Final

WATER RESOURCE INVENTORY AREA 14 FRESHWATER HABITAT STRATEGY UPDATE

Phase 1: Existing Conditions Summary Report

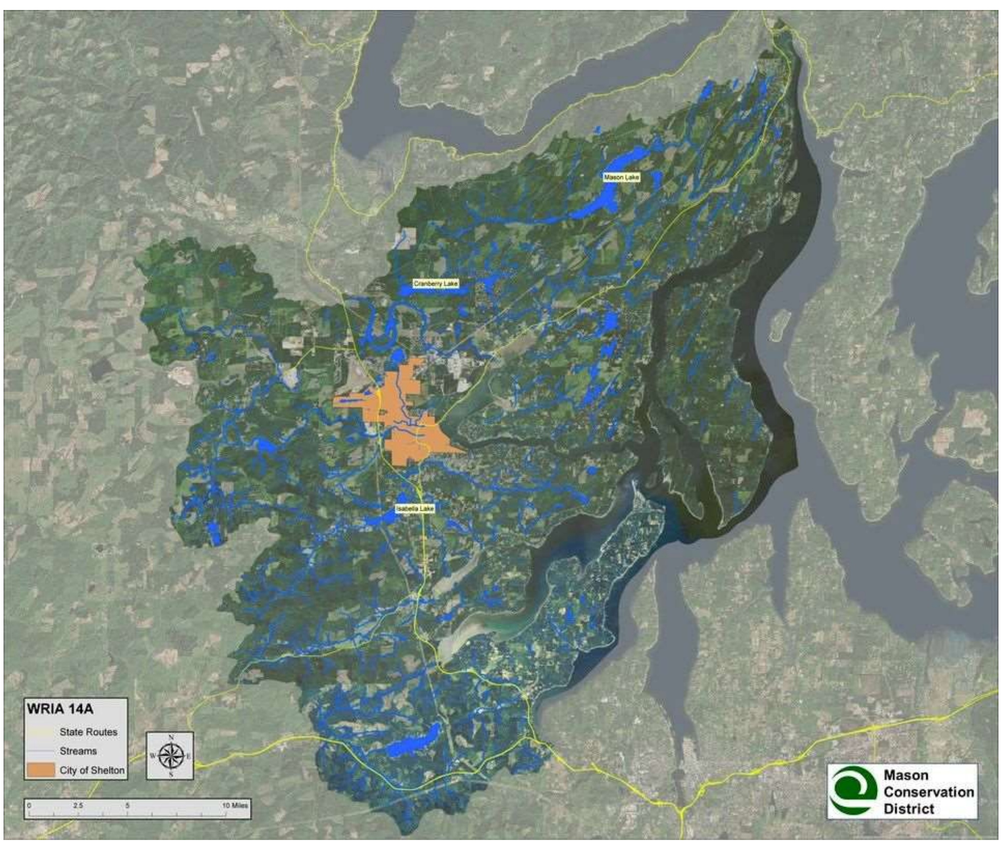
Prepared for

Mason Conservation District and

WRIA 14 Lead Entity Committee

August 2020

ESA



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1 PURPOSE AND INTRODUCTION

The Water Resource Inventory Area (WRIA) 14 Lead Entity Committee (Committee)[1] is updating the freshwater habitat strategy that was first prepared in 2004 and titled Salmon Habitat Protection and Restoration Plan for WRIA 14, Kennedy-Goldsborough (Mason Conservation District Lead Entity, 2004), herein referred to as the Salmon Plan. The WRIA 14 Committee hired Environmental Science Associates (ESA) to assist with the freshwater habitat strategy update. The salmon species and sea-run trout present in WRIA 14 include Chum Salmon (*Oncorhynchus keta*), Coho Salmon (*O. kisutch*), Chinook Salmon (*O. tshawytscha*), and Pink Salmon (*O. gorbuscha*), Steelhead (*O. mykiss*), and sea-run Coastal Cutthroat Trout (*O. clarkii clarkii*), which represent the focal species for the update. As a freshwater habitat strategy update, the project focuses exclusively on freshwater habitats and life stages only and does not evaluate habitat conditions in the estuary, nearshore, or in marine waters. A primary goal of the freshwater habitat strategy update is to restore and protect natural watershed processes in the freshwater environments of WRIA 14 that support biologically diverse runs of salmon capable of self-sustaining natural reproduction

The freshwater habitat strategy update will occur in multiple phases. Phase 1, for which this report was prepared, entails compiling available information, identifying critical data gaps, and characterizing existing conditions. Phase 2 will focus on filling critical data gaps (as needed/possible), prioritizing watersheds and reaches for restoration and protection. Subsequent work after Phase 2 will focus on target setting and adaptive management planning.

The purpose of this Existing Conditions Summary Report is to summarize available information on habitat conditions and salmon populations, and to use this information to evaluate existing conditions in 17 key watersheds within WRIA 14. An earlier memo prepared as part of Phase 1 listed data sources generated since the 2004 Salmon Plan (i.e., post-2004) and identified critical data gaps (ESA 2019). The data compilation memo was organized by WRIA 14 watershed and habitat parameter, which facilitated interpretation of what information was available and for which parts of WRIA 14.

The selected approach for classifying current habitat conditions by WRIA 14 watershed, as presented in this report, utilized recent (post-2004 Salmon Plan) and historic (pre-2004) data on habitat parameters. The habitat parameters, which are classified as indicators for this analysis, were used to evaluate the existing condition of four Key Ecological Attributes (KEAs), specifically: (1) Stream Temperature, (2) Sediment Size and Distribution, (3) Stream Complexity, and (4) Aquatic Habitat Connectivity. KEAs are an aspect of an ecosystem component or habitat types that, if present, define the health of that habitat and, if missing or altered, would lead to the outright loss or extreme degradation of that habitat over time. There are standard definitions for habitats and KEAs developed for Chinook Salmon recovery planning at the regional level, which were combined and modified to work for a multi-species, freshwater approach. The four KEAs were selected because together they represent the primary ecological processes and resultant habitat structure required by anadromous salmonids and their freshwater life stages. This approach applies a salmonid life history perspective to the analysis by explicitly linking the importance of

[1] The WRIA 14 Committee is comprised of a combination of citizen and technical stakeholders.

the individual KEAs to each freshwater life stage of the salmonid species. This approach serves to relate habitat quality and availability to the specific salmonid species and life stages present within each watershed.

In addition, this report presents an overview of each anadromous salmonid species in WRIA 14, including a summary of fish distribution and populations in the watersheds of WRIA 14. The report also identifies existing and potential future threats to salmonid populations in WRIA 14. Threats are defined as the combination of pressures and stressors, or the human impacts that lead to degraded KEAs. Pressures and stressors are further defined and examples provided in Section 4. A list of pressures and stressors most impacting the KEAs in WRIA 14 was developed and reviewed. Where data were readily available for certain pressures like roads or habitat conversion, these were analyzed by watershed and presented in tables. The threats of future population growth and climate that can further exacerbate existing pressures and stressors are described in Section 4.3.

In Section 5, data gaps identified in the existing habitat conditions analysis and the threats analysis are provided. In the final section, recommended next steps for Phase 2 of the freshwater habitat strategy update are provided.

2 SALMONIDS IN WRIA 14

WRIA 14 has known presence of seven species of salmon and trout with sea-run life histories including Coho Salmon, Chum Salmon, Steelhead, Chinook Salmon, Pink Salmon, Sockeye Salmon and Coastal Cutthroat Trout. With the exception of Chinook Salmon, all of these species have been documented as spawning in WRIA 14. Pink Salmon presence on the spawning grounds has been documented by the Washington Department of Fish and Wildlife (WDFW) in recent odd years. Isolated occurrences of Sockeye Salmon and Kokanee, the non-anadromous form of the species, have been documented in the WRIA. Neither Pink Salmon or Sockeye Salmon has a designated stock in the WRIA and the species are not included in the analysis. As the freshwater habitat strategy update is intended to support multi-species recovery efforts, this evaluation includes all of the other five species as focal species. The text below briefly describes each species, including key life history elements, discusses the relative distribution of these species in the WRIA 14 watersheds, and presents information on species abundance within each watershed.

2.1 Species Descriptions

The following sections describe the focal species for the update, including freshwater habitat requirements and general life histories.

2.1.1 Chum Salmon

The Puget Sound/Strait of Georgia Chum Salmon Evolutionarily Significant Unit (ESU) (Johnson et al., 1997; NMFS, 1999) includes three Chum Salmon runs, differentiated by spawn timing. Chum Salmon in WRIA 14 are predominantly fall run, although several watersheds in the WRIA support summer Chum Salmon. No winter Chum Salmon are reported in WRIA 14. While spawn timing also varies by watershed, summer Chum typically spawn from September to November, while fall Chum Salmon spawn primarily in November and December (WDF et al., 1993; WSCC, 2002). This report's interpretation of Chum Salmon runs in the WDFW spawning ground database assumed observations before October 1 were summer Chum Salmon and observations on or after October 1 were fall Chum Salmon. The WDFW spawning ground database documents live fall Chum Salmon on spawning survey reaches between October and December. High numbers of live fall Chum Salmon are documented in October, peak numbers in November, followed by a sharp decline in December. The WDFW spawning ground database documents small numbers of summer Chum Salmon in a subset of creeks in WRIA 14, as described further in Section 2.3.

Adult Chum Salmon typically return to their natal streams as 3- to 5-year-old fish, and tend to migrate upstream during periods of rising river flows and decreasing temperatures, and often spawn within several weeks of entry (Salo 1991; WDF et al., 1993). Chum Salmon generally spawn lower in the watersheds than most other salmonids, typically downstream of the first significant barrier, as they have difficulty leaping over blockages and are often reluctant to use fish ladders. They also tend to spawn in shallower and lower velocity waters than other salmonids (WSCC, 2002).

Many habitat characteristics can influence spawning site selection. Water flow through the substrate (typically groundwater upwelling) and associated water temperature (Geist et al., 2002; Maclean, 2003), substrate type (Chapman, 1988; Kondolf, 2000), and dissolved oxygen concentration (Peterson and Quinn, 1996; Maclean, 2003) are known selection factors for Chum Salmon and other salmonids. Chum Salmon tend to spawn in sand- and silt-free gravel areas, reportedly preferring particle sizes of 0.7 to 7.6 cm diameter, compared to larger or smaller substrate material preferred by other salmonids (Duker, 1977). Johnson et al. (1971) found that Chum Salmon spawn in flows varying from 0.0 to 167.6 cm/sec, with most (80%) spawning in velocities of 21.3 to 83.8 cm/sec.

Chum also appear to prefer gravel areas where groundwater springs or upwelling occur, providing sources of warmer and more stable water temperatures, to protect eggs from freezing (Maclean, 2003; Burril et al., 2010). Similar benefits are provided in intertidal spawning areas, warmed by inundating marine waters during high tidal cycles (Johnson et al., 1997). Acceptable stream temperatures for Chum Salmon incubation range from 4° to 12°C (Richter and Kolmes, 2005). Eggs and then hatched yolk-sac fry remain in the gravel for 5 to 6 months after fertilization (Koski, 1981), typically emerging between March and May (Salo, 1998). As with other salmonids, egg mortality and alevin development are negatively affected by water temperatures exceeding approximately 12° to 15°C, although this appears to be the preferred temperature range for juvenile salmonids (Johnson et al., 1997; Richter and Kolmes, 2005).

Fry emerge at night and immediately begin migration downstream to estuarine/nearshore areas (Koski, 1981; Salo, 1991; Simenstad, 2000). Therefore, except for spawning and incubation conditions, Chum Salmon have limited reliance on freshwater habitats. Upon their arrival in tidal waters, Chum Salmon fry inhabit shallow estuarine habitats and marine shorelines (Nightingale and Simenstad, 2001), where they feed on both freshwater (mayfly and caddisfly larvae and chironomids) and marine (zooplankton and benthic invertebrates) food resources (Salo, 1998).

Chum Salmon fry can either pass directly through natal estuaries into Puget Sound, or they can rear for weeks in estuarine habitats before moving along the shoreline (Fresh, 2006). They typically rear in nearshore areas through June or until reaching a size of 1.7 to 2 inches (45 to 50 mm), when they move to deeper off-shore areas (Salo, 1991; Ames et al., 2000; Simenstad, 2000; Fresh, 2006).

2.1.2 Coho Salmon

Coho Salmon within WRIA 14 are classified part of the Puget Sound/Strait of Georgia Coho Salmon Evolutionarily Significant Unit (ESU). Coho Salmon typically exhibit a 3-year life cycle, with approximately equal time spent in fresh and saltwater (Sandercock, 1991). Returning Coho Salmon in WRIA 14 typically enter freshwater from mid-September to mid-November and spawn from late October to mid-December (WSCC, 2002). River entry typically coincides with increased flows from storm events (Sandercock, 1991). The WDFW spawning ground database documents live Coho Salmon on spawning survey reaches between October and December with a peak normally in December. The WDFW database documents infrequent observations of live Coho Salmon in these areas in September and January. Coho Salmon spawning areas are widespread, ranging from small tributaries to larger rivers, throughout the WRIA. Spawning also occurs over a long timeframe, generally between mid-fall and early winter, but occurs as late as January and February in some areas.

Coho tend to prefer slower water velocity areas than other salmon species, with average velocities of less than 20 cm/s (Bisson et al., 1988). Spawning typically occurs at water temperatures ranging from 4.4° to about 13°C, with peak egg survival typically occurring between 2.5° and 6.5°C, although the wider range of 1.3° to 10.9°C also showed acceptable survival results (Richter and Kolmes, 2005). Similarly, temperatures from 4° to 10.9°C resulted in good alevin and fry survival, while spring water temperatures below 15°C are ideal for successful Coho Salmon smoltification, as impairment can occur above this temperature.

Bed scour can have very high adverse effects on incubating salmon eggs (Tripp and Poulin, 1986; Montgomery et al., 1996). These scoured areas can produce high egg survival rates due to groundwater upwelling (Bjornn and Reiser, 1991; Waters, 1995). Egg survival can be as high as approximately 80% (Quinn, 2005), although average survival to emergence is typically much lower. Moring and Lantz (1975) reported emergence survival rates of about 30% in three small Oregon coastal streams. Survival and emergence of embryos and alevins is greatly influenced by dissolved oxygen supply within the redd (Mason, 1976). Coho Salmon embryos typically hatch after about 6 to 8 weeks in the gravel, although hatched alevins remain in the gravel for an additional 2 to 4 weeks before emergence (Wydoski and Whitney, 2003; Groot and Margolis, 1991).

After emergence, Coho Salmon fry move to low velocity areas, typically along the stream's margins or backwater eddies and pools (Nickelson et al., 1992; Hampton, 1988; Nielsen, 1994; CDFG, 2002), as well as off-channel and backchannel areas (Cederholm and Scarlett, 1982; Sandercock, 1991; Lestelle et al., 1993). Depending on habitat conditions and availability, juvenile Coho Salmon may also disperse upstream or downstream after emergence (Hartman et al., 1982; Murphy et al., 1984; Cederholm et al., 1988; Nielsen, 1994; Bolton et al., 2002). Their spawning distribution and subsequent fry movements can disperse them to streams of all sizes, from small headwater streams to larger channels and other interconnected waterbodies including lakes, ponds, flooded wetlands, and estuarine areas.

The fry exhibit similar habitat preferences through their freshwater rearing stage, which extends for about 1 year, during which time they may remain close to their natal sites. However, depending on habitat conditions, the fry may move considerable distances to find suitable summer and/or overwintering habitat. Juvenile Coho Salmon have been found to move up to 20 miles downstream from summer rearing sites to overwintering habitat (Peterson, 1982; Cederholm and Scarlett, 1982). Factors affecting fry distribution and survival include access to adequate food sources and habitat (particularly over-winter habitat), predation, habitat complexity, and connectivity to suitable habitats (Nickelson et al., 1992; Solazzi et al., 2000; and Johnson et al., 2005).

In Puget Sound, peak Coho Salmon smolt outmigration generally occurs from late April to mid- May, with most smolts ranging from 95 to 115 mm fork length (Weitkamp et al., 1995). Some Coho Salmon display a more complex suite of life history patterns, including the use of estuarine or lake habitat or direct seaward migration by 0-age Coho. In some stream systems, a significant portion of juveniles outmigrate in the fall of their first year (Roni et al., 2012), while in other streams, Coho Salmon migrate to estuarine areas for the summer, then return upstream to overwinter in freshwater (Miller and Sadro, 2003). A redistribution in fall at the onset of high flows or cold temperatures is an adaptation that many salmonids exhibit, particularly Coho Salmon. The range in life history patterns exhibited by Coho Salmon likely contributes to their wide ranging distribution within and between watersheds, suggesting a high degree of adaptability to habitat conditions.

Juvenile Coho Salmon are strongly associated with slow water habitats and areas with high channel complexity and physical cover (i.e., wood debris, vegetated banks, and side channels), although the overall stream flow characteristics are also important (Sandercock, 1991). Summer low flow is a significant limiting factor for Coho Salmon smolt production in Puget Sound streams (Zillges, 1977). Low flow reduces stream habitat quantity and typically corresponds to increased water temperature, both of which can affect competition and predation interactions with other salmonids, particularly during summer rearing. In addition, high winter flows can displace juvenile Coho Salmon and disrupt important habitat features, such as off-channel holding areas (wetlands and ponds), slow moving side channels, backwater pools, and beaver ponds (Sandercock, 1991). Lakes also may be an important overwinter habitat (Baranski, 1989).

2.1.3 Steelhead

On May 7, 2007, NMFS announced the listing of the Puget Sound Distinct Population Segment (DPS, similar to an ESU) of Steelhead as a threatened species under the Endangered Species Act (ESA). Summer-run Steelhead return to their natal streams several months prior to spawning in the spring, while winter-run Steelhead return as sexually mature adults between December and April and typically spawn soon after arrival, between February and May. Steelhead in WRIA 14 are winter-run. Prior to spawning, maturing adults hold in pools or in side channels to avoid high winter flows. Steelhead tend to spawn in moderate to high gradient sections of streams and spawn higher in the watershed compared to other salmonids (USDA, 2019).

Puget Sound Steelhead juveniles usually spend 1 to 3 years in freshwater, with most typically spending 2 years (Busby et al., 1996). Thus, the species relies heavily on freshwater habitats and is present in streams year round. Newly emerged fry move to shallow, protected areas of the stream (typically along the stream margins) and establish and defend feeding areas. Juveniles can be found in riffles but move to pools or deep run areas as they grow larger. Steelhead juveniles are not as dependent on pools or off-channel areas as other species, such as Coho Salmon. Juvenile Steelhead often reside in freshwater for longer periods than juveniles of other anadromous salmonid species and are thus more susceptible to changes in habitat quality that may lower their freshwater survival rate (Scott and Gill, 2008). Fry tend to prefer fast water areas with large substrate for rearing, which allows them to wait in the eddies behind large rocks to feed on insects, salmon eggs, and smaller fish (USDA, 2019). While the marine migration pattern of Steelhead in Puget Sound is not well understood, it is generally thought that Steelhead smolts move quickly offshore (Hartt and Dell, 1986 in Hard et al., 2007).

