend into the fall. November is the month with greatest indicated variability in total monthly flow.

#### Peak Flows

As indicated by this hydrograph for the full watershed, peak flows typically reach ~110 cfs during the winter maximum and ~70 cfs during the late spring maximum. Instantaneous peak flows have not been directly measured on Little River.

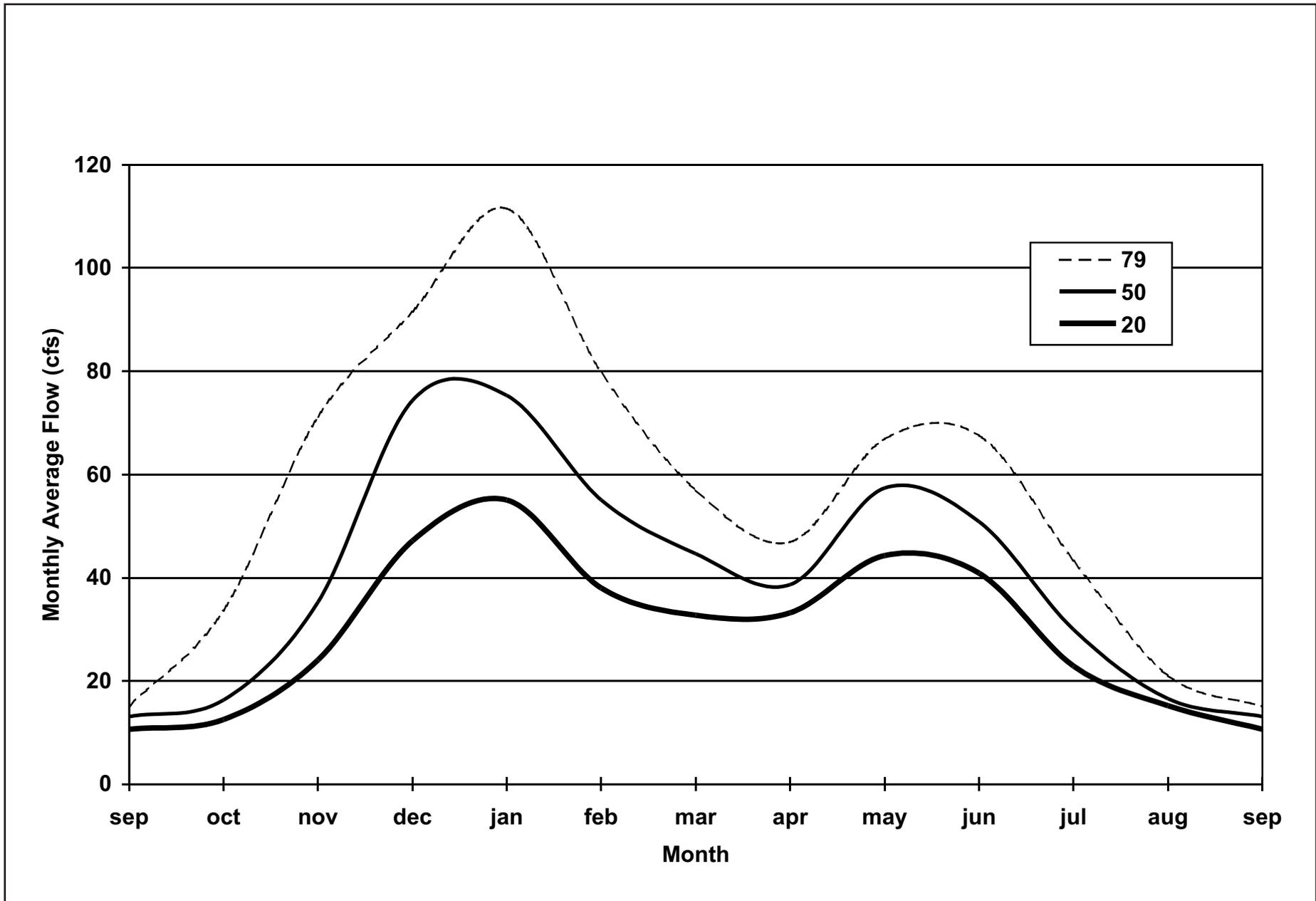


Figure 2.4-6. Little River above Olympic Springs Highway 1952-76. Recent data indicate flows are overestimated. Exceedence Flow Duration Curves at less than or equal to 79, 50, and 20 percent.

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### Stormwater Runoff And Flood Hazard

Though studies have not been conducted, the largest source of stormwater runoff in the Little River watershed is very likely Little River Road itself. The road extends along the entire length of the mainstem Little River valley—a distance of ~6 miles between its upper end at the Ennis Creek divide near Lake Dawn and its lower end at Olympic Hot Springs Road. The extent and nature of this road-based stormwater has not been studied, but is likely to be of relative importance within this watershed.

Otherwise, given the sparse population (~20 residences) and comparatively stable landscape conditions along the length of both the mainstem and the South Branch, the potential for significant stormwater runoff or flood hazards is small and probably of limited consequence.

