2.8 DUNGENESS WATERSHED

This section updates the *Dungeness-Quilcene Water Resources Management Plan* (DQ Plan) published in 1994, and synthesizes the large amount of information that has been developed in studies of East WRIA 18 watersheds over the past 20 years. Sections 2.8.1 through 2.8.6 deal with the mainstem while Sections 2.8.7 through 2.8.14 discuss tributaries of the Dungeness Watershed. Characterizations of the streams in Sections 2.8.7 through 2.8.14 are based primarily on information developed during the Limiting Factors Analysis (Haring 1999).

The *Dungeness River Area Watershed Management Plan* (DWMC and CCDCD 1993) summarizes the special and unique qualities of the Dungeness River Basin and East WRIA 18:

> *The Dungeness River area watershed is unique. Located in the rainshadow of the Olympic Peninsula, it is the only coastal watershed in the Northwest where an irrigation system is necessary for agricultural crops. The irrigation system, the river and many small streams interact with a groundwater system that supplies domestic water for residences and the City of Sequim. The river supports native runs of...salmon and trout. Salmon runs in the Dungeness have declined markedly...and some are threatened. Numerous wetlands in the watershed provide habitat for a range of resident and migratory waterfowl. Low yearly rainfall in the area has given rise to unique plant communities and the watershed is a popular retirement and recreation area.*

2.8.1 Geography

The Dungeness River is relatively short (31.9 miles) and steep. Its average slope is 3.3 percent in the upper 15 miles, flattening to 1.0 percent in the lower 15 miles (Bountry et al. 2002). It drains a watershed of 172,517 acres (270 mi^2), emptying into the Strait of Juan de Fuca.[1] Its largest tributary, the Gray Wolf River, is 17.4 miles long, with a total subwatershed of 76 mi^2, and its second largest tributary, Canyon Creek, is 8.2 miles long, with a total subwatershed of 11.9 mi^2 (WDF 1975) (Figure 2.8-1). A total of 546 miles of streams and tributaries make up the watershed (DWMC and CCDCD 1993).

Upper Dungeness River and Tributaries

The Dungeness drops quickly throughout its upper watershed, which originates at elevations approaching 6,000 feet, to emerge from the mountains about ten miles above its mouth. At approximately RM 15.8, the mainstem is joined at Dungeness Forks by its major tributary system, the Gray Wolf River. An additional 180 miles of smaller tributaries in the upper basin contribute to the Dungeness above RM 10.0.

The upper watershed above the forks is largely protected in National Park and National Forest lands, and the Gray Wolf is largely unexploited. Major exceptions are several clear cuts and a quarry to the west of Slab Camp Creek extending to Deer Ridge.

[1] The Dungeness River Area Watershed Management Plan, DWMC and CCDCD (1993) list the area as 270 mi^2; Bountry et al. (2002) gives the watershed area as about 200 mi^2 and both Haring (1999) and Thomas et al. 1999 gives it as 198 mi^2.

Lower Dungeness River and Tributaries

The watershed landscape changes in the area where the Gray Wolf and Dungeness join as they emerge from the steep-canyons and high mountains of the Olympics. At this elevation the mountains and foothills are rounded and smoothed from having been overtopped by the Cordilleran ice sheet, and, over time, the rivers cut into thick deposits of glacial drift, bringing out bedload and suspended sediments from the middle watershed. The channel gradient flattens, from 180 feet/mile (3.4%) in the mountains to a more gradual drop of 60 feet/mile (1.1%), and the Dungeness flows north through an extensive, flatter middle watershed and a broad lowland plain. Important tributaries are Bear, Hurd and Canyon creeks; further downstream, Matriotti Creek joins the Dungeness near its mouth.

The topography (as described by Thomas et al. (1999) in their report on the lower study area) is characterized as mostly a flat plain, with hills in the southwest and on the Miller Peninsula. The DQ Plan (1994) points out that the intermediate level terrain of the middle watershed is more extensive than it appears. It widens into a broader valley where the river channel begins to braid. The lower Sequim-Dungeness valley has many characteristics of an alluvial fan and delta, but with complexity overlain by the work of the Cordilleran ice sheets. Substantial foothill relief, upland valleys, and evidence of glacial lake ponding and recessional outflows are present.

Dungeness Bay

Tidal influence extends about 0.9 miles up the Dungeness, to about Schoolhouse Bridge. KCM (1990) asserts that this tidal influence has caused the river to deposit its sediments in Dungeness Bay, which, together with net shore-drift, forms the Dungeness Spit. Other analysis suggests that littoral drift from the west forms the main spit and drift from the east forms Graveyard Spit, while fine sediments circulating in the Bay are deposited on the inner spit side (Schwartz et al. 1987).

As is characteristic of braided streams with their rapidly shifting channel alignments, the lower Dungeness has changed its outlet over the course of its geologic history, at one time discharging into Washington Harbor on Sequim Bay. The Dungeness River Restoration Work Group (DRRWG 1997) notes this migration of the river mouth approximately 2,000 feet northeast since 1855, together with the concomitant formation of approximately 75 acres of river delta. Thus, the river that once ran through an intertidal salt marsh estuary at its mouth now bisects a delta cone, which has developed since agricultural diking along the Bay began. The tidal prism (an important sediment transporting feature) in the vicinity of the river mouth appears to have decreased in size by over 100 acres during this time period.

Fluvial Geomorphology

A relatively small river in an ancestral channel that probably resulted from one or more Cordilleran ice sheet recessional outflows, the Dungeness descends steep mountain canyons from the core rocks of the Olympic Mountains. KCM (1990) describe the Dungeness as an “active, high energy river,” characterized in its upper basin by steep unstable canyon slopes and high flow velocities. The upper watershed contributes gravel

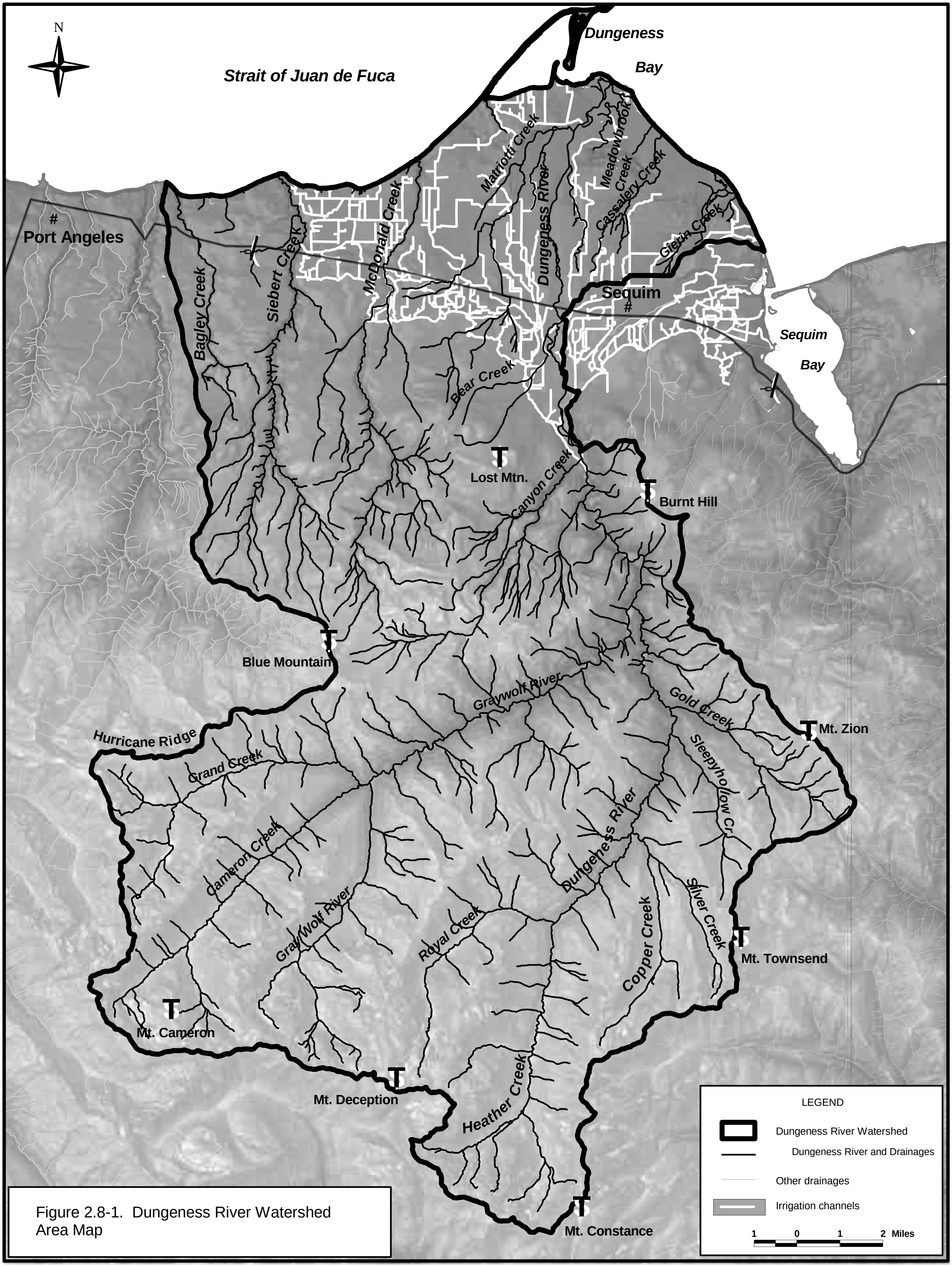

Figure 2.8-1. Dungeness River Watershed Area Map

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and large boulders as well as large woody debris downriver. Emerging from its upper watershed about eleven miles above its mouth, the Dungeness slows and drops its load of rock and sediment as it flows north through an extensive, flatter middle watershed and a broad lowland plain. At low water in late summer and fall, the lower Dungeness flows in broad shallow riffles over its stony bed. Unconfined by canyon walls, the lower river meanders and has shifted channels dramatically during floods. Over the past 10,000 years, its course has wandered from McDonald Creek to Washington Harbor (JSKT 2000, DRRWG 1997).

KCM (1990) characterizes the river channel in the lower basin as braided from about RM 10 to Ward Bridge (RM 3.2), with a shallow, wide (approximately 300 feet) channel, steep bed slope and noncohesive bank material (sand and gravel). These lower basin conditions to some extent reflect the river's role as described in the DQ Plan: "in large part to rework the glacial drifts," sometimes downcutting through them and sometimes transporting and redepositing them as alluvium. The river meanders from south to north, and has not cut a deep canyon into the land surface. Below Ward Bridge, bed slope becomes more gradual and follows a single channel confined by dikes on both sides, with an active width of about 100 feet.

Orsborn and Ralph (1994) undertook a detailed inventory of stream channel geometry in the lower 10.8 RMs, and described channel characteristics for reaches of the lower Dungeness River as follows:

- Above the Highway 101 Bridge, the river channel is predominantly a riffle environment with large bed materials.
- A mixed meander/straight reach channel combination lies between the Highway 101 Bridge and Railroad Bridge.
- A "badly torn up" reach extends about 2500 feet downstream of the Railroad Bridge.
- A braided channel reach extends downstream of the Old Olympic Highway Bridge.
- The lower confined reach is leveed to the mouth.

2.8.2 Hydrology

Dungeness River

The Dungeness is a bimodal flow river, showing two peaks over the course of the year: a smaller December peak associated with winter storm flows, and a larger June peak associated with snowmelt and spring runoff. According to the DQ Plan (1994), "the winter storm flows are less consistent than the major peaks of spring runoff, and even these vary considerably from year to year." Further, the DQ Plan states "the variability of flows is a major problem in the Dungeness River. There is relatively little storage in the upper watershed, so that current-year precipitation directly controls runoff…and the rain shadow location exacerbates the late-summer low flow." The USFS (Dungeness Area Watershed Analysis Cooperative Team 1995) discusses how vegetation management can moderate flow variability—for example, snowfall through canopy cover is protected on the forest floor from rapid melt and runoff, and water retention is increased.

Due to its rainshadow location, the average runoff of the Dungeness River, 2.46 $cfs/mi^{2,}$ is lower than any other major north or east Olympic Peninsula basin (KCM 1990). Annual flows over the 72-year period of record (1924-30, 1938-02) at the RM 11.3 and 11.8 gages range from 197 cfs (1977) to 697 cfs (1999), and average 384 cfs (Welden Clark, drawing on USGS data, pers. comm. January 14, 2003). August-September low flows measure 142 cfs at the 90 percent exceedance level and 207 cfs at the 50 percent exceedance level (Virginia Clark and Welden Clark, pers. comm. August 14, 2000). Simonds and Sinclair (2002) provide high, average, and low annual flow duration curves (Figure 2.8-2) for the Dungeness River at the USGS gage 12048000 near Sequim (point “S1” in Figure 2.8-3). Half-month mean flows measure 230 cfs in late August, dropping to 185 cfs in early September and 161 cfs in late September (water years 1924-30, 1938-02).

The 1999 runoff, unequaled in nearly 70 years of monitoring, reflects a coincidence of the La Niña, the wet and cool phase of the ENSO (El Niño/Southern Oscillation) ocean-atmospheric phenomenon in the equatorial Pacific Ocean, with an apparent shift over the past several years to the wet/cool phase of the longer term Pacific Decadal Oscillation index (PDO), which relates northwest weather to sea conditions (Welden Clark, pers. comm. April 12, 2000). The Dungeness River frequently ran at twice or more its highest daily levels known from the previous record, averaging approximately 1,250 cfs from the first week of June through the first week of August, and peaking at 2,010 cfs on June 15 (WUA 1999a). The flood of record, however, occurred on January 7, 2002 with the river peaking at 7,610 cfs (USGS provisional gage data).

The most recent five-year period (1998-2002) shows a marked increase in flows from preceding periods, averaging 444 cfs, or 116 percent of the longer-term average, even though it includes a drought year (2001) (data from water years 1924-30, 1938-02) (Welden Clark, pers. comm., January 14, 2003). Prior to this, the 1994 DQ Plan had tentatively noted a 40-year downward trend in both flows and bedload transport, as well as declines in winter snowpack and frequency of high-flow events over the past 20 to 30 years. These contrasts underline the importance of caution in interpreting from relatively small snapshots of weather and climate data.

Thomas et al. (1999) concurs that snowmelt in the upper watershed causes consistently high flows in the late spring and early summer, and rainfall in the upper watershed causes high and more variable flows in the winter. The lowest flows occur in September and October; from September to mid-November 25 percent of the daily mean flows over the 67-year record were less than 150 cfs. Flows peak in June, when they exceed 415 cfs in 90 percent of the years, 646 cfs in 50 percent, and 1011 cfs in 10 percent. The 7-day and 30-day Dungeness River low flows are also provided; historic low flows occurred in 1979, and were 65.6 cfs (7-day). However this occurred in February and most likely represents a freeze-over situation. The lowest half-month flow recorded is 73 cfs during October of 1995.

Detailed flow data for the Dungeness River are available in Clark and Clark (1996, with updates through the present year), and more detailed analyses are given the Montgomery Water Group, Inc. (MWG) (1999). Clark and Clark (1996, as updated) provided updates of the half-month mean flow data by water year first reported in the DQ Plan (1994). Snotel instrumentation was installed to monitor the Dungeness River Basin snowpack in 1999, and is now providing data from three locations in the north Olympics (Dungeness, Mt. Crag, and Waterhole, on Hurricane Ridge near the western edge of the Dungeness/

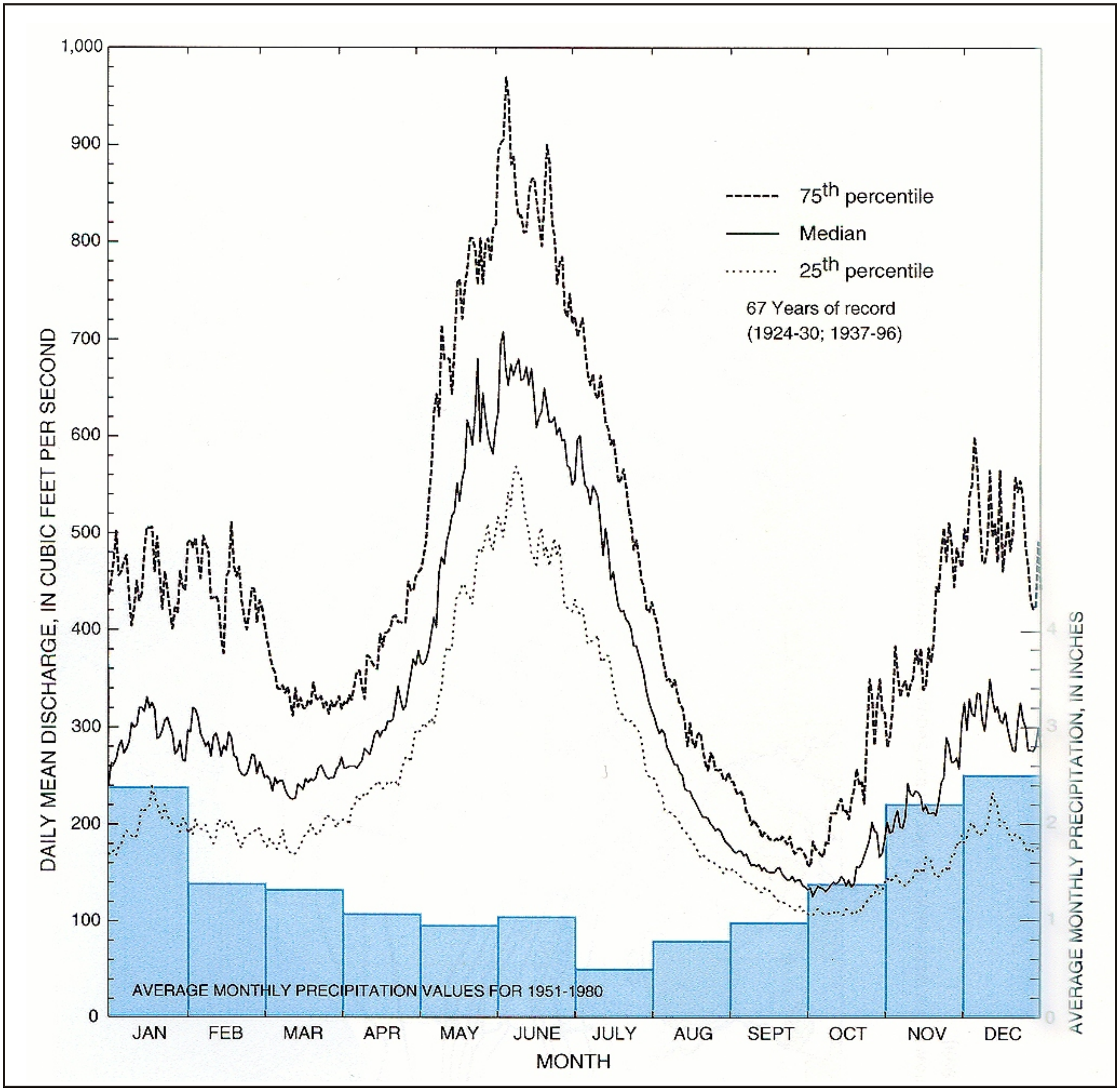

Figure 2.8-2. Mean daily discharge for the Dungeness River and average monthly precipitation near Sequim, Washington (Simonds and Sinclair 2002).

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Gray Wolf Basin). It is worth reemphasizing a point made in the DQ Plan, that below the USGS gage, the river flow situation becomes much more complex due to irrigation diversions and hydraulic continuity between the river and the shallow aquifer, with both gaining and losing reaches in the river.

Dungeness Tributaries

Table 2.8-1, reproduced from the DQ Plan (1994), shows incremental flows for the Dungeness River and its tributaries, moving downstream from the Dungeness headwaters. Again, these flows would vary within and across years depending upon snowpack, melt, runoff, infiltration, and local storm precipitation.

Below the RM 11.8 gage, several surface tributaries enter the Dungeness River. The most significant of these is Canyon Creek, with occasional flow measurements as high as 25 cfs, but typically in the 2 to 8 cfs range. Bear Creek has only small flows recorded and Hurd Creek ranges from 2 to 7 cfs, reflecting both irrigation tailwater and hatchery discharges. Occasional measurements of Matriotti Creek have shown values as high as 20 cfs, but more frequently in the range of 5 to 10 cfs (DQ Plan 1994). Matriotti Creek was listed for low flow on the Surface Water Source Limitation (SWSL) list in 1952.

Table 2.8-1. Incremental Average Annual Flows in the Dungeness River Basin

Segment	Increment	Cumulative cfs	
Dungeness above RM 25	54		
Royal Creek contribution	53	107	
Copper & Silver creeks contribution	23	130	
Dungeness to RM 19 (including Sleepy Hollow, Bungalow, Cougar, Skookum creeks)	13	143	
Gold Creek	13	156	
Dungeness to the Forks (including unnamed creek, Eddy Creek)	13	169	169
Gray Wolf at Three Forks (including Cameron & Grand creeks)	159		
Gray Wolf to the Dungeness (including Slab Camp, Slide, Divide and unnamed creeks)	30	189	358
Dungeness from the Forks to RM 11.8 gage (including Caraco and unnamed creeks)	21		379

Source: DQ Plan, 1994, Figure 2.55

Note: These data do not reflect flows since 1994, which have brought the long term average flow up from the 379 cfs shown in the table to the 384 cfs reported above.

Stormwater Runoff & Flood Hazard

The KCM (1990) *Comprehensive Flood Control Management Plan for the Dungeness River* addressed needs for protecting human life and property, but was also framed at a watershed level and recognized the need for structural flood control measures in order to not damage fish and wildlife habitat, particularly with respect to spring Chinook and pink salmon. KCM provided estimates of Dungeness River flood frequency, ranging from 6,640 cfs for the 10-year flood (as measured at the mouth of the river), to over 14,000 cfs for the 500-year flood. Major flood events of record are listed in KCM (Table 6.2), topped by a 1949 flood of 6,820 cfs. Since then, the Dungeness reached its historical peak at 7,610 cfs in January 2003. A survey of then-current regulations affecting floodplain management in Clallam County is given in KCM Chapter 5, and a summary of conditions or problem areas along the Lower Dungeness River is given by RM in KCM Table 6.1. KCM provided a series of flood control management options, including both structural and non-structural alternatives in Chapter 7, and summarized the impacts associated with these in KCM Table 7.1. The KCM-recommended plan includes:

- Revisions to code and land-use designations
- Initiation of a subregional or community planning process (since completed in DQ and again in 2514 watershed planning)
- Data base development
- Public education
- Engineering review and design of structural modifications

Some of the recommended bridge reconstruction has been completed and most recommendations in the floodplain have been implemented; the plan is now under revision. With land use shifting from an agricultural to a predominantly residential landscape, irrigation canals have become *de facto* drainage ways for stormwater runoff from areas that were previously farmed. The floodplain advisory committee, a subcommittee of the DRMT, suggested amendments to the 1990 Flood Plan focusing on:

- Changes in type of flood hazard.
- Changes in regional approach to both flood hazard and river management.
- Relationships between flood hazard management and fish habitat protection.
- Increased understanding of river processes.
- Relationships to County code and comprehensive plan.

An amended flood plan is now in preparation that will integrate the large body of work (both studies and habitat restoration) that has been undertaken or planned since the KCM Flood Plan was published in 1990.

2.8.3 Geohydrology

Thomas et al. (1999) estimated that groundwater discharge to the Dungeness River and recharge from the river to groundwater were nearly in balance (Table 2.1-1, Section 2.1.5). Average annual groundwater discharge to the Dungeness River was estimated to account for 24 percent of total discharge, or 3.2 inches (27 cfs). Average annual groundwater recharge from Dungeness River leakage was estimated to account for 25 percent of total recharge, or 3.3 inches (28 cfs). Haring (1999) believed that the water table in the lower Dungeness area is "largely controlled by the amount of recharge the Dungeness River provides." Simonds and Sinclair (2002) later measured vertical hydraulic gradients at 27 locations along the Dungeness River, finding that the river generally loses water between RMs 11.8 and 3.6, with small gaining gradients in three localized reaches below RM 3.7.

Simonds and Sinclair measured gains and losses in five reaches of the Dungeness in 2000-2001 (Figure 2.8-3). During spring (April), losses were almost precisely twice the losses in both years, although the absolute amounts were twice as great in 2000 as in 2001 (-50.6 cfs in losing reaches in April 2000 and +25.2 cfs in gaining reaches; -24.2 cfs in losing reaches in April 2001 and +12.1 cfs in gaining reaches). However, in October 2000, gains were negligible (+0.6 cfs in one gaining reach) while losses (-20.8 cfs) were nearly as high as they were the following spring.

Thomas et al. found one Dungeness reach with measured gains (Railroad Bridge to Woodcock Road, corresponding to Simonds and Sinclair reaches 3 and 4), flanked both up- and downstream by losing reaches (USGS gage to Railroad Bridge, corresponding to Simonds and Sinclair reaches 1 and 2, and Woodcock Road to Schoolhouse Road, corresponding to Simonds and Sinclair reach 5). From Simonds and Sinclair, it appears that the gains identified by Thomas et al. occur in the area between Old Olympic Highway Bridge and Woodcock Road Bridge. Simonds and Sinclair also found some indication of gains in the upper reach between Dungeness Meadows and Railroad Bridge Park.

The general picture to emerge from their work is that the Dungeness River gains predominantly in its lowest 3 miles; gaining reaches are localized, and are associated with locally unique conditions (e.g., a clay layer found at Schoolhouse Bridge). Groundwater "accumulates" to the north, with distance from the bedrock to the south and the opportunity for infiltration to build up storage. Streambed conductivities were found to be lower in the lower reaches (4 and 5), perhaps because fine-grained materials carried downstream fill the voids between cobbles and boulders, reducing the permeability of the streambed. More detailed analysis of Dungeness River reaches can be found in Simonds and Sinclair.