The optimal egg incubation temperature appears to be below 11° or 12°C, while juvenile growth is optimized at about 15° or 17°C (Richter and Kolmes, 2005). Spring water temperatures below 12°C are preferred for Steelhead smoltification, as impairment can occur at higher temperatures (Richter and Kolmes, 2005).

Steelhead are iteroparous, meaning that unlike salmon, not all Steelhead die after spawning (Hard et al., 2013). A portion of spawned-out adults, called kelts, return to saltwater and will return to spawn in future years.

Current Steelhead abundance in WRIA 14 streams is currently very limited, echoing larger trends in Puget Sound in recent decades. Gayeski et al. (2011) estimated the total Puget Sound Steelhead abundance in 1895 as between 485,000 and 930,000. This compares to a 25-year average abundance for all of Puget Sound of 22,000 for the 1980 to 2004 period, indicating that current abundance is likely only 1 to 4% of the abundance immediately prior to the 20th century. Preliminary analyses of wild Steelhead adult abundance trends (and wild and hatchery smolt-to-adult survival rates) suggest that Steelhead populations along the Pacific Coast, from British Columbia through Oregon, share a pattern of declining abundance from the mid-1980s through the mid-90s (Myers et al., 2015). It also appears Steelhead distribution may be shrinking on the Kitsap peninsula (PSEMP, 2012). The shared pattern suggests that common, Pacific region-level factors such as climate and ocean conditions were driving survival and that juvenile Steelhead mortality in the Puget Sound marine environment constitutes a major, if not the predominant, factor in that decline.

The number of observed Steelhead in WRIA 14 in recent years is very low. Although spawning surveys in WRIA 14 do not specifically target Steelhead spawn timing, the number of observed Steelhead spawners has decreased substantially. A total of 67 live Steelhead have been reported during spawning surveys. Of these, only 27 of the observations occurred since 1990 and 13 observations since 2000. Since 2007, only one Steelhead has been recorded during spawning surveys. The current presence and extent of self-sustaining populations in WRIA 14 represents a data gap.

NOAA released the final ESA Recovery Plan for Puget Sound Steelhead in December 2019 (NMFS 2019). The plan highlights relevant pressures to address for Steelhead recovery, includes newly available findings on early marine survival, and it highlights the necessary strategies and actions by major population group. The plan also provides considerations for how watersheds should consider climate, passage and other important elements for local Steelhead population recovery as they develop local plans or project lists.

2.1.4 Chinook Salmon

NMFS issued a ruling in May 1999 listing the Puget Sound ESU Chinook Salmon as threatened under the ESA (NMFS, 1999). No documented spawning of Chinook Salmon has been reported in the streams of WRIA 14. Those Chinook Salmon that have been documented in WRIA 14 are fall-run. Fall-run Chinook return to freshwater in August and spawn between late September and January (Myers et al., 1998). Johnson et al. (1971) report that most Chinook Salmon spawn in mainstem stream areas with flow velocities ranging from 10 to 150 cm/sec, while Hanrahan et al. (2004) report a wider preferred range of 25 to 225 cm/s. Chinook also tend to prefer water depths greater than 30 cm (Geist and Dauble, 1998) and substrate sizes between 2.5 and 30.5 cm (Hanrahan et al., 2004). Adult migrations are typically blocked by temperatures exceeding about 20°C (Richter and Kolmes, 2005). While Hicks (2000) reported a maximum spawning temperature of about 14.5°C, incubation temperatures above 9°C resulted in measurably increased mortality, and complete mortalities were reported between 13.9 and 19.4°C. Optimal juvenile growth temperature is estimated at about 15°C but can range between 12° and 17°C

(Richter and Kolmes, 2005). Ideal temperatures for Chinook Salmon appear to be variable but likely range from 12°C to 17°C, at which point impairment of smoltification begins.

Chinook migrate to estuarine areas in spring (typically April to mid-July) (Fresh, 2006). As with Chum Salmon and Coastal Cutthroat Trout, juvenile Chinook are estuary-dependent, as they feed extensively in pocket estuaries and inlets along the marine coast, particularly on forage fish that spawn along area beaches (Fresh 2006). The shallow intertidal areas provide optimal rearing conditions, with vegetated cover and abundant prey. Estuarine residence time and migration timing into offshore Puget Sound habitats are a function of several factors, but fish size at estuarine arrival and residence time in the delta tend to be inversely related (Fresh, 2006).

In the WDF et al., (1993) and (2002) stock inventory reports, the fall Chinook Salmon spawning aggregations observed in south Puget Sound independent tributaries were not rated. No stock status was given, with just Chinook Salmon observed and documented). Although Chinook Salmon have been documented in WRIA 14 streams, no known spawning occurs in the WRIA. This is not surprising for the following reasons: (1) The independent tributaries in south Puget Sound are not typical Chinook Salmon habitat because of relatively small stream size and low flows during the late summer/early fall spawning season, (2) The current low escapements of Chinook Salmon documented in WRIA 14 are likely the result of past hatchery plants or straying from either current South Sound hatchery production or viable south Sound natural populations, and (3) fall Chinook Salmon likely were not historically self-sustaining in these habitats and have little chance of perpetuating themselves through natural production. There are no self-sustaining populations of Chinook Salmon in WRIA 14 and Chinook Salmon presence is likely limited to hatchery strays.

2.1.5 Coastal Cutthroat Trout

Coastal Cutthroat Trout display at least four distinctive life history forms. The most basic division is between the anadromous (sea-run) form and those that live exclusively in freshwater. WDFW (2000) classified WRIA 14 Cutthroat trout as part of the Western South Sound Coastal Cutthroat stock complex. This stock, which is classified as native and whose status was rated as unknown by WDFW (2000), is thought to be distinct from other South Sound stocks based upon the later timing of freshwater entry exhibited by its anadromous component and its distribution in the small to medium-sized independent streams of south and western Puget Sound.

The anadromous life history form is likely to be found in most of these systems, but presence and distribution in freshwater may be quite seasonal because of summer and fall low flows. It is expected that these fish are late-entry. The fluvial form probably inhabits all of the medium-sized streams, and the adfluvial form may be present in as many as 12 lakes within the range of this stock complex. The resident form of this stock complex is present in virtually all perennial independent streams in western South Puget Sound.

Coastal Cutthroat Trout typically spawn in areas where water velocities are intermediate between Coho Salmon and Steelhead preferences (Vanderhoff, 2007), typically in pea gravel riffles and water depths of 15 to 45 cm (Johnston, 1981; Hunter, 1973; Jones, 1978; Trotter, 1989). Over six spawning season (2008 to 2014) Skookum Creek (between RM 5.5 and 7.5) was surveyed for live and dead Coastal Cutthroat

Trout and redds once weekly from early October to early June during (Losee, et al. 2016). Over the entire study period, 148 live adults and 544 redds were observed. A key finding is that redd construction timing was highly variable among years, with 50% of redd detections occurring by as early as February 13 or as late as April 27, a period of over two months. These findings indicate that the general January to March spawn timing previously described for Coastal Cutthroat Trout in Washington does not accurately depict the potential spawning period of the subspecies in south Puget Sound. The variable spawn timing in Skookum Creek occurred over a duration of up to 4 months and showed high intra-annual variability. Data from Losee (2016) indicated Coastal Cutthroat Trout redds were typically found in substrate composed of small gravel (1.3–3.8 cm) and large gravel (3.8–7.6 cm) and in water with an average velocity of 0.60 m/s.

Eggs hatch within 6 to 7 weeks, depending on water temperature, and alevins remain in the gravel for about 2 weeks after hatching (Trotter, 1989). Fry emerge from spawning gravels in March through June (Johnson et al., 1999). Newly emerged fry move quickly to low velocity water along stream margins and backwaters and remain there through the summer to feed (Trotter, 1989). However, in the presence of Coho Salmon juveniles, which emerge earlier and at a larger size, Coastal Cutthroat Trout are often driven into higher velocity waters (Trotter, 1989). Most anadromous juveniles remain in freshwater for 2 to 4 years before smolting and migrating to saltwater, although the range extends from 1 to 6 years (Giger, 1972; Lowery, 1975). Other forms tend to move downstream to larger water bodies as their size or competition for prey or space increases. Anadromous outmigrations occur in the spring, with the fish tending to rear extensively in shallow intertidal areas, preying on forage fish (Mason Conservation District, 2004). After feeding in saltwater and estuaries for several months, most anadromous Coastal Cutthroat return to freshwater to overwinter and spawn, although sexual maturity of returning fish varies by geography and sex (Fuss, 1982; Tipping, 1981). Like Steelhead, anadromous Coastal Cutthroat Trout are iteroparous and adults may spawn in multiple years (Trotter, 1989). An Oregon study estimated that approximately 40% of spawned-out adults survive to return to saltwater (Crocker, 1995). Additional studies in Skookum Creek in the spring of 2017, utilized passive integrated transponder (PIT) tags (Losee, et al., 2017). Based on this data, it is estimated that 91 adult Cutthroat trout entered the index area of Skookum Creek and produced 74 redds, resulting in s preliminary estimate of number of fish per redd is 1.23. Applying this estimator and expanding redd counts to include spawning habitat in Skookum Creek outside then index area, resulted an average escapement estimate of Coastal Cutthroat Trout for Skookum Creek during the previous study period (2008-2015) was calculated as 132 (± 39.5 S. D.). In addition, genetic stock identification data from Losee, et al. (2017) indicates that anadromous Coastal Cutthroat Trout regularly make marine migrations outside of natal inlets, regularly leave their natal inlet and exhibit a high degree of variability in migration distance.

2.1.6 Other Salmon Species

Pink salmon and Sockeye salmon have no identified stocks in the WRIA 14 area. The closest pink salmon stock is in the Nisqually River watershed (WDF et al., 1993) and the closest Sockeye salmon stock is in the Cedar River watershed (WDF et al., 1993). Both species have been documented infrequently in WRIA 14 streams.

2.2 Distributions by Watershed

Table 1 summarizes the extent of documented and presumed presence (including spawning) by watershed for Coho, fall Chum, summer Chum, and Chinook Salmon, Coastal Cutthroat Trout and Steelhead by WRIA 14 watershed based on the Statewide Integrated Fish Distribution (SWIFD) database. For more detailed distribution information in WRIA 14, Tables A-1 through A-4 in Appendix A present distribution by stream miles and presence type (documented presence, spawning, rearing, or presumed) for Coho, fall Chum, and summer Chum Salmon as well as winter Steelhead.

Of the salmonid species, Coastal Cutthroat Trout have the most widespread presumed distribution in WRIA 14, with 337.8 stream miles. Coho Salmon have the second most widespread documented distribution in WRIA 14, with 155.6 stream miles of combined documented and presumed habitat. Next are fall Chum Salmon (132.8 stream miles), Steelhead (109.2 stream miles), Chinook Salmon (12.1 stream miles), and summer Chum Salmon (26.5 stream miles). Coho Salmon, fall Chum Salmon, and Coastal Cutthroat Trout are present in all watersheds, while other salmonid species have been documented in only a subset of watersheds. Steelhead distribution occurs across a subset of watersheds in the WRIA. Chinook Salmon distribution is documented in a small number of watersheds in WRIA 14.

Although Pink and Sockeye Salmon spawning is documented in WRIA 14, the WDFW (2019a) SWIFD does not show any distribution in WRIA 14 watersheds. Table 2 shows the WDFW Spawner Survey reaches in which live Pink and Sockeye Salmon have been documented in each watershed. SWIFD does document Kokanee, the resident form of *O. nerka*, in short stretches of Schumacher Creek and downstream in Mason Lake.

It should be noted that a substantial portion of the SWIFD data is based on historical observations. For example, Table 1 indicates Steelhead distribution in Skookum Creek over 12.4 river miles. However, Steelhead have not been documented in Skookum Creek since 1984 (WDFW, unpublished data *in* Losee, et al., 2016). In addition, WRIA 14 is comprised on numerous small independent drainages with multiple small tributary streams. Many of these systems have limited to no data on salmonid distribution and abundance, representing a substantial data gap.

Of the total distribution, documented spawning of Coho Salmon has been reported to occur over 56 stream miles of WRIA 14, while the extent for fall Chum Salmon, summer Chum Salmon, and Steelhead spawning is 51 miles, 13 miles and 24 miles, respectively (see Tables A-1 through A-4 in Appendix A). Chinook Salmon spawning is not documented in WRIA 14.

Table 1. SWIFD Distribution by Species in Each Watershed by Stream Miles

(Grey Shading Indicates the Three Watersheds with Greatest Distribution Per Species)

Watershed	Coho Salmon	Fall Chum Salmon	Summer Chum Salmon	Winter Steelhead	Fall Chinook Salmon	Coastal Cutthroat Trout
Campbell Creek	1.8	0.9		2.6		8.1
County Line Creek	0.7	0.6				2.2
Cranberry Creek	8.0	11.1	5.5	8.5	1.0	16.7
Deer Creek	10.4	3.0	1.5	8.3	1.3	20.9
Goldsborough Creek	23.2	10.6		20.3	3.4	56.6
Hiawata Creek	0.5	0.5				0.8
Johns Creek	9.1	7.9	4.0		0.8	10.8
Kennedy Creek	3.8	3.1		3.6	0.7	36.6
Lynch Creek	2.9	2.1		2.0		2.5
Malaney Creek	2.6	2.6		2.6		5.2
Mill/Gosnell Creeks	26.2	17.9		23.5	4.1	46.4
Perry Creek	1.6	1.5		1.2		5.0
Schneider Creek	4.6	4.2		5.2		8.2
Shelton Creek	2.7	3.4		1.7		3.9
Sherwood/Schumacher Creeks	24.3	32.2	15.6	16.8	0.8	35.8
Skookum Creek	17.3	17.2		11.9		31.3
Snodgrass Creek	0.6	0.6				2.7
Uncle Johns Creek	1.9	1.0		0.5		2.6
All other watersheds	13.6	12.5		0.5		41.5
Total	**155.6**	**132.8**	**26.5**	**109.2**	**12.1**	**337.8**

Source: WDFW (2019a) SWIFD

Note: Stream miles shown include areas with presence documented, spawning, and presumed. For Chinook Salmon, there are no spawning or presumed areas. For Coastal Cutthroat Trout, there are no documented presence or spawning areas.

Table 2. WDFW Spawner Survey Database Distribution of Pink Salmon and Sockeye Salmon in Each Watershed by Stream Miles

Watershed	Pink Salmon	Sockeye Salmon
Cranberry Creek	0.0 – 3.5	0.0 – 2.6
Deer Creek	0.0 – 1.3	0.0 – 1.3
Goldsborough Creek Coffee Creek tributary	0.5 – 2.2 0.0 – 0.3	0.5 – 2.2 -
Johns Creek	0.0 – 1.8	-
Sherwood/Schumacher Creeks	0.0 – 1.1	0.0 – 1.0[a]

Note: a) Kokanee have also been documented in Sherwood/Schumacher watershed in Mason Lake and stream reaches upstream of the lake.

2.3 Relative Abundance of Salmon Spawning Among Watersheds

The WDFW spawning ground database was analyzed to characterize the number of returning adult salmonids to each watershed in WRIA 14 (WDFW, 2019b). The primary purpose of the analysis was to estimate the relative numbers of returning salmonids to each watershed to understand which watersheds support more returning adult salmonids than others. The database includes survey entries approximately every 1 to 2 weeks during the spawning season of the target species. The analysis focused on counts of live fish between 2000 and 2017. It should be noted that this analysis timeframe corresponds with some of the lowest marine survival recorded among Coho Salmon smolts in the Salish Sea (Zimmerman et al., 2015). Data from all survey types documented in the WDFW database were included in the analysis (e.g., index, supplemental, and partial).

The fall Chum and Coho Salmon population analysis described below used "annual peak" counts as an indicator of run size. The “annual peak” is the highest single day count of live fish in the WDFW database during the entire spawning season of that year. This is not an estimate of total run size. Annual peak was used instead of using other metrics, such as total run size, because it avoids the likelihood of double counting live fish observed during multiple surveys and avoids interpretations of how complete the survey reaches are compared to all spawning in watersheds. For all other species and runs reported, the total number of live fish documented each year by WDFW is reported because the numbers are so low.

2.3.1 Chum Salmon

WDFW surveys adult Chum Salmon in 18 watersheds in WRIA 14. Chum Salmon are the most numerous salmon species in WRIA 14. This is due to a large run of fall Chum Salmon. Low numbers of summer Chum Salmon returns to a subset of watersheds in WRIA 14.

2.3.1.1 Fall Chum Salmon

The average of the annual peak counts of fall Chum Salmon between 2000 and 2017 in the 18 watersheds are provided in Figure 1. Kennedy Creek has the highest average annual peak count of fall Chum Salmon (12,892) which far exceeds the two next highest which are Skookum (7,544) and Perry (7,421). Six additional watersheds have an average annual peak of greater than 1,000: Cranberry, Johns, Mill/Gosnell, Sherwood, Lynch, and Schneider.