### Low Flows

As indicated by the hydrograph for the full watershed, low flows typically drop to ~48 cfs during the spring low flow period and to ~15 cfs during the late spring maximum.

In July, 2000, a low-flow investigation was conducted to measure the baseflow of the upper Little River in the vicinity above the confluence of Little River with South Branch Little River. Results of this measurement indicated that flow of the stream was 1.92 cfs, which is equivalent to about 120 acre-feet per month. This value indicated that flow in the stream had receded to baseflow. The position of this value within the expected range of variation noted for the overall hydrograph (above) of the stream, compares well with similar conditions noted for the headwaters highland subwatershed of Ennis Creek, which borders the upper Little River watershed, to the east.

## **Geohydrology and Hydraulic Continuity**

### Septic Recharge

Given the extremely sparse population, septic recharge is highly unlikely to be a factor of consequence to the hydrology of the Little River watershed.

## **Water Quality Constraints to Water Present and Available**

No such constraints have been identified.

## **Factors of Change**

### **Human Influences/Major Projects**

#### Dams

There are no dams in the Little River watershed.

#### Diversions

None identified in the watershed.

#### Dikes

None identified in the watershed.

#### Land Development

Future land use activities such as timber harvest, land conversion and development.

## **Modifications to Hydrograph/Fluvial Geomorphology**

### Channel Conditions

Though portions of the watershed outside the national park experienced extensive logging in past decades, the forested areas are now largely composed of stable second growth. Channel conditions in this comparatively stable context appear to be more or less stable as well, though the size, location and character of the current channel is probably somewhat different from its historic form.

### *Constrictions and Confinements*

None identified.

### Log Jam and Large Woody Debris Removal

The history of logging in the watershed, and especially along the riparian area, has resulted in a lack of truly large woody debris. However, there is ample and adequate woody debris throughout the length of the channel.

A large log jam, probably resulting from destabilized riparian zone/floodplain created during past logging, has been firmly anchored in the main channel at ~RM 1.7 for many years. Though it probably has a minor, if any, effect on the hydrology or fluvial geomorphology, this log/debris jam does constitute a substantial fish passage barrier.

### Substrate

No significant changes to Little River's streambed have been identified.

### *Gravel Removal*

No specific info found. Presumably there has been occasional, incidental removal on a localized basis.

### Stormwater

Stormwater quantities do not currently appear to have any significant impact on hydrology or fluvial geomorphology.

### Recharge

Recharge appears to be operating at more or less natural levels and does not appear to have any significant impact.

### **Soil Erosion and Sediment Load**

Soil erosion and sediment load have not been identified as having any current significance. However, these sorts of impacts might accompany future land use activities in the watershed and therefore it may be useful to monitor this in the future.

### **Land Use and Demographics**

#### Effects of Current and Anticipated Land Use

##### *Areas Protected*

Approximately 15 mi.<sup>2</sup> of the Little River watershed are fully protected within Olympic National Park. This protected portion represents nearly all of the South Branch subwatershed, leaving out ~1.5 mi.<sup>2</sup> at its lower end. An additional ~3 mi.<sup>2</sup> of the watershed are partially protected under the management of the National Forest Service in the Olympic National Forest. This partially protected portion includes nearly all the remainder of the South Branch subwatershed and nearly all the southern (left-bank) slopes of the lower mainstem subwatershed.

##### *Areas Most Affected*

Given the limited extent of development in the Little River watershed, and being confined to the ~8 mi.<sup>2</sup> outside the national park, areas most affected are the various areas of second growth that are still stabilizing and maturing and the existing residential and hobby farm properties. The overall impact of these current activities, however, is comparatively moderate.

##### *Areas at Greatest Risk of Future Impacts*

Future impacts are most likely to occur as conversions of timber lands are implemented, and/or as additional hobby farm or residential activities expand in the private lands in the watershed. These private lands constitute ~5.5 mi.<sup>2</sup> oriented along the upper and lower mainstem valley of Little River. To the extent that the lands within Olympic National Forest might experience timber sales in the future, those sales would also represent potentially significant impacts.

## **Water Quality**

Water quality monitoring has generally not been conducted in the Little River watershed. Consequently, characterization of water quality can only be made through inference and consideration of the typical impacts of activities and land uses present in the watershed.

## **Stream Channels**

### Nonpoint Sources

Though present only in moderate density and intensity, there is an array of typical nonpoint sources throughout the watershed. Forest practices, agricultural/hobby farm activities, highway runoff, and septic systems are found throughout the mainstem Little River watershed. It is unknown whether or not these activities are causing significant nonpoint impacts to water quality.

### *TMDLs*

There are no TMDLs in place or proposed for the Little River watershed.

### Point Sources

There are no point sources in the Little River watershed.

## **Groundwater**

### Seawater Intrusion

Seawater intrusion is, in all likelihood, not present in the Little River watershed given its nearly six mile distance from the saltwater of the Strait of Juan de Fuca.