Monitoring

The USGS has gaged the Dungeness River at numerous points since 1898. From October 1898 through December 1902 it was gaged one mile above its mouth, from June 1923 through September 1930 it was gaged at RM 11.3, and from June 1937 to present it has been gaged at RM 11.8. The present gage (RM 11.8) is located above all diversions and below all tributaries except Canyon, Bear, Hurd, and Matriotti creeks. A second gage was installed in September 1993 at the Railroad Bridge site (RM 5.65), but was later removed on May 24, 1994 as it was difficult to develop a rating curve due to river bed changes (USGS website January 7, 2003, Welden Clark, pers. comm. September 2000, DQ Plan, 1994).

A new gage was installed by the USGS and Ecology near one of the original sites at the Anderson Road/Schoolhouse Bridge crossing (RM 0.75) in November 1999, Ecology currently collects data for this gage (Chris Evans, pers. comm. January 9, 2003).

Irrigation flow monitoring occurs during the irrigation season to determine withdrawals and conservation. Biweekly flow measurements are taken on the five irrigation outtakes from the river and on all tailwaters at the ends of the ditches. The WUA publishes an annual report of withdrawals and flows.

2.8.4 Factors of Change

Human Influences/Major Projects

Human activity within the lower Dungeness River (RM 0.0 to 10.5) has altered natural river processes, and as a result, river morphology. Bountry et al. (2002) discuss how various human alterations to the Dungeness River have impacted physical process. The Bountry report identifies six primary human activities responsible for river alterations:

- Construction of levees
- Clearing of riparian vegetation
- Construction of highway and railroad bridges
- Construction of riverbank protection structures
- Gravel extractions
- Water diversions

Bountry et al. (2002) assessed these six human activities within five reaches of the Dungeness River to quantify the degree of human impact throughout the lower river (Table 2.8-2). The river was subdivided based on significant changes in physical characteristics. A qualitative assessment was based on the following characteristics:

- Active channel pattern
- Number, location, and pattern of side and overflow channels
- Definition of banks that define the floodplain and the estimated ages of the surfaces above these banks
- Sizes of sediment transported through the reach and the sizes that are being stored in gravel bars
- Estimated gradient of the river
- Widths of the active channel and present floodplain
- Number, location, and pattern of unvegetated bars (those that are frequently modified by flows)
- Number, location, and pattern of vegetated bars and low terraces (those that are infrequently modified by flows) and an estimate of the number of vegetated bars of different ages
- Amount, location, and pattern of large woody debris
- Type, location, and extent of man-made features and activities

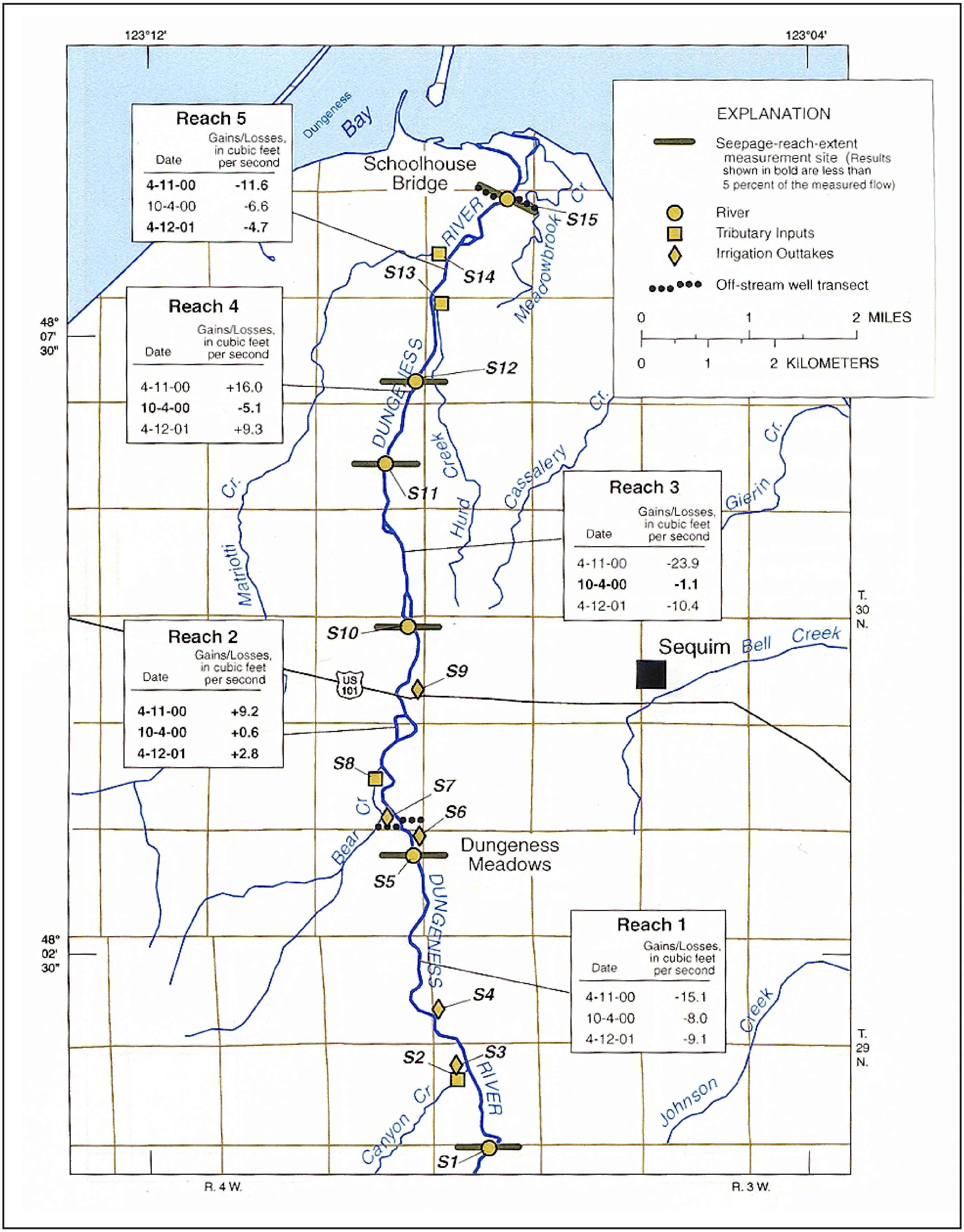

Figure 2.8-3. Calculated gains and loses in the five subreaches of the Dungeness River.

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Table 2.8-2. Lower Dungeness River (RM 0 to 10.5) Subdivisions.

Reach	River Miles	Major Landmarks	Amount of Human Impact
1	RM 0 to 2.6	ACOE and Olympic Game Farm Levees, and Schoolhouse Bridge	High
2	RM 2.6 to 4.6	Burlingame and Woodcock Bridges	Mid to High
3	RM 4.6 to 7.0	Highway 101 and Railroad Bridges	Mid to High
4	RM 7.0 to 9.0	Dungeness Meadows Subdivision and Levee	High
5	RM 9.0 to 10.5	Kinkade Island and Fish Hatchery	Mid to High

Source: Bountry et al. 2002

Reach 1 and 4 are considered to be highly impacted by human activities primarily because levees were built along both banks of the river within these reaches. For example, levees determine how sediment is transported within Dungeness Bay. The Dungeness River once formed a delta at its mouth, however levees have increased sediment transport and channelization such that sediment aggradation now occurs within a single area in Dungeness Bay, preventing formation of a natural delta (Bountry et al. 2002).

Reach 2 and 3 are less impacted, but contain bridge embankments and roads that have degraded the habitat. Reach 5 is the least impacted and contains small amounts of levees and bank protection structures.

Figure 2.8-4 shows the various capital facilities that have been constructed along the Dungeness River.

Levees and Dikes

Levees (dikes) and river constrictions comprise a key limiting factor on the lower Dungeness. The WDFW is concerned about channel constrictions and the lack of large woody debris in the Dungeness River, and the effects that these conditions have on channel stability and fish habitat. Levees and other constrictions increase aggradation and degrade habitat (Ecology 1998).

Bank protection and reinforcement has been occurring along the banks of the Dungeness River since the 1900s. Levees are identified by Bountry et al. (2002) as the greatest single factor in altering physical river processes due to the number of processes affected and the length of the river impacted. There are six major levees along the banks of the lower Dungeness River (Table 2.8-3).

Table 2.8-3. Major Levees (Dikes) along the Lower Dungeness River and Related Reaches.

Levee	River Mile Extent	Reach	Bank	Description / Year Built
Kinkade Levee	9.6 to 9.9	5	East	Bank protection began in 1940s and present levee was built in 1971
Haller Dike	8.57 to 8.87	4	West	Originally a private levee, but replaced and setback by the County in 1997
Dungeness Meadows Levee	7.5 to 8.1	4	East	Private levee at Dungeness Meadows Neighborhood built in 1960s
Army Corps of Engineers Levee (ACOE Levee)	2.6 to near the mouth	1	East	Originally smaller, private levee that was lower in elevation and not continuous, rebuilt and significantly enlarged by the ACOE in 1961
Olympic Game Farm Levee (a.k.a. Beebe's Levee)	2.1 to 1.0	1	West	Private levee originally built in early 1900s and later expanded
River's End Levee	0.8 to near the mouth	1	West	A private levee constructed to protect private residences

Source: Bountry et al. 2002

Levees have these key effects (Bountry et al. 2002, Haring 1999):

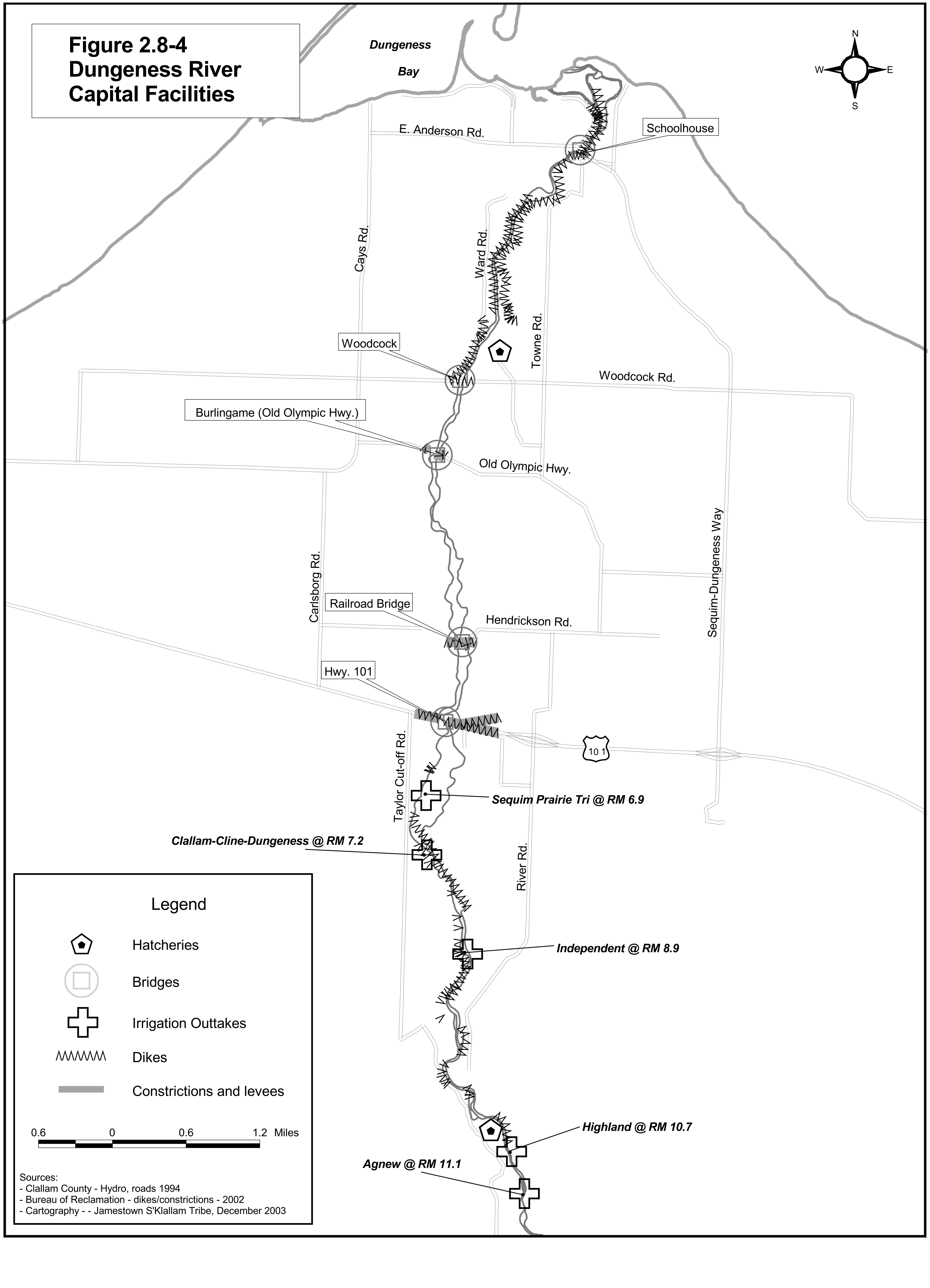
- Cut off access to side channels and floodplain habitat used by salmonids for off-channel rearing and spawning (e.g. Dungeness Meadows Levee)
- Increase flow velocities and depths during flood flows because the water is constricted through a narrow path
- Simplify the channel, as higher velocities and depths reduce woody debris recruitment, and degrade anadromous fish habitat
- Reduce subsurface flows and groundwater contribution to the stream

Clearing of Riparian Vegetation

The loss of riparian vegetation reduces slope stability. For example, logging practices degrade the soil, making it less permeable to precipitation and increasing runoff. Increased runoff in turn increases bank erosion processes (e.g. landslides), increasing the amount of fine sediment load transported to the river. Bountry et al. (2002) reported that an estimated 760 feet of sediment was eroded along the west bank downstream of Railroad Bridge due to vegetation clearing during 1942 to 1943.

Loss of riparian vegetation also reduces shading, and decreased bank porosity (Haring 1999). A decrease in bank porosity (i.e. filtering qualities) will transfer nutrients and toxins into the river where they may accumulate during low-flow periods. These effects decrease the overall water quality of the river. Reduced shading increases water temperatures and can also lead to increased predation on rearing salmonid smolts.

Figure 2.8-4
Dungeness River Capital Facilities



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Construction of Highway and Railroad Bridges

Five bridges span the lower Dungeness River (Table 2.8-4). Depending on where bridges are built, they can constrict the active river channel (old Burlingame Bridge and Woodcock Bridge) or their associated levees may cut off access to side channels and the floodplain (e.g. Railroad Bridge).

Table 2.8-4. Bridges along the Lower Dungeness River and Associated Impacts.

Bridge	River Mile (RM)	Reach	Span (ft)	Impact
Schoolhouse Bridge	0.7	1	200	Located in a natural constriction formed by glacial knobs. Levees upstream of bridge force all water to pass under the bridge and caused backwater effects that result in flooding on the upstream side.
Woodcock Bridge (a.k.a. Ward Bridge or Ward Road Bridge)	3.3	2	405	Cuts off access to historic floodplain, constricts the channel migration zone, and causes sedimentation deposition upstream of the bridge.
Burlingame Bridge on Old Olympic Highway	4.0	2	430	Bridge was replaced in 1998-99. Old bridge constricted the active river channel and cut off access to side channels and floodplain. New bridge does not.
Chicago, Milwaukee, St. Paul & Pacific Railroad Bridge (Railroad Bridge)	5.7	3	1005	A dike was built in 1961, and recently cable logs were added, to protect the new River Center just east of the bridge. The dike cuts off the east floodplain.
Highway 101 Bridge	6.4	3	590	Bridge does not constrict the active river channel, but levees protecting the structure cut off access to side channels and the historic floodplain.

Source: Bountry et al. 2002

Construction of Riverbank Protection Structures

Numerous small riverbank protection structures occur along the Dungeness River (e.g. a riprap wall that prevents bank erosion). These structures have much the same kind of impact as levees, but do not cause the same degree of impact because they are shorter and/or smaller (Bountry et al. 2002). Similar to levees, bank protection structures are higher than the surrounding floodplain, and can prevent natural migration and recruitment of LWD. (However, riverbank protection can also be a form of mitigation when designed and constructed as erosion control [Bountry et al. 2002]).

Gravel Extraction

Historically, gravel has been mined from the Dungeness River for various reasons. These reasons have included mitigation for aggradation caused by levee constrictions, commercial extraction, and various channel manipulations (Bountry et al. 2002). Gravel extraction, which has not been conducted on the Dungeness River since the early-mid

1990's, can benefit the system if the rate of extraction matches the rate of deposition, however many potential problems are associated with this action. They include:

- The channel may migrate laterally during a flood event;
- Headcut erosion can migrate upstream from the excavation area and destabilize the stream if too much gravel is removed;
- Removed materials may be quickly replaced during a winter flood if too little gravel is removed; and
- Excavation areas can attract spawning fish, leading to suffocation of their redds the following winter when high flows refill the excavated area with sediment.

Water Diversions

The diversion for the Agnew ditch, the first irrigation canal in the Dungeness River, was completed on May 1, 1896 at RM 11.1 (Foster Wheeler 2002). Currently, there are five principal irrigation diversions located between RM 11.8 and the Highway 101 Bridge. Two are located along the west bank (RM 11.1 and 7.2) and three along the east bank (RM 10.7, 8.5 and 6.9 [Foster Wheeler 2002]).

Irrigation water is diverted from the Dungeness River between April 15 and September 15; diversions have averaged 55 cfs (1999 to 2001) (WUA 2001). Similar to levees, irrigation diversions prevent channel migration and LWD recruitment (Bountry et al. 2002). Irrigation diversions also reduce river flow, depth, velocity, and wetted perimeter because the timing of these withdrawals coincide with lower river flows. A decrease in these physical properties can also increase water temperature and fine sediment deposition (Bountry et al. 2002).

Land Development

The Dungeness watershed landscape has changed from one dominated by commercially irrigated farmland in the 1950s to a landscape of growing urbanization today (Foster Wheeler 2002). Urbanization has changed water and land use in the following ways:

- Increased impervious surfaces (i.e. roads, roofs, parking lots)
- Reduced aquifer recharge and increased runoff due to increased impervious surfaces
- Increased withdrawal from the Dungeness area aquifers (number of wells grew from 200 in 1970 to over 4,000 in 2000)

There are three aquifers in the Dungeness area. The shallow aquifer supports approximately 67 percent of the well water withdrawals in the area, the middle aquifer approximately 13 percent, and the deep aquifer approximately 1 percent (Thomas et al. 1999). Gross withdrawals from aquifers in 1996 were estimated at 1.0 inches (8.4 cubic feet per second [cfs]) and net withdrawals (pumpage minus return flow from septic systems) were estimated at 0.6 inches (5.2 cfs) (Thomas et al. 1999). Table 2.8-5 shows land use by land cover in the Dungeness watershed as of 1998 (Haring 1999).

Table 2.8-5. Land Use in the Dungeness River Area Watershed.

Land Use	Acres	Percent of Area Watershed
Commercial Forestland	74,624	43.26
Residential High Density	1,364	0.79
Residential Low Density	5,940	3.44
Cropland	420	0.24
Pasture/Hayland	9,899	5.74
Grass/Scrub/Shrub	7,103	4.12
Private Woodlots	8,735	5.06
Conversions	2,377	1.38
Urban Lands	410	0.24
Ponds/River Channels	808	0.47
Quarries	167	0.10
Olympic National Park	51,308	29.74
Unclassified	9,362	5.43
Grand Total	**172,517**	**100**

Source: Haring 1999

Modifications To Hydrograph/Fluvial Geomorphology

Erosion, slope movement and sedimentation occur at an accelerated rate in the lower Dungeness River, resulting in extraordinarily high levels of sediment load in the river and severe bed aggradation. The rocks and soils of the basin are highly erosive, and rock slope failure and soil mass movement occur frequently (KCM 1990). Erosion-sensitive areas are mapped in the Clallam County Profile (CCDCD 1992: Map III-5). Sediment is supplied primarily from the upper basin; five major sources are identified by Bountry et al. (2002) (Table 2.8-6). The upper basin annually yields approximately 55,608 tons per year (Table 2.8-6). The lower basin annually yields approximately 10,300 cubic yards per year through mass wasting processes (Bountry et al. 2002).

Table 2.8-6. Sediment Sources from the Upper Dungeness River Basin and Annual Yield.

Sediment Source	Description	% of Basin's Surface Area	Yield (tons/year)	% of watershed sediment yield
Steep alpine slopes above timberline	sediment deposits (talus) are generally conical in shape, steep, unstable	15	2,623	5
Forested slopes	undisturbed forested slopes and second growth forests > 10 years old.	--	28,000	50
Logged slopes	6 alpine glaciers reported within Dungeness watershed	< 1	20,000*	36
River terraces and bar deposits	clear-cut areas and forest regrowth < 10 years old	4	4,985	9
Active glaciers	3 observed terraces in Dungeness watershed, high runoff distributes sediment stored on gravel bars	--	--	--

*most likely an overestimation
Source: Bountry et al. 2002

At the headwaters of Gold Creek, the most extensive tributary subbasin in the middle Dungeness, the watershed was stripped by a major clear-cut just northwest of Bon Jon Pass, leaving no riparian buffer (DQ Plan 1994). That plan noted that numerous landslides, associated both with natural occurrences and timber harvest, contribute sediments to the Dungeness River. Restoration attempts made on the Gold Creek slides have “underestimated the extent of the deposits and the long-term history of the movements.”

The DRRWG (1997) recognized that river restoration efforts cannot succeed unless sediment inputs are in balance with sediment extraction and the sediment transport and storage capacity of the river channel, floodplain and estuary. At the time the “Blue Book” was published, the DRRWG (1997) noted that increased sediment recruitment and the loss of floodplain are well recognized, but changes at the river mouth and estuary had received less attention. The DRRWG summarized the underlying issues as follows:

> *Natural river processes include the migration of a meandering river across the landscape, floodplains that develop from the spill of flood waters and sediment over the banks, and the development of complex in-channel habitat functions from the creation of log jams that once were numerous throughout the river. Problems arise when a channel is fixed into place, for example, by a bridge. The natural lateral migration of the river or meander development is inhibited, resulting in exacerbated channel instabilities upstream and downstream. Important river processes are altered when a dike is built that doesn’t allow flood waters to dissipate energy by spreading out across the floodplain, or that inhibits the river’s natural ability to store excessive sediment outside of the channel. These problems are the primary causes for increased flooding risks and declining fish populations in the Dungeness.*

A more complete discussion of sediment processes involving aggradation and channel braiding can be found in the following discussion.

Channel Constrictions and Confinements

Bountry et al. (2002) state that levees and dikes are responsible for most of the impact on physical river processes within the lower Dungeness River. Levees cut off the active channel from access to side channels and to the floodplain, where excess sediment and woody debris would be deposited to create off-channel salmonid habitat or simply to relieve the river of material pressures. Cutting off access to peripheral areas creates higher water velocities, depths, and sediment-carrying capacities (the ability of a river to transport materials) through areas with levees because the river’s energy is not dissipated into floodplains or side channels (Haring 1999). In some areas of the Dungeness River, increased flood velocities cause backwater effects upstream of the levee. A backwater is a lower velocity area where sediment deposition occurs and the channel bed is raised; typically these areas are found upstream of levees (e.g. ACOE and Olympic Game Farm levees). In other areas of the Dungeness, increased flood velocities create high turbidity due to excess amounts of fine sediment. The find sediments accumulate and are transported to the mouth of the river, to be deposited along Dungeness Spit.

Higher velocities, depths, and carrying capacities preclude the development of logjams and scour pools that are used by fish and other aquatic species. Scour pools provide temperature refugia for fish during summer-low flow periods, and logjams provide velocity refuge areas during winter and spring high runoff periods (Bountry et al. 2002). Levees limit the amount of usable aquatic habitat available for various salmonid life stages.

Aggradation and Braiding

The average annual sediment supply to the Dungeness River is estimated to be 10,300 cubic yards per year. Sediment is predominantly supplied by the upper watershed through the five sources presented in Table 2.8-6; however the distribution of sediment within the lower watershed depends upon channel restrictions and carrying capacity. Sediment is transported to the lower watershed primarily during late fall and winter flood flows. Many of the main aggradation points are related to bedrock constrictions that reduce sediment transport capacity due to backwater and eddy effects upstream of the constrictions (Bountry et al. 2002). In other areas with channel constrictions, high velocities can increase transport capacity and move more sediment downstream. For example, the lower river (Reach 1) contains levees on both banks of the river. Because access to the floodplain is restricted, an overabundance of sediment is transported to the river's mouth where it deposits in one region of the Dungeness Bay, elongating the east end of the Dungeness Spit (Bountry et al. 2002).

Although acknowledging that logging and logging roads accelerate slope failures in some areas, KCM (1990) considers natural geologic processes to be the primary cause of high sediment loads and bed aggradation in the Dungeness River. Hiss (1993b) differs with KCM's conclusion, asserting that human influence is responsible for accelerated erosion and an unnaturally high rate of bedload aggradation. He relies on anecdotal evidence in asserting that the Dungeness side channels once ran mainly through forest, whereas by the time of the instream flow studies in the early 1990s he found them flowing primarily through open gravel bars. An oral history taken from a long-time Dungeness area fisherman (Lichatowich 1993a) also suggests that human intervention in the watershed may be responsible for the aggradation. However, Lichatowich (1993b) also notes that the recent high rates of sediment transport and accumulation in the Dungeness River to some degree represents a return to the early, post-glacial conditions ending approximately 1,700 years before present, when erosion and sediment yields were 2 to 14 times current yields.