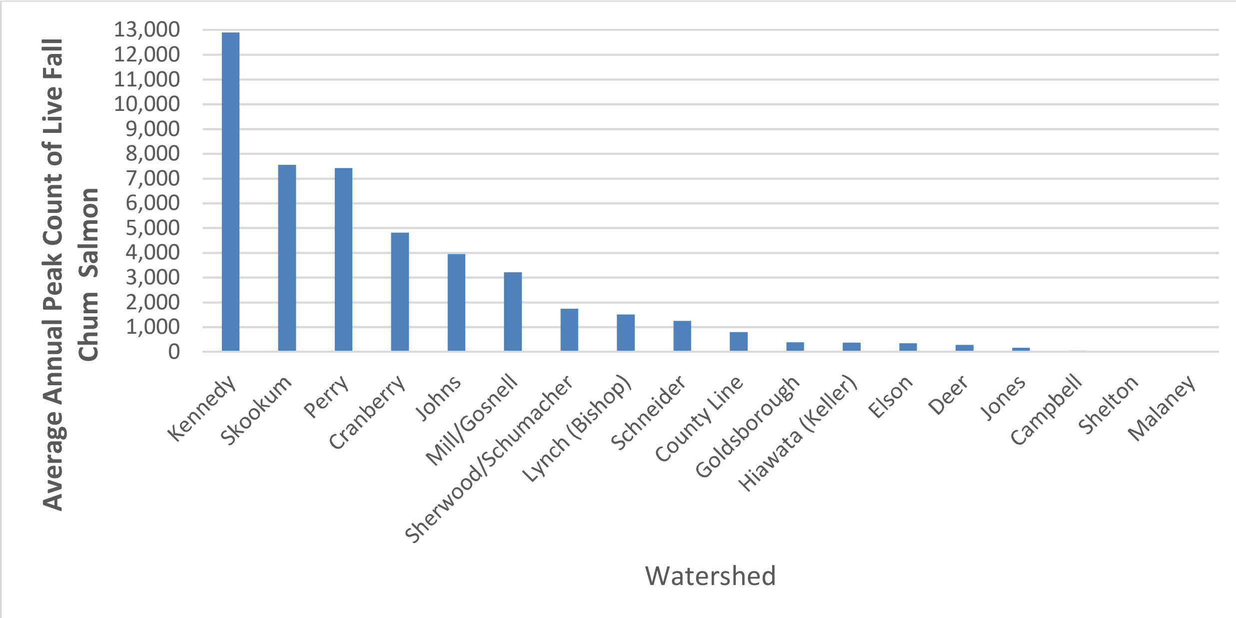


Figure 1. Average Annual Peak Counts of Live Fall Chum Salmon by Watershed, 2000-2017

Figure 2 shows the annual peak counts of live fall Chum Salmon by watershed between 2000 and 2017. In all years except 2001, the average annual peak in the top three watersheds (Kennedy, Skookum, and Perry) accounted for more than 50% of the total annual peak documented in all 18 watersheds. Between 2000 and 2007, the average of the annual peaks across all watersheds was generally higher and more variable compared to 2008 through 2017 where fairly consistent annual peaks have been documented.

Another analysis was conducted to look at trends in individual watersheds between 2000 and 2017. In each watershed, the highest annual peak of fall Chum Salmon between 2000 and 2017 was determined and compared to the annual peaks of all other years. Skookum Creek annual peaks stand out as an exception compared to other watersheds (Figure 3). Skookum Creek annual peaks of fall Chum Salmon have remained high through the time period ranging between 61% and 100% in all but one year. In contrast, the other eight watersheds had maximum numbers between 2000 and 2007, but since them have infrequently had annual peaks more than 50% of the maximum annual peak. The only exceptions were in Johns and Perry Creeks where annual peaks in no years were higher than 61% of the maximum. In the nine watersheds with lower annual peaks of fall Chum Salmon, the proportions were highly variable and no trends were apparent over time.

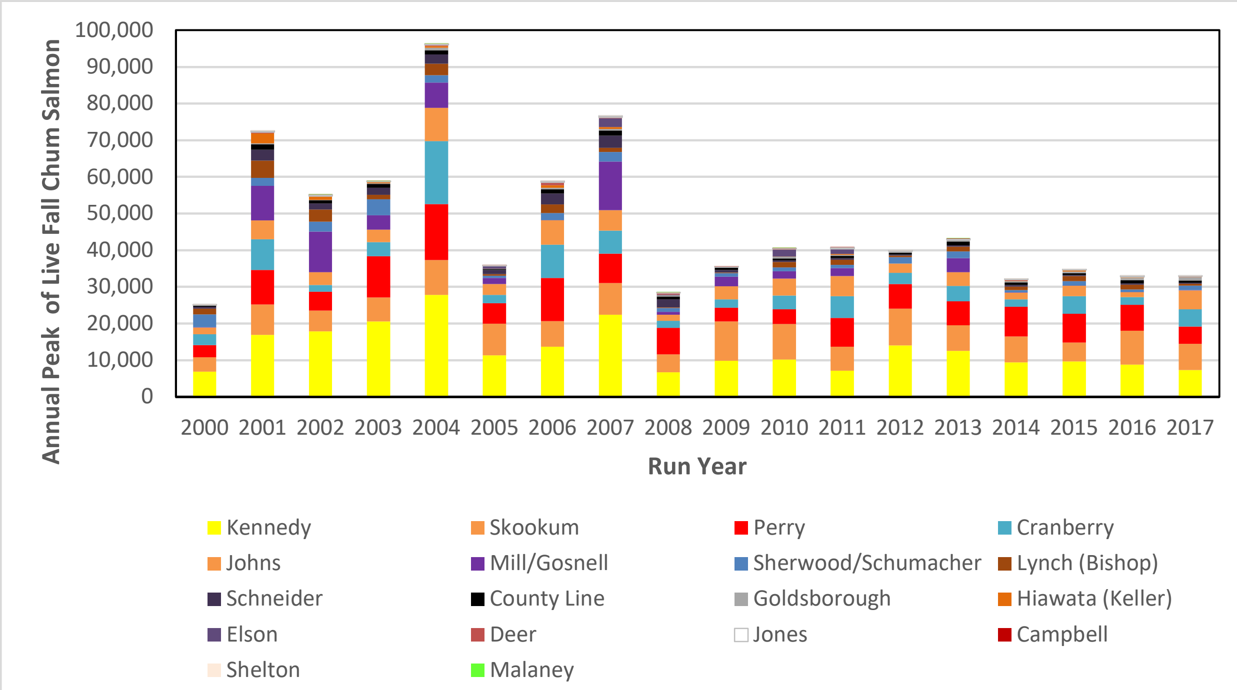


Figure 2. Annual Peak Counts of Live Fall Chum Salmon by Watershed, 2000-2017

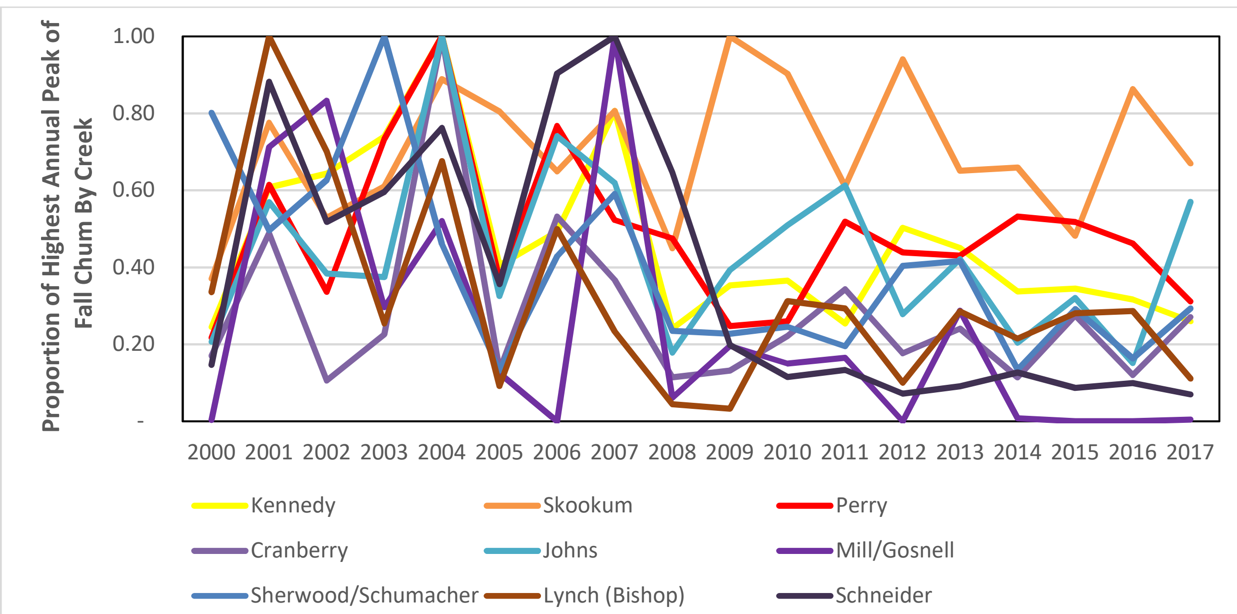


Figure 3. Proportion of Highest Annual Peak Live Fall Chum, 2000-2017

2.3.1.2 Summer Chum Salmon

Summer Chum Salmon were identified as those Chum Salmon on the spawning grounds before October 1. Summer Chum Salmon adults returned regularly to five watersheds in WRIA 14 (Figure 4). Johns Creek has the highest average annual peak of summer Chum Salmon (275). The other four watersheds in descending order are Cranberry (59), Deer (30), Sherwood/Schumacher (21), and Goldsborough (6).

Summer Chum Salmon annual peaks were highest in the early and mid-2000s (Figure 5). Since 2007, summer Chum Salmon annual peaks have been much lower with almost all being documented in Johns Creek. From 2014 to 2016, the annual peak across all watersheds was 50 or fewer. In 2016 the annual peak was three in Johns Creek and two in Goldsborough Creek. The numbers rebounded slightly in 2017 such that the annual peak across all five watersheds was 145 summer Chum Salmon.

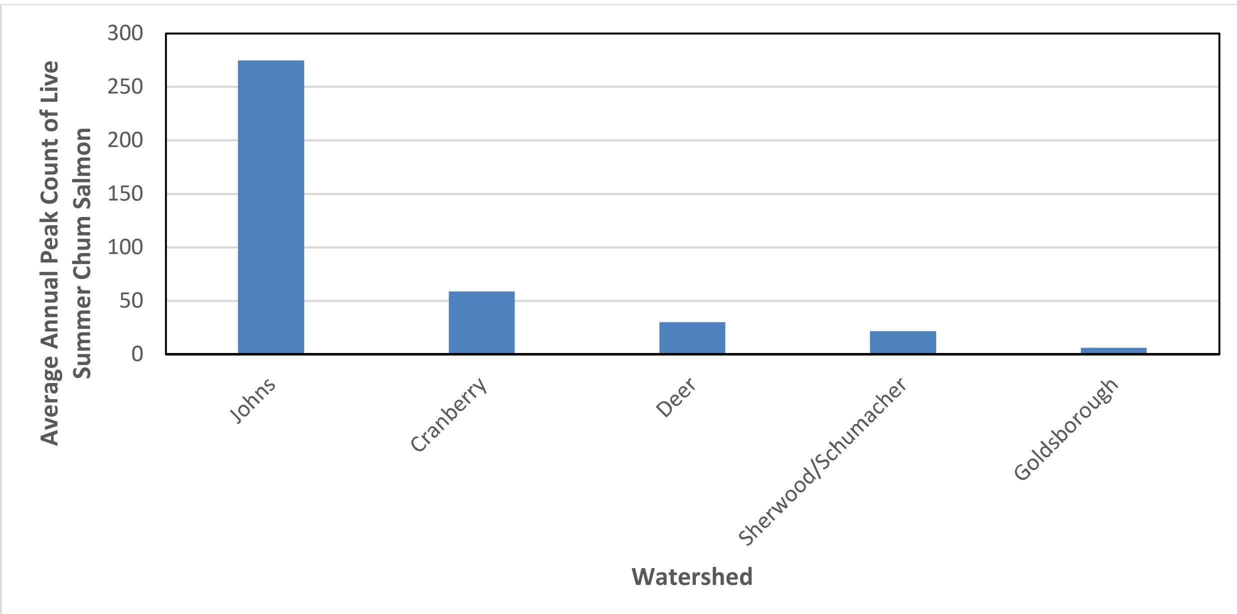


Figure 4. Annual Peak Counts of Live Summer Chum Salmon by Watershed, 2000-2017

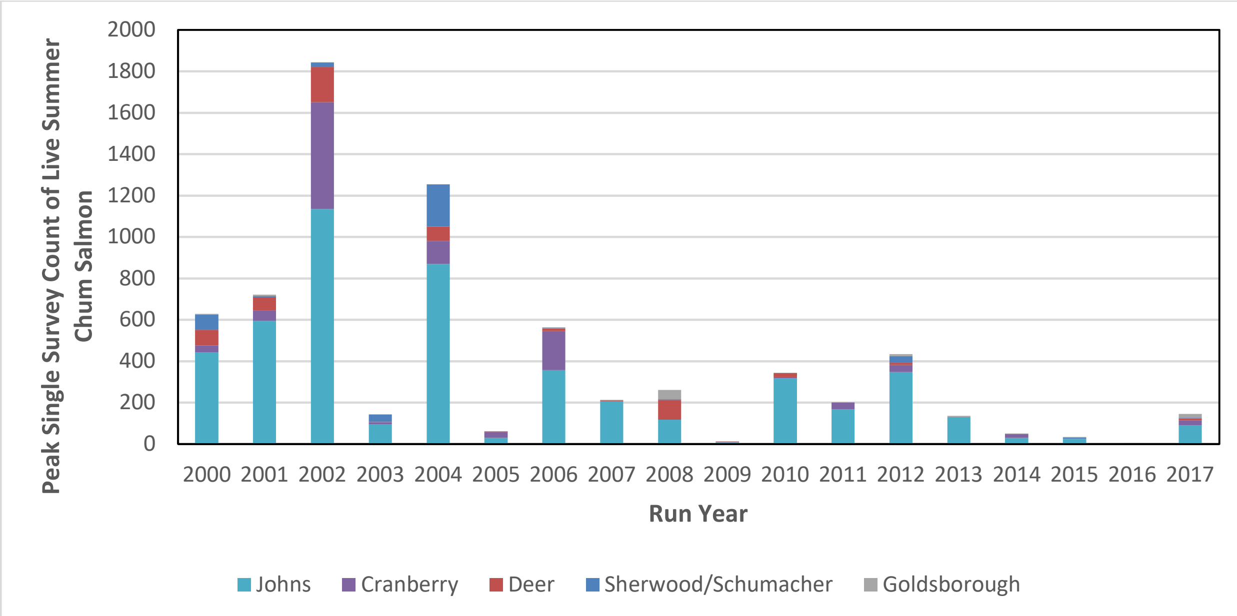


Figure 5. Annual Peak Counts of Live Summer Chum Salmon by Watershed, 2000-2017

2.3.2 Coho Salmon

Based on WDFW spawning ground database of adult Coho Salmon live counts, ten creeks in WRIA 14 have one or more Coho Salmon returning almost every year since 2000. The average of the annual peak counts between 2000 and 2017 in the 10 watersheds are provided in Figure 6. Other watersheds in WRIA 14 with documented Coho Salmon in the WDFW database include Hiawata (Keller), Jones, Lynch, Campbell, and Shelton Creek, but the numbers are very low and Coho Salmon are infrequently observed.

Figure 7 shows the annual peak counts of live Coho Salmon by watershed between 2000 and 2017. In most years, Goldsborough Creek has by far the highest annual peak of live Coho. The annual peak of live Coho Salmon documented in Goldsborough Creek surveys has been highly variable since 2000 with a low of one Coho Salmon in 2005 and a maximum of 367 Coho Salmon in 2016.

Annual peak count data in the other nine creeks is presented in Figure 8. Other than Goldsborough Creek, the annual peak of live Coho Salmon in all other watersheds did not exceed 100 except once (147 in Sherwood/Schumacher in 2000). Among the other watersheds, Kennedy and Sherwood/Schumacher have consistently had among the highest annual peak numbers of live Coho, especially since 2008. Between 2000 and 2010, any trends annual peak counts of live Coho Salmon varied considerably among watersheds. Since approximately 2011, there has been a clearer pattern of "good years" and "bad years." That is, in any given year, the annual peak of live Coho Salmon is high in many watersheds or low in many watersheds. The years 2012 and 2016 stand out as good years. The years 2014, 2015, and 2017 were generally bad years with low annual peaks of live Coho Salmon in most watersheds.

Another analysis was conducted to look at trends in individual watersheds between 2000 and 2017. In each watershed, the highest annual peak of Coho Salmon between 2000 and 2017 was determined and compared to the annual peaks of all other years. In Goldsborough, Kennedy, and Skookum creeks, the highest annual peak between 2000 and 2017 occurred in 2016. This is shown in Figure 9 which displays the proportion of the maximum annual peak count in each watershed by year. In 2012, the highest annual peak of live Coho Salmon was documented in Mill/Gosnell and Perry Creeks. Conversely, in 2014 and 2015, no watershed has annual peak returns higher than 25% of the highest observed since 2000 and most creeks had fewer than 10%.