## **Stormwater**

Stormwater in this watershed is limited to that coming off paved surfaces (Little River Road, driveways, etc.), other impervious surfaces, and eroding landscape. The extent of this stormwater has not been specifically investigated, so it is difficult to determine the level of impacts that may be present.

## **Fish and Habitat**

With the exception of certain watershed-specific fisheries and habitat information included below, this subject is addressed primarily in the Elwha River watershed subsection (2.4.2).

## **Salmon Distribution, Abundance & Stock Status**

### Natural Productivity

Given the lengthy interruption of anadromy caused by the dams, natural productivity of the Little River watershed is difficult to quantify. No historic records have been identified and no watershed-specific evaluations have been conducted.

### Indigenous Fish Distribution, Abundance & Status

The current productivity of the watershed is limited to some trout found in various portions of the Little River watershed.

### Salmonid Stocks, Status and Life Histories

#### *Chinook Salmon*

Based on informal qualitative assessment of the Little River watershed, tribal biologists infer that chinook would likely have been occasional occupants of some of the lower portions of the creek where flows and channel characteristics would have been consistent with their requirements (McHenry, pers. comm., 2002). The life history would be closely aligned with what is described in the Elwha River subsection.

#### *Coho Salmon*

Based on informal qualitative assessment of the watershed, tribal biologists infer that coho would likely have been common in the watershed (McHenry, pers. comm., 2002). The life history would be closely aligned with what is described in the Elwha River subsection.

#### *Chum Salmon*

Though not currently found, Little River is likely to have supported a chum population of moderate size. The life history would be closely aligned with what is described in the Elwha River subsection.

#### *Pink Salmon*

Though not currently found, Little River is likely to have supported a pink population of moderate size. The life history here would be closely aligned with what is described in the Elwha River subsection.

#### *Kokanee (Sockeye) Salmon*

There is no indication that any sockeye salmon (or their nonanadromous form, kokanee) would have been found in the Little River watershed, though their typical life history suggests the possible exception of strays entering the lower part of the river.

### Harvest

There are no substantive records of harvest specific to the Little River watershed.

### Reintroduction and Restoration Strategies

Within the framework of the Elwha restoration, Little River would be involved in the restoration of nearly all stocks. The details of the fisheries restoration plan component of the overall Elwha River restoration effort continue to evolve following the first "draft" provided as part of the Elwha EIS (USDI et al. 1996).

### *Chinook (Summer/Fall) Salmon*

The Elwha EIS (USDI et al. 1996) restoration plan offers an option for the use of Little River (and Indian Creek) as a low elevation outplant acclimation site for chinook fingerlings (120-150/lb.) for up to two months and ending no later than June 30, at which time they would be freed to volitionally emigrate.

### *Coho Salmon*

Tribal biologists have suggested that Little River may be a productive stream for coho, which will be attracted to the extensive wetland and other preferred habitat (McHenry, pers. comm., 2002). The watershed may be a candidate for active outplanting or may simply offer a fertile opportunity for natural recolonization.

### *Chum Salmon*

The restoration plan suggests use of Little River as a site for smolt (450/lb.) outplants and egg outplants in remote incubators, with outplanting conducted in spring.

### *Pink Salmon*

Pink salmon would be “mass” outplants (to swamp predators) as smolts (1125/lb.) and as eggs in the lower river (below RM 16 on mainstem and principal tributaries such as Little River).

### *Sockeye Salmon*

Little River is not planned to be an explicit part of potential sockeye restoration, which would focus on Lake Sutherland and the Indian Creek watershed. It is possible that recolonizing sockeye will make use of some parts of the Little River watershed, especially the lower reaches,

### *Steelhead Trout*

Tribal biologists have suggested that Little River will be a potentially productive stream for steelhead, especially in the upper portion of the watershed (McHenry, pers. comm. 2002). The watershed may be a candidate for active outplanting or may simply offer a fertile opportunity for natural recolonization.

## **Instream Flows**

No instream flows have been established.

## **Habitat Connectivity**

For purposes of fisheries restoration, Indian Creek’s habitat is more or less intact. There may be some passage constraints through the culvert at the lower highway crossing, and through some low-elevation wetlands during periods of low flow.

## **Habitat Use and Availability**

### Spawning And Rearing Habitat

Existing riparian habitat would benefit from targeted improvements in order to support restored stocks as intended. Some habitat improvements to enhance passage and to add larger pieces of LWD may be appropriate.

### **Introduced Species/Predation**

None reported.

### **Ecosystem Functions and Conditions**

While seeming to be in generally reasonable condition, little recent attention has been given to the Little River watershed. Clallam County and the Lower Elwha Klallam Tribe will be conducting survey/assessment activities in 2003.

### Riparian Corridor and Floodplain

The corridor and floodplain have been modified by logging and rural residential activities over the past decades. However, the overall condition of these ecosystem components is fairly intact and is probably adequate to support healthy populations of restored stocks.

### Wetlands

The Little River valley has numerous wetland areas that appear to be more or less stable. Historic logging and other land use activities may well have altered and expanded some of these wetland areas.

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