Analysis of Dungeness River channel geometry between 1937 and 1993 by Orsborn and Ralph (1994) showed the channel responding to increased debris and sediment load from upstream sources between 1967 and 1986 at flows less than 200 cfs. They found that the Highway 101, Railroad, and Woodcock (Ward) bridges collect large amounts of bed load and large woody debris upstream, and are inefficient at passing the load downstream. Channel responses to increased debris and sediment load contributed from upstream sources are reflected in subsequent downstream channel pattern changes at the Highway 101 and Railroad bridges (changing from a straight to a meandering pattern). Possible causes of channel pattern and cross-section geometry changes during the 1967-1986 period identified by Orsborn and Ralph (1994) included:

- land/debris slides in Silver and Gold creeks 1968 to 1972, and smaller failures in 1972, 1975, 1977, 1978, 1980, and 1989-1991;

- Forest Service road construction in the basin, which almost doubled between 1965 and 1983;
- a shift (increase) in the peak flooding relationship between Gold Creek and the Dungeness River between 1969 and 1972; and
- precipitation and high flow events (greater than 1000 cfs average daily flow) were both high between 1967 and 1972.

Orsborn and Ralph (1994) conclude that a series of natural and artificial events have combined to cause downstream impacts on channel width, braiding, and bed elevation. Braided streams are highly erosive, suspending and carrying large sediment loads during high flows. These loads are dropped in slower reaches, causing bed aggradation, reducing main channel capacity, and increasing the occurrence of flooding. Braided streams also tend to uproot trees, eroding river banks from around their roots and carrying them downstream to form debris jams. All of these conditions are chronic on the Dungeness (KCM 1990).

In general, sediment aggradation occurs along the outside of a meander bend and accretion occurs along the inside (Bountry et al. 2002). This pattern is the result of differential distribution of energy. As the river gains energy around a meander bend, it gains velocity and can more easily erode bank material and transport larger particles; energy decreases along the inside of a meander bend and the carrying capacity of the river decreases and deposits material. The same phenomenon is found when channel bed slope is shallow and the river is wider so that velocities have more area to dissipate.

Bountry et al. (2002) state that channel braiding is decreasing in the lower Dungeness River due to channel restrictions. When levees cut off access to the floodplain, sediment and water movement that would normally form a meander will elongate instead, because lateral movement is inhibited. When a meander bends too far, a meander cut-off channel forms during floods and the low flow channel becomes straighter.

The ongoing migration of the river channel, particularly in the braided river reaches, presents serious challenges to riverbank landowners and they have responded with interventions that have decreased the stability and habitat quality of the lower river system as a whole. Orsborn and Ralph (1994) point out that it is stream responses to extra bedload that have in turn brought about these human responses, such as building dikes for flood protection and bulldozing to combine multiple low flow channels for fish migration. The most significant impacts to the Dungeness River channel identified by Orsborn and Ralph (1994) have been due to:

- Clearing of trees in the riparian zone;
- Destabilization of the river banks due to vegetation removal and cattle grazing;
- Blocking meander channels and forcing river flow down shorter, steeper channels;
- Removing vegetation from the river channel;
- Land slides in the basin;
- Road-building and logging;
- Off-season irrigation diversions; and

- Confining the channel with levees along the banks, accelerating the movement of spawning gravels through bedload transport.

Flood events, in the aftermath of human interventions in the channel (including construction of levees which narrowed the channel or cut off meander bends), now tend to fluidize the stream bed, leaving salmon redds little chance of success if even only small floods occur prior to fry emergence (Orsborn and Ralph 1994). Orsborn and Ralph note that the chance of a flood occurring after the first of October (after redd establishment) is quite high.[2]

Orsborn and Ralph (1994) indicate that since 1988 the incoming sediment load (at the Highway 101 bridge) has decreased and the channel pattern downstream has become generally straighter (less braiding or meandering), apparently indicating that a load of sediment has been working its way downstream. The USFS (DAWACT 1995) notes a change from massive sediment loading in the river following stand replacement fires with 200 year recovery, to small chronic amounts of sedimentation from various human land and transportation uses. (USFS roads and portions of road fill slopes, including culvert outlets, are chronic sediment sources according to the DAWACT).

Log Jam and Large Woody Debris Removal

Log jam and LWD removal impacts salmonid refugia. As noted above and elsewhere throughout this plan,, different life stages of salmonids depend on log jams formed and expanded during high flow events. They create temperature refugia during low flow events and velocity refugia during high flow events (Bountry et al. 2002). Many species of salmonids emerge from redds during spring runoff periods and are vulnerable to high velocities. High temperatures experienced during low-flow periods can stress adult and juvenile salmon during migration.

LWD also tends to limit the amount of bank erosion that occurs along the outside of meander bends (Bountry et al. 2002). The presence of LWD slows down velocities that tend to increase around meander bends and decrease the carrying capacity of the river.

Substrate

Gravel removal in the Dungeness River, as discussed above, can alter aquatic habitat in a variety of ways that impact salmonids. The primary influence occurs when excavation pits attract spawners whose redds are buried in the following winter's floods. Excavation can also change velocity patterns and form headcut erosion that destabilizes the river upstream of the gravel pit (Bountry et al. 2002). In addition, channel scouring can occur when river hydrology is altered due to gravel manipulation, bank alteration, changes to the hydrograph or other actions. This scouring can cause the elimination of valuable spawning gravels, loss of woody debris, reduction in channel complexity, and other significant substrate-related impacts.

[2] This updates Hiss (1993a), who expected that winter storm flows in the Dungeness River would likely be adequate for channel maintenance (natural scour and deposition) sufficient to maintain fish habitat diversity.

Recharge

Average annual recharge to the Dungeness aquifers (reported in December 1995 to September 1997) was approximately 17.7 inches (or an inflow rate of 151 cfs) (Thomas et al. 1999). Groundwater is recharged from the following sources (Thomas et al. 1999):

- Infiltration and percolation of precipitation (approximately 8.6 inches or 74 cfs[3])
- Percolation of unconsumed irrigation water (3.1 inches or 26 cfs)
- Leakage from irrigation ditches (part of value from unconsumed irrigation water, above)
- Subsurface inflow through the southern study area boundary (2.7 inches or 23 cfs)
- Leakage from streams (3.3 inches or 28 cfs)

The irrigation ditches and canals within the Sequim-Dungeness peninsula are routed across coarse and highly permeable soils that drain into aquifers (Foster Wheeler 2002, Haring 1999, MWG 1999). This type of recharge has created an artificially high water table. An additional source of recharge to the aquifer (discussed above) is through leakage from the Dungeness River (approximately 28 cfs) (Thomas et al. 1999).

The following factors have reduced the deep percolation return to the aquifer (Thomas et al. 1999, MWG 1999):

- Decrease in agricultural water use due to a change from flood irrigation to sprinkler or drip irrigation.
- Loss of agricultural land in the watershed.
- A shift to less water-intensive crops.
- Increased water conservation by irrigators.
- Increased urbanization has also decreased recharge to the aquifer over the past 50 years as impervious surfaces eliminate rainwater percolation and increase runoff (Foster Wheeler 2002).

Recharge also occurs through the streambed due to high permeability in the soils. During sustained periods of high river stage (spring snow melt and winter storms) groundwater levels increase (Simonds & Sinclair 2002). Simonds and Sinclair (1999) estimated river seepage levels at different reaches of the river (Figure 2.8-3) and calculated vertical hydraulic conductivity values of the streambed sediments. Average vertical hydraulic conductivity ranged from 1 to 29 feet per day (ft/d): reaches 4 and 5 ranged from 29 to 8 ft/d, and reaches 1, 2, and 3 ranged from 2, 1, and 4 ft/d, respectively.

2.8.5 Water Quality

Dungeness Watershed Water Quality Overview:

The *Dungeness River Area Watershed Management Plan* (DRAW Plan) (DWMC and CCDCD 1993) and its underlying 1991 DRAW Report prepared by the Puget Sound

[3] Note: this number is an overestimation of precipitation due to a higher than average precipitation value (by 1.35 times) that occurred during the study. The long-term average annual recharge from precipitation was estimated to be 5.4 inches (48 cfs).

Cooperative River Basin Team establish a framework for maintaining and improving water quality in eastern Clallam County.[4] Standards for water quality are specified in the Clean Water Act, as amended, and Chapter 246-290 WAC (see Chapter 1).

The DRAW Plan (1993) stated that current water quality and biological health of the watershed were sufficient at the time to permit all recognized beneficial uses. However, the Plan cautioned that non-point sources of pollution threatened the future use of water for recreation, wildlife, finfish, shellfish, and domestic water supply (see below for an update on shellfish harvest closure in Dungeness Bay). The 1993 Plan listed five key goals:

- Develop a community stewardship ethic
- Maintain and improve water quality to support all beneficial uses
- Improve knowledge and understanding of watershed processes
- Encourage interagency cooperation, coordination and management to protect water quality
- Fully implement the actions and intent of the Plan

It also provided source control strategies for five areas: agriculture, forestry, on-site sewage disposal, stormwater, and groundwater protection.

The 1993 DRAW Plan reported very little water quality sampling of surface water in the Dungeness area prior to 1990. However, in 1991 to 1992, Clallam County monitored fecal coliform in East WRIA 18 on a weekly basis, and found elevated levels in many streams in eastern Clallam County. The study was later expanded to include additional water quality parameters. Results indicated fecal coliform standards were not met in the tailwaters of four out of five irrigation ditches and eight out of 10 streams. Dissolved oxygen levels were high, and temperatures exceeded 20ºC in some locations, indicating a situation that likely worsened by late summer.

According to Hempleman and Sargeant (2002), bacterial contamination has been documented in Matriotti Creek since 1991 through monitoring efforts by the Conservation District and Clallam County (Figure 2.8-5). Matriotti Creek, a major tributary to the Dungeness River, was placed on the 1996 and 1998 303(d) lists of impaired water bodies due to its failure to meet state standards for fecal coliform. The Dungeness River was placed on the 1996 and 1998 303(d) lists for instream flow violations. The 2002 303(d) list was not produced.

In 1997, during routine, ongoing monitoring activities to monitor shellfish safety for human consumption), the DOH reported elevated fecal coliform bacteria in the Bay near the mouth of the Dungeness River (a more detailed water quality history of Dungeness Bay is provided in the Dungeness Bay section below). In response to water quality problems affecting shellfish harvesting in the Bay, the Jamestown S'Klallam Tribe and Clallam County conducted monitoring on the Dungeness River and tributaries in an effort to determine the source of bacteria.

[4] One of DRMT's missions is to implement this plan.

Since elevated levels of fecal coliform were found in multiple sites and a definitive source could not be identified, in 1998 the Tribe and County requested that Ecology provide technical assistance. Ecology agreed to conduct a TMDL study on Matriotti Creek and other tributaries in the lower Dungeness and in cooperation with the Jamestown S'Klallam Tribe and Clallam County conducted monitoring activities in the lower Dungeness River basin in 1999 and 2000. Kahle Jennings (Ecology) indicated (November 15, 2000 letter from Ecology the CCBC) that the Clean Water Strategy would be a major component of the overall effort to reduce fecal coliform contamination in the watershed. A summary of the TMDL results for the Dungeness River and Matriotti Creek, including information regarding Dungeness Bay, is discussed below. Additional information on this subject can be found in the following documents:

- *Quality Assurance Project Plan for Dungeness River/Matriotti Creek Fecal Coliform Bacteria TMDL Study* (Sargeant 2000);
- *Dungeness River and Matriotti Creek Fecal Coliform TMDL Study, Preliminary Results for November 1999 through October 2000* (Sargeant 2001);
- *Draft Dungeness River and Matriotti Creek Fecal Coliform Bacteria TMDL Study (Sargeant 2002)*; and
- *Draft Water Quality Plan for Bacteria in the Lower Dungeness Watershed TMDL Submittal Report* (Hempleman and Sargeant 2002).

Additional known water quality issues, such as stormwater, Sequim Bay shellfish closure, groundwater problems affecting well owners in the Agnew area, and groundwater impacts in the Carlsborg Urban Growth Area are detailed in Appendix D of the Clean Water Strategy (CCBC and Clean Water Work Group 2002).

Dungeness River and Tributaries

The State of Washington classifies the Dungeness River and its tributaries from the mouth to its confluence with Canyon Creek as Class A (Excellent) under WAC 173-201 A. All portions of the river above Canyon Creek are classified as Class AA (Extraordinary).

Dungeness River water quality problems are affecting critical and depressed salmon stocks in the river, as well as shellfish in the bay. Ecology (1998) found numerous problems in the Dungeness River associated with excessive sediments and nutrients, dissolved oxygen and temperature problems in some segments.

The *Dungeness River Area Watershed Management Plan* (DWMC and CCDCD 1993) provides a detailed discussion of beneficial uses in the watershed. Key beneficial uses include:

- Habitat for native marine and freshwater fish, including resident and anadromous salmonids and resident trout (Chinook, coho, chum, pink, summer and winter-run steelhead, cutthroat and rainbow trout, Dolly Varden).
- Seals and otters attend the fish runs. Bald eagle and peregrine habitat is found in the stream corridor.
- WDFW hatcheries on the mainstem (chum and coho salmon) and on Hurd Creek (coho).

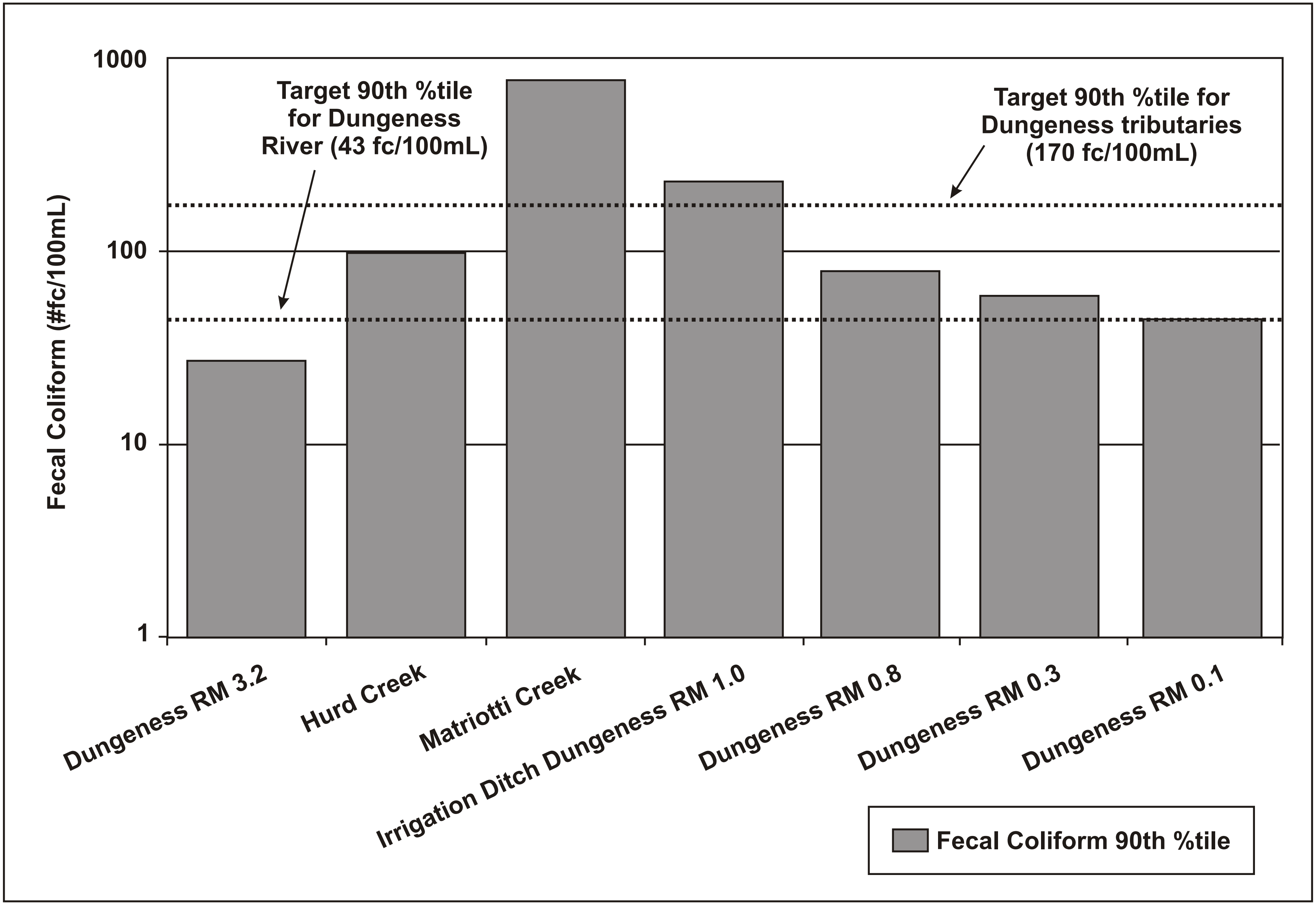

Figure 2.8-4. Dungeness River and tributaries study fecal coliform 90th%tiles, and target fecal coliform 90th%tile concentrations (Hampleman and Sargeant 2002).

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- Baitfish and commercial fishing areas for bottomfish located directly offshore.
- Intertidal marine invertebrate habitat and harvest.

Total Maximum Daily Load (TMDL)

Under Section 303(d) of the Federal Clean Water Act, the State of Washington is required to develop plans aimed to identify and correct water bodies which have failed to meet water quality standards set forth by the State (see Appendix 1-A). A TMDL, or Water Cleanup Plan, is required for every pollutant that caused the water body to fail the specified water quality standard(s).

Addressing multiple fecal coliform bacteria violations, a TMDL study for the lower Dungeness River, Matriotti Creek, and tributaries to Dungeness Bay was conducted by Ecology with assistance from the Jamestown S'Klallam Tribe and Clallam County. Approximately 35 to 40 stream sites were sampled for fecal coliform from November 1999 through October 2000. Dungeness Bay, Matriotti Creek, Meadowbrook and Cooper creeks, and Golden Sands Slough each violated fecal coliform water quality standards (Sargeant 2002).

The goals of the TMDL Study were to characterize fecal coliform pollution and develop an implementation plan to reduce the fecal coliform in order to protect beneficial uses. In addition, objectives listed in the 2002 TMDL Study included:

- Characterize fecal coliform bacteria concentrations and identify areas of major bacterial loading sources along Matriotti, Meadowbrook, and Hurd Creeks and the lower Dungeness River.
- Determine maximum acceptable fecal coliform loads and concentrations allowable at the mouth of the Dungeness River to meet marine standards at DOH station 113.
- Determine maximum acceptable fecal coliform loads and concentrations in Matriotti Creek to meet the TMDL targets in the Dungeness River.
- Determine the percent reduction in fecal coliform bacteria concentrations necessary to meet the above targets.

As required by the State, annual and seasonal patterns of fecal coliform concentration and loading data were also evaluated during the TMDL Study. Results indicated higher fecal coliform concentrations were present during the irrigation season for most sites, as was fecal coliform loading for a majority of the tributaries and the Dungeness River above RM 0.8. However, loads at the site closest to the mouth (at RM 0.1) on the Dungeness remained fairly consistent throughout the year, with only a slight increase during the wet (fall and winter) season (Hempleman and Sargeant 2002).

Following the TMDL Study, the *Draft Water Cleanup Plan for Bacteria in the Lower Dungeness Watershed, TMDL Submittal Report* (Hempleman and Sargeant 2002) was established to address the elevated levels of fecal coliform found within the lower Dungeness River watershed (Table 2.8-7). This 2002 TMDL Submittal Report applies to the lower Dungeness River below RM 3.2, including Hurd and Matriotti Creek tributaries, as well as Meadowbrook Creek and Slough, Golden Sands Slough, Cooper Creek and several irrigation ditches that empty into Dungeness Bay (Hempleman and Sargeant 2002).

Because the beneficial use with the most restrictive fecal coliform criteria is shellfish harvesting in Dungeness Bay, the TMDL targets fecal coliform reductions for the Dungeness River and tributaries to protect downstream beneficial uses (Hempleman and Sargeant 2002).

Table 2.8-7. Fecal Coliform TMDL Load Allocations - Dungeness River and Tributaries.

Site	Percent of Change Required to Meet Water Quality Criteria	Target FC Load Allocations (conc. x flow)	Percent of Total Load Contribution
Dungeness River RM0.1	-9%	6812	30.90%
Dungeness River RM 0.3	-29%	5288	23.99%
Dungeness River RM 0.8	-47%	5059	22.94%
Irrigation Ditch at Dungeness River RM 1.0	-29%	24	0.11%
Matriotti Creek	-78%	1267	5.74%
Hurd Creek	0%	316	1.43%
Dungeness River RM 3.2	0%	3279	12.87%
	Totals	22,045	100%

Source: Hempleman and Sargeant 2002.

Nonpoint Sources

Nonpoint pollution issues listed by *Dungeness River Area Watershed Management Plan* (DWMC and CCDCD 1993) (the "DRAW Plan") included:

- Animal access
- Impacts of flooding on fish habitat
- Intermittent cover on the lower portion of the river
- Erosion
- Channel dynamics
- Lack of habitat
- Low flows

Dungeness River tributaries (i.e. Matriotti and Hurd Creeks) and irrigation ditches were noted for disturbances that exacerbate the problems associated with the nonpoint pollution issues stated above. These disturbances included:

- Vegetation removal
- Compaction and sedimentation
- Elevated bacterial counts.

The DRAW Plan also characterized non-point sources of pollution, including forest practices, agricultural practices, residential and urban areas, and recreational boating. In addition, the *City of Sequim Comprehensive Water Plan* (Polaris Engineering and Surveying, Inc. 1993) contained an appendix discussing non-point sources of pollution, with attention to the same key sources. The *City of Sequim Water System Comprehensive Plan*

(Gray and Osborne, Inc. 2000) discussed nonpoint sources referring mainly to groundwater contamination.

After the closure of Dungeness Bay to commercial shellfish harvest (discussed below), efforts were redoubled to contact remaining farmers and assist them in 303(d) compliance. The Water Users' Association (WUA) reports (1999a) that it has worked in cooperation with the Conservation District, Jamestown S'Klallam Tribe, and Clallam County to advise farmers of 303(d) requirements and their responsibility to keep livestock out of irrigation ditches and small streams, either by fencing or pipelining. The WUA estimates that 80 percent of livestock access from WUA member operations has been removed. Pipelining ditches eliminates the opportunity for contamination by livestock, and could benefit shellfish in Dungeness Bay. On the other hand, reduced dilution resulting from reduced irrigation recharge may exacerbate some groundwater quality issues, such as nitrate concentrations. The *Comprehensive Water Conservation Plan* (MWG 1999) concludes that implementation of proposed improvements could improve water quality by reducing the runoff of bacteria in irrigation ditches, many of which were found to be out of compliance with fecal coliform standards.

Point Sources

According to Hempleman and Sargeant (2002), there are no point sources or regulated stormwater discharges to Matriotti Creek or within the study area (RM 3.2 to mouth) of the Dungeness River and its tributaries.

Irrigation Ditches

The extensive irrigation network maintained by the WUA is described in Section 2.3.3 (and Figure 2.3-2). Irrigation ditches are considered waters of the State. As such, they are classified and treated in the same manner as streams. However, if a ditch originates from Class A waters (such as the lower Dungeness) and empties into a Class AA water body, then it must meet the higher standard.

Data obtained from water quality monitoring conducted on some irrigation ditches that empty into Dungeness Bay are presented in the *Draft Water Cleanup Plan for Bacteria in the Lower Dungeness Watershed TMDL Submittal Report* (Hempleman and Sargeant 2002).

As discussed above in the Stream Channels section, the *1993 Dungeness River Area Watershed Management Plan* indicates disturbances such as vegetation removal, compaction, sedimentation, and elevated bacterial counts have exacerbated problems associated with nonpoint pollution in irrigation ditches.

Dungeness Bay

Dungeness Bay is listed as class AA (Extraordinary) marine water. For many years the Washington Department of Health (DOH) has certified Dungeness Bay as "Approved" for commercial shellfish harvest (CCBC and Clean Water Work Group 2002). The Bay is an important location for recreational harvest of crab and clams as well as the source of commercial harvest of crab, and the site of two commercial shellfish farms (approximately 1,183 beds were approved). Three Native American Tribes have Treaty rights to harvest finfish and shellfish with Dungeness Bay. One of those tribes, the Jamestown S'Klallam Tribe, is a founding member of the Clean Water Work Group.

The DOH routinely monitors water quality at 13 sampling stations within the Bay. The highest levels of fecal coliform were initially found in 1990. Subsequently, a major dairy farm on the Dungeness River ceased operations, and coliform levels dropped. In 1995 and 1997, federal standards were exceeded again at one monitoring station. Since 1997, DOH has monitored the bay every other month and in 1998, the agency gave early warning that the Dungeness Bay shellfish area was threatened with a downgrade due to fecal coliform contamination. Monitoring and measures to identify and correct fecal coliform sources were recommended (Ecology 1998). Two additional sampling stations failed, leading DOH to prohibit commercial shellfish harvest in about 300 acres of the bay, effective April 28, 2000. In 2001, the DOH prohibited an additional 100 acres of the Bay from commercial shellfish harvest. The shellfish area was downgraded because fecal coliform levels exceeded National Marine Sanitation Requirements for water quality standards in commercial shellfish harvesting areas (Hempleman and Sargeant 2002).

Under the 1994 *Puget Sound Water Quality Management Plan*, DOH was required to initiate a closure response process following downgrade of a shellfish area. A response group (formerly called the Shellfish Downgrade Response Team and now identified as the Clean Water Work Group) consisting of state and local agencies, tribes, and other interests was assembled; Clallam County agreed to act as lead agency to develop a shellfish closure response plan in cooperation with the Clean Water Work Group. The *Clean Water Strategy for Addressing Bacterial Pollution in Dungeness Bay and Watershed (*CCBC and Clean Water Work Group 2002*)* updates the 2000 Clean Water Strategy originally based on the *Dungeness Bay Shellfish Closure Prevention Response Strategy* (1997-1998), as well as the *Dungeness Bay Watershed Management Plan* (1994). The purpose of the Clean Water Strategy, which is updated as needed, is to coordinate and guide actions that will ensure improvement and long-term protection of water quality.