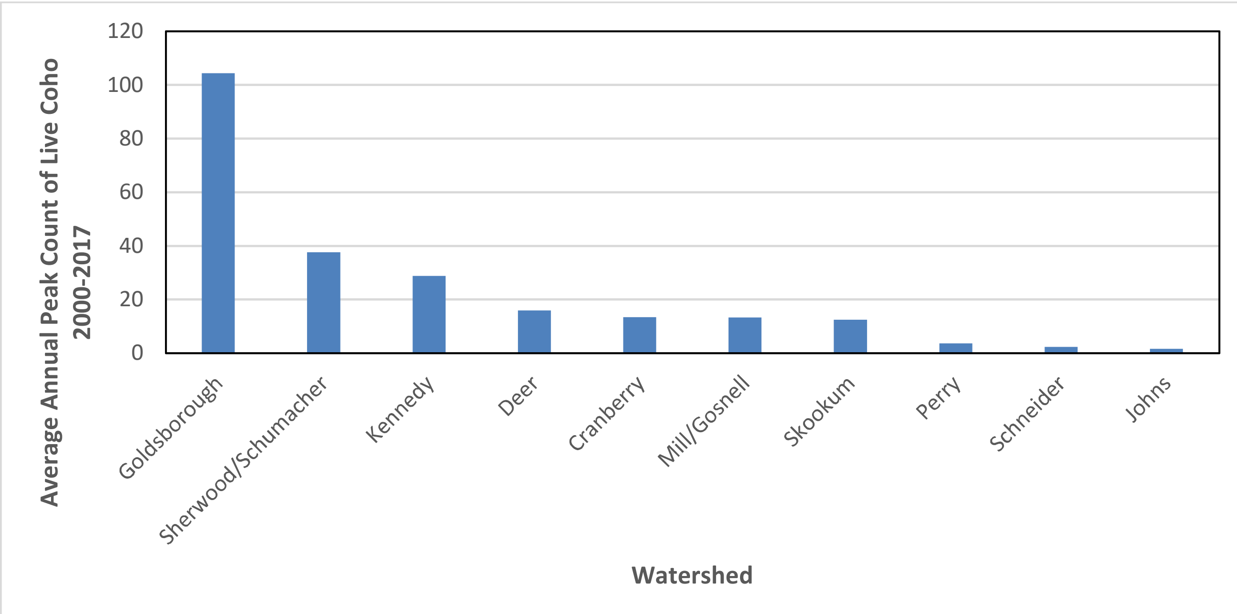


Figure 6. Average Annual Peak Counts of Live Coho Salmon by Watershed, 2000-2017

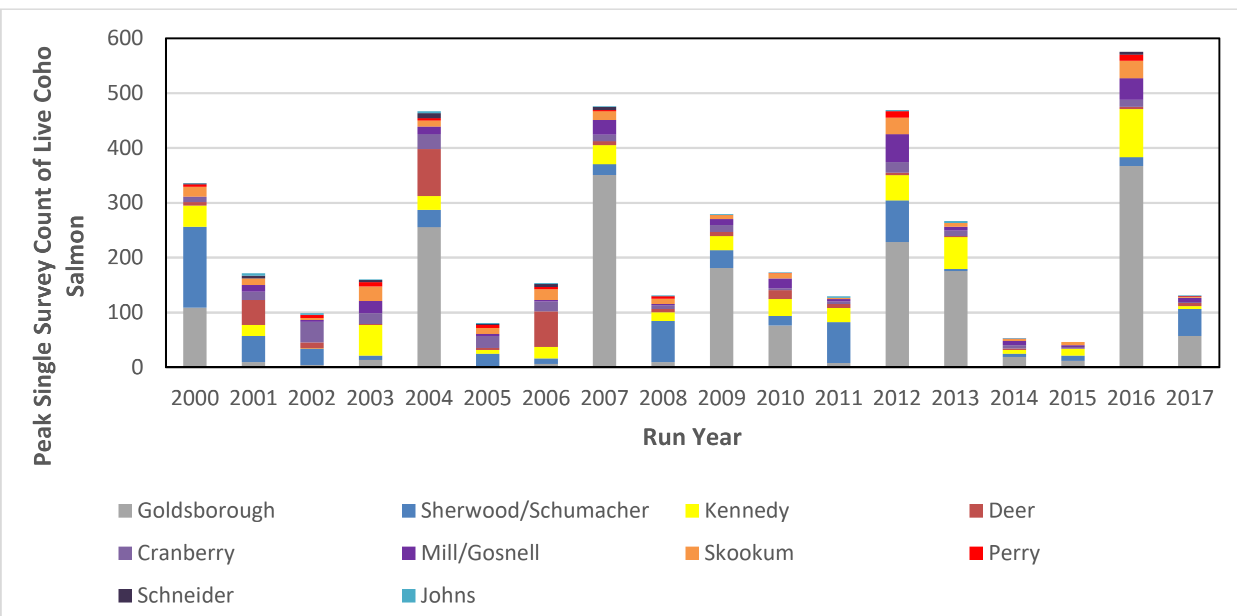
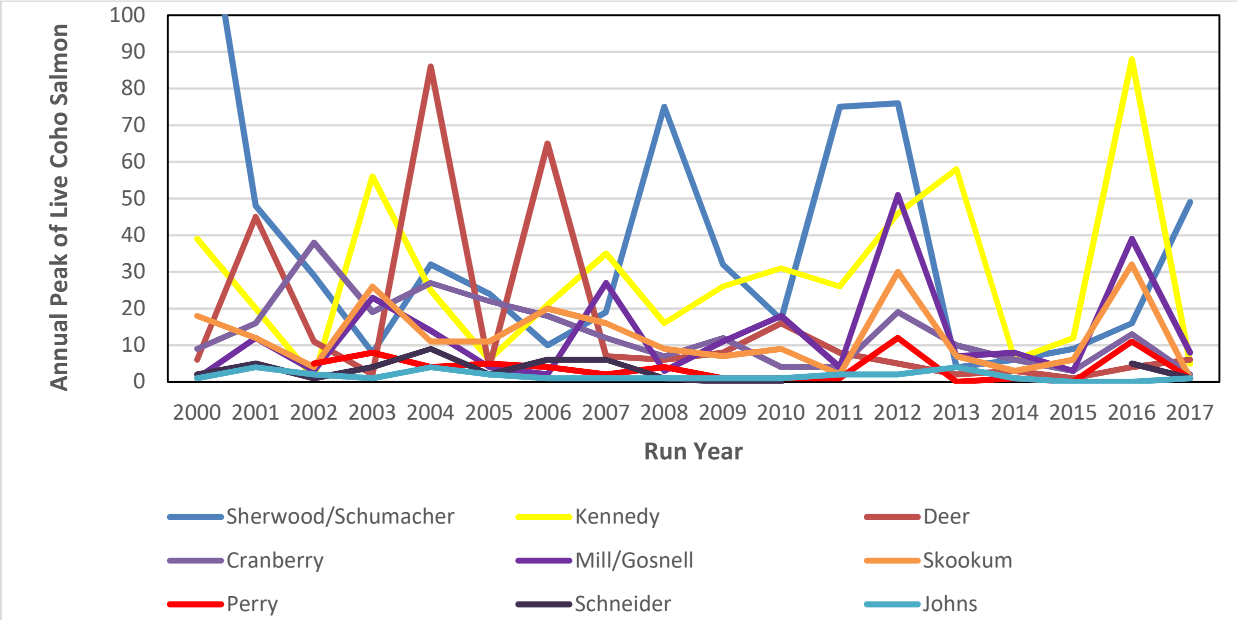


Figure 7. Annual Peak Counts of Live Coho Salmon by Watershed, 2000-2017



Note: Annual peak in Sherwood/Schumacher Creeks in 2000 was 147 live Coho Salmon.

Figure 8. Annual Peak Live Coho Salmon by Watershed excluding Goldsborough, 2000-2017

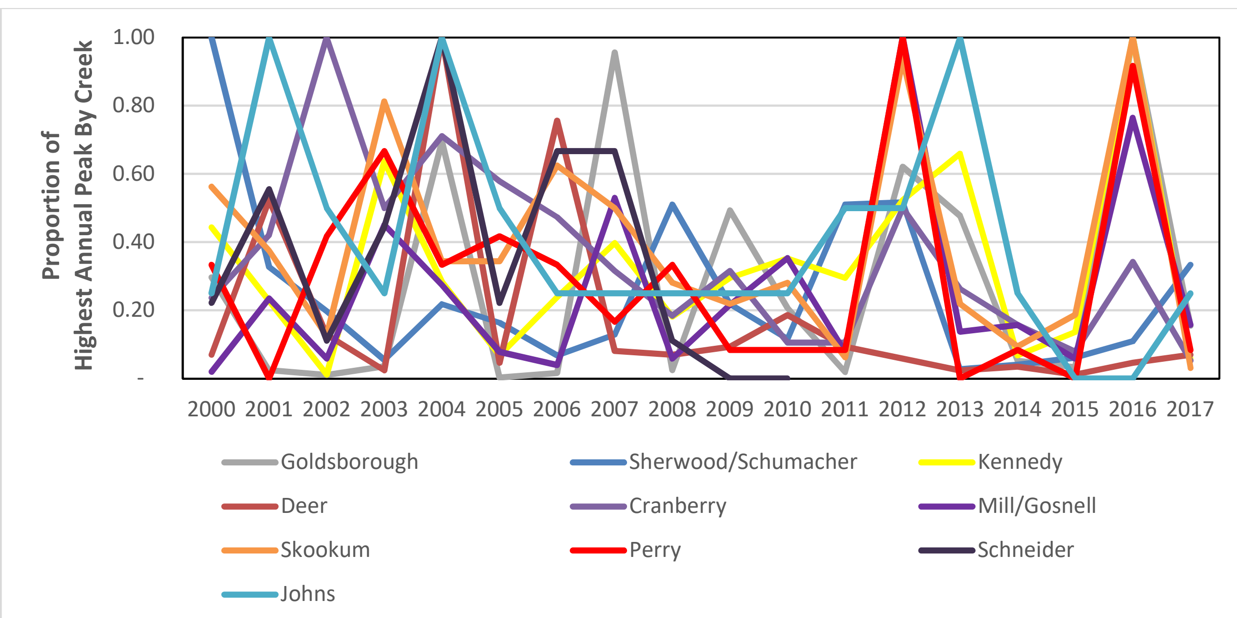


Figure 9. Proportion of Highest Annual Peak Live Coho, 2000-2017

Steelhead

Due to low numbers of Steelhead in the WDFW spawning ground database, all analysis provided below is based on the total live counts documented – as opposed to the annual peak counts reported for Chum and Coho Salmon. Between 2000 and 2017, live Steelhead were documented in five WRIA 14 watersheds: Sherwood/Schumacher, Deer, Cranberry, Kennedy, and Skookum. Over this period, entries in the WDFW were intermittent, but only 12 Steelhead total have been documented (Figure 10).

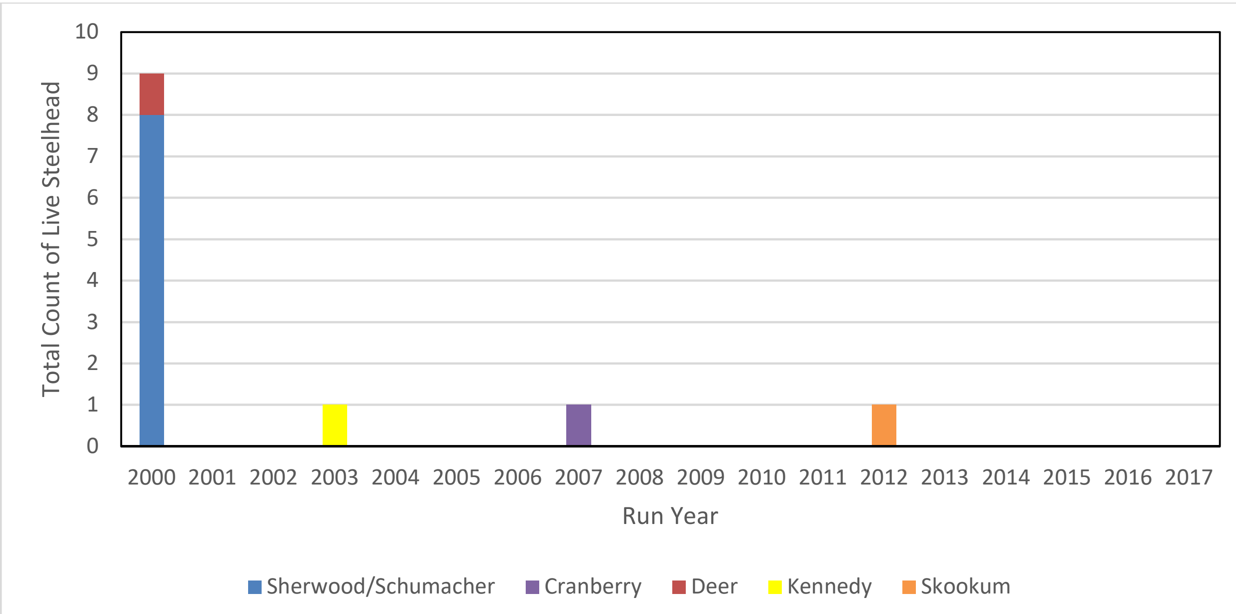


Figure 10. Sum of Live Steelhead Counts by Watershed and by Year, 2000-2017

2.3.3 Chinook Salmon

Due to low numbers of Chinook Salmon in the WDFW spawning ground database, all analysis provided below is based on the total live counts documented – as opposed to the annual peak counts reported for fall Chum and Coho Salmon. Between 2000 and 2017, live Chinook Salmon were documented in six WRIA 14 watersheds: Sherwood/Schumacher, Deer, Goldsborough, Cranberry, Johns, and Skookum. Over this period, 683 Chinook Salmon were documented in Sherwood/Schumacher which nearly doubles the total observed in all other watersheds combined (Figure 11).

Figure 12 shows the total counts of live Chinook Salmon by watershed between 2000 and 2017. The Sherwood/Schumacher contribution to the total Chinook Salmon numbers in 0% and 100% in any given year with the creek accounting for an average of 59% of the total Chinook Salmon observed in WRIA 14. Annual total counts were highest between 2000 and 2005, then decreased through 2015. Most recently in 2016 and 2017, the total number of Chinook Salmon was equal to the lowest numbers observed between 2000 and 2005.

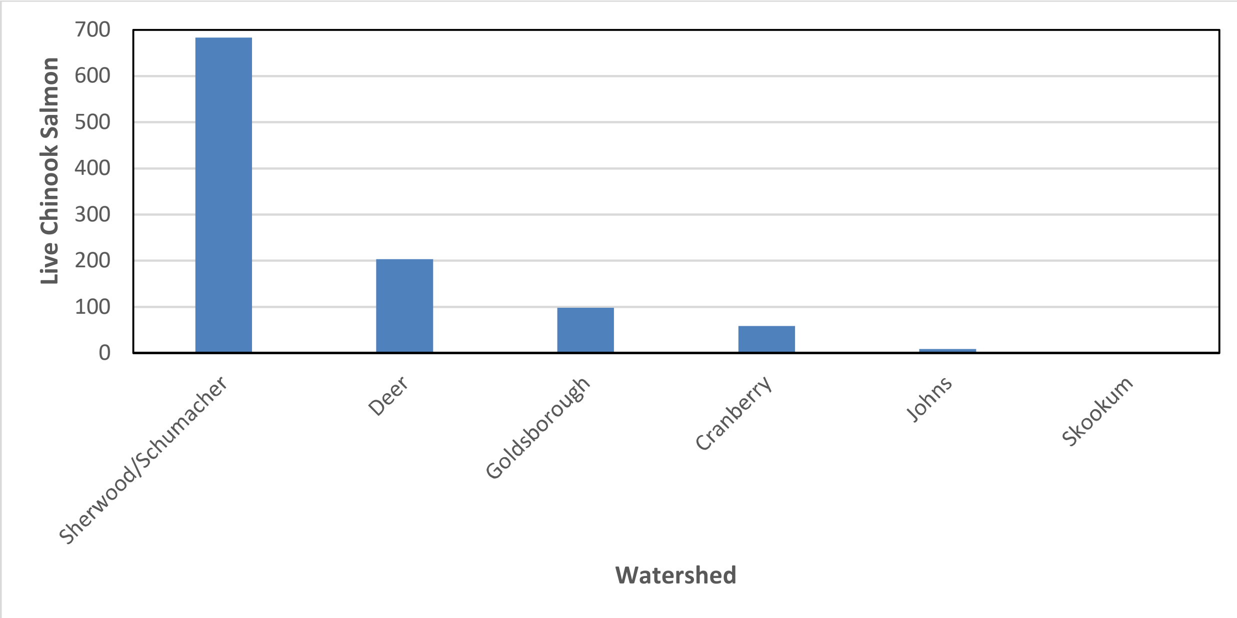


Figure 11. Sum of Live Chinook Counts by Watershed between 2000 and 2017

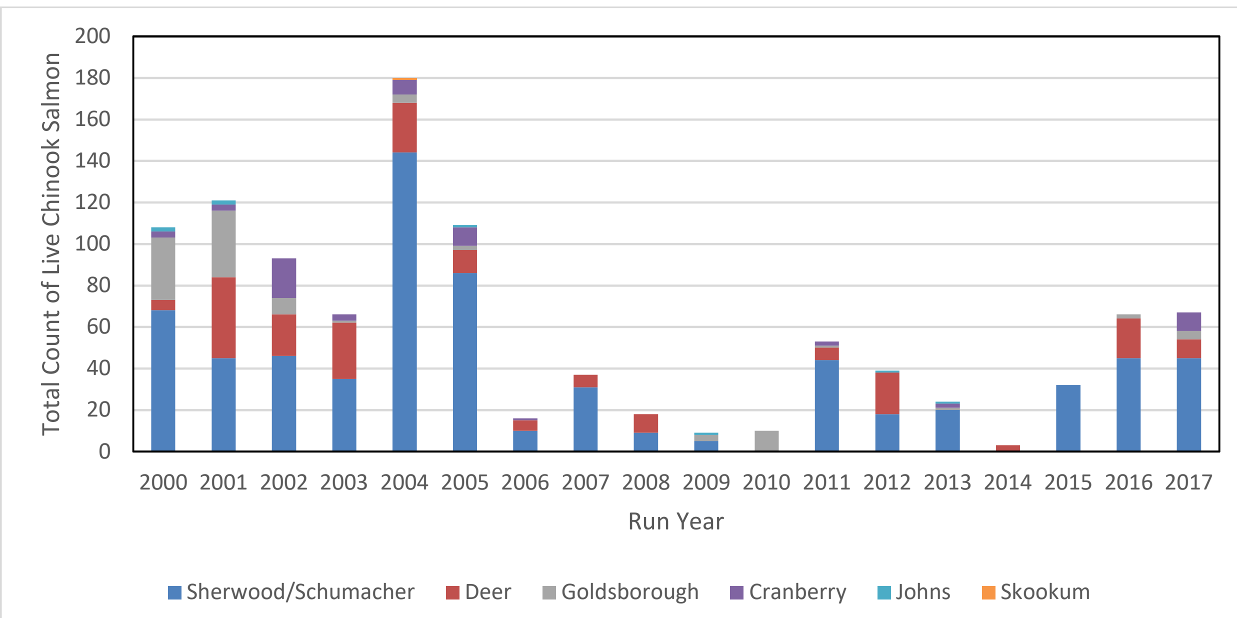


Figure 12. Sum of Live Chinook Salmon Counts by Watershed and by Year, 2000-2017

2.3.4 Coastal Cutthroat Trout

Due to low numbers of Coastal Cutthroat Trout in the WDFW spawning ground database, all analysis provided below is based on the total live counts documented – as opposed to the peak counts reported for Chum and Coho Salmon. Cutthroat trout distributions are widespread in WRIA 14, but only limited observations have been recorded in spawner surveys. Between 2000 and 2017, live Coastal Cutthroat

Trout were documented in 12 WRIA 14 watersheds. In order from highest to lowest total count, the watersheds are: Skookum, Johns, Kennedy, Deer, Sherwood/Schumacher, Cranberry, Perry, Goldsborough, Schneider, Lynch (Bishop), Shelton, and Mill/Gosnell (Figure 13). Given the incompleteness of the dataset, it is not advisable to use these data as indicative of which watersheds have more Cutthroat than others. The counts by year are presented in Figure 14.