Clallam County was also required (pursuant to RCW 90.72.045) to form a shellfish protection district. Subsequently, the Sequim-Dungeness Clean Water District (Clean Water District) was in 2001, by ordinance CCC.27.16 (CCBC and Clean Water Work Group 2002). Figure 2.8-6 illustrates the geographic extent of the Clean Water District, in combination with the Shellfish Closure Area and the area covered by the TMDL.

Potential sources of fecal coliform include livestock, pets, birds, marine mammals, and failing septic systems near ditches, streams, rivers, and along the edge of the bay. Existing data suggests that the river-borne contribution is likely the largest fraction, as coliform concentrations are relatively high near the river mouth and are inversely correlated with salinity. Ecology is conducting a Total Maximum Daily Load (TMDL) study to determine sources of bacteria, establish targets for source reduction, identify actions to reduce bacteria and establish monitoring of the effectiveness of these efforts. The TMDL Study for Dungeness Bay will reportedly be available sometime in early 2003. According to the 2002 Clean Water Strategy, additional assessments of the Bay should include a circulation study, bathymetric mapping and water column sampling.

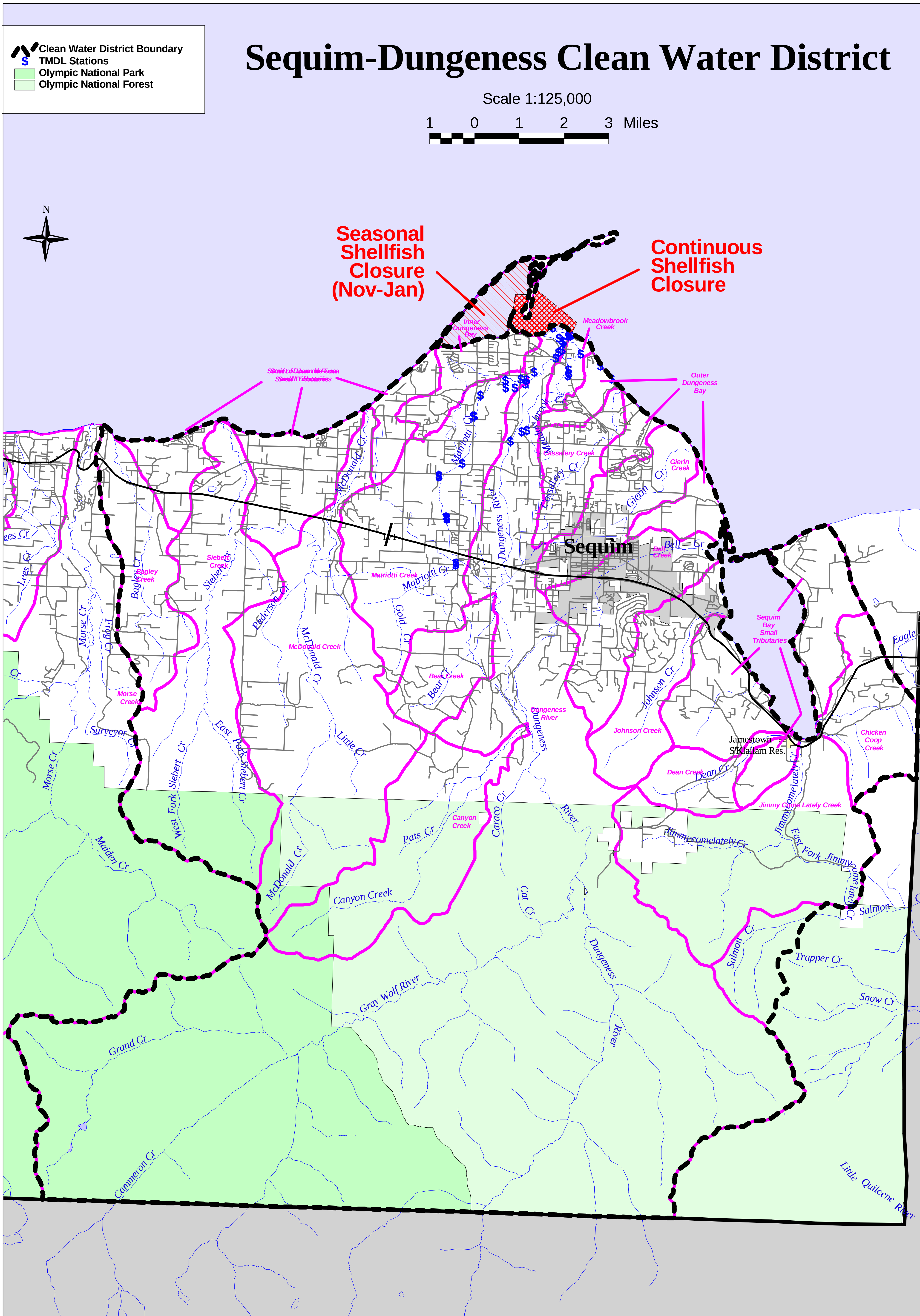
Sequim-Dungeness Clean Water District
Clean Water District Boundary
TMDL Stations
Olympic National Park
Olympic National Forest
Scale 1:125,000
1 0 1 2 3 Miles
N
Seasonal Shellfish Closure (Nov-Jan)
Continuous Shellfish Closure
Inner Dungeness Bay
Meadowbrook Creek
Outer Dungeness Bay
Cassalery Creek
Gierin Creek
Bell Creek
Sequim
Sequim Bay Small Tributaries
Matriotti Creek
McDonald Creek
Bear Creek
Dungeness River
Johnson Creek
Dean Creek
Jimmy Come Lately Creek
Chicken Coop Creek
Canyon Creek
Siebert Creek
Bagley Creek
Morse Creek
Jamestown S'Klallam Res.
Surveyor Cr
West Fork Siebert Cr
East Fork Siebert Cr
Maiden Cr
Grand Cr
Cameron Cr
Gray Wolf River
Pats Cr
Caraco Cr
Cat Cr
Salmon Cr
Trapper Cr
Snow Cr
Little Quilcene River
Eagle Cr

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Table 2.8-8 displays actions to remove/remediate pollution sources, direct public outreach and further assess pollution sources. The table essentially repeats Table 2 from the Clallam County and Clean Water Work Group's 2002 *Clean Water Strategy for Addressing Bacterial Pollution in Dungeness Bay and Watershed* (see Appendix A of Hempleman and Sargeant 2002).

Table 2.8-8. Dungeness Bay Action Plan

Action	Assignment	Timeline	Funding Source
Pollution Source Removal or Mitigation			
Irrigation ditch piping to reduce input of pollutants to surface water	CCD, Water Users Assoc.	Ongoing	Conservation Commission
Riparian restoration & fencing to stabilize stream banks & reduce the movement of pollutants	CCD	Ongoing	Partial, inadequate. WCC & DOE
Develop and implement dairy nutrient management plans	CCD	Ongoing	Partially- WCC
Develop and implement farm plans specifying best management practices	CCD	Ongoing	Partial, inadequate- WCC & DOE
On-site septic system investigations	CC	Ongoing	Partially- CC General Fund
Development of On-site O&M Program	CC	Ongoing	Partially-DOE
Ecology enforcement action	DOE	As needed	DOE
Public Outreach			
Public Hearing for Water Clean-up Plan	DOE	April 2002	DOE
Neighborhood meetings	DOE, CC, CCD, JKT	April 2002	DOE
Sequim 7th Grade Watershed Week	RC	April 2002	EPA
Septic 101 Workshops	CC	January – May 2002	JKT via EPA
Natural Landscaping Workshop	CCD	April/May 2002	JKT via EPA
Horse and Pony Care	CCD	May 2002	JKT via EPA
Salmon and Wildlife Workshop	JKT	2002	JKT via EPA
Quarterly newsletters mailed to watershed residents about Clean Water District, associated strategies and stewardship activities	CC	2002 and 2003	CCWF
Presentations to local community groups	CC, JKT	2002	None
Festival/Fair Booths – shellfish, water quality, on-site maintenance, and riparian protections	CC, CCD, Ecology	2002	Partially-Various Sources
Source Assessment			
Total Maximum Daily Load Study (TMDL) for Matriotti, Meadowbrook and Dungeness River & Bay	DOE	April 2002	DOE, JKT
Marine water quality sampling	HEALTH, JKT	Ongoing	HEALTH, EPA
Water quality sampling of irrigation ditches	CCD, CC	Ongoing	Yes, Partially - WCC/CCWF
Circulation Study of Dungeness Bay	JKT	2003	EPA
On-site system database with GIS mapping, starting with problem areas identified with water quality data	CC	Partially completed for some areas	Partially- CC General Fund
Information/data on wildlife populations and usage with the bay	USFWS	Ongoing	USFWS
Additional sampling of specific stream reaches	JKT, CC	Ongoing	EPA, DOE
Analysis of fecal coliform inputs from stormwater conveyances	Not Assigned	???	None
Characterization of fecal coliform (or E. coli) bacteria, using genetic or chemical markers	Under review by CWW and MRC	???	None

Source: Clallam County 2002 – updated

Total Maximum Daily Load

As noted above, the completion of a TMDL report for Dungeness Bay is reportedly expected in early 2003. The Draft Water Cleanup Plan for Bacteria in the Lower

Dungeness Watershed TMDL Submittal Report included fecal coliform allocations for the tributaries to Dungeness Bay (Hempleman and Sargeant 2002). The 2002 TMDL Report was intended as a step to help protect marine water quality standards and shellfish harvesting in Dungeness Bay. Thus, fecal coliform load allocations for Dungeness Bay tributaries discussed in the 2002 TMDL Report were to be examined to determine if adjustments will need to be made for the 2003 Dungeness Bay TMDL report, in order to protect the shellfish harvesting in the Dungeness Bay (Hempleman and Sargeant 2002).

Table 2.8-9 lists flow, mean fecal coliform load, target fecal coliform load allocations, required changes necessary to meet water quality criteria, and relative contributions of flow and fecal coliform loading to inner and outer Dungeness Bay. The table was recreated with information obtained from Sargeant 2002 and Hempleman and Sargeant 2002.

Table 2.8-9. Instantaneous Mean Daily Values for Fecal Coliform (FC) Concentration, Loading and Allocations, Flow, and Relative Contributions of Flow and Fecal Coliform Loading to Inner and Outer Dungeness Bay.

Site	Mean Flow (cfs)	Mean FC Load (#cf/100mL x cfs)	Target FC Load Allocation (conc. x flow)	Required Change (%)	Freshwater Flow to Bay (%)	Freshwater FC Load to Bay (%)
Dungeness River RM 0.1	413	7589	6817	-9	97	88
Meadowbrook Creek CM 0.2	6	484	200	-59	1.4	6
Cooper Creek	5	299	214	-28	1.2	4
Golden Sands Slough	1	187	33	-82	0.2	2
Irrigation Ditch 1	<1	18	12	-33	0.0	0
Irrigation Ditch 2	<1	2	<1	-84	0.0	0

Sources: Hempleman and Sargeant 2002, Sargeant 2002.

Groundwater

The primary beneficial use of groundwater in East WRIA 18 is as potable supply for public water systems and single domestic use. It also provides both primary and supplemental irrigation water. Groundwater also provides stream base flows, particularly important during late season low flow periods and for smaller streams.

According to the DQ Plan (1994), an Ecology study of east Clallam County groundwater issues looked at non-point sources, nitrate, seawater intrusion, and contaminant threats. It concluded that groundwater quality was generally good, although nitrate levels had increased since 1980. Seawater intrusion remained more a matter for monitoring than immediate concern.

The Sequim-Dungeness Groundwater Committee prepared a strategy for protection of groundwater resources in eastern Clallam County (SDGC and CCDCD 1994). Both localized increases in nitrate levels and the vulnerability to contamination resulting from a predominance of highly permeable, well-drained soils over a shallow aquifer were of concern.[5] The close association between groundwater, surface streams and irrigation ditches provides avenues for contamination to move between water sources through recharge and discharge (see discussion above). The 1994 Strategy notes that pesticide

[5] See discussion of Carlsborg soils, above.

and herbicide use in the area is largely uncertain, but soil conditions make potential contamination a concern. Sampling programs were carried out for nitrates, chlorides, stormwater contaminants and water levels (see Appendix D of the 1994 *Sequim-Dungeness Groundwater Protection Strategy* for well data on water quality). The Strategy itself includes a review of actions to date or in process at that time, proposed actions, and action lists to achieve its goals. The Strategy's goals relate to:

- Groundwater susceptibility to nitrates, pesticides, stormwater, underground storage tanks, and seawater intrusion;
- Well construction and abandonment;
- Water supply permit processing (with attention to water right application backlogs that motivate higher rates of exempt well drilling, the problems of financially non-viable small water systems, permit coordination, and "water resource preservation"); and
- Information management, public involvement, and funding.

As a part of their wellhead protection, the *City of Sequim Water System Comprehensive Plan* (Gray and Osborne, Inc. 2000) discusses potential groundwater contamination sources and included potential contaminant inventories in and around zones of contribution. The Plan identifies potential contamination from industrial and commercial activity, nearby septic systems, dangerous waste generators, and underground and leaking underground storage tanks.

Nitrates

Nitrate concentrations are often used as indicators of aquifer health because nitrate is a highly soluble, mobile contaminant in groundwater and is produced from a variety of non-point sources. Levels greater than one ppm (or 1 mg/l) generally indicate unnatural accumulations. Human health effects from drinking nitrate-contaminated water would not be expected until concentrations exceed 10 ppm[6] (the State drinking water standard). Potential sources of nitrogen include recharge from precipitation, recharge from irrigation and leakage from the Dungeness River, dry deposition from dairy farms, mineralization from soil organic matter, application of agricultural fertilizers, application of residential fertilizers, effluent from septic systems, storage and application of manure, and leakage from dairy manure lagoons.

The *Sequim-Dungeness Regional Comprehensive Plan* (CCDCD 1994) covers a regional planning area roughly equivalent to East WRIA 18. This Plan considers nitrate levels of 3 ppm to indicate moderate degradation and levels of 5 ppm to indicate more "advanced" degradation. Samples collected during August 1992, of more than 340 wells, showed that 25 percent of all wells had undetectably low levels, but 31 percent were greater than 1 ppm and 10 percent had levels in excess of 3 ppm (SDGC and CCDCD 1994). Only 4 wells violated the state drinking water standard. Three areas exhibited elevated levels of nitrate: Carlsborg, northeast Sequim, and the west end of Woodcock Road (detail on these areas is contained in the Groundwater Protection Strategy and in the Regional Plan Appendix B). Because nitrate concentrations may be significantly affected by dilution, it was expected that levels would be highest following the season of lowest precipitation.

[6] This level was established primarily to protect infants ("blue baby" syndrome).

Where annual patterns exist, highs were found most often in late summer and lows in early spring (however no winter data were collected (SDGC and CCDCD 1994).

Carey (1995) found a high potential for nitrate contamination of groundwater at the Sunland water reuse application site north of Sequim, due to shallow depth to water, spray field operation (crop not removed, sprinkler rotation, and winter application), and excessive effluent application rate. Carey (1995) recommended a number of improvements, including bringing the application rate within design guidelines to avoid downgradient increases in nitrate concentrations. Ecology (1998) reports earlier concerns (from 1994) with the Sunland lagoon/sprayfield as a potential source of contamination, and recommended careful evaluation of the City of Sequim reuse project for the same reason.

Thomas et al. (1999) found a small but statistically significant increase in nitrate concentrations in groundwater over the 1980 to 1996 period. Median concentrations in the Sequim-Dungeness study area were 0.32 mg/l, but in the central part of their study area they were 0.46 mg/l in 1996 as compared to 0.37 mg/l in 1980 (Drost 1983). A 1992 sample of more than 340 wells by Clallam County showed a median concentration of 0.55 mg/l with a similar areal pattern (Ann Soule pers. comm. 2001).

Thomas et al. collected groundwater samples from 65 wells in July-August 1996. Of these, 83 percent were from the shallow aquifer. Elevated nitrates were found in a large area east of the Dungeness River and north of Bell Creek and Highway 101. In this area 42% of the samples had greater than a 1.0 mg/l increase in concentration, according to Thomas et al. Elevated concentrations were also found at scattered locations to the west of the river and east of McDonald Creek. Although the *Sequim-Dungeness Groundwater Protection Strategy* (SDGC and CCDCD 1994) reported localized increases in nitrate over the preceding 15 years, Thomas et al. (1999) state that the areal pattern of elevated nitrate concentrations has not changed appreciably during the past 15 years.

Thomas et al. (1999) found nitrate concentrations were higher in the shallow aquifer (0.53 mg/l) than the middle aquifer (0.24 mg/l) because the shallow groundwater is closer to nitrogen sources. Median values for other nitrogen species were <0.01 mg/l for nitrite, <0.04 mg/l for ammonia, and <0.2 mg/l for ammonia plus organic nitrogen. Values ranged from less than detection limits to 4.3 mg/l for nitrate, 0.04 mg/l for nitrite, 2.7 mg/l for ammonia, and 3.1 mg/l for ammonia plus organic nitrogen (Thomas et al. 1999).

Natural background levels of nitrate were estimated to be <1.0 mg/l by Thomas et al. Concentrations in the shallow aquifer were significantly higher under residential areas (1.3 mg/l) than under natural grasslands or forests (0.12 mg/l). Concentrations under agricultural areas fell about in the middle (0.55 mg/l), but these values could not be separated with statistical significance from either the residential or grassland and forest values. Estimated nitrogen loadings showed a similar distribution (40 lbs./acre for residential areas, 20 lbs./acre for agricultural areas, and 1 lb./acre for grasslands and forests) (Thomas et al. 1999).

Thomas et al. (1999) estimates that about 543,200 pounds of nitrogen annually enters the groundwater system in the core (74 mi^2) study area. Residential fertilizer (24%), septic systems (21%), mineralization of soil organic matter (20%), and agricultural fertilizers (20%) contribute about equally as sources of nitrogen (Thomas et al. provide more detail as to the loading analysis and the quality of data used). Most of the remaining nitrogen is sourced from dairy farms (8%). Which of these sources account for the increase in nitrate concentrations from 1980 to 1996 is uncertain, however. Thomas et al. found some evidence that a decrease in dilution (with decreased irrigation recharge) may account for the increased nitrate concentrations, as the area of most consistent nitrate concentrations is also the area with the most consistent declines in groundwater levels. A correlation of nitrate to septic system density reflected the expected distribution of results (0.16 mg/l in low densities, 0.57 mg/l in medium densities, and 0.92 mg/l in high densities), but statistical significance could not be shown with this sample.

Seawater Intrusion

In proximity to shorelines, the diffusion zone between fresh and seawater sometimes yields water with unacceptable chloride levels. Low productivity aquifers in these areas may be vulnerable to seawater intrusion with excessive pumping (DQ Plan 1994). USGS studies (Drost 1983, 1986) conclude that, while few instances of poor groundwater quality were identified, chloride concentrations in excess of 250 mg/l have been measured along the shoreline from the southwest side of Sequim Bay to the northeast part of Miller Peninsula (particularly in the Diamond Point area), where wells have been drilled into the zone of diffusion. Although seawater intrusion was not considered a problem at that time, Drost cautioned that increased pumping could lead to deterioration of water quality in existing wells and enlargement of the problem areas.

The *Sequim-Dungeness Groundwater Protection Strategy* (SDGC and CCDCD 1994) established baseline chloride data, using 49 coastal wells sampled in June 1993. Historical data were available for comparison for two-thirds of the wells. Seawater intrusion was described as a problem particularly along the shorelines of Sequim Bay, Miller Peninsula, Dungeness Bay and the Fairview area. This work was done in conjunction with Forbes (1993) who sampled 86 wells in June and July 1993. Sampling confirmed that Diamond Point and the east, west, and south shores of Sequim Bay continued to be vulnerable to seawater intrusion; severe, but localized cases were noted from the past. However, the 1993 data did not indicate a pervasive problem in eastern Clallam County at the time.

Thomas et al. (1999) results do not change this picture. Measured chloride concentrations ranged from 1.5 to 120 mg/l; the median was 6.2 mg/l and five samples had concentrations in excess of 20 mg/l. No geographic pattern was apparent and seawater intrusion was not indicated as a source.

Effect on Surface Water Temperatures

In losing reaches, the river temperature and groundwater temperatures tend to match closely. In gaining reaches, groundwater is typically warmer in winter and cooler in summer than the river (Simonds and Sinclair 2002).

Biological Contamination

According to Drost (citing data now 20 years old), groundwater quality had not at the time been greatly affected by on-site domestic sewage disposal systems, or at least coliform results were not interpreted to be from any particular source. This was not a focus of study in the 1990s investigations.

pH
Thomas et al. (1999) measured pH in 74 water samples collected in July-August 1996. Values ranged from 5.6 to 8.4; the median was 7.4, both overall and for the shallow aquifer. The median pH of the middle aquifer was 7.7.

Iron
Thomas et al. (1999) measured iron in 74 water samples collected in July-August 1996. Values ranged from <3.0 to 1,700 mcg/l, and the median was 30 mcg/l. Six samples had concentrations elevated above 300 mcg/l. Again, no geographic pattern was apparent and elevated concentrations were attributed to natural causes. Iron concentrations were about the same in the shallow and middle aquifers.

Dissolved Oxygen
Thomas et al. (1999) measured dissolved oxygen in 74 water samples collected in July-August 1996. Values ranged from <0.1 to 10.2 mg/l; the median was 2.4 mg/l. Concentrations of DO were higher in the shallow aquifer (median 3.0 mg/l). The median DO of the middle aquifer was 1.0 mg/l.

Specific Conductance
Thomas et al. (1999) measured specific conductance in 74 water samples collected in July-August 1996. Values ranged from 167 to 712 mcS/cm, with a median of 312 mcS/cm. The median for the shallow aquifer was 294 mcS/cm and the median for the middle aquifer was 404 mcS/cm.

Stormwater Contamination
The *Sequim-Dungeness Groundwater Protection Strategy* (SDGC and CCDCD 1994) included sampling for organic compounds and metals in wells near infiltration systems for highway runoff during the fall of 1992. Timing was selected to allow autumn rains a chance to infiltrate to shallow groundwater and reach nearby wells. Overall results indicated that widespread, serious contamination from highway runoff did not exist at the time, although localized contamination from runoff in other seasons could not be ruled out.

2.8.6 Fish and Habitat

Comprehensive overviews of fisheries resources and aquatic habitat in East WRIA 18 are provided in the WRIA 18 Limiting Factors Analysis (Haring 1999), Orsborn and Ralph (1994), and the DQ Plan (1994).

The LFA provides:

- Extensive background on habitat elements
- A watershed description for the Dungeness river and Bell, McDonald and Siebert creeks
- A review of the distribution and condition of salmon and steelhead stocks
- A discussion of habitat limiting factors by subbasin, including Bell, Gierin, Cassalery, Cooper, Meadowbrook, Matriotti, Hurd, Bear, Canyon, Caraco, Gold,

Silver, McDonald, Siebert, and Bagley Creeks, the Gray Wolf and Dungeness Rivers, and marine habitats

- An assessment of habitat limiting factors by subbasin
- A summary of high quality habitats in need of protection
- A review of data gaps

Orsborn and Ralph (1994) link physical dynamics of the river to fish habitat. They surveyed fish habitat in the Dungeness River and assessed habitat and channel stabilization opportunities, and solutions to passage problems. Orsborn and Ralph report original research and analysis, rather than summarizing other work. Their research included:

- Analyzing the Dungeness River channel and its historical changes
- Bridge influences
- Gravel traps and riprap
- Land use impacts; hydrologic influences
- Spawning habitat characteristics
- Stream temperatures

The DQ Plan (1994) provides an inventory and overview of technical information resources, fish and habitat studies commissioned or undertaken by the DQ planning team, and habitat studies and projects. The latter include habitat assessments, habitat protection projects, and habitat restoration and enhancement projects.

Salmon Distribution, Abundance & Stock Status

Natural Productivity

The most complete recent discussion of the distribution and condition of salmon and steelhead stocks in WRIA 18 is given in Haring (1999). Seven anadromous salmonid species are indigenous to the fresh waters of the Dungeness River Basin and East WRIA 18 (Table 2.8-10).

Table 2.8-10. Indigenous Stocks of Salmon and Trout of the Dungeness River Basin

Common Name	Scientific Name	Federal Status	State Status
Chinook salmon	Oncorhynchus tshawytscha	T	C
Coho salmon	Oncorhynchus kisutch	None	None
Pink salmon	Oncorhynchus gorbusha	None	None
Chum salmon	Oncorhynchus keta	T	C
Steelhead trout	Oncorhynchus mykiss	None	None
Cutthroat trout	Oncorhynchus clarki	None	None
Bull trout (Dolly Varden)	Salvelinus fontinalis	T	C

T = Threatened, C = Candidate Species, none = no status

Source: WDFW website 2003

Lichatowich (1993b) estimates that the salmon stocks in the Dungeness River had substantially larger populations for several thousand years prior to white settlement. He provides several estimates of fish numbers. Based only on consumption by the S'Klallam Tribe, his estimates ranged from 12,470 to 63,667. Estimated run size based on harvest rate by the S'Klallam ranged from 17,814 to 106,111. Estimated run size based on production of pink and Chinook in pristine spawning habitat expanded harvest rate range from 19,502 to 26,003 for Chinook salmon and 449,350 to 599,133 for pink salmon. Lichatowich's historical reconstruction of run size, rounded to probable significant digits, is summarized in Table 2.8-11.

Table 2.8-11. Historical Reconstruction of Pink and Chinook Salmon Run Size

Species	Dungeness River Spawning Habitat	Pristine Spawners/Mile	Pristine Spawning Escapement	Total production based on 40% to 70% harvest rates
Chinook	21.2 miles	400	8,000	13,000 to 26,000
Pink	20.9 miles	8,600	180,000	300,000 to 600,000

Source: Lichatowich 1993b, numbers rounded to probable significant digits.

Salmonid Stocks, Status and Life Histories

The seven salmonid species have life histories that closely coincide with irrigation activities (Table 2.1-9, Section 2.1). Irrigation flows can affect adult migration with false attraction flows into tributaries of the Dungeness (i.e. McDonald Creek), stress migrating adult salmonids with low flows and high temperatures, or impede juvenile rearing with high velocity reaches.

Chinook Salmon

Chinook salmon of the north Olympic Peninsula return primarily to major rivers in the spring and summer months to spawn. Chinook enter the Dungeness primarily in late spring or early summer and have been recorded as far upstream as RM 18.7 in the Dungeness, RM 2.5 in the Gray Wolf River tributary, and RM 0.1 in the Gold Creek tributary (Bountry et al. 2002). Females form redds in late summer and early fall, eggs hatch by early winter. They dig their redds deep in cobble-size gravels in the main river channels, a strategy that leaves them vulnerable to severe winter (JSKT 2000). The Bountry et al. (2002) study estimated 18 sites were available for Chinook spawning within the Dungeness and Gray Wolf Rivers and an additional 13 potential sites that were within the preferred gravel size range (Table 2.8-12).

Table 2.8-12. Evaluation of River Bed Material as Suitable Fish Spawning Gravel

		Chinook	Chum		Steelhead		Pink	
		Spring/ summer	Summer	Fall	Summer/ winter	Coho	Upper	Lower
Habitat Range (RM)	Dungeness River	0 to 18.7	0 to 10.8	0 to 11.8	0 to 18.7	0 to 18.7	9.7 to 18.7	0 to 6.5
	Gray Wolf River	0 to 2.5	N/A	N/A	0 to 9.6	0 to 8.6	0 to 8.6/9.6	N/A
Mean spawning bed (mm)		36.5	28.1		25.5	20.2	9	
Maximum spawning bed (mm)		78	62		42	35	11	
Number of samples for each species range		33	26	29	33	33	9	18
Percent of samples finer than mean		55	46	48	45	30	11	11
Percent of samples finer than maximum		94	92	93	64	58	11	16

Source: Bountry et al., 2002.

Fry emerge in early spring and rear in fresh water for three to six months, although some stocks remain in fresh water for up to a year. Recently, juveniles released from the captive broodstock program have been shown to very actively use side-channels in the lower river, especially in times of low flow (Hirschi 1998). Generally, fish spend one to six years at sea before returning to spawn. Like chum and steelhead, Chinook employ a strategy of returning to spawn at more than one age over multiple years, reducing their vulnerability to catastrophic events that may affect a single age class.

Reliable estimates of natural Chinook spawners in the mainstem Dungeness are available only for recent years, according to Haring (1999). Estimates of spring Chinook natural spawning escapement to the Dungeness River range from more than 300 fish to fewer than 100 fish returning to spawn in recent years (1986-1998 data; JSKT 2000). Tribal counts documented 252 redds in 2002 (equating to 630 adult Chinook spawners) and 181 redds in 2001 (equating to 453 spawning adults) (JSKT, unpublished data). Tribal data map redds by RM, however current use by Chinook is not considered reflective of past life history strategies of native stock. The stock has shown a precipitous decline since 1973, is listed as threatened under the Endangered Species Act, and is classified as critical in the Dungeness River. Peak hatchery spawning escapements for the period of record are 880 fish in 1938 and 1,305 Chinook in 1959. Lichatowich (1993c) found that severe depletions in Dungeness River spring Chinook spawning stocks were noted as early as 1909. Continuous records were initiated with annual counts at the Dungeness Hatchery rack near RM 10 from 1938-1981. However, Lichatowich questions the reliability of annual counts of spring Chinook at the hatchery rack as an accurate index of relative abundance.

Coho Salmon

Coho salmon spawn in a diversity of habitats and are noteworthy for occurring in most anadromous streams, including the headwaters of major rivers and their tributaries, side channels, and small coastal streams. Coho were reported within the Dungeness River as far upstream as RM 18.7, within the Gray Wolf River to RM 8.6, and in the Gold Creek River to RM 0.1 (Bountry et al. 2002). The Bountry et al. (2002) study estimated that 10 sites were available for coho spawning within the Dungeness and Gray Wolf Rivers and that an additional 9 potential sites that were within the preferred gravel size range (Table 2.8-12). They make significant use of Dungeness side-channels. Freshwater entry occurs in early fall and spawning spans October through January. Fry emerge in April of the following spring and remain up to one year to rear, usually in small streams and side channels. During rearing, coho juveniles are territorial and feed on drifting insects. They usually rear in small streams and their freshwater survival depends on maintenance of suitable instream flows through the drier late summer and early fall period. Smolt usually emigrate after one year, spending 1.5 years at sea before returning to spawn as three-year-olds.

Dungeness River coho are a “composite” stock, dominated by hatchery production (Haring 1999). However, natural coho spawning occurs in many of the small creeks and tributaries of East WRIA 18. The wild stock is considered depressed. Hiss (1994) notes that delaying hatchery release of coho until after June 1 appears to protect wild pink and chum fry from predation in nearshore waters, due to the larger size of hatchery versus wild salmon.

Chum Salmon

Chum salmon frequently spawn near the mouths of rivers and most streams, but may migrate up large rivers to spawn in the headwaters and tributaries. Chum arrive in two separate runs, summer and fall. The Dungeness River is the westernmost drainage with summer chum in Puget Sound and the Strait of Juan de Fuca, the summer run is found within the Dungeness to RM 10.8. A very small population of summer chum arrives in the river in August, and spawns in the main channel in September and October, primarily downstream of Woodcock Bridge at RM 3.3 (Bountry et al. 2002). Fall chum, the latest of the Pacific salmon to arrive, may enter fresh water from October through January and spawn from November through February. The fall runs have a slightly larger extent within the Dungeness (up to RM 11.8), but spawn within the same vicinity as the summer run (Bountry et al. 2002). (According to the JSKT [2000], the fall chum run enters the Dungeness in September and spawns, mostly in side channels, into November and December.) Preferred spawning gravel size for both runs was analyzed by Bountry et al. (2002) and the results are provided in Table 2.8-12. Fry emerge in early spring (March and April) and migrate directly to sea with little time spent rearing in fresh water.

The numbers of summer chum in the Dungeness River are very low, but the run is thought to have always been low (Haring 1999, Lichatowich 1993a). It is listed as threatened under the ESA. Historically, fall chum were the second most numerous species in WRIA 18 streams (Lichatowich 1993a) and the fall chum population in the Dungeness River is larger. The stock status should be considered critical according to Haring (1999), as there is only a “handful” of fish returning on an annual basis.

Pink Salmon

Pink salmon, the smallest of the Pacific salmon, arrive in this southernmost extent of their range only in odd years. Like chum, pinks return to the Dungeness in two distinct stocks. They usually spawn near river mouths but also are known to migrate up large rivers to spawn. The lower-river fall pinks enter the Dungeness in late August and complete spawning in the lower main channel by late October. A unique upper-river summer pink stock swims upstream in summer and spawns well up the Gray Wolf River (RM 8.6) as well as in the upper Dungeness River (RM 9.7 to 18.7) and in Gold Creek (RM 0.1) (Bountry et al. 2002, JSKT 2000). This run spawns beginning in late July and is done by the end of September. Bountry et al. (2002) analyzed gravel size within the Dungeness

River, Gray Wolf River, and Gold Creek and discerned only two locations (plus an additional potential site) where the gravel was suitable based on a preferred gravel size range for pink salmon (Table 2.8-12).

Fry emerge in the spring and migrate directly to sea under cover of darkness. Adults return to spawn in the second summer. The two-year life cycle of pink salmon is invariable, isolating year classes from one another. Because both stocks spawn during the low flow period of late summer and early fall, they generally are found in whichever streams or side channels are accessible, given flow conditions. The two stocks overlap in the central portion of the Dungeness, where numbers of pink are disproportionately larger than at any other point in the river. A variety of potential explanations for the increased presence of pink in the central river are hypothesized by Haring (1999:55), but do not appear to have been studied.

Once legendary in their numbers, by 1997 fewer than 5,000 upper-river pinks and only 270 fall pinks returned to the river. A comparison of Dungeness pinks to other pink salmon populations in Puget Sound shows that trends in both populations tracked closely until 1981, when the two diverged with Dungeness going into decline. This points directly to habitat problems in the Dungeness rather than other factors such as ocean conditions or fisheries management as the cause of decline (Haring 1999, JSKT 2000). Lichatowich (1993b) suggested that the possible causes of decline for the Dungeness stocks of pink salmon include:

- The 1968-1969 large slide in Gold Creek;
- Streambed aggradation through braided channels could create barriers to migrating adults, and shifting bedload may kill incubating eggs; and
- Artificial propagation of coho may increase predation on pinks.

Orsborn and Ralph (1994) found that existing habitat conditions throughout the lower Dungeness River are particularly perilous for late run pink salmon, which have traditionally spawned below the Highway 101 Bridge. Elevated summer-fall water temperatures, exaggerated low-flow conditions during spawning and upstream migration, bed instability after spawning, and armored bed substrate act in concert to reduce the chances for egg-to-alevin survival.

Hiss (1995) examined the return to escapement of both Dungeness pink stocks in relation to nine environmental variables for the period 1959-1983, using multiple regression analysis. Of the nine factors, sea-surface temperature had the greatest influence on return to escapement for the summer-run population. Peak instream flows and low winter air temperatures were important secondary influences; low flow between the time of adult return to the river and spawning was of tertiary importance. For the fall-run, low winter air temperature had the greatest influence, followed by sea surface temperature and marine upwelling. Other factors not amenable to statistical analysis were also examined. Annual acres clear-cut over the study period did not coincide with trends in escapement. Slope failures appeared to have an immediate and temporary effect of depressing escapement. The largest increases in streambank protection (armoring, diking) appeared to coincide with the current depressed escapement.

<u>Steelhead</u>
Steelhead are the anadromous (sea-going) form of rainbow trout. The anadromous habit is accompanied by morphological differences and is hereditary. Summer and winter running tendencies also appear to be inherited. Because of these genetic characteristics, steelhead are now classified as a salmon, not a trout. Steelhead spawn in large rivers and their tributaries, and most anadromous streams. Summer steelhead generally arrive in May through October and spawn from February through April. Winter steelhead enter fresh water as early as December, continuing through April. Both steelhead stocks occur within the Dungeness River upstream to RM 18.7 and within the Gray Wolf River upstream to RM 9.6. Only the winter run steelhead occur within Gold Creek up to RM 0.1. Bountry et al. (2002) evaluated potential spawning gravel sites within the Dungeness and Gray Wolf Rivers (Table 2.8-12). Emergence occurs in spring or early summer and juveniles may spend 1 to 4 years (most typically 2 to 3 years) in freshwater before emigrating to sea. Steelhead make significant use of the lower river and side-channel habitat. An additional 2 to 3 years are spent at sea, and steelhead may return to spawn two or three times. Both wild stocks are considered in critical condition and at risk of extinction (JSKT 2000).

<u>Bull Trout</u>
Bull trout stocks are identified for the upper Dungeness River and the Dungeness/Gray Wolf (Haring 1999). Successful spawning is probably confined to the colder waters of the upper watershed, but the extent of spawning is unknown. Bull trout, also known as “char”, are able to move up steep gradients, and it is not clear whether the cascades near the three forks on the Gray Wolf present a barrier. Anglers report that historically char were very common and widespread from the lower to the upper watershed. They report that they are still widespread, but greatly reduced in numbers. Some bull trout have been observed in Bell Creek, leading to the hypothesis that they may occur in Cassalery and Gierin creeks as well.

<u>Salmon Recovery</u>
A cogent overview of the challenges of salmon recovery in the Dungeness River Basin is provided in the Washington PCHB (1999) *Final Order* regarding the Trust Water Rights MOU. The PCHB states:

> *Two stocks, the Dungeness pink and Dungeness spring Chinook salmon, presently face possible extinction. Only a few hundred pink salmon have returned to the Lower Dungeness in past years. Likewise, less than 300 Chinook have returned to spawn annually in the recent past. Other stocks, including coho, chum and winter and summer steelhead, are depressed.*
>
> *Insufficient stream flow is a principal cause of this overall decline in the fishery. The United States Fish and Wildlife Service conducted an instream flow study which demonstrated that the river needed instream flows of at least 180 cfs to support native Chinook and pink salmon. That instream flow study concluded that retaining 50 percent of the total flow instream, as the irrigators had agreed to do, was only the starting point to recovering salmon runs in the Dungeness-Quilcene.*

The 1994 DQ Plan recommended that fish management actions reflect the need to protect and rebuild wild stocks. It contains a regional recommendation to protect and restore salmonid habitat to provide functions and values necessary for native, wild fish. The DQ Plan notes that a planning process to rehabilitate Dungeness fall pink salmon in the lower river has been initiated by state and federal agencies.

The USFWS and WDFW operate two hatcheries on the Dungeness River. The Dungeness Salmon Hatchery produces coho salmon yearlings for release into the Dungeness River. A satellite facility on Hurd Creek, a tributary of the Dungeness, produces fall Chinook salmon juveniles and yearlings for the Elwha River and supports a Chinook salmon captive broodstock program on the Dungeness.

The Dungeness Hatchery, originally built on Canyon Creek in 1902, was relocated and rebuilt in 1945. Surface water is diverted from the Dungeness River and Canyon Creek. Intake water is passed through a large settling pond, and effluent water is passed through a state-of-the-art abatement pond and wetland. The Dungeness Hatchery needs include screening for the siphon intake and adult holding, sorting, and upstream passage improvements.

The Hurd Creek Hatchery began operation in 1980. All incubation and rearing at this facility is currently accomplished with groundwater. Major emphasis at this hatchery for the past eight years has been on rearing captive brood for a Dungeness Chinook rebuilding project. Hurd Creek also rears steelhead and catchable trout and plays a major role in recovery efforts for local stocks of pink, coho, and summer chum salmon.

Because the estimated annual returns of Chinook salmon to the Dungeness River had declined to an average of 200 per year by the early 1990s, a cooperative rebuilding program was developed and initiated in 1993 to restore the stock (Smith and Wampler 1995, JSKT 2000). The DQ Plan (1994) describes the Dungeness Chinook captive broodstock program, which began in 1993 (1992 brood) and scheduled its first release of progeny for 1996. The program has three major strategic components: salmonid enhancement, habitat restoration, and harvest management. The enhancement component relies upon a captive broodstock program to increase recruitment to the native population while allowing wild stock production to continue in the river.

Naturally-spawning Chinook salmon eggs and juveniles are harvested from spawning gravels and pools, reared to maturity and artificially spawned. Their progeny are incubated and short-term reared at the Dungeness fish hatchery, then released at times and places appropriate to their life history. An acclimation pond constructed on the Gray Wolf by the Jamestown S'Klallam Tribe is used to imprint young fish to the upper watershed. Fish are also marked to monitor success and evaluate survival at sea and contribution of the broodstock program to the fishery. The program was expected to run through 2003, with the goal of establishing a self-sustaining Chinook population by 2008. The Dungeness Hatchery produces ±1.5 million Chinook progeny from a local stock captive brood program. These are released throughout the Dungeness and Gray Wolf River basins. In addition it rears and releases 500,000 fall coho and 10,000 winter steelhead. Appendix 2-E provides detail on the Chinook plantings from the Dungeness hatcheries.

The Hurd Creek cooperative stock recovery program has the goals of preserving genetic characteristics and rebuilding the Dungeness Chinook population once primary limiting factors are addressed on the river. Fry are reared to maturity, marked, and split between the Hurd Creek facility and a saltwater captive brood site. The planned duration of the captive broodstock production is eight years.

Recommendations for Dungeness River hatchery programs have been made by the DQ Plan (1994), the Hatchery Scientific Review Group (HSRG 2002), and the DRRG (1997).

The DQ Plan (1994: Chapter 4) contains a list of recent and planned habitat studies and projects, including protection, restoration, and enhancement projects. The Plan also notes that restoration and enhancement projects were being planned and funding was being sought to improve river habitat for wild fish under existing flow regimes. DQ Plan recommendations included:

- Forest practices and County land use review
- Dungeness River bank stabilization
- Dungeness fish screen upgrades (Highland Ditch intake)
- Dungeness gravel traps
- Outreach and education targeted to landowners for pollution prevention (soil and water)
- Fencing and other measures to protect stream corridors in agricultural areas
- Restoration on Meadowbrook Creek
- Dungeness River overwintering pools
- Johnson, Gierin, Meadowbrook, and Matriotti creek habitat projects
- Upper Dungeness watershed habitat restoration projects

The DRRWG (1997) developed a restoration plan with emphasis on the critical pink and spring Chinook stocks. Restoration activities are complicated by the fact that most of the river bed in the lower Dungeness River is privately owned. These same lower stretches of the river are believed to be the most degraded, providing unstable spawning habitat, as well as poor migratory routes for up-river stocks. Habitat restoration activities in the river will require cooperation and permission from property owners.

The lower 10.8 river miles are the focus of the DRRWG (1997), because of their high habitat value and sensitivity to disturbance. Virtually all of the bank hardening, diking, water withdrawals, gravel mining, bed aggradation, floodplain development, riparian clearing and woody debris removal has occurred in the lower river (Orsborn and Ralph 1994). The goal articulated by the DRRWG is to *create river conditions that are resilient to natural disturbances, make the river bed and channel more stable, reduce flood damage, and provide for the distribution, abundance and connectivity of habitat types that will allow for the full expression of life history strategies of salmon and other species*. The following objectives speak to this goal:

- Restore river, riparian, and floodplain functions that are self-sustaining and resilient to natural disturbances.
- Correct problems that inhibit the migration of adults and juveniles to traditional spawning grounds and rearing habitat.

- Correct problems that inhibit the ability of juveniles to emigrate out of the river at optimum times.
- Improve the stability of spawning habitat in areas where conditions are detrimental to the egg-to-fry survival of stocks and species at risk.
- Improve the quantity of productive spawning habitat.
- Ensure adequate water quality and quantity during adult migration, spawning, incubation, juvenile rearing, and fry emigration.
- Improve the quality, quantity, and stability of rearing habitat in areas that are limiting to stocks and species at risk.
- Create a wide range of spawning conditions, including refuge spawning (e.g. side channels).
- Decrease sediment input occurring above acceptable natural levels, which can create unstable bed and channel conditions in the lower river.

The Restoration Plan prepared by the DRRWG is careful to take account of subreach variation in key dynamics. Sediment recruitment, transport, and deposition occur at varying rates throughout the lower 11 miles of the Dungeness River. Designs for sediment management and options for sediment source control, stream energy management, and gravel extraction need to be reach-sensitive. Chinook, pink, and other salmonid species have different life history strategies as well as varying needs at different life stages. Restoration in each subreach is tailored to benefit specific life history stages and strategies for each stock. Habitat features also function differently depending upon where they are in the watershed.

The DRRWG defined “seven pillars” for river restoration:

- Reestablish functional floodplain in the lower 2.6 miles through dike management and constriction abatement.
- Abate human constrictions upstream of RM 2.6.
- Create numerous stable, long-term log jams.
- Manage sediment to stabilize the channel and reduce the risk of flooding.
- Construct or protect side channels.
- Restore suitable riparian vegetation and adjacent upland vegetation.
- Conserve instream flows.

Hiss (1993b) cautions that problems caused by aggradation do not imply that the best solution would be to simply bulldoze a channel for adult fish passage during low water. He draws attention to the importance of side channel habitat and the need to maintain access to side channels. In his view, the best overall solution is likely to involve a mix of instream flows and stream bed and bank restoration to promote stability and recovery without loss of complexity or over-allocation of water.

HSRG recommendations address fish passage concerns along the Dungeness and main tributaries. The HSRG noted migration barriers on Canyon Creek, cold water temperature barriers within the Dungeness River, and unscreened intake structures on the old siphon line in the Dungeness River. Specific recommendations made by the HSRG include:

- Address the low-flow fish passage barrier on Canyon Creek by releasing more water into this section of the river;
- Install an intake screen on the old siphon line; and
- Change hatchery source water from surface water to ground water to assure a consistent supply of available water.

Figure 2.8-7 shows the locations and types of restoration projects within the Dungeness River Area Watershed.

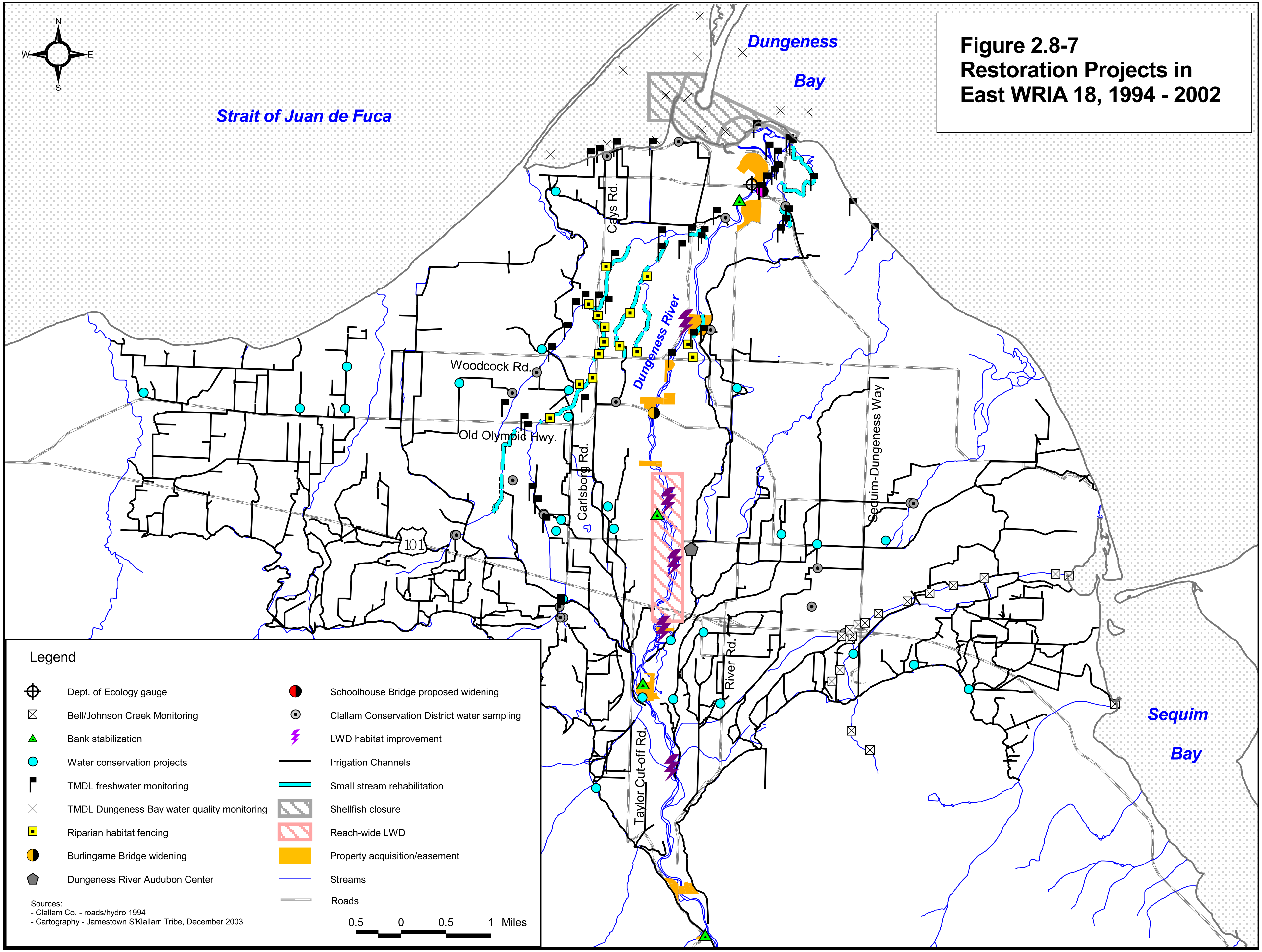

Figure 2.8-7 Restoration Projects in East WRIA 18, 1994 - 2002

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Instream Flows

River flows are critical to both up-migrating adults and out-migrating smolts. Among the ecological services to fish provided by the volume and timing of flows are direct habitat; long term-maintenance of the river channel habitat itself, including bed and bank stability; and development of alternating steeper gradient runs of riffles or glides and still pools that provide resting habitat and cover; habitat for food resources that live in or fall into the water; and temperature management and amelioration (both directly and in nourishing the roots of riparian plants which shade smaller streams and rivers).