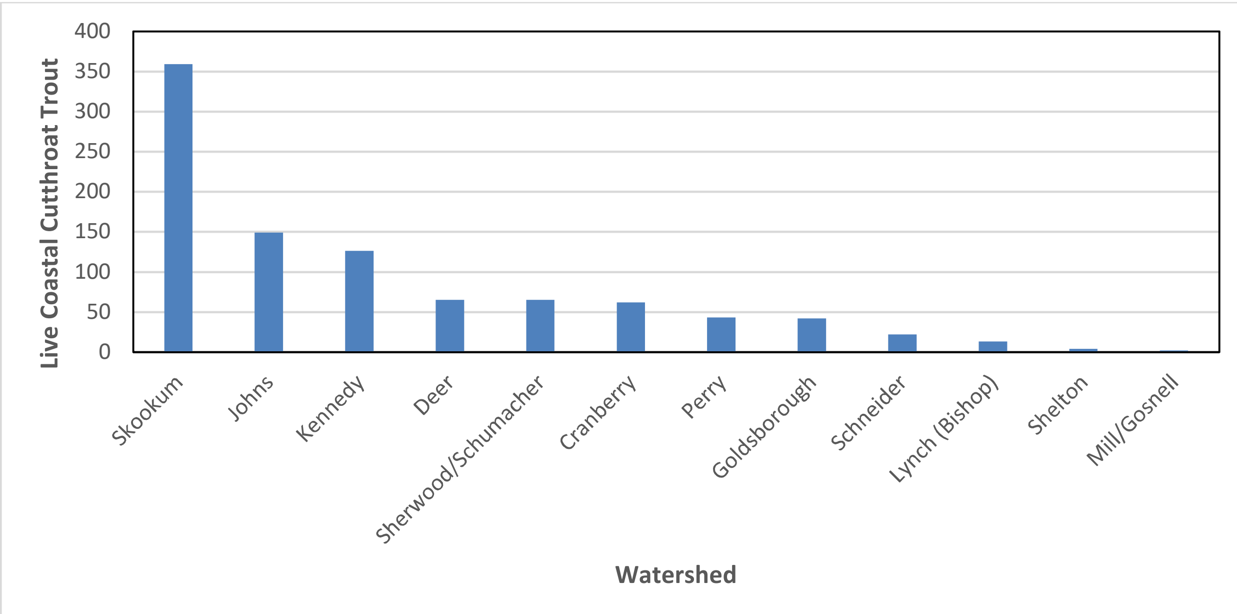


Figure 13. Sum of Live Coastal Cutthroat Trout Counts by Watershed between 2000 and 2017

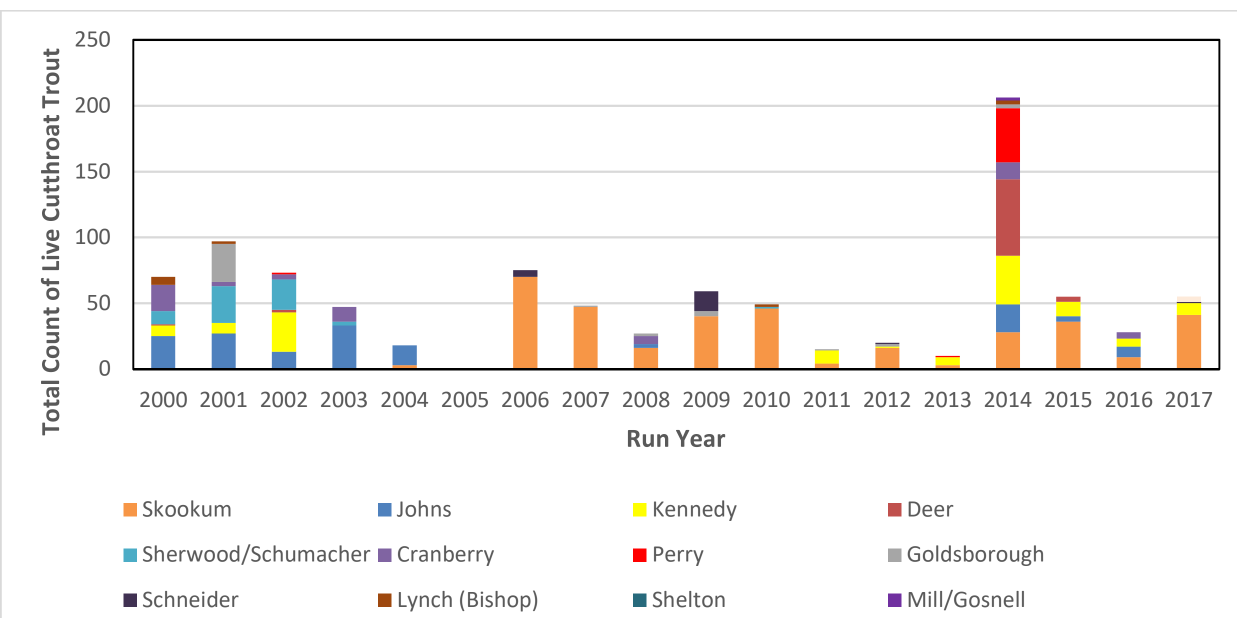


Figure 14. Sum of Live Cutthroat Trout Counts by Watershed and by Year, 2000-2017

2.3.5 Pink Salmon

Due to low numbers of Pink Salmon in the WDFW spawning ground database, all analysis provided below is based on the total live counts documented – as opposed to the annual peak counts reported for Chum and Coho Salmon. Pink Salmon have been recorded in odd years in WRIA 14 since 1969. Observations are intermittent in the database, but there is a higher number of Pink Salmon documented in recent years (Figure 15). The counts have been highest in Sherwood/Schumacher and Goldsborough Creek between 2000 and 2017 (Figure 16). Pink Salmon counts by watershed and year are displayed in Figure 17.

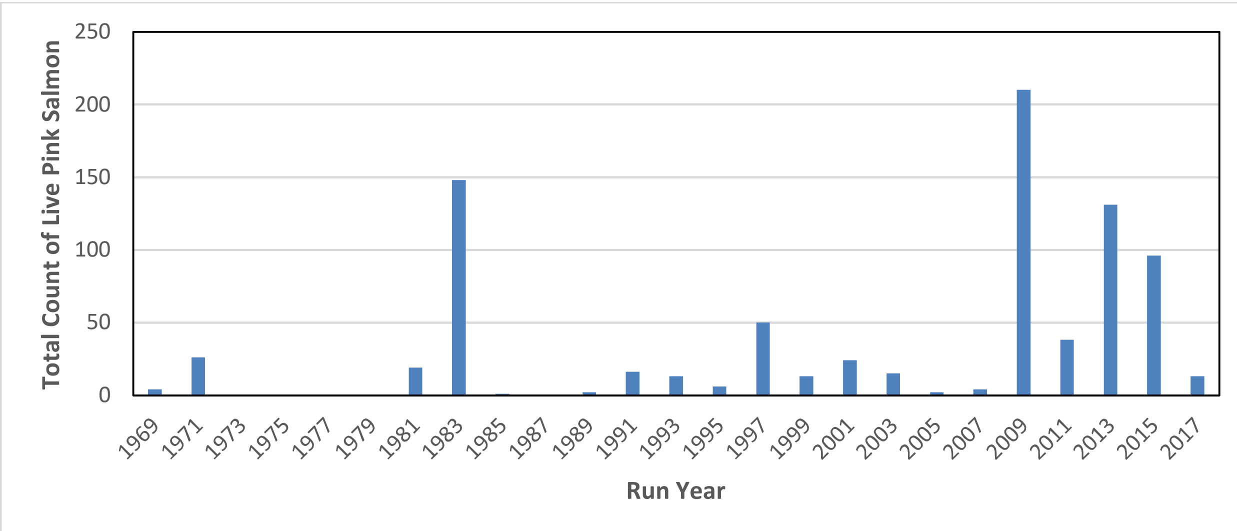


Figure 15. Sum of Live Pink Salmon by Year Since 1969

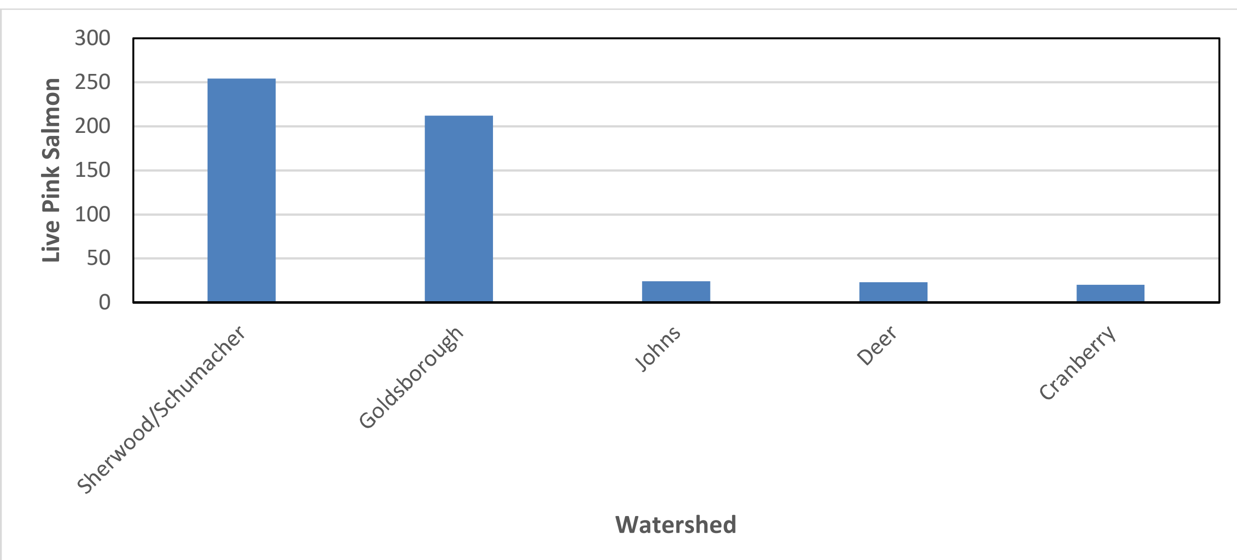


Figure 16. Sum of Live Pink Salmon Counts by Watershed between 2000 and 2017

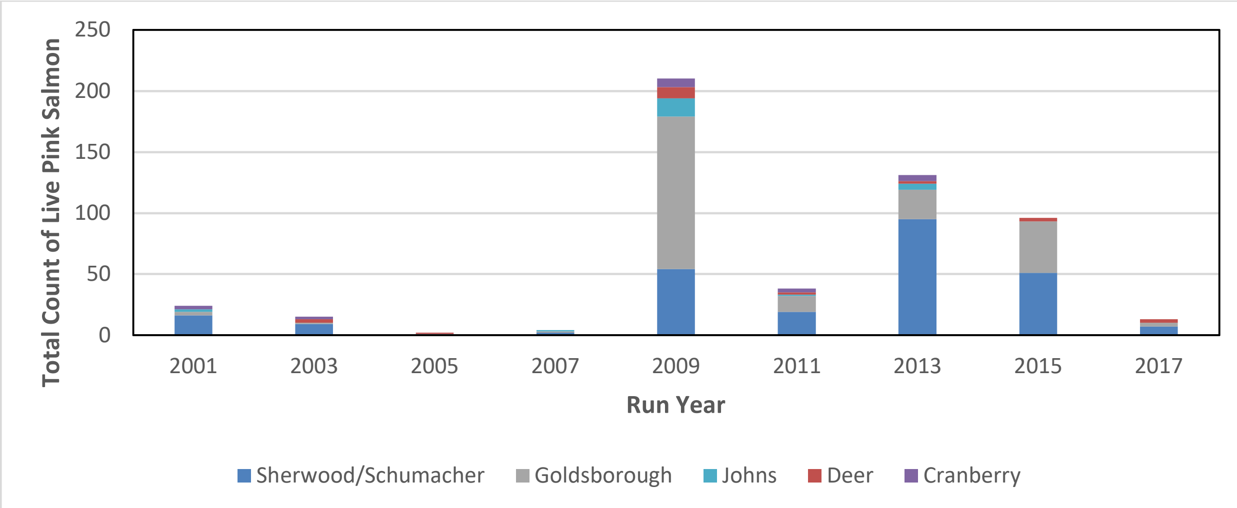


Figure 17. Sum of Live Pink Salmon Counts by Watershed and by Year, 2000-2017

2.3.6 Sockeye Salmon

Due to low numbers of Sockeye Salmon in the WDFW spawning ground database, all analysis provided below is based on the total live counts documented – as opposed to the peak counts reported for Chum and Coho Salmon. Between 2000 and 2017, live Sockeye Salmon were documented in 4 WRIA 14 watersheds: Sherwood/Schumacher, Deer, Cranberry, and Goldsborough. Over this period, entries in the WDFW were intermittent, but only 20 Sockeye total have been documented (Figure 18).

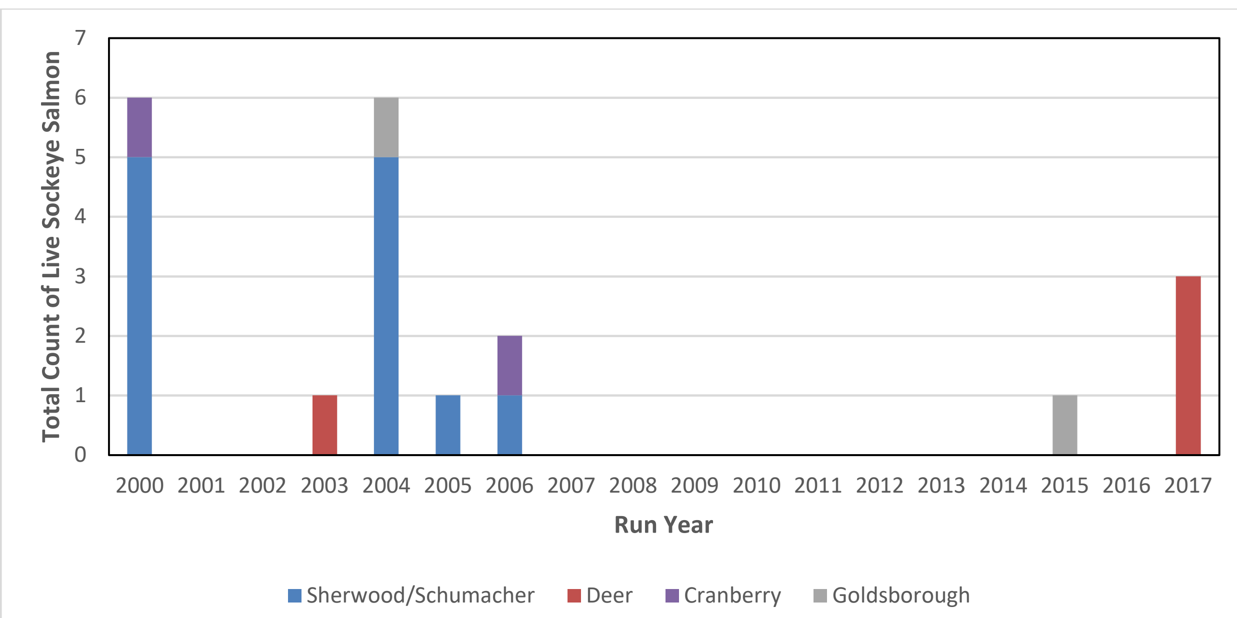


Figure 18. Sum of Live Sockeye Counts by Watershed and by Year, 2000-2017

2.4 Coho Salmon Smolt Production

The Squaxin Island Tribe has monitored Coho Salmon production in recent years in a combined effort with WDFW. The Squaxin Island Tribe has been monitoring the outmigration of Coho Salmon smolts in the Sherwood, Mill/Gosnell, Cranberry, Johns, Skookum, and Goldsborough Creek systems (Squaxin Island Tribe, 2017).

Figure 19 shows the Coho Salmon smolt production numbers by creek system (Squaxin Island Tribe, 2017). Since the Goldsborough Creek numbers are substantially higher, they are shown on a separate axis than other creek results. Goldsborough Creek has had a generally upward trend in the number of Coho Salmon smolts produced each year. Coho Salmon smolt production in all other creek systems shows no such trend. In Cranberry and Skookum creeks, Coho Salmon smolt reduction was higher in the early 2000s but has dropped off considerably since around 2010. Coho Salmon smolt production in Mill and Gosnell has been strong in recent years with peak numbers in Mill Creek in 2014 and 2017.

In an evaluation of Coho Salmon populations in Mill, Sherwood, and Cranberry creeks, Stillwater (2007) found a strong correlation between average monthly stream flows when adult Coho Salmon are migrating upstream and the number of Coho Salmon smolts outmigrating two years later. Higher flows during the adult Coho Salmon migration correspond with higher Coho Salmon smolt numbers two years later. The smolts leaving two years later are predominately age 1+ and therefore are the offspring of the adults migrating two years earlier. Stillwater (2007) investigated whether the above relationship may be the result of flow-dependent restrictions to adult upstream passage and concluded that it appears likely in some watersheds, but not in others.

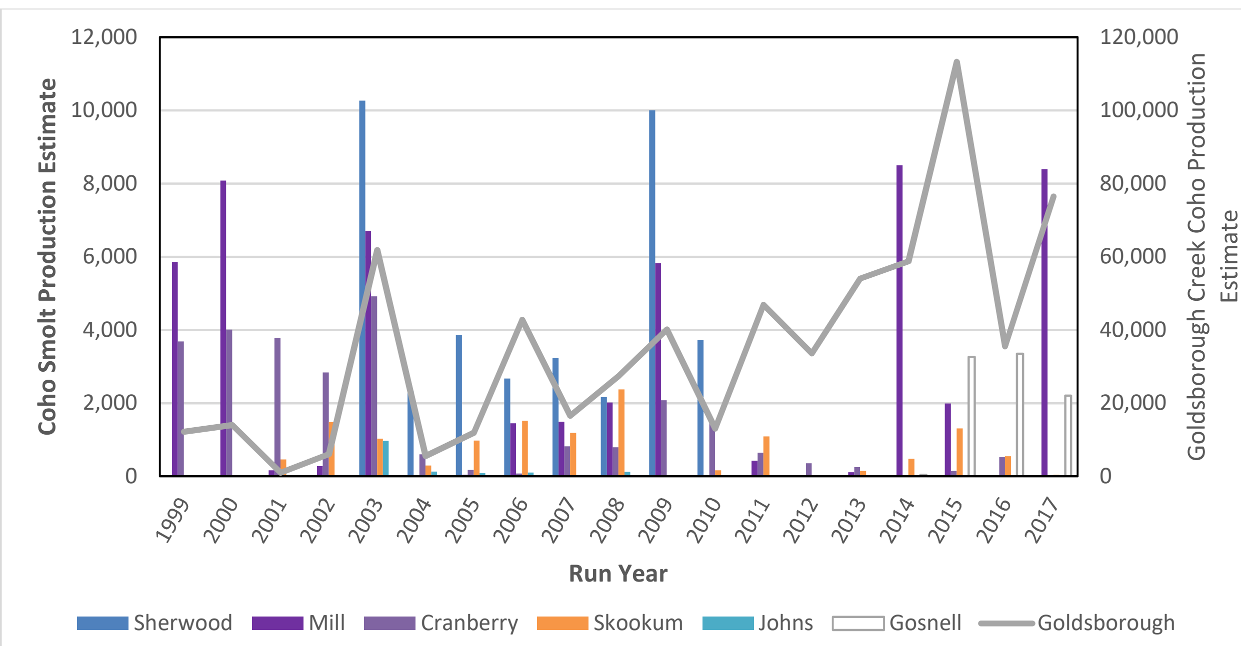


Figure 19. Coho Salmon Smolt Production Estimate, 1999 to 2017

2.5 Key Ecological Attributes in Freshwater by Species and Life Stage

The freshwater habitat strategy update work to be completed in Phase 2 will ultimately determine priorities for salmonid restoration and protection within the watersheds that comprise WRIA 14. To identify priorities for restoration and protection, it is necessary to conduct an analysis of existing and potential future habitat conditions (see Sections 3 and 4) to determine habitat limiting factors and the stressors that cause or contribute to these factors. To inform that analysis, the habitat parameters were linked to the needs of each species and life stage. This allows the formulation of a restoration strategy that is inherently linked to salmon biology and to the biological, chemical, and structural requirements of the species addressed. Therefore, it is useful to explicitly relate key habitat elements to the life history components of salmonids. Table 3 analyzes the relative importance of four primary habitat elements referred to as Key Ecological Attributes (KEAs), to all stages of the freshwater life history of Chum Salmon (summer and fall run), Steelhead (winter run), Coho Salmon, Chinook Salmon (fall run), and Coastal Cutthroat Trout (sea run and resident).