In a study seeking the determinants of the sharp decline in Chinook numbers, Lichatowich (1993c) considered flow to be a major determinant of spring Chinook production in the Dungeness River, but found no significant relationship between water-related environmental variables (including flow) and the number of Chinook salmon captured at the hatchery rack. He concludes that the collapse of spring run Chinook resulted from ecosystem-wide degradation, including flow, hypothesizing that the influence of flow is compounded with other changes in river and salmon habitat, including:

- Gravel aggradation in lower Dungeness River (RM 0 to 10.5)
- Channel braiding
- Loss of stable riparian vegetation
- Loss of pool habitat
- Increased sedimentation (due to timber harvest and road-building)

IFIM

The USFWS performed an instream flow study for the lower Dungeness River using the Instream Flow Incremental Methodology (IFIM) during 1988-1989 to discern the relationship between flow and salmonid habitat (Wampler and Hiss 1991). IFIM is the generally accepted method for quantitatively relating instream flow in a particular river reach to potential fish habitat area. Predictions of weighted usable area (WUA) per 1000 feet of stream were developed for study sites located at RMs 2.3 and 4.2. The two study sites were selected to represent instream habitat found in river reaches from RM 1.8 to 2.5 and RM 3.3 to 6.4, respectively. Both these reaches lie below the five irrigation diversions on the river. Ten models were developed for the upper site and four models were developed for the lower site. All models were run on single sets of velocities from a series of transects, obtaining WUA predictions against a range of modeled discharges. WUA predictions were obtained for steelhead (spawning, juvenile, and adult), bull trout (Dolly Varden) juvenile, coho (spawning and juvenile), Chinook (juvenile, spring Chinook spawning, and adult), and pink salmon (spawning). It was observed that diminished flows in August and September reduced usable holding habitat for adult spring Chinook. Low flows also increased barriers to upstream passage, particularly for pink salmon attempting to migrate to upstream spawning habitat during these months. Although the IFIM was completed in 1989, its results were confirmed by DRRWG in January 2002 as continuing to reflect current processes within the Dungeness River (DRRWG, meeting notes, January 14, 2002).

A 1990 *Executive Summary of the Dungeness River IFIM Study* (Hiss and Lichatowich 1990) tentatively selected priority months (August and September) and life stage combinations (Chinook migration, spawning and rearing; pink spawning; and steelhead rearing). The summary did not prioritize upper versus lower reaches, or side channels versus the main channel, nor did it select a single key species and life stage. In December 1992, the Dungeness Instream Flow Group (including the USFWS, JSKT, NMFS, WDFW, and Ecology) was reconvened to complete the evaluation and interpretation of the instream flow study. A paper entitled *Recommended Instream Flows for the Lower Dungeness River* (Hiss 1993b) was prepared "to condense instream flow study results into one recommended monthly flow representing maximum fish habitat, representing a balance of key combinations of species and lifestages." The group intended to provide the DQ planning process a means to evaluate the flows left in the river after irrigation and determine how much habitat could be gained from any given increase in instream flow immediately downstream of the irrigation diversions. To accomplish this, the Dungeness Instream Flow Group:

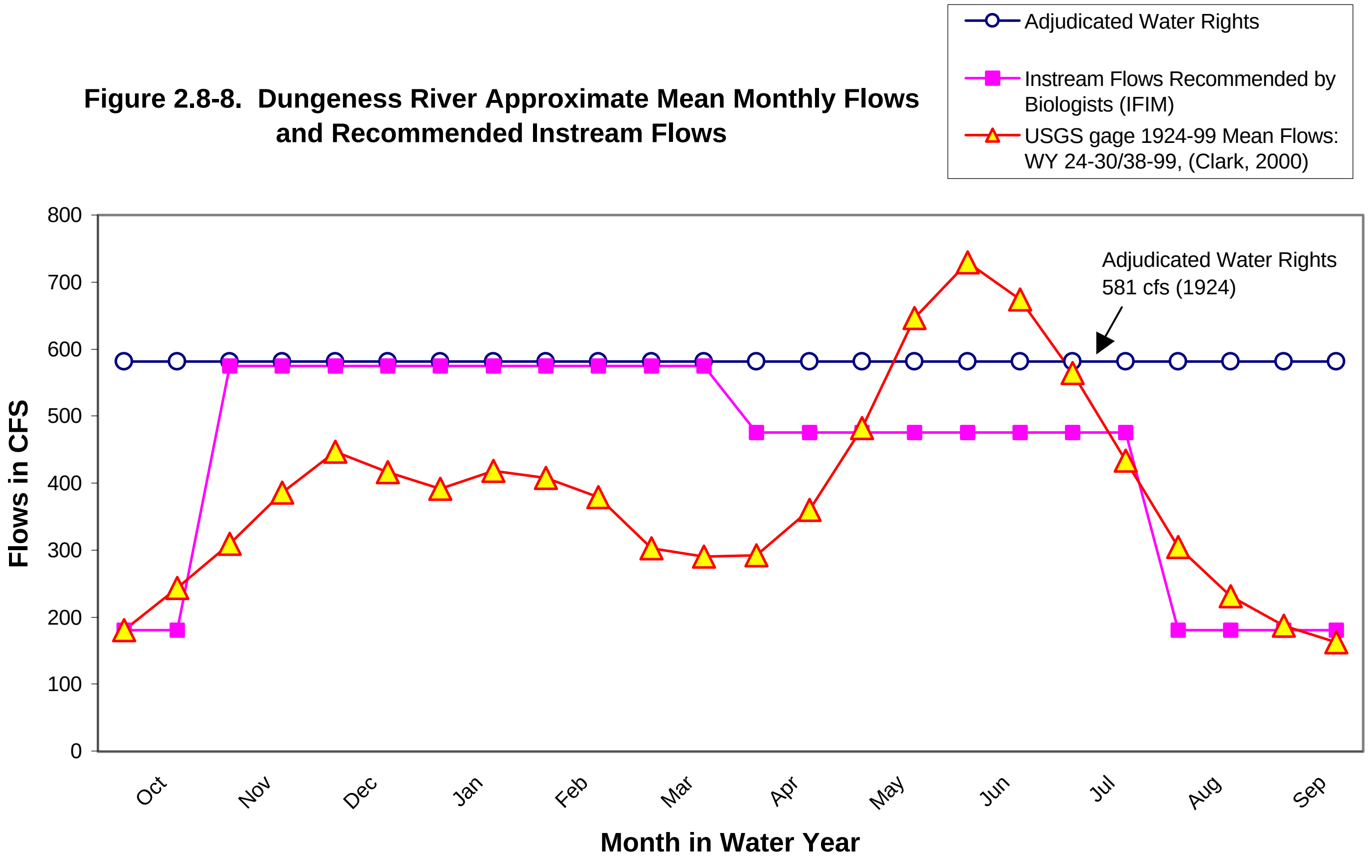
- Developed a list of species and life stages;
- Determined flows providing maximum habitat area for each species, life stage and reach;
- Established priority species and life stages;
- Established a preference for the upper Dungeness river; and
- Established a seasonal priority for the main channel versus side channels.

Based on the selection of species, life stages, reaches, and channels, the Dungeness Instream Flow Group set Dungeness River flow targets for maximum fish habitat immediately below the irrigation diversions for each month. Three flow levels were initially recommended; these were reviewed in a January 14, 2002 meeting of the DRRWG and reaffirmed:

- November through March: 575 cfs
- April through July: 475 cfs
- August through October: 180 cfs

The recommended instream flow values were compared to adjudicated water rights and mean flow at a Dungeness River USGS gage (Figure 2.8-8). These flow recommendations did not consider historic low flows; rather they were based entirely on maximizing potential fish habitat as calculated by the IFIM. They provide a biological benchmark against which any flow can be evaluated in terms of its ability to maximize fish habitat. Hiss (1993b) states that while flows for downstream smolt migration were not addressed explicitly, recommended flows are expected to be adequate for this life stage. The August through October time period coincides with Chinook and pink spawning and migration. The low flow recommendation for that period provides 100 percent of the spawning WUA for these two species, which represent the highest ranked species-life stage combination identified by Wampler and Hiss (1991).

Figure 2.8-8. Dungeness River Approximate Mean Monthly Flows and Recommended Instream Flows



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According to MWG (1999), August-October natural instream flows above all irrigation diversions were 93 percent of the recommended flows at the 50 percent exceedance interval, and 62 percent of recommended flows at the 90 percent exceedance interval (for period of record of 1923-30 and 1937-1994). Below the diversions, flows dropped to 65 percent of those recommended by Hiss for the 50 percent exceedance and 34 percent of the recommendation for 90 percent exceedance. That is, there is a 28 percent difference in achievement of recommended instream flows before and after irrigation diversions.

Table 2.8-13 shows the flows providing maximum habitat area for each species and life stage evaluated by the Dungeness Instream Flow Group based on IFIM results. Table 2.8-14 reports recommended monthly flows below the irrigation diversions as compared to monthly exceedance flows at the USGS gage upstream of the diversions. The table indicates the percent of time that half-monthly Dungeness River flows do not meet the recommendation (19 percent of the time over the average year).

Table 2.8-13. Flow Providing Maximum Habitat Area by Species and Life Stage

Species	Life Stage	Lower Reach Dungeness River	Upper Reach Dungeness River	
			Main Channel	All Channels
Chinook	Migration	390	240	575
	Spawning	200	220	575
	Rearing	80	50	475
Pink	Spawning	140	150	575
Coho	Spawning	120	110	575
	Rearing	40	30	375
Chum	Spawning	200	220	575
Steelhead	Migration	120	80	80
	Spawning	180	260	600
	Rearing	180	130	475
Bull Trout	Rearing	220	160	650

Source: Hiss, J. (1993b).

Table 2.8-14. Recommended Monthly Flows vs. Monthly Exceedance Flows

Month	Recommended Flow	Percent of Time Flow Not Met[1]	Exceedance Flow at USGS Gage (cfs)		
			90%	50%	10%
January	575	14%	150	360	640
February	575	15%	190	330	630
March	575	19%	190	250	410
April	475	3%	220	360	420
May	475	0%	400	560	800
June	475	0%	460	710	1000
July	475	<1%	300	510	730
August	180	21%	180	270	370
September	180	62%	140	180	250
October	180	58%	120	190	360
November	575	21%	150	270	550
December	575	14%	200	370	680

1. Percent of time half-monthly average flows are less than recommended flow.

Source: Hiss, J. (1993b); reaffirmed by DRRWG (2002).

As Table 2.8-14 shows, the recommended flows exceed natural flows at the 50 percent exceedance level in 6 of 12 months, and at the 10 percent level in 3 of 12 months. (However, these minimum instream flows reflect the potential quantity of naturally-occurring habitat that could be realized if water were available, not the ability of a watershed to produce that amount of water.) Hiss (1993b) states that higher flow requirements are probably due to the fact that river braiding consumes a great deal of water that does not contribute usable habitat area. Hiss argues that flows for maximum fish habitat are intimately related with the dynamics of streambed gravel aggradation, which has created wider, shallower channels with higher bars. The DQ planning group agreed upon a "target flow" of 100 cfs under average late summer flow conditions. The group agreed that when more water was available, a higher flow would be desirable for long-term Chinook survival over a range of flow conditions. As described elsewhere in this document, these discussions led to an agreement with the irrigation community not to divert more than half of the flow at any time, and a more recent voluntary decision to not divert an amount of water that would cause flow to drop below 60 cfs in the river. These "targets" are currently being reviewed through the CIDMP process, which may result in a formal agreement and performance standards for irrigation in compliance with the ESA.

Orsborn and Ralph (1992), in reviewing Wampler and Hiss (1991) state that while the report clearly documents that diminished flow regimes have reduced the overall quantity of important instream habitat for anadromous fish in the lower ten miles of river, it has a major shortcoming. That shortcoming, according to Orsborn and Ralph, lies in its failure to take account of stream geomorphology and physical changes responsible for channel changes associated with altered basin hydrology and sediment input. They point out that profound alterations to the river channel (making it wider and shallower), makes it difficult to use IFIM flow results as stand-alone guidelines for restoration and recovery. They concluded that interpretation and application of IFIM results is of limited value for that reason and pointed out that the reduced overall quantity and quality of instream habitat is most dramatically emphasized by the large discharges that would be necessary to provide even moderate amounts of habitat – far exceeding the normal distribution of flows during July-October even without irrigation diversions.

Haring (1999) explains that due to unique watershed conditions associated with irrigation system effects on stream flows and lengths, the hydrologic models used in the toe width methodology for determining recommended flows on the smaller streams and for the Dungeness River IFIM models may not match local conditions. The flow curves on which these models are generated are based on the hydrology of streams draining the Cascades of western Washington and Oregon, which typically have rain or rain-on-snow peak flows, as opposed to the bimodal (winter storm and spring runoff) distribution of peak flows seen in East WRIA 18 (see discussion in Chapters 2 and 3). Consequently, many of the recommended flows may be physically impossible to achieve. Also, channel width measurements, used as input values in the toe width method, may reflect artificially elevated average and peak flows, due to irrigation diversions having led to higher groundwater and stormwater inputs to these streams. It is expected that as these streams return to more natural channel configurations (which may take several decades), channel widths will decrease.

Orsborn and Ralph (1992) felt that the objectives of restoring complexity and stability depend upon better understanding of the character, spatial distribution, and stability of habitat types. They noted that Dungeness flows had not been analyzed with respect to related:

- Temporal variation (within-year and between-year comparisons)
- Changes in land use
- Life-stage seasonal flows for fish
- Variable channel geometry (net of flow and sediment changes associated with land use), and effects of geomorphology changes on fish habitat

Later studies by Orsborn and Ralph (1994) addressed some of these data gaps, particularly with respect to channel geometry and land use.

DQ Flow Goals and Minimum Flows

Figure 2.8-9 based on Hiss (1993b) shows percent of optimum fish habitat realized as a function of instream flow for both pink and Chinook spawning. The figure indicates that maximum value for Chinook is reached at a slightly lower flow than shown in Table 2.8-13. Based on the original Hiss base graph, it was concluded in the DQ planning process that Dungeness River flows of 60 cfs would preserve a little less than 50 percent of the weighted usable area needed for Chinook spawning, 100 cfs would preserve about 75 percent of the weighted usable area, and 180 cfs would provide 100 percent of the weighted usable area. The DQ Plan (1994) set a 100 cfs “target” for the Dungeness River (also shown on Figure 2.8-9) and recommended that the Department of Ecology set instream flows for the Dungeness River based on IFIM studies conducted for the Plan. The 100 cfs flow “target” was based on an analysis of the Chinook spawning area versus flow curve, and represents the break point at which gains in habitat begin to diminish with increased flows. Instream flows have not been adopted by rule in the years since the DQ Plan, but are recommended in this watershed plan.

Instream flows set by rule do not constrain those who hold more senior water rights from diverting even when flow in the river is below the established minimum. However, such minimum flows will set a benchmark of protection affecting future water right allocations. To assure that minimum flows are met would require negotiations with those who hold existing water rights.

Trust Water Agreement

Irrigators historically diverted 80 percent of the natural flow of the Dungeness River, but have now limited themselves under the 1998 Trust Water Agreement (TWA) between Ecology and the WUA (see discussion in Section 2.1.3). The TWA provides assurance that irrigators will divert no more than half the flow of the Dungeness River at any time.

The WUA also agreed to leave as much water as possible in the river after August 1, when the arrival of salmon coincides with declining flows. Recognizing that the historic August-September low flows for the Dungeness River have been 119 cfs, the MOU agreement to divert no more than half the water effectively protects about 50 percent of the weighted usable area needed for Chinook spawning.

The MWG (1999) revisited the IFIM analysis to calculate increases in instream flows that would occur in the Dungeness River if improvements in the Comprehensive Water Conservation Plan were implemented. Replacing the open irrigation canals and laterals with pressurized pipe, as proposed in the Comprehensive Water Conservation Plan, is expected to increase flows in the Dungeness River by 5 to 18 percent (MWG 1999). Percentage changes in September instream flows were compared to present conditions for the 50 percent and 90 percent exceedance flows, used as proxies to represent normal and dry years, respectively. Results were expressed in terms of habitat availability, not salmon production, which depends upon a variety of other limiting factors, such as escapement. After implementation of the proposed water conservation improvements, it was determined that Dungeness River flows should increase approximately 16 to 28 cfs, resulting in 50 percent exceedance flows of 133 to 145 cfs and 90 percent exceedance flows of 78 to 90 cfs.

These improvements would increase instream flows at the 50 percent exceedance level by 14 to 24 percent and at the 90 percent exceedance level by 26 to 45 percent. As noted above, the half-month minimum flow (October 1995) was 73 cfs; with irrigation improvements, this flow might have improved to 92 to 106 cfs. The improved flows would achieve 74 to 81 percent of the Hiss (1993) recommendations at 50 percent exceedance and 43 to 50 percent of the recommendation at 90 percent exceedance, a 16 percent gain in the frequency at which instream flow recommendations are achieved.

By contrast, flows in smaller streams are projected to be diminished by the proposed program of water conservation improvements, in effect shifting water that has artificially created fisheries habitat in them back into the Dungeness River. The MWG (1999) projects that coho and cutthroat would be most affected, and to a lesser extent fall chum and winter steelhead. However, the WRIA 18 Limiting Factors Analysis (Haring 1999) states that benefits to fish resulting from water conservation efforts that restore instream flow to the Dungeness River are expected to greatly overshadow the habitat losses in the smaller streams.

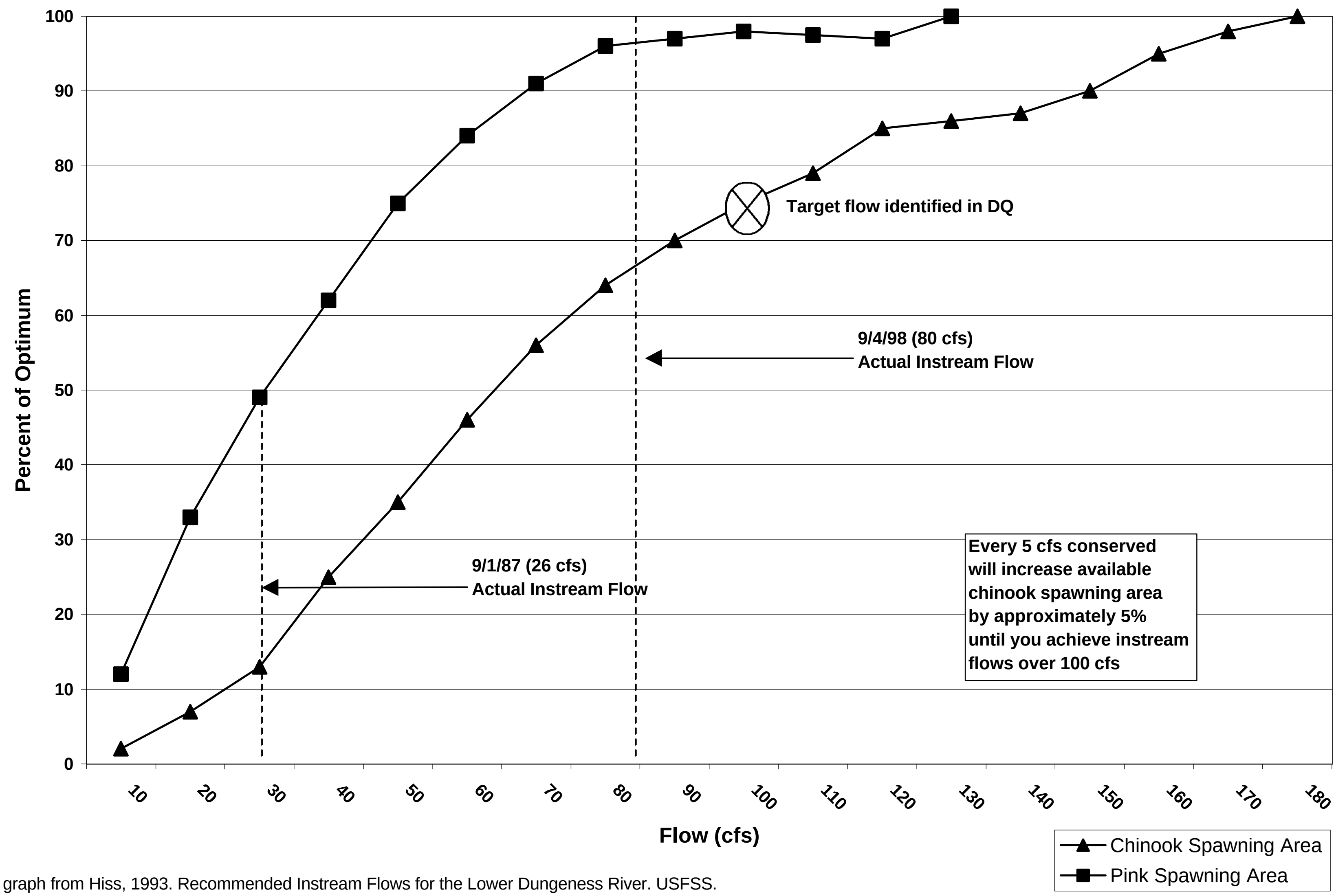
Habitat Use and Availability

Lower Dungeness River

Mainstem Spawning Habitat

Spawning habitat, especially glides associated with pool tailouts and heads of riffles (those having the requisite depth, velocity, and substrate characteristics for both Chinook and pink salmon) appears to be extremely limited (DAWACT 1995). Orsborn and Ralph (1994) concluded that Lower Dungeness River spawning habitat is limited by lack of suitable-sized spawning gravels, and that what spawning habitat exists is distributed in small patches. Bed scour and fill in the river below RM 9 (and general downstream translation of these effects) appear to be a significant limiting factor for both pink and Chinook redds. Spawning in several reaches (RM 6.4 to RM 10.8) appears to be limited by extensive bed armoring. Orsborn and Ralph found that human interventions in the channel tend to fluidize the stream bed, leaving salmon redds highly susceptible to scour and aggradation during even moderate winter storms. Thus, where spawning does occur in these reaches, there appears to be little chance of success even if only small floods occur prior to fry emergence.

Figure 2.8-6. Increases in Spawning Area with Increases in Instream Flows.



Base graph from Hiss, 1993. Recommended Instream Flows for the Lower Dungeness River. USFSS.

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Gravel mining in the lower 10 miles of river was documented by Orsborn and Ralph to have negative effects on salmon spawning. Redd losses near these mining locations suggest that hydraulic conditions there may actually attract spawners, with redds then destroyed by subsequent bed scour and fill. They found that the installation of gravel traps on point bars along the shore may also be contributing, during low flow, to the instability of nearby spawning sites.

Winter steelhead spawn in the spring, when Dungeness River high flows render portions of the stream channel unsuitable due to excess water velocities. However, the area of spawning habitat is not typically considered a limiting factor in the production of steelhead (MWG 1999).

Chinook redd distribution was surveyed for the 2001-2002 spawning seasons (Table 2.8-15 presents results by river reach). A total of 168 and 244 Chinook redds were observed in the lower Dungeness River in 2001 and 2002, respectively, from RM 0.2 to RM 18.7. The Dungeness River system (including tributaries) totaled approximately 181 redds produced from approximately 453 adults. In 2002, a total of 253 spawning redds were counted in the system, corresponding to 633 adult Chinook spawners.

Table 2.8-15. Dungeness River System Chinook Redd Distribution, 2001-02 Spawning Seasons.

River	Survey Reach Description	Survey Reaches (miles)			Chinook Redds	
		Lower RM	Upper RM	Length	2001	2002
Dungeness River	Mouth to Woodcock Bridge	0.2	3.3	3.1	21	28
	Woodcock Bridge to Hwy 101	3.3	6.4	3.1	29	48
	Hwy 101 to Taylor Cut-Off/May Rd.	6.4	9.2	2.8	36	55
	Taylor Cut-Off/May Rd. to Canyon Creek	9.2	10.8	1.6	36	41
	Canyon Creek to Gauging Station	10.8	12.0	1.2	13	39
	Gauging Station to Clink Bridge	12.0	13.8	1.8	11	
	Clink Bridge to Forks Campground	13.8	15.8	2.0	12	14
	Forks Campground to East Crossing	15.8	17.5	1.7	10	16
	East Crossing to Gold Creek	17.5	18.7	1.2	0	3
Subtotal				**18.5**	**168**	**244**
Gold Creek	Gold Creek	0.0	0.3	0.3	0	0
Gray Wolf River	Mouth to RM 1.0 Bridge	0.0	1.0	1.0	9	6
	RM 1.0 Bridge to Above 2 Mile Camp	1.0	2.5	1.5	2	3
	Above 2 Mile Camp to Cliff Camp	2.5	4.0	1.5	1	0
	Cliff Camp to Slab Camp	4.0	5.1	1.1	0	0
	Slab Camp and upstream 1 mile	5.1	6.1	1.0	1	0
Subtotal				**6.1**	**13**	**9**
Total Redds				**24.9**	**181**	**253**
Total Spawners					**453**	**633**

Source: Cooper, Randy, pers. comm.. (2004).

Mainstem Rearing Habitat

Orsborn and Ralph (1994) conclude that rearing habitat is seasonally limited by water withdrawals and elevated temperatures in the lower river, especially in the reaches from RM 1.9 to RM 8.8 (Matriotti Creek to powerline crossing). Riffles throughout these reaches are wide and shallow, with little cover, while pool habitat is generally limited to scour pools at meander bends where water column velocity exceeds what rearing juvenile Chinook prefer for feeding. The wetted margins of the low-flow channel provide some habitat, but offer little cover from predators, especially where riparian vegetation is absent. Interspecific competition for these limited refuges may occur from resident trout or steelhead. Orsborn and Ralph reported observing a substantial number of juvenile salmonids stranded in pools adjacent to the wetted channel. Declining water levels during August and September are thought to dry the outlet channels and isolate these pools. In some, cool waters indicated subsurface inflow.

Side Channels

The productive "Dawley" side-channel is located on the east side of the river, south of Highway 101. This wooded, shaded channel is partially spring-fed and has been documented to serve as spawning, rearing, and overwintering habitat for several salmon stocks. The presence of Chinook, coho, pink, steelhead, and bull trout has been recorded in this side-channel (Hirschi 1998, and Randy Cooper WDFW pers. comm. July 25, 2000).