KEAs are used to evaluate the condition of freshwater habitat in WRIA 14. KEAs are an aspect of an ecosystem component or habitat types that, if present, defines the health of that habitat and, if missing or altered, would lead to the outright loss or extreme degradation of that habitat over time. There are regionally adopted definitions for habitat types and KEAs that were developed for Chinook Salmon recovery by the Puget Sound Regional Implementation Technical Team (RITT 2015) for Chinook Salmon planning at the regional and local levels. Because these RITT definitions are specific to one species, they were combined and modified to work for a multi-species, freshwater approach.

The four KEAs selected for their effect on salmonid life history analysis are identical to the KEAs used to compare existing habitat conditions (Section 3). The selected KEAs include: (1) Stream Temperature, (2) Sediment Size, Distribution, and Embeddedness (3) Stream Complexity, and (4) Aquatic Habitat Connectivity. The rationale for KEA selection, as well as the various components of each of the following four KEAs is documented in Section 3.2.

Table 3 can be used to assess the relevant importance of a KEA for a specific species and life history stage. For example, stream entry and upstream migration of adult summer Chum Salmon is very sensitive to stream temperature and therefore considered having high importance, based on the river entry timing of this stock when elevated summer stream temperatures may be present (August or September). Conversely, winter Steelhead adults enter freshwater much later (December to March) when stream temperatures in WRIA 14 are naturally cool, indicating that the Stream Temperature KEA is of low importance. Likewise, rearing Coho Salmon juveniles are extremely dependent on complex habitat, including off-channel and side channel habitats for the 1+ years they spend in freshwater, indicating the Aquatic Habitat Complexity KEA for rearing Coho Salmon is of high importance, while for Chum Salmon (both summer and fall run) the same KEA has low importance, as juvenile Chum Salmon spend little time rearing in freshwater as they outmigrate soon after gravel emergence.

Table 3. Relative Influence of Key Ecological Attributes on the Life History Stages of Salmonids Present in WRIA 14

Key Ecological Attributes	Chum Salmon (Summer Run)				
	River entry/ migration	Spawning	Egg incubation	Rearing	Smolt out-migration
Stream Temperature	+++	++	++	+	+
Sediment Size Distribution and Embeddedness		+++	+++	+	
Habitat Complexity	++	++		+	+
Habitat Connectivity	+++	+++		++	+++

Key Ecological Attributes	Chum Salmon (Fall Run)				
	River entry/ migration	Spawning	Egg incubation	Rearing	Smolt out-migration
Stream Temperature	++	+	++	+	+
Sediment Size Distribution and Embeddedness		+++	+++	+	
Habitat Complexity	++	++		+	+
Habitat Connectivity	+++	+++		++	+++

Key Ecological Attributes	Steelhead (Winter Run)					
	River entry/ migration	Spawning	Egg incubation	Rearing	Smolt out-migration	Kelt out-migration
Stream Temperature	+	++	++	+++	+	++
Sediment Size Distribution and Embeddedness		+++	+++	++		
Habitat Complexity	++	++	+	+++	+	++
Habitat Connectivity	+++	+++		+++	+++	+++

Key Ecological Attributes	Coho Salmon				
	River entry/ migration	Spawning	Egg incubation	Rearing	Smolt out-migration
Stream Temperature	++	+	++	+++	+
Sediment Size Distribution and Embeddedness		+++	+++	++	
Habitat Complexity	++	++		+++	+
Habitat Connectivity	+++	+++		+++	+++

Key Ecological Attributes	Chinook Salmon (Fall Run)				
	River entry/ migration	Spawning	Egg incubation	Rearing	Smolt out-migration
Stream Temperature	+++	++	++	+	+
Sediment Size Distribution and Embeddedness		+++	+++	++	
Habitat Complexity	++	++		+++	+
Habitat Connectivity	+++	+++		+++	+++

Key Ecological Attributes	Cutthroat Trout (Sea Run and Resident)					
	River entry/ migration (Sea Run only)	Spawning	Egg incubation	Rearing	Smolt out-migration (Sea Run Only)	Kelt out-migration
Stream Temperature	+	+	++	+++	+	++
Sediment Size Distribution and Embeddedness		+++	+++	++		
Habitat Complexity	++	++	+	+++	+	++
Habitat Connectivity	+++	+++		+++	++	+++

KEY
blank = minimal importance
+ low importance
++ moderate importance
+++ = high importance

o

3 EXISTING HABITAT CONDITIONS

Section 3 describes the methods and results of an assessment of habitat quality in WRIA 14, including a review of the existing data sources and the framework used for the assessment. Based on the status and condition of a number of constituent indicators informing a KEA, all of the watersheds were rated as one of three “condition bins” (good, fair, or poor).

The assessment of existing conditions was conducted at the watershed scale in order to evaluate habitat conditions on a scale that is meaningful and supported by available data. The assessment was conducted in 17 watersheds. The watersheds were similar to those evaluated in the 2004 Salmon Plan; however, three watersheds (Hiawata Creek, Lynch Creek, and Pickering Passage Tributaries) in the 2004 report were not evaluated in this update process. Instead, Perry Creek was added and the remainder of the drainage areas in WRIA 14 was rolled into a single analysis unit. The decision on the specific watersheds to be addressed in the update was made based on group discussions with the Committee. Note that some of the data tables contain information pertinent to several watersheds that were not specifically analyzed for existing habitat and KEA condition (Hiawata Creek and Lynch Creek); however, the data are presented for completeness.

3.1 Background and Review of Existing Information

The Existing Information and Data Gaps technical memorandum (ESA, 2019), prepared earlier in the project, provided a list of the datasets compiled, which included materials provided by the Committee. Various data categories were provided including databases, project reports, watershed planning documents, among others. A summary list of the data reviewed is provided as Table A-5 in Appendix A. ESA (2019) utilized all available data sources to prepare a data matrix, as presented in the technical memorandum, which assessed data availability and completeness for various habitat and fish population parameters, by watershed. It should be noted that a data gap evaluation found that eight of the watersheds (Campbell Creek, County Line Creek, Deer Creek, Kennedy Creek, Malaney Creek, Perry Creek, Schneider Creek, and Snodgrass Creek) had significant data gaps, in both historical and current data, on most of the specific habitat parameters needed to assess the salmonid limiting factors in the watershed. Furthermore, although the remainder of the watersheds (Cranberry Creek, Goldsborough Creek, Gosnell Creek, Mill Creek, Johns Creek, Schumacher/Sherwood creeks, Shelton Creek, Skookum Creek, and Uncle Johns Creek) had more recent data on a number of habitat parameters, the information was not suitable to evaluate the full suite of habitat factors. Specifically, recent comprehensive quantitative information on instream habitat conditions (such as large woody debris [LWD], bank condition and armoring, channel morphology, off-channel features) and sediment dynamics (such as sediment conditions, sources, delivery) is lacking and was identified as an overall WRIA 14 data gap in the technical memorandum.

Subsequent to delivery of the data gaps memo, the Mason Conservation District and the Committee provided additional site-specific information on instream habitat and stream temperature conditions, including some recent data from the summer of 2019. All applicable data were used to assess existing habitat conditions, as described in the following section.

3.2 Approach

The primary goals of the existing conditions analysis were to characterize the relative condition of those KEAs most important to the salmonid species in WRIA 14. This framework allows for the identification of primary salmonid limiting factors within a meaningful geographic area and an assessment of the potential effect of the habitat features on the fish species and life stages present in the watershed. The framework will also facilitate the development of the recovery strategies in Phase 2 (see Section 5, Recommendations and Next Steps).

Watersheds were evaluated based on the condition of KEAs. Each KEA represents multiple, and sometimes interrelated, ecological processes and habitat dynamics. For example, stream temperature can be affected by riparian conditions (including riparian width, species composition, and canopy density), stream flow, groundwater inputs, tributary inputs, stream orientation, stream width, and the presence of large lakes and/or wetlands. These biotic and non-biotic factors can all influence the proper functioning of the Stream Temperature KEA, which in turn can have significant implications for multiple life stages of salmonids (see Table 3). Furthermore, most of the factors that determine the relative temperature KEA condition can be measured directly. The constituent factors that influence the functioning of a KEA and can be tracked over time to rate the condition of a KEA are referred to as indicators.

The four KEAs selected for the existing conditions analysis are as follows:

- Stream Temperature
- Sediment Size and Distribution
- Stream Complexity
- Aquatic Habitat Connectivity

These KEAs are introduced below and the analysis described in Section 3.3. The KEAs were selected based on the linkage between each KEA and salmon life history stages (see Section 3.3). There are well-documented relationships between these KEAs and salmonid habitat needs for all five focal species evaluated, and most of WRIA habitat limiting factors (Kuttel, 2002) can be considered attributes of one or more of the KEAs. Some key linkages with each KEA to salmonids are listed below:

- **Stream Temperature:** Directly affects the metabolism and growth of juvenile salmonids, which can directly affect survival. Extreme temperatures can result in death or increased exposure/effect to disease in returning anadromous spawners and/or serve as upstream or downstream migration barrier. Directly affects egg incubation length and emergence timing and can also effect egg survival. Affects timing and abundance of macroinvertebrate species that serve as prey. High temperatures can reduce habitat availability and use by rearing juveniles, particularly those that spend significant time in freshwater (e.g., Coho Salmon and Steelhead) as well as reduce access to habitat refugia. Can also cause shifts in species assemblages, with a greater distribution and abundance of warmwater fish resulting in increased predation on salmonids. Temperature has a direct relationship with other key water quality elements, such as dissolved oxygen.

- **Sediment Size and Distribution:** Directly affect spawning habitat quality/quantity. Excess fines can result in vastly reduced egg and alevin survival. Serve as key driver to channel morphology, which in turn affects the Stream Complexity KEA.

- **Stream Complexity:** Inherent link to spawning and rearing habitat quality and quantity. Lack of stream cover and LWD can increase predation on juveniles, both piscivory and avian predation. Lack of complexity can limit food sources for juveniles, both allochthonous inputs and aquatic macroinvertebrates. Floodplain, wetland, and off-channel elements provide important juvenile refugia. Directly contributes to natural equilibrium between dynamic and stable stream channel and streambanks. Also linked to Stream Temperature and Sediment Size and Distribution KEAs.

- **Aquatic Habitat Connectivity:** Barriers to fish movement, including physical barriers and temperature barriers, can directly affect access of salmonids to high quality spawning and rearing areas, resulting in direct completion for available habitats, decreased spawning success (e.g., redd superimposition), and delay or alteration of upstream and downstream migration.

The condition of each of the selected KEAs was assessed by watershed. This condition assessment, which resulted in binning each watershed into one of three categories (good, fair, or poor), was conducted using the following methods.

1. **Assemble Data:** The relevant data were reviewed and evaluated as described in Section 3.1 above.

2. **Assess and Assign Relevant Indicators:** For each of the four KEAs, all available data were reviewed and, where appropriate, assigned as an indicator for a specific KEA. The types of indicators relevant to a KEA include indicators assessed or measured in watershed studies; governmental regulatory assessments (e.g., Ecology 404(d) process); state, Mason Conservation District, tribal, and non-governmental organization (NGO) data on water quality and habitat; and state databases (e.g., WDFW fish passage database). In addition, geographic information system (GIS) analysis was conducted to assess the status of some indicators, such as land cover in entire watersheds and within riparian zones, as well an analysis of anadromous fish distribution above and below culverts. Table A-6 details all assessed indicators by watershed, and Table A-7 lists details on each indicator (see Appendix A for both tables). Tables A-8 and A-9 present the land cover data used in the condition rating, both for each watershed and the riparian areas within each watershed.

   In some cases, no recent, relevant information exists pertaining to all watersheds in WRIA 14. Therefore, for all KEAs, we included some indicators directly from the Kuttel (2002) limiting factors analysis (LFA). As the LFA information is older, and in some cases based only on qualitative assessments, it should be considered as a partial data gap where applied. However, it was included in the analysis because, in some cases, the LFA represents the only available assessment of relevant KEA indicators. For each of the four KEAs, each indicator used to assess KEA function is listed in Table 5, which also includes a reference to the indicator source data or analysis methods.

3. **Rank Relative Indicators:** For a given KEA, some indicators inform the condition of the KEA to a greater or lesser degree than do others. Therefore, the listing of indicators by KEA is in order of relative weight of the indicator in determining the condition of the KEA in each watershed (Table 5). In general, weighting was applied as follows, from higher to lower priority:

    a) Indicators that serve as a direct measurement of the KEA (e.g., 303(d) temperature listing for Stream Temperature KEA).

    b) Indicators that are based on recent (post-2002) quantitative field data and studies.

    c) Indicators based on recent (post-2002) qualitative analysis of a limiting factor from recent reports. In cases where the report did not assess the level of the limiting factor, best professional judgement was applied to assign indicator a score of low, medium, or high.

    d) Indicators from the Kuttel (2002) limiting factors analysis. The LFA rated each indicator as good, fair, or poor. Due to the age of the data, and because the LFA relied both on quantitative data and best professional judgement, LFA data were used as the primary source to assess the KEA condition only in cases where more recent data do not exist. The basis for the ratings from Kuttel (2002) is presented in Table A-10 in Appendix A.

4. **Assign Condition Rating to KEAs by Watershed:** Table A-7 in Appendix A lists the data and data sources for each applicable indicator in each watershed, and displays the condition data or summary. Note that the good, fair, and poor ratings of specific watershed indicators are based on the degree the indicator is functioning (as interpreted by best professional judgement) and does not represent an analysis of the data source or quality. Based on the data in the table, and the relative ranking criteria listed above, each KEA was assigned a condition rating of either good, fair, or poor. The ratings can be classified as follows:

    - **Good:** KEA is properly functioning throughout most of the watershed, providing or supporting most relevant habitat elements required by all salmonids and life history stages.

    - **Fair:** KEA is properly functioning throughout some portion of watershed or is of moderate function through most of the watershed, providing or supporting some relevant habitat elements required by all salmonids and life history stages.

    - **Poor:** KEA is not properly functioning throughout all or most of watershed, providing or supporting few relevant habitat elements required by all salmonids and life history stages. Likely a limiting factor to salmonid production.

Table 4. Relevant Indicators and Data Sources Utilized for Key Ecological Attribute Condition Binning

Key Ecological Attributes	Relevant Indicators	Data Source (see Table A-7 in Appendix A)
Stream Temperature	Category 5 303(d) Temperature and Dissolved Oxygen Listings	1
	Stream Temperature (Multiple Data Sources)	2
	Canopy Cover (Multiple Data Sources)	3
	Major Lakes (basin position)	4
	Percent Forest in Riparian Buffer	5
	Canopy Height (% low canopy from MCD, 2016b)	6
	Streamflow Rule Adherence (% of summer numerical rule not met)	7
	Stream Temperature (from Kuttel, 2002)	8
	Canopy Closure (from Kuttel, 2002)	9
	Streamflow/Low Flow (from Kuttel, 2002)	10
Sediment Size and Distribution	Sediment Size and Distribution (Multiple Data Sources)	11
	Embeddedness (Multiple Data Sources)	12
	Embeddedness (from Kuttel, 2002)	13
	Changes in Flow Regime (high flow) (from Kuttel, 2002)	14
	Streambank Condition (from Kuttel, 2002)	15
Stream Complexity	Pool Frequency (Multiple Data Sources)	16
	Off-channel Habitat (Multiple Data Sources)	17
	LWD Frequency (Multiple Data Sources)	18
	Habitat Limiting Factors From Recent Reports	19
	Pool Frequency (from Kuttel, 2002)	20
	Pool Quality (from Kuttel, 2002)	21
	Off-channel Habitat (from Kuttel, 2002f)	22
	LWD Frequency (from Kuttel, 2002)	23
	LWD Key Pieces (from Kuttel, 2002)	24
	Floodplain Connectivity (from Kuttel, 2002)	25
Aquatic Habitat Connectivity	Number of WDFW Fish Passage Barriers on Stream Segments with Fish Distribution (WDFW, 2019c)	26
	Connectivity (low flow and temp) - from Temperature KEA	27
	Fish Passage at Water Crossings (from Kuttel, 2002)	28

Where quantitative data on the KEA indicators were lacking completely for specific watershed and the condition rating was based exclusively on 2002 LFA data, the condition rating was assigned a qualifier as a data gap. In addition, ESA had a discussion with the Water Quality Coordinator at the Squaxin Island Tribe on the appropriate Stream Temperature KEA for each individual watershed where the KEA condition rating was finalized.

3.3 Key Ecological Attributes Condition Analysis

Table 5 presents a summary of the results of the condition rating for each KEA in each of the WRIA 14 watersheds. As the table shows, most of the watersheds have KEA conditions that vary substantially as to condition, depending on which KEA is examined. Only the Goldsborough Creek and Schneider Creek watersheds (both rated fair for all KEAs) and Skookum Creek (rated as poor for all KEAs) have uniform KEA conditions throughout. The following subsections describe the results by KEA and provide a brief summary for WRIA 14.

3.3.1 Stream Temperature

The Stream Temperature KEA was rated as good in three watersheds, fair in six, and poor in eight (Table 5). Across all KEAs, this parameter had the highest number of watersheds in poor condition. The presence of inline and headwater lakes presumably contributes to higher stream temperatures downstream through solar heating of surface waters in a lake. Six of the eight watersheds rated as poor have an inline or headwater lake.