Upper Dungeness River

Orsborn and Ralph (1994) recommended that Upper Dungeness River reaches are not good candidates for restoration. Although upriver habitat has been altered by bridge crossings and sediment input associated with timber harvesting, chronic landslides and road failures, the overall effects have been less persistent than in the lower river. These reaches are typically confined, steep, resistant to bedform changes, and have suffered only temporarily from the cumulative effects of upstream slope failures. The bed transport capacity of the upper river tends to pass sediment and flow downstream (to depositional areas) where the effects are cumulative, widespread, both persistent and transient, and ecologically significant. One exception occurs near the Dungeness Forks, where the channel widens (Orsborn and Ralph 1994). The Dungeness Forks is in the upper Basin (upstream of where the Gray Wolf River joins the Dungeness) and there are no channel constrictions. Channel slope decreases as the river comes out of the mountainous region and sediment delivery expands to the floodplain.

Habitat Connectivity

Low Flow Channel

The primary fish access concern noted by Haring (1999) is low stream flow during late summer to early fall. Orsborn and Ralph (1994) explained that lower stream flows create potential barriers on the lower Dungeness River such as long, steep riffles coupled with shallow migration flow conditions (e.g., in Dungeness Meadows, and just upstream of the Highway 101 and Railroad bridges). Haring (1999) also noted the presence of slip-face cascades that form in lower flows over nine miles of river, predominantly near the Schoolhouse Bridge and from Hurd Creek to Ward Bridge. In order for fish to be able to swim faster than the water velocity around its body, there must be sufficient depth for support. Although salmon may negotiate shallow riffles at half-body depth, this comes at a cost in stress and energy, potentially affecting spawning success.

Floodplain and Side Channels

Low flows, levees and other constrictions also cut off salmonid access to higher quality side channels, the river's flood plain, and tributaries. Backwater effects can aggrade the river bed (in some cases by as much as 10 feet) to a higher elevation than the floodplain (Bountry et al. 2002). The lack of watered side channels and river access to the floodplain cause higher velocities in the mainstem. This inhibits the development of logjams and scour pools that provide refuge to rearing and migrating salmonids. Further, without the ability to access side channels and tributaries, salmonids tend to construct their redds in the thalweg of the mainstem. As indicated above, the mainstem is susceptible to scour due to the high flow velocities caused by the constrictions on the river. This can have detrimental effects on fish populations. Side channels provide highly productive spawning and rearing habitat for salmonids when access is available (Foster Wheeler 2002). Side channels offer abundant food supplies, lower velocities, lower temperatures, better vegetative cover, and groundwater supplies. These factors promote higher survival rates for salmon.

In a recent study to assess the relationship between flows in the Dungeness mainstem and flows in the Dungeness side-channels during the irrigation period, the United States Bureau of Reclamation (USBR) (2003) evaluated ten specific side channels (five between the USGS gage (RM 11.8) and the Railroad Bridge gage (RM 5.7), and five between the Railroad Bridge gage and the Schoolhouse Bridge gage at RM 0.7). Data from the assessment showed that, during the irrigation period flow range that was evaluated, surface water connected side channels met several of the criteria for various fish species, while the side channels that were only groundwater connected during the study period met habitat parameters for only one salmonid species. Thus, maintaining a surface water connection between the mainstem and side channels can increase the range of beneficial salmonid habitat parameters available, and support a greater diversity of fish species (USBR 2003).

Of the ten side channels studied, five were found to maintain a surface water connection with the main river channel for all or virtually all of the study period (between September 2001 and July 2002), during which time low flows (less than 100 cfs) occurred. The five that maintained a surface connection included:

- Anderson
- Dawley
- Kinkade (East, Middle, and West channels)
- Lower Railroad Bridge
- Stevens/Savage

The remaining five side channels exhibited only a groundwater connection during the study period. These included:

- Anderson[7]
- East Gagnon
- West Gagnon
- Upper Railroad Bridge (East and West)
- Spring Creek

In a separate study, Hirschi and Reed (1998) identified the following five Dungeness River side channels (four of which were examined in the USBR study) as important fish habitat:

- Gagnon (RM 3.25 to 4.0)
- West Railroad Bridge (RM 5.6 to 6.4)
- Campsite (associated with the West Railroad Bridge side channel)
- East Railroad Bridge (RM 5.65 to 6.4)
- Dawley Side Channel (RM 6.4 to 7.5)

These side channels change their physical structure based on flow and sediment input. They offer good habitat (primarily for Chinook and coho) because of their pool-like qualities, they maintain flow nearly year-round, and they are almost always connected to the mainstem (Foster Wheeler 2002).

<u>Upper Dungeness River</u>
Side channels in the Upper Dungeness, at least as far as the suspected passage barriers above Gold Creek, have been recognized for their importance to the life histories of salmon and other stocks. Biologists Mike Reed and Ron Hirschi, in *Salmon and Trout Life History Study in the Dungeness* (JSKT 1998) suggested several benefits, including: serving as refuge areas from steeper gradients and higher flows, providing notably diverse habitat (especially for coho and for rearing Chinook), and as a potentially limiting factor for salmonids in the upper watershed.

Above the Gold Creek confluence, three cataracts (boulder cascades) probably form barriers to salmon migration to the upper reaches of the Dungeness (Orsborn and Ralph 1994). Also, above the Gold Creek confluence is an impassible falls at RM 18.7 that acts as a passage barrier to spawning habitat in the upper watershed (Bountry et al. 2002).

Habitat-Forming Processes and Causes of Change

Natural Disturbances
Fish production is limited by both natural and human factors. While they have evolved to adapt to the former, the latter may stress their adaptive capabilities beyond natural limits. The LFA adopts the definition of "limiting factors" from ESHB 2496 as "conditions that limit the ability of habitat to fully sustain populations of salmon." Generally, limiting factors act on the quality or quantity of habitat available. These include migration passage barriers,

[7] Note that Anderson side-channel maintained a groundwater connection during the entire study period, but only exhibited a surface water connection when flows were above 160 cfs.

climatic fluctuations and extreme conditions, excessive or low water flows, stream geomorphology which is unstable or has lost critical functions or values, siltation and sedimentation, pollution, loss of food and shelter, and predation. Among natural processes or conditions that limit or affect habitat on the Dungeness are its steep gradient, naturally occurring landslides on unstable slopes in the upper watershed, and the boulder cascades limiting access above Gold Creek.

Human Disturbances and Alteration of Natural Disturbance Regimes

Multiple and synergistic effects of human interventions in the Dungeness River system broadly affect habitat-forming processes. While the subsequent discussion addresses each separately, in practice these effects are tightly interwoven.

DQ Plan Analysis

Human intervention in natural systems can exacerbate limiting factors through such actions as timber harvest, urban and suburban development, floodplain constrictions (e.g., bridges and dikes), and agriculture, if these land uses are not properly planned and mitigated. The following, repeated from the DQ Plan (1994) and quoted with approval by Orsborn and Ralph (1994), summarizes the interaction of human influences and habitat-forming processes, in this case with regard to the dynamic relationship between instream flows and the fluvial geomorphology of the river:

> *Although stream flows vary from season to season, they must remain fairly constant to support a healthy stream. Very low water levels during salmon runs and spawning season make travel difficult or impossible. Juvenile fish rearing in streams are dependent upon stable, abundant flows for growth and survival. Water levels which are too high damage or destroy habitat and displace or strand fish, or cause mortalities. Eggs deposited within the streambed during spawning can be scoured out or stranded by shifting channels. During heavy rains, even a healthy riparian zone and stream system will not prevent flood erosion. However, under natural stream conditions flood erosion creates good instream habitat. Flood waters wash out gravel banks, creating spawning beds. They wash trees, logs, and stumps into the stream, creating hiding, resting and feeding places. Finally, they wash out banks, causing trees to lean out over the water, cooling it and creating feeding and hiding places. Under natural conditions, a stream may have any or all of the following: side channels, meanders, ox bows, associated wetlands, and flood plains. These features slow and temporarily store flood waters coming down the stream and offer fish and other water dwellers a refuge from rushing flood waters. The stream can flood and cause some erosion without destroying habitat and killing stream dwellers.*
>
> *Alteration of a watershed from forestry, agriculture or urbanization can impose dramatic changes to stream hydrology, often overwhelming the buffering ability of the riparian zone to protect the stream. Increases in channel width and depth, increased bank erosion and downstream sediment loading, instability of large woody debris, and loss of summer flows are all attributable to altered hydrology. In response we often take protective measures such as armoring stream banks with riprap or straightening the*

> *channel, in the process eliminating riparian vegetation, which in turn reduces or eliminates the stream's natural flood control abilities. Under these conditions, floodwaters rush down the stream with unnaturally high volume and force. The stream transfers this energy to any part of the stream that is not armored, causing severe bank erosion, washing out spawning beds and instream habitat, and killing instream animals. Floodwaters may also wash armoring along the bank into the main channel. This decreases the channel capacity and creates greater erosion forces on the bank.*

The DQ Plan (1994) found that the lower nine miles of the mainstem Dungeness River has extremely degraded and unstable habitat, suffering from many of these problems. Large amounts of sediment have been deposited in the lower river, whether from natural or human causes. Streamside development has altered natural overflow channels and caused instability, increasing braiding, and bedload. Constrictions from bridges, riprap and dikes affect stream dynamics and remove large trees, causing a loss of productive habitat. These conditions combine to create a severely unstable environment, unsuitable for fish. The private ownership status of the river channel complicates habitat improvement or channel stabilization. The DQ Plan summarized limiting factors due to human interventions affecting fish in the Dungeness as follows:

> *The Dungeness River is located in a rainshadow and is subject to large irrigation water withdrawals. Historically, the naturally limiting factor for the Dungeness River may have been its steep gradient in the upper watershed, with spawning restricted to limited gravel patches. Today, fresh water production is limited by a combination of human impacts resulting from agriculture, urbanization (including flood control) and forest practices. Five irrigation withdrawals remove as much as 60 percent of the natural flow during critical low flow periods (August and September), which happen to coincide with Chinook and pink spawning in the river.... [These impacts] have destabilized the riparian corridor and adjacent land...the resulting erosion has caused sediments to be deposited in the river at a rate exceeding the river's ability to transport them, creating extensive gravel aggradation and channel braiding. These...bottlenecks compound the low flow water impacts to fish by reducing water depth, increasing water velocity and temperature, and destabilizing river bedload. An increase in fine sediments reduces the quality of spawning habitat by smothering salmon eggs during incubation. Flood control measures, such as dikes, funnel the energy of the river into a confined space during high water events, subjecting fish and their habitat to extreme conditions. In combination, these factors [limit] fish production by impeding both upstream and downstream migration, reducing the quantity and quality of available spawning and rearing habitat, and killing incubating salmon eggs.*

<u>Post-DQ Studies and Analysis</u>

A number of studies since the DQ Plan (Orsborn and Ralph 1994, Dungeness Area Watershed Analysis Cooperative Team 1995) have also described the lower 10.8 miles of the Dungeness River as extremely degraded and unstable fish habitat. Orsborn and Ralph provided a detailed discussion of habitat characteristics in this portion of the Dungeness River for ten river reaches.

The DRRWG (1997) notes that restoring self-sustaining salmon stocks in the Dungeness will require an approach that recognizes and restores important river functions in transporting water and sediment from the mountains to the mouth. Proper functioning of the Dungeness River floodplain has been altered by many human activities, including diking, bridge and road constrictions, removal of log jams and large woody debris, forest and agricultural land management, and water withdrawals (Orsborn and Ralph 1994). According to the DRRWG, limiting factors that have contributed to the decline of critical stocks of pink and Chinook salmon include:

- Absence of stable mainstem habitat caused by horizontal (channel shifting) or vertical (scour and deposition) bed instability. This has been validated by post-flood salmon redd sampling (Smith and Wampler 1995), scour chain data and aerial photo analysis (Orsborn and Ralph 1994), river cross sections (WDFW 1997), and field observations (see discussion below of the delivery and routing of sediment).
- Lack of high flow refugia and good quality pool habitat for juvenile rearing, adult holding and stream energy dissipation, attributed primarily to the depletion of stable log jams, loss of historical floodplain and the concentration of flows by diking and human constrictions, the decline of suitable riparian vegetation, bed instability, and truncation of meanders (Orsborn and Ralph 1994) (see discussion below of the delivery and routing of water and organic materials).
- Low stream flows, attributed to irrigation withdrawals, exacerbated by bed aggradation. This has limited the availability and quality of spawning and rearing habitat and has generally impeded adult salmonid migration (Hiss and Lichatowich 1990) (see discussion below of the delivery and routing of water and sediment).

The DRRWG (1997) identified six key factors that have affected river habitat and flooding:

- Diking
- Constrictions and confinements
- Log jam and large woody debris removal
- Forest management, agriculture and land development
- Diversion of irrigation water
- Gravel removal

The USFS Dungeness Area Watershed Analysis (DAWACT 1995) also concluded that river conditions are different from historic conditions in ways critical to the survival of salmon. Key changes identified by the Watershed Analysis Cooperative Team were a loss of rearing habitat (deep pools and large woody debris), a higher summer water temperature regime, barriers to upstream areas during low flows, and less stable spawning conditions in the streambed. The Team felt the river appears to be returning to an earlier, less stable and less productive condition. Similar to other habitat assessments, the Team noted problems with sediment transport and bed aggradation, reduced flows, and a widened channel.

Limiting Factors Analysis

The Washington State Conservation Commission Limiting Factors Analysis (Haring 1999) is careful to note that a number of data gaps exist and that a "full" limiting factors analysis was not done, which would have required extensive additional scientific studies for each subwatershed. The objectives of the LFA were to compile the best available information on the current distribution and condition of salmonid stocks, for use in determining potential benefits of salmonid habitat protection and restoration. The LFA updates SASSI status for each stock (see LFA Table 5-3) and provides detailed distribution maps (see LFA Table 5-1 for a summary of distribution). LFA Table 5-7 presents a summary assessment of the severity of habitat limiting factors for major WRIA 18 salmon-bearing watersheds (Haring 1999).

The LFA contains a list of "habitat themes" common to the watersheds of WRIA 18 that is similar to the assessments of Orsborn and Ralph (1994), DRRWG (1997), the DAWACT (1995), and the DQ Plan (1994), but adds a few important factors (edited to include only those pertinent to East WRIA 18):

- Natural stream ecological processes have been significantly altered due to adjacent land management practices and direct actions within the stream corridor;
- Substrate sediment transport processes have been altered to the extent that stream morphology has changed due to excess sediment contribution from watershed land use practices;
- Fine (<0.85 mm) sediment levels in the gravels of several streams are identified as likely being high enough to adversely affect spawning success and benthic invertebrate production;
- Lack of adequate large woody debris in streams, particularly large key pieces that are critical to developing pools, log jams, and other habitat diversity important to salmonids;
- Lack of adequate pool frequency, or large deep pools that are important to rearing juvenile salmonids and adult salmonids on their upstream migration;
- Loss of natural floodplain processes due to confinement of channels by dikes, levees, bank armoring, and channelization, including the loss of functional off-channel habitat;
- Loss of riparian function due to removal/alteration of natural riparian vegetation, which affects water quality, lateral erosion, streambank stability, and instream habitat conditions;
- The presence of a significant number of culverts and screens that preclude unrestricted upstream or downstream access to juvenile and adult salmonids;
- Significant increase in peak flow frequency and magnitude due to channelization, routing of stormwater through the irrigation delivery system, and increased stormwater runoff from lands that have been converted to non-forest status (many of the less developed streams are facing similar threats from new development and growth);

- Alteration and reduction of the normal stream flow regime due to irrigation and other water withdrawals (the Dungeness River valley has the most intensively developed irrigation use of any western Washington river system); and
- Estuarine and marine function is significantly impacted by physical alteration of natural estuaries, and shoreline armoring in Dungeness Bay.

In a section entitled “Salmon Habitat Concerns” summarizing the assessment of habitat limiting factors, the LFA discusses the history of watershed development and interventions reviewed in this report. Important impacts have included rapid logging of headwaters areas for many streams; road construction and logging practices that led to increased mass wasting and sedimentation; timber removal and land conversion in rural development in the rain-on-snow zone, leading to significantly increased storm runoff; agricultural development in the lower watershed; interventions in the channel to constrict, dike, and remove gravel; diversions of water for human use, reducing instream flows during critical low flow periods when adult salmonids are migrating upstream and spawning; changes to stream geomorphology which have resulted in salmon redds being constructed in channel areas that are extremely susceptible to scour and deposition; and increased impervious surface associated with land development and its concomitant effects on groundwater recharge and stormwater runoff (Haring 1999).

Adult salmonids, in their spawning behavior, also affect the nature of channel substrate and channel shape, according to Haring (1999), and the decline in populations returning to spawn has resulted in a loss of these geomorphic functions that would benefit future generations of salmonid spawners. The loss of carcasses also reduces the nutrient base that supplies the food web upon which juveniles and invertebrates depend. The loss of these ecosystem functions reduces ecosystem productivity as a whole.

The LFA describes the tributaries and independent drainages as heavily influenced by the WRIA 18 history of irrigation system development, stream channelization, riparian vegetation removal, and open access to livestock. McDonald, Siebert, and Bagley creeks drain through incised ravines and their lower reaches are generally intact, but habitat in the upper reaches of these creeks is adversely affected by recent forest practices, agriculture, and rural development (Haring 1999).

Estuaries have been physically altered at the mouths of many WRIA 18 streams, affecting habitat and physical functions characteristic of natural estuaries. These estuaries provide critical rearing and transition habitat for salmonids as they move from fresh to salt water as juveniles and back from marine environments to fresh water as adults. Nearshore marine environments support juvenile salmonid rearing and migration and produce food fish for salmonids. The nearshore marine environment has been severely impacted throughout much of the WRIA. Shoreline armoring is less extensive in East WRIA 18 than to the west, with the exception of Dungeness Bay. The Dungeness estuary has been completely modified by extensive diking and conversion to agriculture and residential development. The marine nearshore habitat in Dungeness Bay has been affected by the alteration of sediment transport from the Dungeness River, shoreline armoring, and loss of eelgrass habitat.

Delivery/Routing of Water

A primary fish concern in the Lower Dungeness River is that low stream flows during late summer and early fall impede adult salmon migration and decrease useable juvenile habitat in more than ten miles of the lower river (Haring 1999, Orsborn and Ralph 1994), PSCRBT 1991, Lichatowich 1990). As flows drop, access to side-channels is eliminated and fish in them are forced back to the degraded mainstem. The *Salmon and Trout Life History Study in the Dungeness* (JSKT 1998) identified severe problems for Chinook and other juveniles created by low flow conditions, as well as problems for spawning fish. With low flows, spawnable areas are eliminated, leaving only areas along the edges of the mainstem (which often dry as flows remain low), and in the narrow deep channels in the mainstem. Fish spawning in these unsuitable high-flow areas usually results in the redds being destroyed in the first high flows of fall. During low flows, various braids become disconnected from the main flow. Additional flows are needed to keep pools connected to flowing water and to keep connections between side-channels and the main flows. The Tribe has documented passage barriers to critical side-channel habitat due to low flows in late summer (JSKT 1999). Diversions for irrigation in late summer have dried out side channels, killing up to 100+ juvenile salmonids. Loss of side channel habitat may be a key contributor to the severe decline of lower river spawning stocks. Late summer and fall low flows also may cause slip-face cascades that fish cannot pass.

Irrigation diversions have reduced flows, contributing to the low-flow related problems identified above (Orsborn and Ralph 1994). Mean flows for September, measured before irrigation withdrawals, were 181 cfs (1995-2002), meaning that after irrigation withdrawals, flows in the lower ten miles may approach or fall beneath the 100 cfs “target flow” established in the DQ process to protect Chinook. (In 2001, average irrigation diversions from August 15-September 15 were 45.55 cfs while river flow declined toward 100 cfs. From about September 1 on, diversions would have reduced river flow to less than 100 cfs, reaching lows in the low 60 cfs range.) Water conservation efforts since DQ have increased late summer lower river flows by about 30 percent, with a 15 percent increase in lower river flow year round (JSKT 2000).

Delivery/Routing of Sediment & Energy

River channels naturally evolve by moving gradually and predictably across the landscape in a dynamic equilibrium. Channel confinements such as bridges and intrusive bank protection projects fix a point of the channel rigidly into a given location. The eventual result is rapid and convoluted channel changes, as the upstream and downstream channels continue to evolve and are forced to respond to the fixed portion of the channel.

Most of the Lower Dungeness River is extremely unstable. Dikes have reduced or cut off the Dungeness River from its floodplain, concentrating flood energy and sediments into the main channel. This has led to bed and channel instability from increased velocities, and a loss of resilience and flexibility of the channel to respond to flood events and the changing sediment loads (Orsborn and Ralph 1994). It has exacerbated the extent and rate of channel aggradation by eliminating floodplain sediment storage capacity. By inhibiting normal meander development, important stable side channel habitat has been eliminated, as well as the opportunity for the creation of new side channel habitat. The habitat continues to change due to the impacts of constrictions (bridges, dikes, bank-hardening, development), excessive gravel flows and movement of sediment (with continued input from major failures of forest roads). While the river is not significantly degrading at present, long-term stability is not assured and will require major restoration efforts (e.g., bridge and dike setback, floodplain and estuary restoration, major LWD structures).

Artificial structures such as levees and narrow bridges constrict and confine the channel. Constrictions back up flood waters, causing increased sediment deposition and the associated consequences of bed aggradation, bank erosion, and increased flooding risk (Orsborn and Ralph 1994).

Erosion events (and at extreme levels, landslide activities) also provide sediment to the system. Sasich et al. (2002) completed a study for the Olympic National Forest that inventoried all existing mass wasting features and how they correlated to forest management activities (Table 2.8-16). Of the 467 existing features inventoried, 14% were associated with vegetation removal, 25% were associated with roads, 61% were associated with natural events, and less than 1% were unknown. Table 2.8-16 also shows how activities (e.g. clearcut or road construction) are associated with accelerated erosion (e.g. debris slides and surface erosion). The study also points out that a high rate of natural mass wasting occurs in the upper basin (Gray Wolf and upper Dungeness area), while the majority of management-related erosion events occurs in the lower basin (lower and mid Dungeness).

Table 2.8-16. Erosion Features by Process Type and Land Use or Land Condition for the Mass Wasting Inventory.

Land use or condition	Number of features inventoried (events identified in the mass wasting inventory)					
	Shallow Rapid Landslides					
	Debris slides	Debris flows	Snow avalanches and debris torrents	Surface erosion	Deep-seated	Streambank erosion
Clearcut	29	1	-	2	-	2 (1)
Wildfire (within last 150 years)	15	9	1	-	-	1
Natural (includes historical fire disturbances as well as other causes)	56	81	96	-	34	-
Roads	38 (32)	11 (6)	-	56 (11)	6 (1)	-
Unknown	-	2	-	-	-	-
TOTALS:	148 (142)	104 (99)	97	58 (13)	40 (39)	3 (2)

Source: Sasich et al. (2002).

A study of the Gold Creek Slide area found a relationship between harvest and road management activities with an acceleration of mass wasting processes in the Slide area and immediately upstream in Gold Creek and an unnamed tributary (Sasich et al. 2002). The two primary triggering mechanisms were 1) large areas of immature vegetation with wet soil areas in depressions that likely are concentrating infiltration of water and 2) concentrated road runoff directly linked with instability along newly created stream channels and existing “underfit” stream channels.

The cumulative result of historic and ongoing land uses has been to increase sediment routing and storage problems already exacerbated by diking, depletion of stable log jams, and removal of large woody debris. Land clearing adjacent to the river channel results in weakened river banks that are then vulnerable to erosion, compounding sediment problems on the river.

Sand and gravel have historically been removed from river channels to manage flood risks. From 1992 to 1996, roughly 200,000 cubic yards of sediment were removed from the river channel. This volume likely exceeds the cumulative total of all gravel extractions occurring on the river in the previous 150 years. At one location in the vicinity of the most intensive gravel removal operations, the channel downcut eight feet over this same four-year period, causing repeated damage to the Dungeness Meadows dike extension.[8] It was associated with the greatest channel instability observed on the river in recent memory, according to the DRRWG (1997). Many riparian property owners view gravel accumulations as the underlying cause of their bank erosion problems, however high rates of bank erosion also are seen on vertically stable rivers and sediment-starved rivers. Sand and gravel removal can affect habitats by destabilizing the channel locally, flattening the channel and eliminating vegetation and debris important for shading, bank stabilization, and large woody debris formation.

Delivery/Routing of Organic Materials and Nutrients

Historically, removal of large woody debris and log jams was a prominent element of flood control activities on the Dungeness River. Stable log jams are now scarce throughout this lower section of river (Orsborn and Ralph 1994). In a sand and gravel bedded river such as the Dungeness, much of the structure that defines the channel is provided by embedded wood and debris jams. Removal of debris jams perceived as being flood hazards has resulted in increased velocities, with associated channel instability and bank erosion.

At one time, returning salmon brought up to 250,000 tons of nutrients into Pacific Northwest upstream ecosystems in the form of post-spawning salmon carcasses. Salmon delivered marine-sourced essential elements – carbon, nitrogen, and phosphorus, and were fed upon by at least 22 species of wildlife (JSKT 2000). A program of returning salmon carcasses has been underway since 1996, using surplus hatchery carcasses. The spawned salmon carcasses are distributed in the upper Dungeness and Gray Wolf rivers. An average of 5,000 Chinook and coho carcasses have been returned each year, representing more than 12 tons of nutrients.

Delivery/Routing of Toxins

No information indicates that toxins are an important limiting factor on the Dungeness River.

Delivery of Heat

The Dungeness River is a 303(d) listed river for temperature. Heightened water temperatures caused by open irrigation ditches and low flows cause oxygen depletion and pollution (Haring 1999).

[8]Downcutting was also associated with the removal of an old diversion dam for the Cline-Clallam-Dungeness ditches. The dam was eight feet high, and its removal caused some head-cutting toward Dungeness Meadows.