Although there is a relationship between the amount of forest vegetation (trees) within riparian buffer, there is no direct correlation. For example, while Johns Creek has 40% forested buffer, the least of any watershed, and County Line Creek has 81% forested buffer, the most of any watershed, both watersheds received a rating of fair for the Stream Temperature KEA. This is partially explained by the presence of large wetlands in Johns Creek, within a relic outwash channel from the Skokomish River, where natural solar radiation results in elevated stream temperatures that gradually cool as the stream enters the downstream canyon (Marbet, pers. comm.). Such solar radiation effects have also been documented in Mill Creek, downstream of Isabella Lake, and in Cranberry Creek, downstream of both Cranberry Lake and Lake Limerick (e.g., Marbet and Caldwell 2015). Such warming can severely restrict the distribution of juvenile Coho Salmon and Steelhead in the late summer months.

Data gaps for this KEA are present within five of the watersheds (Campbell Creek, County Line Creek, Malaney Creek, Snodgrass Creek, and Uncle Johns Creek), all of which are smaller watersheds ranging from 800 to 3,000 acres.

Table 5. Summary of Condition Rating of Key Ecological Attributes by WRIA 14 Watershed (DG Indicates KEA is a Data Gap)

Watershed	Key Ecological Attribute (KEA)			
	Stream Temperature	Sediment Size and Distribution	Stream Complexity	Aquatic Habitat Connectivity
Campbell Creek	Poor (DG)	Fair (DG)	Fair (DG)	Fair
County Line Creek	Fair (DG)	Fair (DG)	Poor (DG)	Poor
Cranberry Creek	Poor	Fair (DG)	Fair to Good (DG)	Poor
Deer Creek	Poor	Fair (DG)	Good (DG)	Fair
Goldsborough Creek	Fair	Fair	Fair (DG)	Fair
Gosnell Creek	Good	Fair (DG)	Fair	Poor
Mill Creek (including Isabella Lake)	Poor	Fair (DG)	Fair	Fair
Johns Creek	Fair	Fair (DG)	Fair (DG)	Poor
Kennedy Creek	Fair	Fair (DG)	Good (DG)	Good
Malaney Creek	Poor (DG)	Fair (DG)	Fair to Good (DG)	Good
Perry Creek	Good	Fair (DG)	Poor (DG)	Good
Schneider Creek	Fair	Fair (DG)	Fair (DG)	Fair
Schumacher Creek	Poor	Fair (DG)	Fair (DG)	Fair
Sherwood Creek	Poor	Fair (DG)	Good (DG)	Fair
Shelton Creek	Good	Poor (DG)	Poor (DG)	Poor
Skookum Creek	Poor	Poor	Poor (DG)	Poor
Snodgrass Creek	Fair (DG)	Poor (DG)	Poor (DG)	Good
Uncle Johns Creek	Poor (DG)	Poor (DG)	Poor (DG)	Poor

Note: DG indicates there is a data gap for recent data to characterize this KEA.

3.3.2 Sediment Size and Distribution

The analysis of the Sediment Size and Distribution KEA in the WRIA is based solely on information presented in the Kuttel (2002) LFA, with the exception of limited data on sediment conditions in the Goldsborough Creek, Mill Creek, Johns Creek, Schumacher/Sherwood Creeks, and Skookum Creek watersheds from the Squaxin Island Tribe and others (see Table A-6 in Appendix A). For most of WRIA 14, this constitutes a data gap (see Section 5 below) based on the lack of quantitative information on the individual indicators for many of the watersheds, as well as the age of the data that are presented. Therefore, there is relatively high uncertainty on the accuracy of the ratings for the Sediment Size and Distribution KEA, as compared to the other three KEAs, where a substantially greater amount of recent data was available. This uncertainty may account for why this KEA was not rated as good in any of the 17 watersheds, but rather was rated fair in 13, and poor in four (Table 5).

3.3.3 Stream Complexity

The Stream Complexity KEA was rated as good in two watersheds, fair in nine, and poor in six (Table 5). However, with the exception of more recent studies and associated data on instream habitat conditions in the Goldsborough Creek, Mill Creek, Johns Creek, Schumacher/Sherwood creeks, and Skookum Creek watersheds from the Squaxin Island Tribe and others (see Table A-6 in Appendix A), the analysis of the Stream Complexity KEA in the rest of the WRIA is based solely on information presented in the Kuttel (2002) LFA. However, even in the cases where stream complexity indicators came exclusively from the LFA, the KEA rating is somewhat more robust than the Sediment Size and Distribution KEA, as there are six separate indicators (versus three for sediment) that inform the overall KEA, and these indicators are generally based on quantitative data (see Table A-7 in Appendix A). Furthermore, where newer studies evaluated pool frequency, LWD frequency, and off-channel habitat, the results generally concurred to the indicator rating applied by the LFA (see Table A-6 in Appendix A). A lack of floodplain connectivity and off-channel habitats, as well as a lack of LWD frequency, was a common occurrence for those watersheds where the Stream Complexity KEA rated as poor.

3.3.4 Aquatic Habitat Connectivity

The Aquatic Habitat Connectivity KEA was rated as good in four watersheds, fair in six, and poor in seven (Table 5). With the exception of Kennedy Creek, which contains a natural barrier falls that precludes anadromous fish passage, the remaining watersheds that were rated good (indicating no barriers affecting anadromous fish) were much smaller (Malaney Creek, Perry Creek, and Snodgrass Creek), likely related to a lesser extent of road network within these basins. The watersheds that were rated as fair represented those where fish passage barriers affected a moderate percentage of anadromous fish habitat (as compared to total available) or a large amount of resident fish habitat. Those watersheds rated as poor had barriers that affected a large amount percentage of anadromous fish habitat.

It is important to note the rating was focused on anadromous fish habitat and the effect of one or more man-made fish passage barriers on the habitat. The rating did not explicitly take into account the barrier's status (total or partial) or the number of barriers present. Therefore, in some cases the remedy of one or two barriers in the lower reaches of a watershed may change the rating status from poor to good (e.g., County Line Creek), while in other cases this would require the correction of several barriers (e.g., Gosnell Creek and Skookum Creek watersheds). The relative number and severity of barriers is addressed as a pressure, in Section 4.2.2.

An overview of the miles of fish habitat in each watershed based on data in the WDFW Fish Passage and SWIFD databases is presented in Figure 20. The mileage calculations in each watershed includes the mainstem and contributing tributaries. In each watershed, there is an anadromous zone defined as the upstream extent where one or more salmonid species has been documented in. This anadromous zone is divided into the portion downstream of all barriers and the portion upstream of one or more barriers, including partial, total, and unknown barriers in the WDFW database. Also presented is the length of habitat upstream of anadromous salmon distribution in each watershed where Coastal Cutthroat Trout are documented. The upstream extent of the anadromous zone ends at a natural barrier (e.g., falls or cascade) in Perry Creek (RM 1.2), Kennedy Creek (RM 2.5), and County Line Creek (RM 0.6).

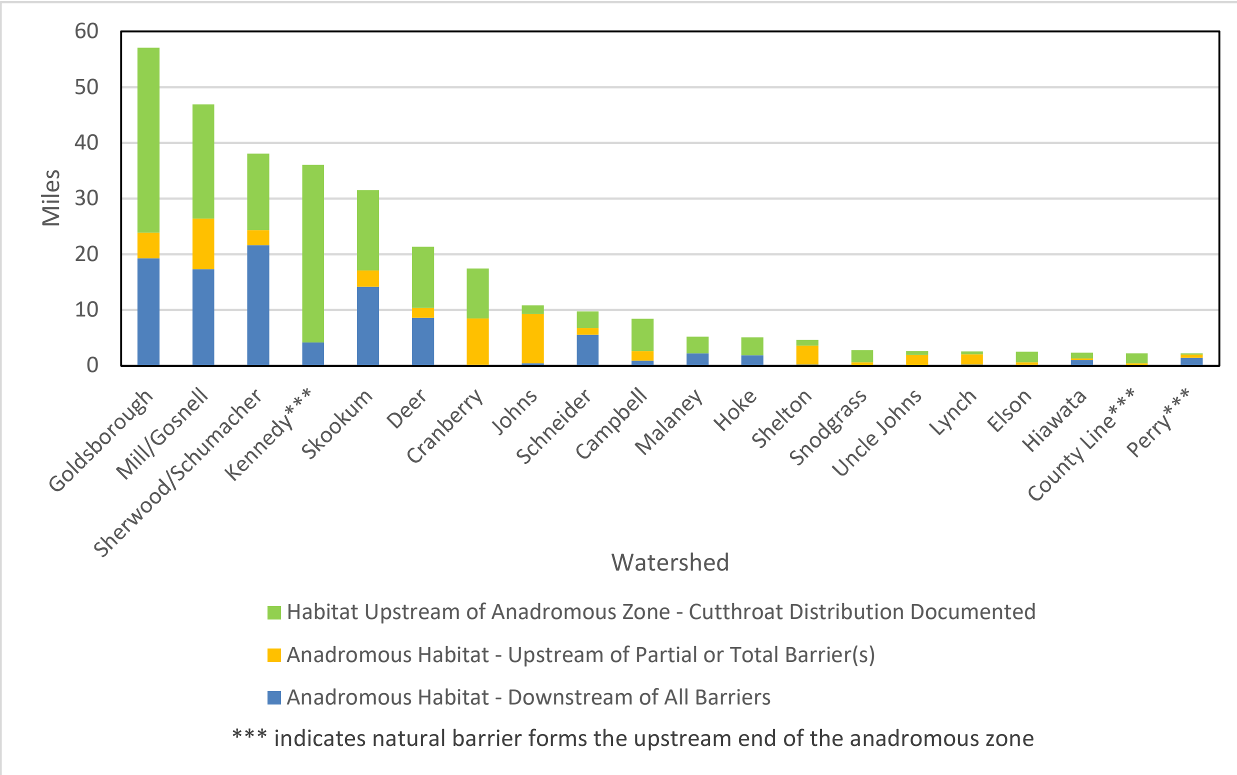


Figure 20. Anadromous fish habitat downstream and upstream of barriers and Coastal Cutthroat Trout habitat upstream of anadromous zone in WRIA 14 watersheds

Keeping in mind that the analysis shown in Figure 20 does not depict the number of barriers or whether the barriers partially or totally block fish access, it shows that Schumacher/Sherwood creeks have the longest stream length below all barriers. Conversely, several creeks have barriers near their mouth and therefore very little stream length below any barriers. The longest creeks with barriers close to the mouth are Johns Creek and Cranberry Creek. The partial fish passage barrier near the mouth of Cranberry Creek is planned to be replaced in 2020. When replaced, an additional 3.6 miles of anadromous habitat will be accessible below the first remaining barrier in Cranberry Creek.

3.3.5 Summary of Conditions in WRIA 14

Overall, there are some patterns that can be detected in relation to the KEA condition analysis, and the abundance and distribution of anadromous salmon in WRIA 14. The five largest watersheds in WRIA 14 are, in order of area from largest to smallest, Goldsborough Creek, Schumacher/Sherwood Creeks, Mill/Gosnell Creeks, Kennedy Creek, and Skookum Creek. These five watersheds account for slightly over 70 percent of the entire land area of WRIA 14. They have the greatest amount of habitat (measured by documented presence by stream miles) for Coho and fall Chum Salmon and, in most cases, also represent the watersheds that demonstrate the highest abundance of Coho and fall Chum Salmon.

These five key watersheds vary substantially in existing conditions. The Kennedy Creek watershed has an overall condition of fair to good for all four KEAs, while the Skookum Creek watershed, based on the

KEA analysis, has uniformly poor existing habitat conditions. Although both of these watersheds support high numbers of fall Chum Salmon relative to other watersheds in WRIA 14, Kennedy Creek does so with only 2.5 miles of documented habitat, while the Skookum Creek watershed has over 14 miles of fall Chum Salmon habitat (based on Chum Salmon distribution), over five times as much. In this case, the production of fall Chum Salmon in Skookum Creek is likely limited by the quality of available habitat, while in Kennedy Creek, habitat quantity is likely limiting fall Chum Salmon production. Not surprisingly, smaller watersheds that display poor existing conditions for most or all KEAs, such as Shelton, Snodgrass, and Uncle Johns creeks, have very limited production of both Coho and fall Chum Salmon.

4 THREATS

The identification of threats to salmon in WRIA 14 is a key element of assessing existing and future impacts posed by human activity on the landscape. As part of a process for developing a freshwater habitat strategy, the threats should be evaluated for scope, severity, and irreversibility as they relate to each of the species and/or habitats of interest. While a complete assessment was beyond the scope of this effort, the key threats have been identified and available data compiled to be incorporated in a prioritization of reaches and/or set up the WRIA 14 Lead Entity for moving into an assessment phase that will conclude with the identification of strategies and actions to address and decrease the key threats. In all salmon recovery plans and strategies, it is important to recognize that the threats include legacy impacts (past conversion, channel straightening, removal of wood), as well as current threats from continued conversion or management that impairs the KEAs listed in the previous section. Future threats such as population growth and climate change should also be considered when evaluating threats, so that a robust recovery strategy can include restoration actions to repair legacy damage while protecting, preventing, or ameliorating the threats that are on predicted to increase in the future.

4.1 Approach

In the interest of conforming to a standard regional language for clarity and consistency across local and regional planning efforts, the threats are referred to below as pressures and stressors. The region (Puget Sound Partnership) developed a list of pressures and stressors with definitions (2012) and described in the Toolkit developed for Chinook Monitoring & Adaptive Management (Puget Sound RITT 2016). A pressure (or a pressure source) is defined as "human activities or natural processes that have caused, are causing, or may cause the destruction, degradation, or impairment (of ecosystem components)." Stressors are the biophysical factors that are altered by pressures. Stressors are the "proximate cause of change in the Puget Sound ecosystem." In other words, these are the human impacts that lead to degraded KEAs as described above. An increase or worsening of the pressure or stressor could change the condition of a KEA from fair to poor or good to fair.

Several previous plans and the current WRIA 14 Salmon Plan (2004) articulate pressures and stressors (threats) that were most important to address for salmon recovery locally. Using the previous work, a list of pressures and stressors was compiled and presented to the Committee and the understanding that this list could be further refined during a formal pressures assessment in Phase 2. Connecting each pressure and stressor through to degraded KEAs and subsequently to each salmonid species will help the Lead Entity articulate assumptions and develop a conceptual model for how these threats lead to degraded ecosystems and threatened or declining fish populations.

It is important to note that other pressures and stressors relevant to recovery of WRIA 14 salmonid populations, but unrelated to freshwater habitat KEAs, are not included in the list below. Other relevant pressures and stressors important for salmonid recovery may include hatchery management, marine food web breakdown/predation, nearshore development pressures, harvest management, invasive predators, and others that are outside the scope of this effort. For some pressures, their impact may be best addressed through a regional assessment and strategy development with the entities responsible for managing those aspects of recovery beyond habitat, which is the current focus and scope for the WRIA 14 freshwater habitat strategy update.

4.2 Key Pressures and Stressors

Figure 21 shows the key pressures and stressors identified as potentially important to address for improving freshwater habitat conditions, and ultimately salmonid recovery in WRIA 14.

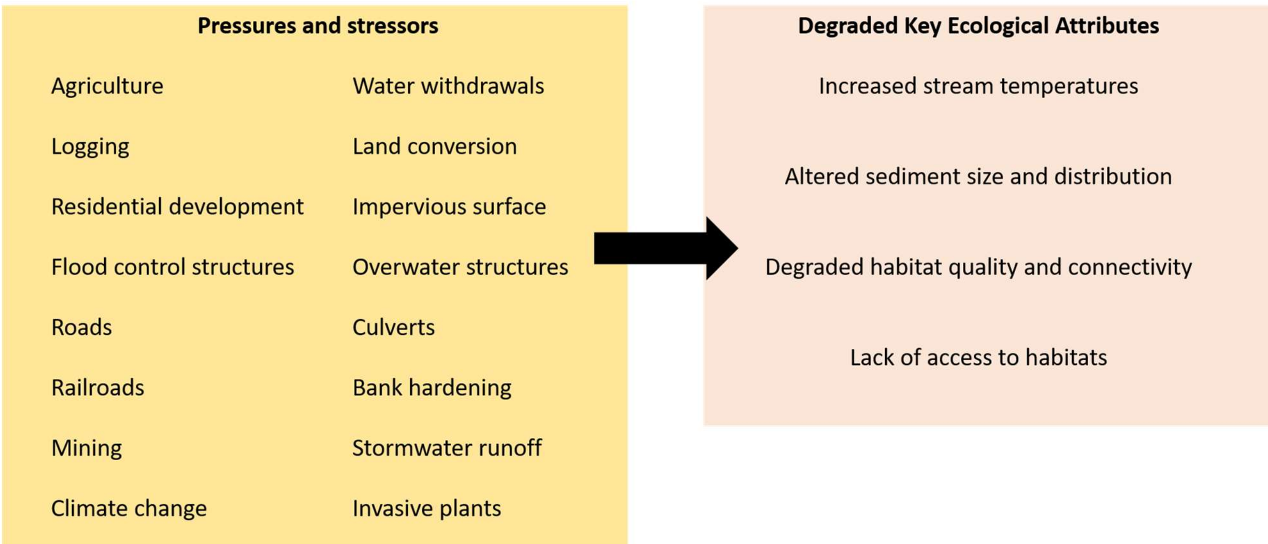


Figure 21. The pressures and stressors identified in existing WRIA 14 plans and resources which lead to degraded KEAs

The draft list of key pressures and stressors were compiled from the WRIA 14 Salmon Plan (Mason Conservation District, 2004), the Squaxin Island Tribe chapter of State of Our Watersheds Report (2016), and other reports and summaries like the Local Integrating Organization's Alliance for a Healthy South Sound webpage on freshwater habitat (click for link), and the Puget Sound Partnership's Phase 1 Monitoring & Adaptive Management Phase 1 Report for South Sound.

To the extent that data was available for the key pressures and stressors listed above, the information was analyzed and summarized by watershed for WRIA 14 to align with the approach for summarizing KEA conditions. The source and methods for each pressure, along with any notes are caveats, follow the summary information in each table.

4.2.1 Road and Railroads

Road and railroads can both serve as pressures on salmon KEAs. Both types of man-made features can affect most of the KEAs used to assess existing conditions in WRIA 14 watersheds. Roads and railroads can result in barriers to fish migration due to undersized culverts, which can also negatively affect natural sediment dynamics and downstream transport of LWD. In addition, these features, especially those constructed in the early to mid-1900s have often resulted in stream rerouting and channelization of the stream to a location parallel to the road or railroad, resulting in simplified channel form and function, reduced riparian width and quality, and a reduction or elimination of floodplain and off-channel habitats. Roads and railroads running parallel to and along the bank of creeks can result in extended areas of disconnected floodplain habitats that are isolated by the transportation corridor. Paved roads serve to collect pollutant constituents, such as dissolved copper and zinc, which can runoff into streams and negatively affect salmonids. Unpaved roadways can serve as sediment sources, where runoff from the roads into streams increases the percentage of fines in the systems, potentially increasing turbidity and contributing to sedimentation that can negatively affect incubating salmonids. The National Marine Fisheries Service (1996) has indicated that watersheds with a road density of greater than 3 road miles per square mile represent conditions that are “not properly functioning” as salmonid habitat.