Native stocks of anadromous salmonids have evolved physiological and behavioral adaptations in response to temperature regimes characteristic of their natal streams. Salmon respond to stream temperatures during all phases of their fresh water life history. Elevated temperatures (in excess of 20ºC) have caused delays in upstream migration of adult salmon and steelhead. This can be of particular concern when timing of upstream migration and spawning coincides with periods of low flow, when water depths and velocities are well below the optimal range for spawning and adult migration. Water temperatures also determine the length of incubation and the timing of fry emergence; elevated temperatures may result in emergence earlier than normal. Increased summer water temperatures during rearing can render some stream habitat unusable, and may increase competition by crowding juveniles into limited habitat space. Table 2.1-6 (see Section 2.1.6) summarizes preferred temperatures and lethal limits for key species occurring in East WRIA 18.

Orsborn and Ralph (1994) documented extensive portions of the Lower Dungeness River where temperatures exceeded the preferred maxima. They stated that a number of locations were observed in which schools of juvenile salmonids were found trapped in pools or other low spots along the margin of the wetted channel. Judging by the cool water temperatures, these pools were thought to be fed by groundwater. Other such pools and low spots were drying and warming rapidly. Orsborn and Ralph stated that such isolated pools are a natural feature of low gradient flood-plain rivers, but that in the case of the Dungeness, their high numbers appear to be related to the significant drop in flows from mid-August through mid-October.

Ecosystem Functions and Conditions

Riparian Corridor and Floodplain

The lower Dungeness watershed is highly constricted with levees and bridges spanning the width of the river. These constrictions block access of the active channel into the floodplain (Bountry et al. 2002). In the upper watershed the river is allowed to meander and alter its course into the floodplain during high flow events. In the lower watershed, due to restricted access to the floodplain, sediment and LWD are transported to areas where velocities are low enough to allow deposition; sometimes this is not until the mouth of the river (Bountry et al. 2002).

Orsborn and Ralph (1994) found that three of the five bridges on the Dungeness River (Highway 101, Railroad and Woodcock [Ward] bridges) collect large amounts of bed load and large woody debris upstream, and are inefficient at passing the load downstream. This low efficiency is due in part to the deposition upstream, which causes the main flows to enter the bridge openings at an angle of about 45 degrees, rather than at a right angle. The other two bridges (Schoolhouse and Old Olympic) are in more confined channels, and pose less problems.

The riparian corridor in the lower basin has been highly impacted due to clearing activities for roads and urban development (Bountry et al. 2002). The loss of riparian habitat decreases the availability of LWD that can form log jams and scour pools used by fish and other aquatic organisms (Bountry et al. 2002). The loss of riparian habitat also decreases the amount of shading available along the river banks and can increase water in these areas (Bountry et al. 2002, Haring 1999).

Wetlands

Wetlands are described, and more than 900 wetlands are mapped in the Dungeness Watershed based on the National Inventory of Wetlands, as part of the Riparian Module within the USFS Dungeness Watershed Analysis (1995). Also in 1995 CCDCD published an *Assessment of Wetland Functions and Wetland Management Guidance for the Lower Dungeness River Area and Sequim Bay Watersheds.* Funded through the State Wetland Integration Strategy (SWIS), the County developed a wetland database and management strategy based on landscape and watershed processes specific to the Dungeness River and Sequim Bay. Wetlands were categorized according to seven "hydrology types." The updated inventory identified 353 regulated wetlands totaling 4,525 acres and 174 artificial wetlands with a total extent of 156 acres. The two main types of hydrologic input to wetlands within the area were unconfined aquifers and perched water tables. Size distribution analysis revealed that 5 percent (19) of the identified natural wetlands accounted for 57 percent of total area. Most of the wetlands identified are classified as palustrine emergent or palustrine forested types (Cowardin 1979). Seventeen percent of the wetlands were contiguous to anadromous fish bearing streams. At least 28 provided priority habitat for migrating waterfowl and 11 provided priority habitat for resident waterfowl. A summary of wetlands at risk found 27 wetlands on parcels without sufficient non-wetland area for a building site. Twelve were at risk from proposed state transportation projects (Highway 101), and 10 percent of the total (432 acres) were located in designated urban growth or high intensity rural zones. An additional 40 percent were located in land designated for moderate rural density zones (1 unit per 2.4 to 5 acres) and the remainder in low intensity rural density or commercial forest lands.

Nearshore/Estuary

The DRRWG (1997) states that the implications of changes in the Dungeness River mouth (e.g., development of a delta cone and loss of tidal prism) have not yet been adequately assessed and the need for restoration has not yet been determined.

Monitoring

In addition to the flow monitoring described above, two permanent water temperature gages have recently been installed by the USGS at approximately RM 11 and RM 0.7. In addition, up to 12 continuous-recording in-river temperature instruments and 2 ambient air temperature gages were installed during summer 2002 and will be operated for at least 2 years under Centennial Clean Water Fund (CCWF) grant funding. In addition, the WUA conducts maintenance monitoring of all pipelines throughout the year. The Tribe monitors fish use of side-channels, pools, and other Dungeness River areas. WDFW conducts annual spawner surveys and other monitoring related to the Dungeness Chinook captive broodstock program and pink program.

2.8.7 Matriotti Creek (WRIA #18.0021)

Matriotti Creek is the largest low elevation tributary to the Dungeness River, entering the left bank (looking downstream) at RM 1.9. It is one of the streams that is more extensively linked to, and affected by, the irrigation network.

Fish & Habitat

Haring (1999) notes that culvert(s) in Bear Creek, (a major tributary to Matriotti Creek, and not to be confused with nearby Bear Creek 18.0030), are regarded as being at least partial barriers to fish access. The Mariposa Lane crossing, just upstream of Atterberry Road, is an additional blockage point. Fish access to the upper 0.25 to 0.5 mi. of Matriotti Creek itself is blocked by a 3-foot drop where it flows across the Agnew Ditch. The inaccessible area includes some good habitat, including a large wetland.

Floodplain

The character and location of Matriotti Creek is altered significantly from its historic condition. The drainage was channelized from Ward Road to Atterberry Road (CM 0.3 to 5.8), although significant portions of this reach have benefited from restoration projects within the last 15 years. Haring (1999) indicated it is unknown whether the channel upstream of Bear Creek (left bank tributary entering Matriotti at CM 3.6, not the same as Bear Creek 18.0030) actually existed historically, or whether it is an artifact of the irrigation delivery system. Historically, local biologists believe that Matriotti Creek likely had greater meander and flowed through numerous wetlands. Streambanks are trampled in parts of the drainage due to unrestricted animal access, with significant impacts through the Olympic Game Farm (Randy Johnson; PSCRBT 1991; Hiss and Lichatowich 1990, as referenced in Orsborn and Ralph 1994). There are two tributaries to Matriotti Creek, between Hooker and Atterberry roads, that are currently captured by the Dungeness Irrigation Company. Haring urged that the use and diversion of these tributaries into the irrigation system should be reviewed within this watershed planning process. Reconnection of these tributaries to Matriotti Creek would provide small amounts of additional habitat, wetlands, and flow to Matriotti Creek.

Channel Condition

Pool presence within the unrestored sections of Matriotti Creek is characterized as poor (Randy Johnson). The only significant LWD downstream of Atterberry Road is wood that has been placed as part of habitat restoration projects. The quality and quantity of wood varies among the project reaches (Randy Johnson, Paul Hansen). Outside the restored sections, LWD condition is poor. The stream reach between Spath and Runnion Roads (west of Carlsborg Road) remains severely degraded (Walt Blendermann), though it has been improved (Joe Holtrop, CCD, 4/24/03).

The Dungeness Irrigation Company system transfers stormwater flows to Matriotti Creek, which would otherwise not be significantly affected by the stormwater flows. High loads of fine sediment are conveyed to Matriotti Creek during flood events in the Dungeness River through the irrigation network (Haring, 1999).

Substrate

A number of habitat restoration projects have been done in the Matriotti Creek drainage to improve habitat conditions. These projects have included removal of accumulated fine sediments and addition of gravels to the sections of restored channel. No specific substrate concerns were identified at the time of the Limiting Factors Analysis (1999).

Riparian Condition

Streamside vegetation is generally destroyed due to animal access and agricultural practices, with significant impacts through the Olympic Game Farm (PSCRBT 1991; Hiss and Lichatowich 1990, as referenced in Orsborn and Ralph 1994). There is a lack of woody vegetation in most areas (Haring, 1999).

Water Quality

Matriotti Creek is listed on the Clean Water Act Section 303(d) list of impaired waterbodies, based on elevated fecal coliform counts (Ecology 1998). Direct animal waste input due to animal access is common throughout the drainage, with significant impacts through the Olympic Game Farm (PSCRBT 1991; Hiss and Lichatowich 1990, as referenced in Orsborn and Ralph 1994). Coliform counts were very high in the unconfined reach between Runnion and Spath roads, although stock have been removed. Water quality is also adversely affected by return flows from various irrigation ditches (Haring, 1999). Although fecal coliform is not known to adversely affect salmonids directly, it is often an indicator of other water quality impacts in the watershed that can adversely affect salmonids. These include direct animal access to the channel which affects riparian condition and bank stability, high fine sediment levels in the substrate from stormwater or agricultural runoff, and high nutrient levels in the stream which may cause excessive plant growth and affect dissolved oxygen levels.

Water Quantity

There are two tributaries to Matriotti Creek, between Hooker and Atterberry roads that are currently captured by the Dungeness Irrigation Company. Reconnection of these tributaries to Matriotti Creek would provide small amounts of additional habitat, wetlands, and flow to Matriotti Creek. Stormwater flows and high fine sediment loads are conveyed to Matriotti Creek through irrigation delivery systems. These may be Dungeness River water early in the storm season, and/or they may be stormwater runoff into the main irrigation canals once the outtake from the Dungeness River is shut down (Mike Jeldness, personal communication). Matriotti Creek would otherwise not normally be significantly affected by stormwater flows (Haring 1999).

Instream flow recommendations, based on toe width measurements made at Lamar Lane, have been made for Matriotti Creek. These recommendations are included as part of Section 3.3.2. Instream flows in Matriotti Creek are likely influenced by groundwater return flows and stormwater flows from irrigation. Although toe width is primarily determined by bank full flow events, toe width may have increased due to increased stormwater flows and increased groundwater delivered through the irrigation systems. The limited flow data that is available for Matriotti Creek was not reviewed to ascertain consistency with recommended instream flows.

2.8.8 Hurd Creek (WRIA #18-0028)

Hurd Creek is a relatively small, low elevation tributary to the lower Dungeness River, entering the right bank (looking downstream) at RM 2.7. It is a short, low gradient stream, providing significant, high quality tributary rearing and refuge habitat.

Fish Access

The majority of spawning and rearing habitat in Hurd Creek is in the spring-fed lower quarter mile of stream (downstream of Woodcock Road). Previously, adult salmonid access was precluded upstream of the hatchery rack near Woodcock Road (RM 0.5); however WDFW provided adult access beginning in 1999. The TAG indicates there is little adult spawning habitat upstream of Woodcock Road. Some juvenile salmonids are currently passing upstream of the hatchery rack to access rearing habitat.

Floodplain Modifications

No floodplain modification concerns are identified at this time.

Channel Condition

The PSCRBT (1991) indicated the stream is heavily impacted by unrestricted animal access to the channel, with trampled stream banks. However, the TAG indicated (2002) that animal access problems had been resolved and were no longer a significant concern. Downstream of Woodcock Road, there are some log jams and beaver dams, and some remnant individual LWD pieces. Upstream of Woodcock Road (where some juvenile salmon presence has been noted (TAG)), LWD condition is poor. The channel through WDFW property, adjacent to the Hurd Creek Hatchery, has been completely modified to allow for its use as a component of current and historic hatchery activities, and no longer functions as a natural channel or salmonid habitat. Some of the most extensive channel alterations are for hatchery activities that are no longer conducted, providing opportunities for restoration.

Substrate

Substrate downstream of Woodcock Road supports anadromous salmonid spawning; no concerns of fine sediment or substrate instability were identified.

Riparian Condition

The PSCRBT (1991) indicated that stream banks were trampled, and streamside vegetation was absent or in poor condition. However, the TAG characterized much of Hurd Creek as being fully overstoried with riparian vegetation, with the major area of concern being the WDFW-owned hatchery property, which lacks riparian vegetation.

Water Quality

The PSCRBT (1991) indicated the stream was heavily impacted by unrestricted animal access to the channel, with trampled stream banks. However, the TAG indicated that animal access problems have been resolved and are no longer a significant concern.

Water Quantity

No water quantity concerns have been identified.

2.8.9 Bear Creek (WRIA #18-0030)

Bear Creek is a medium-sized low elevation tributary to the lower Dungeness River, entering the left bank (looking downstream) at RM 7.3.

Fish Access

The TAG reported that a low dam used for irrigation pumping (just upstream of the current confluence of Bear Creek with the mainstem Dungeness River) had formed a barrier to upstream fish passage. The channel downstream of the dam was much lower than prior to the 1990 flood, and had headcut back to the dam. Sediment buildup has occurred upstream of the dam over time, and all upstream culverts in Bear Creek are set at the grade established by the dam. If the dam is to be removed, there is concern that the channel might head cut further upstream than the dam site, unless grade controls were incorporated with the dam removal. However, the Dungeness River and the mouth of Bear Creek have recently aggraded (Joel Freudenthal), resolving the previous passage barrier, and the creek no longer appears to be at risk of a major regrade. Fish passage access at or below the dam site should be monitored.

Floodplain Modifications

The mouth of Bear Creek changed as a result of the 1990 flood, when the end of the Dungeness Meadows dike blew out, rerouting the main flow down a previous side channel of the Dungeness River and capturing the previous lower portion of Bear Creek into the main Dungeness River channel. However, this is a natural phenomenon, not requiring restoration. Bear Creek crosses its own alluvial fan where it leaves the foothills and hits the former geomorphic floodplain of the Dungeness River. This alluvial fan is functioning and acting like a normal alluvial fan, with resultant channel instability which threatens some private roads. Several projects have been implemented in the last 5 years by landowners to attempt to stabilize the alluvial fan; these projects have met with limited success (Joel Freudenthal).

Riparian Condition

The downstream end of Bear Creek has some mature riparian alder, but only an estimated 25% of the stream has what could be characterized as fair riparian condition (TAG), with the remainder rating as poor. The upstream portion of Bear Creek has several areas where cattle access to the channel is unrestricted, which would benefit from fencing and riparian revegetation.

Water Quality

Stormwater flows and high fine sediment loads are conveyed from the Dungeness River to Bear Creek through the Agnew Irrigation Company delivery system during peak flow events in the Dungeness River. Bear Creek would otherwise not normally be affected by stormwater flows (TAG). There are no identified water temperature concerns in Bear Creek (TAG).

Water Quantity

Stormwater flows and high fine sediment loads are conveyed to Bear Creek through the Agnew Irrigation Company delivery system. The stormwater conveyance may include some Dungeness River stormwater flows early in the storm season, with later flows representing stormwater runoff into the main irrigation canals after the outtakes from the Dungeness River have been shut off (Mike Jeldness, personal communication). Bear Creek would otherwise not normally be significantly affected by stormwater flows (TAG). Channel toe-width is primarily determined by bank full flow events, but may be increased due to increased stormwater flows and increased groundwater delivered through the irrigation systems.

2.8.10 Canyon Creek (WRIA # 18-0038)

Canyon Creek is the uppermost tributary draining to the lower Dungeness River. It is mid-elevation, draining the Dungeness foothills, and enters the left bank (looking downstream) at RM 10.8.

Fish Access

A hatchery water intake dam at CM 0.08 is a complete barrier to upstream fish passage. WDFW currently has funds allotted to engineer and construct modifications to the dam for fish passage, or to fully restore physical and biological processes by removal of the dam. There is approximately 1.5-2.0 miles of potential habitat upstream of the dam, although only the upper 1/3 of the additional habitat is currently considered to be in good condition.

Floodplain Modifications

Canyon Creek, downstream of Fish Hatchery Road, is altered significantly from historic condition. The TAG believes that lower Canyon Creek previously paralleled the Dungeness River for approximately 1,800 feet downstream of the current mouth, and that this was probably the best habitat in Canyon Creek. This reach was channelized directly to the Dungeness, and the previous lower channel area was used for pond construction at the WDFW hatchery. The resulting channel is higher gradient than the previous natural channel, and in combination with the sediment transport alteration created by the dam, the resulting substrate in lower Canyon Creek is larger than desired for spawning or rearing, and there is little habitat diversity. The left bank is also confined by a WDFW-owned dike made up of river gravels. Restoration of the historic low gradient habitat that paralleled the Dungeness River would likely require the relocation of the adult holding pond and a 0.5-acre rearing pond at the hatchery to an area that is outside the floodplain.

Channel Condition

From Fish Hatchery Road to the mouth, there is little LWD present, and limited riparian vegetation to provide future LWD (see Map 8 (WRIA 18 Depleted LWD and Channel Constrictions) in separate Maps file included with Haring 1999). Upstream of the dam, Canyon Creek has abundant LWD, with additional LWD contribution potential, as the canyon has not yet been logged. LWD is generally stable, as Canyon Creek typically does not have enough energy to actively move LWD.

Substrate

Approximately 0.25 miles upstream of the dam, habitat is adversely affected by an active slide. The system upstream of the dam is unraveling, with significant water quality and quantity concerns. Periodic high bedload transport, high fine sediment levels, and high turbidity are all identified as concerns (TAG). There are no LWD or other channel features to hold gravel and fine sediment in the portion of Canyon Creek downstream of the dam, consequently the substrate is coarse, providing little spawning potential.

Riparian Condition

Riparian condition is poor downstream of the dam, with sparse deciduous vegetation. Riparian condition is generally good upstream of the dam, as it is located in a deep ravine that has not been logged.

Water Quality

Water quality is periodically affected by high turbidity levels resulting from the active slide upstream of the dam.

2.8.11 Caraco Creek (WRIA #18-0046)

Caraco Creek is a mid-elevation tributary to the Dungeness River canyon, entering the left bank (looking downstream) at RM 12.1. No anadromous salmonid use of Caraco Creek is known. Road densities in the watershed are high, at 3.0 mi/mi^2 (DAWACT 1995). This level is in excess of the 2.5 mi/mi^2 threshold of concern identified in the USFS Watershed Analysis.

2.8.12 Gray Wolf River (WRIA # 18-0048)

The Gray Wolf River is the largest tributary to the Dungeness River, draining the mountainous portions of the upper watershed and entering the right bank (looking downstream) of the Dungeness River at RM 15.8.

Fish Access

A series of natural falls/cascades at RM 9.0, and just upstream of the “Three Forks” confluence (Gray Wolf River, Cameron Creek, and Grand Creek), impairs or prevents upstream anadromous salmonid access. Due to limited survey effort and accessibility problems in this remote area, there is very limited information on the specific extent of upstream presence of individual salmon and steelhead species.

Floodplain Modifications

The Gray Wolf is located in a deep narrow canyon, which is naturally confined by topography.

Channel Condition

From the mouth to RM 9.3, pools occupied 27.6% of the wetted channel, average distance between pools was 200 ft., 192 pools were >3 ft. deep, mean pool depth equaled 4.4 ft., and mean residual pool depth was 2.9 ft. (Orsborn and Ralph 1994). Dick Goin has observed a loss of pools in the vicinity of the bridge in recent years. These values would normally be considered as poor pool condition for a channel >15m wide, but may be representative of the historic natural pool condition to be encountered in this channel. LWD is present throughout the channel corridor, but few pieces are located within the channel. Most pieces are located on the edge of the ordinary high water mark. There was conjecture in the TAG that the USFS may have bucked LWD, which floated out on high water. However, Lloyd Beebe (sport fisher, resident) doesn't ever recall seeing any saw cuts on the LWD that remained in the channel. Other TAG participants believe the LWD location and abundance may be close to the natural state, as there are few features for the LWD to lock into in the active channel during high flows.

No information was accessed indicating fine sediment concerns; however, fine sediment would likely carry through the Gray Wolf and be deposited downstream. Fine sediment, particularly from forest roads in the upper watershed, is identified as a concern for the Dungeness River. Forest roads in the Gray Wolf watershed (including tributaries) should be evaluated, and actions taken to minimize the entry of fine sediment to downstream areas.

Riparian Condition

Riparian condition was reported to not be of concern in the Gray Wolf River (TAG), although the importance of retaining intact riparian vegetation in the canyon was identified as a high priority.

2.8.13 Gold Creek (WRIA #18-0121)

Gold Creek is a medium-sized tributary to the upper Dungeness River, entering the right bank (looking downstream) of the Dungeness River at RM 18.7.

Fish Access

Upriver pink, coho, and steelhead spawning is reported to have historically occurred to CM 1.5 (Streamnet), but slides in lower Gold Creek have limited anadromous salmonid access in recent years to only the lower 0.1 mile. Several LWD and rock barriers have prevented migration upstream of this point, and map gradient in lower Gold Cr. is >6% (Orsborn and Ralph 1994), which is greater than typically used by salmon for spawning. However, Randy Cooper reports that over 1,000 pink salmon were observed spawning up to RM 0.3 in 1999. Access was likely improved by higher flow conditions than in prior years.

Floodplain Modifications

Gold Creek is located in a confined canyon, which has been significantly affected by large mass wasting events. Gabion baskets (wire mesh baskets filled with coarse gravel) were used to attempt to stabilize the slide and provide fish passage through the slide area (TAG). This has highly altered both channel condition and stream energy, potentially affecting the success of restoration efforts in the lower channel.

Channel Condition

The lower 0.5 mi. of Gold Creek has abundant LWD, which is buried under large amounts of slide material. Gold Creek is currently reworking a channel through this slide material, and it is too early in this process to identify what the channel characteristics will be once the channel reaches a new equilibrium.

Substrate

The PSCRBT (1991) identified the roads in the Gold Cr. drainage as actively eroding. Natural deep mass wasting problems result from Vashon Ice Sheet drifts (Golder 1993, as referenced in Clark and Clark 1996). Logging, road building, bank erosion, and channel changes, have further exacerbated erosion contribution from natural deep-seated failures and increased the occurrence of shallow-rapid landslides. Approximately 58% of sediment yield is estimated to be from undisturbed forested areas, with 42% associated with disturbed or clearcut areas. The road density in the watershed is high, at 2.7 mi/mi^2 (DAWACT 1995). The channel substrate in lower Gold Creek is composed of a combination of large amounts of LWD and large outwash material in the slide debris. This has resulted in a steep gradient step-pool habitat that prevents upstream anadromous fish access.

Riparian Condition

Riparian condition in the Gold Creek watershed has been significantly affected by mass wasting events and past forest practices. Upper Gold Creek is at a relatively high elevation in the Mountain Hemlock Zone. Bon Jon Pass, which forms the upper limit of the Gold Creek Watershed, as well as the Gold Creek Valley itself, is a large, U-Shaped valley, created by glaciers as they migrated up the valley and over the divide. It provides an excellent funnel for south winds from Hood Canal to travel down valley. Riparian zones and forest stands adjacent to clear-cuts were subject to recurrent blowdown events, and consequent recurrent timber salvage of the blowdown. Over time, the entire valley floor down to the edge of the stream was harvested or salvaged. Mountain Hemlock is notorious for its difficulty in re-establishing stands under such conditions due to the depth of snow that accumulates in the clearcuts. Although the watershed is entirely within USFS ownership, and is now designated as riparian reserve, it may be several decades before hydrologic maturity occurs in the upper Gold Creek valley. In the meantime, the depth of snow and high wind velocities provide ideal conditions for rain-on-snow events. The resultant increased flow and greatly increased stream energy (especially when viewed in conjunction with removal of LWD when the road was constructed through the canyon below) may have more than anything to do with the severity and ongoing nature of the Gold Creek slide.

Water Quality

Water temperature data have been collected, indicating temperatures above the level considered optimal for salmonid spawning and incubation (Joel Freudenthal). Water temperature is likely affected by poor riparian condition in the upper watershed. The flood magnitude in Gold Creek appears to have increased by 35% as a result of the 1969 slide in Gold Creek, raising the flood magnitude in the Dungeness River to a total of 4,100 cfs (Orsborn and Ralph 1994).

Water Quantity

Runoff from forested areas has likely been significantly increased as a result of extensive forest harvests and roads in the upper watershed (TAG), but flow information is not available to verify the extent of any changes that have occurred.

2.8.14 Silver Creek (WRIA #18-0131)

Silver Creek is a medium-sized tributary to the upper Dungeness River, entering upstream of Dungeness Falls on the right bank (looking downstream) of the Dungeness River at RM 22.1. The major landslide that occurred in Silver Creek in 1972, in saturated glacial till, briefly dammed the Dungeness River. It is thought to have been precipitated by increased saturation in the year or so following a large clearcut above (according to Long in Clark and Clark 1996). The slide was the result of a clearcut, which was harvested to pay to expand the road network for future harvest on that side of the upper river. Consequently, the road that was constructed was much larger than needed for the clearcut. Unfortunately, the triple switchback that was built did not make it through the winter, and took most of the valley wall with it. The slide proceeded down the narrow valley, scouring to bedrock up to about 180 feet on the valley walls as it went toward the river, briefly damming it. A conservative estimate of the slide volume, made by Joel Freudenthal, was 300,000 cubic yards minimum, plus whatever it picked up during its travels down to the river, scouring the valley walls. Most of the slide material moved down river to the Dungeness, but a large logjam remained which became a fish blockage. An attempt was made to restore passage by cutting out the logjam with chainsaws. The logjam failed during the next flood (~1979), and all of the sediment behind the jam moved downriver. Many of the locals blame this second slug of sediment for much of the damage that occurred above Dungeness Meadows during the 1980s. The Silver Creek slide was a major, if not the major sediment impact in the Dungeness River over the last 30 years. Slides remain active, but Forest Road 2860 and revegetation captures much of the sediment, preventing it from passing to downstream areas in the Dungeness River (DAWACT 1995).

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