Based on GIS analysis of roads data (GDRC, 2019), Table 6 lists for each watershed the length of road by ownership type and the road density average. A total of approximately 2,000 miles of roadway is present in WRIA 14 (which encompasses 234 square miles). Road densities range from 2.7 to 10.8 miles of road per square mile in the watersheds, with average road density of 6.5 miles of road per square mile over the entire WRIA. Road density is directly related to the degree of development within a watershed, with those watersheds having high levels of residential, commercial, and industrial land use, such as the Shelton Creek watershed, having higher road densities. However, the analysis also includes forested roads in commercial timberlands that account for approximately half of the overall road network.

Railroad density (Table 7) was also examined by watershed, using GIS. Approximately half (eight) of the primary watersheds in WRIA 14 contained railroad lines for a total of 41 miles of railway. More than half of the railway is located in two watersheds; Goldsborough Creek (14 miles) and Skookum Creek (8 miles). The overall railroad density in WRIA 14 is 0.16 miles of railroad per square mile. The highest railroad densities are in the Goldsborough Creek and Skookum Creek watersheds, 0.46 and 0.39 miles/square mile, respectively.

4.2.2 Man-made Fish Passage Barriers

Man-made fish passage barriers (culverts, bridges, dams, etc.) directly affect the connectivity of aquatic habitats and can impede or preclude movement of adult fish, juvenile fish, sediment, and wood within the stream channel. Section 3.3.4 of this report discussed the Aquatic Habitat Connectivity KEA in terms of available habitat. The presence of fish passage barriers also represents a threat to salmonids, which can affect both the distribution and abundance of a given species within a specific subwatershed. In addition, these effects vary by species, based on the species swimming and jumping ability. For example, Chum Salmon, who do not exhibit strong swimming or jumping, can be precluded by a water surface drop at a pipe inlet or a velocity barrier in a culvert, where other fish species such as Coho Salmon or Steelhead would be more likely to be able to pass due to swimming and jumping abilities. Fish passage barriers are also problematic for juvenile fish trying to move upstream and downstream between habitats over the course of the year.

Table 8 summarizes some of the primary fish passage barriers that have been identified by WDFW (2019c), including barrier status (partial or total) and the approximate amount of habitat effected, both for anadromous species and resident species. Efforts are underway to design and construct fish passable barriers in multiple creeks in WRIA 14.

Table 6. Road Ownership and Road Density in WRIA 14 Watersheds

		Road Ownership[a] (miles)								
Watershed	**Sub-watershed Area (square miles)**	**County**	**State**	**Federal**	**USFS**	**Other Public**	**Private Forest**	**Other Private**	**Total Road Miles**	**Road Density (road miles per square mile)**
Campbell Creek	4.6	11.3					12.1	3.9	27.3	5.9
County Line Creek	1.5	1.6		1.6			6.8	2.9	12.8	8.8
Cranberry Creek	14.0	26.6	0.3	2.6			44.5	41.4	115.4	8.2
Deer Creek	14.9	19.6	4.7	6.8			78.3	18.3	127.7	8.6
Goldsborough Creek	59.8	61.3	0.2	4.5	0.1	31.0	270.5	75.1	442.8	7.4
Hiawata Creek	1.4	2.1	0.6				2.0	6.3	11.0	8.1
Johns Creek	10.4	16.3	0.2	4.1			23.6	26.2	70.4	6.8
Kennedy Creek	19.9	12.5	9.5	0.1			82.7	12.6	117.5	5.9
Lynch Creek	1.3	7.5					1.2	1.4	10.1	7.8
Malaney Creek	3.6	8.9	0.2				4.3	5.7	19.1	5.3
Mill/Gosnell Creeks	29.8	35.5	1.6	2.7		2.1	136.8	24.2	202.8	6.8
Perry Creek	6.4	1.9	7.5	0.5				10.9	20.9	3.2
Schneider Creek	7.2	7.0		5.5				7.2	19.7	2.7
Shelton Creek	3.3	8.4	0.8	0.6		19.7	2.0	3.7	35.2	10.8
Sherwood/Schumacher Creeks	33.1	43.5	4.7	3.8		0.5	162.7	67.4	282.6	8.5
Skookum Creek	19.4	7.0	7.6	6.9		0.2	68.5	50.9	141.0	7.3
Snodgrass Creek	1.3	2.1					0.6	4.8	7.4	5.8
Uncle Johns Creek	1.8	3.5					0.1	2.5	6.1	3.5
All other watersheds	75.9	190.1	12.6	11.9		15.1	48.0	59.2	337.0	4.4
Total	**233.6**	**466.7**	**50.5**	**51.6**	**0.1**	**68.6**	**944.5**	**424.7**	**2006.8**	**6.5 (WRIA wide)**

[a] Road ownership data from GDRC, 2019

Table 7. Railroad Density in WRIA 14 Watersheds

Watershed	Watershed size (square miles)	Length of Railroad Line (miles)[a]	Railroad Line Density (mi per square mile)
Campbell Creek	4.6	0	0
County Line Creek	1.5	0	0
Cranberry Creek	14.0	2.6	0.19
Deer Creek	14.9	6.8	0.46
Goldsborough Creek	59.8	13.9	0.23
Johns Creek	10.4	2.2	0.21
Kennedy Creek	19.9	0	0
Malaney Creek	3.6	0	0
Mill/Gosnell Creeks	29.8	1.9	0.06
Perry Creek	6.4	0	0
Schneider Creek	7.2	0	0
Shelton Creek	3.3	1.1	0.35
Sherwood/Schumacher Creeks	33.1	4.8	0.14
Skookum Creek	19.4	7.7	0.39
Snodgrass Creek	1.3	0	0
Uncle Johns Creek	1.8	0	0
All other watersheds	78.6	9.4	0.12
Total	**233.6**	**41.0**	**0.16 (overall average)**

[a] Railroad data from Mason County GIS Data, 2019.

Table 8. Fish Passage Barriers in WRIA 14 Watersheds

Watershed	Number of WDFW Fish Passage Barriers on Stream Segments with Fish Distribution and Length of Anadromous and Resident Cutthroat (CT) Affected (WDFW, 2019c)
Campbell Creek	2 total barriers (culvert and dam) on mainstem (precluding passage to 2.2 mi of 5.4 mi CT only habitat)
County Line Creek	2 partial barriers on mainstem impacting fish passage to 0.6 mi (out of 0.7 mi total) anadromous habitat and additional 1.4 mi (out of 1.5 mi CT only habitat)
Cranberry Creek	2 partial barriers on mainstem and 2 total and 3 partial barriers on tributary. Partial barrier (low private bridge) at mouth affects 8.5 mi of 8.6 mi total anadromous habitat and an additional 8.2 mi (out of 8.3 mi) of CT only habitat. The partial barrier at mouth is planned to be replaced in 2020.
Deer Creek	1 partial barrier on mainstem, 3 total barrier and 2 partial barriers on tributaries (partial barriers affect 1.6 mi anadromous habitat (out of 10.4 total mi) and 2.9 CT only habitat (out of 10.5 mi) and total barrier affects 2.2 mi CT habitat (out of 10.5 mi)
Goldsborough Creek	Coffee Creek = 1 partial barrier mainstem, 6 partial and 6 total barrier on tributaries limiting access to 3.2 mi of anadromous habitat and 3.9 miles of CT habitat; Other Goldsborough Tributaries = 1 total barrier and 5 partial barriers limiting access to 2.7 mi of anadromous habitat and an additional 23.3 mi of CT habitat
Gosnell Creek	1 partial barrier on mainstem and 5 total barriers and 2 partial barrier on tributaries affecting 8.3 mi of anadromous habitat and additional 12.8 mi CT habitat
Mill Creek (including Isabella Lake)	2 total barriers and 4 partial barriers on tributaries affecting 0.7 mi anadromous habitat and an additional 0.1 CT habitat. Also, 2 unknown barriers may affect 1.5 mi CT habitat
Johns Creek	3 partial barriers on mainstem impeding access to 8.2 mi of anadromous habitat and 1.9 mi of CT habitat
Kennedy Creek	1 partial barrier on tributary below natural barrier (0.4 mi CT only habitat access); Upstream of falls, 14 total barriers and 6 partial barriers affect 10.4 mi of CT only habitat
Malaney Creek	No barriers
Perry Creek	1 partial barrier on tributary (0.4 mi CT habitat access)
Schneider Creek	2 partial barriers on tributaries and one on mainstem (2.1 mi anadromous habitat affected)
Schumacher-Sherwood Creeks	Sherwood = 1 total barrier and 4 partial barriers on tributaries; Schumacher = 1 total barrier on tributary. Limits access to 3.0 mi of anadromous habitat and 9.1 mi of CT habitat
Shelton Creek	2 total barriers (one near mouth) and 1 partial barrier on mainstem which limit access to 1.7 mi of anadromous habitat and 0.8 mi of CT habitat and precludes access to 0.9 mi of anadromous habitat and 1.1 mi of CT habitat.
Skookum Creek	4 total barriers and 6 partial barriers, all on tributaries (Total barriers preclude passage to 1.1 mi anadromous and 3.8 mi CT habitat access while partial affect 2.5 mi anadromous and 3.2 mi CT)
Snodgrass Creek	1 barrier on tributary (1.1 mi CT habitat access)
Uncle Johns Creek	2 partial barriers on mainstem and 3 partial barriers on tributaries. Barrier near mouth affects 1.9 mi of anadromous plus 0.7 miles of CT habitat access.

4.2.3 Land Jurisdiction

Although the type of jurisdiction (local, county, tribal, or state) on the landscape does not, by itself, constitute a direct pressure or stressor, it can inform the identification of these elements. For example, development pressure is related to development density and zoning classifications. Within the boundaries of designated cities or UGAs such as Shelton, allowed development density is generally higher than that outside the boundaries, such as within Mason or Thurston Counties. Likewise, areas where the state has jurisdiction are generally state-owned forests, managed for multiple uses, including timber production. These two cases both represent pressures or stressors, although the specific stressors in city/UGA areas (forest cover loss, impervious surface, increased road network) can be substantially different than in state-owned jurisdiction (logging roads and sediment delivery).

Table 9 lists the jurisdiction within each primary watershed in WRIA 14. WRIA-wide, county jurisdiction is present within 80 percent of the WRIA, state jurisdiction 12 percent, city/UGA 7 percent, and reservation/uncategorized the remaining 1 percent. City/UGA ownership predominates in only a handful of watersheds (13 watersheds have zero such ownership), including essentially the entirety of Shelton Creek (99.5%) as well as Johns and Goldsborough Creeks (13% and 11 percent, respectively).

State ownership also varies substantially, with six watersheds having zero state ownership, ranging to a maximum of approximately 74 percent state ownership of the Perry Creek watershed. Six other watersheds have moderate state ownership (10 to 40 percent) while the remaining watersheds have state ownership of less than 10 percent. As stated previously, this data can be analyzed with land cover and land use data to determine pressures and threats from commercial forestry.

4.2.4 Land Use

Land use GIS data, compiled by the Northwest Indian Fisheries Commission (NWIFC), also informs potential pressures and threats in WRIA 14. Table 10 shows the land use data, by watershed, in WRIA 14. Forest/timber is by far the dominant land use in the WRIA, accounting for 60 percent of all land use. Residential land use (16 percent) and undeveloped land use (14 percent) account for the bulk of the remainder of the WRIA. The remaining land use categories, agriculture, commercial, governmental services, open space, and transportation/utilities, when combined account for a total of approximately 7 percent of land use in the WRIA, with unknown/not classified land uses accounting for the remainder. As with land ownership, land use results can point to pressures through examination of the location of the land use in relation to the stream network. Forest/timber can negatively affect conditions and processes immediately adjacent to the stream network, such as riparian condition, road crossings, and valley bottom roads, but can also act as a pressure or threat based on watershed-wide conditions, including effective cleared area and road networks associated with forestry. Likewise, residential development can have effects on salmonid KEAs at similar scales.

In the watersheds, developed the amount of undeveloped land uses (forest/timber and undeveloped) is generally inversely proportional to the amount of developed land uses (combining commercial, governmental services, residential, and transportation/utilities. This relationship applies to Shelton, Malaney, Snodgrass, Schneider, and Uncle Johns watersheds, which have the highest amount of developed uses, as well as Deer, Skookum, Kennedy, and Sherwood/Schumacher Creeks watersheds, demonstrating the lowest.

Table 9. Land Jurisdiction (by Percentages) in WRIA 14 Watersheds

Watershed	Total Area (acres)	Land Jurisdiction				
		City/UGA/ Municipal	County	Reservation	State	Uncategorized
Campbell Creek	2,954	0	100.0	0	0	0
County Line Creek	929	0	83.3	0	15.9	0.8
Cranberry Creek	8,978	0	98.1	0	1.9	0
Deer Creek	9,537	0	91.9	0	8.1	0.1
Goldsborough Creek	38,241	11.2	75.5	0	12.4	0.9
Hiawata Creek	871	0	99.8	0	0.0	0.2
Johns Creek	6,651	13.3	74.1	0	10.3	2.2
Kennedy Creek	12,766	0	62.7	0	36.3	1.0
Lynch Creek	830	0	100.0	0	0	0
Malaney Creek	2,326	0	99.4	0	0.6	0
Mill/Gosnell Creeks	19,058	1.4	94.9	0	1.9	1.8
Perry Creek	4,116	0	26.4	0	73.5	0.1
Schneider Creek	4,631	0	59.9	0	40.1	0
Shelton Creek	2,085	99.5	0.4	0	0	0.1
Sherwood/Schumacher Creeks	21,174	2.9	73.2	0	16.2	7.8
Skookum Creek	12,437	0	95.7	0.3	3.8	0.2
Snodgrass Creek	811	0	99.7	0	0	0.3
Uncle Johns Creek	1,136	0	100.0	0	0	0
All other watersheds	48,596	3.5	88.4	1.8	5.2	1.1
Average	10,428	4.9	81.4	0.5	11.5	1.6

[a] Data from NWIFC, 2016 Data sources: SSHIAP 2004; USFWS 2014, WADNR 2014a,b,c; WSDOT 2013; Ecology 1994, 2010, 2011a, 2013.

Table 10. Land Use (by Percentages) in WRIA 14 Watersheds

Watershed	Total Area (acres)	Land Use[a]								
		Agriculture	Commercial	Forest/ Timber	Gov't. Services	Open Space	Residential	Transportation/ Utilities	Un-developed	Unknown/ Not Classified
Campbell Creek	2,954	0.4	0	61.3	0	2.1	17.2	0	16.2	2.7
County Line Creek	929	0	0	59.4	0	6.3	9.2	0	21.1	3.9
Cranberry Creek	8,978	4.1	0.1	75.4	0	1.8	9.9	0.7	6.1	1.9
Deer Creek	9,537	2.5	0.6	79.1	0	0.8	7.9	1.5	6.2	1.4
Goldsborough Creek	38,241	1.6	4.4	72.9	1.1	1.6	8.3	1.7	5.6	2.8
Hiawata Creek	871	0.3	0	72.3	0.0	0.5	11.7	0.1	12.7	2.4
Johns Creek	6,651	0.6	2.2	73.4	0.3	0.2	11.0	0.5	8.0	3.8
Kennedy Creek	12,766	0.1	0.9	80.5	1.1	0.2	6.8	0	3.3	7.3
Lynch Creek	830	2.7	0	36.9	0	0.4	31.6	3.5	21.2	3.8
Malaney Creek	2,326	1.0	1.4	44.3	0.2	9.2	25.1	0	16.2	2.6
Mill/Gosnell Creeks	19,058	3.6	0.4	62.1	0.0	2.0	17.4	0.2	10.7	3.6
Perry Creek	4,116	0.7	0.1	70.0	4.5	0.1	15.7	0	4.8	4.1
Schneider Creek	4,631	5.6	0.4	57.3	0.0	0	22.8	0.2	10.1	3.6
Shelton Creek	2,085	1.5	11.5	22.2	0.8	4.3	20.0	4.7	24.1	10.9
Sherwood/Schumacher Creeks	21,174	0	0.2	75.2	0	0.6	5.9	2.1	7.2	8.7
Skookum Creek	12,437	6.3	1.1	78.3	0	0.2	5.7	0.6	5.6	2.2
Snodgrass Creek	811	0	0	39.5	0	0	25.4	0	33.6	1.6
Uncle Johns Creek	1,136	13.9	0	38.9	0	0	21.2	0	24.4	1.7
All other watersheds	48,596	1.9	0.8	37.9	0.3	1.2	29.4	1.2	23.4	3.9
Average	**10,428**	**2.1**	**1.5**	**62.8**	**0.5**	**1.2**	**15.2**	**1.1**	**11.6**	**4.1**

[a] Data from NWIFC, 2016 Data sources: SSHIAP 2004; USFWS 2014, WADNR 2014a,b,c; WSDOT 2013; Ecology 1994, 2010, 2011a, 2013.

4.2.5 Land Cover Change Over Time

In order to determine potential stressors and pressures at the watershed scale, it is also useful to assess the change of land cover over time. NWIFC provided land cover data for WRIA 14 and a GIS analysis was performed to classify the data by watershed (see Table A-11 in Appendix A for details). The land cover data was available for two different time steps, 2006 and 2011, allowing an analysis of the change in land cover over this time period. Several of the land cover data categories were combined, in order to analyze the total change in developed land covers, forest land covers, and wetland land covers (Table 11).

Table 11. Summary of Changes (acres) in Developed, Forested, and Freshwater Wetland Land Cover Types from 2006 to 2011 in WRIA 14 Watershed[a]

Watershed	Sub-watershed Area (acres)	Change (acres) in Total Developed (High, Medium, Low Intensity and Open Space Developed)	Change (acres) in Total Forest (Deciduous, Evergreen, and Mixed Forest)	Change (acres) in Total Freshwater Wetland (Palustrine Forested, Scrub/Shrub, and Emergent)
Campbell Creek	2,954	0.0	-186.4	-0.1
County Line Creek	929	0.1	-8.8	0.0
Cranberry Creek	8,978	0.2	-153.7	4.9
Deer Creek	9,537	0.6	-994.4	0.4
Goldsborough Creek	38,241	216.4	-1539.8	0.2
Hiawata Creek	871	0.0	0.0	0.0
Johns Creek	6,651	37.8	-254.7	1.0
Kennedy Creek	12,766	0.4	-885.0	-0.2
Lynch	830	-0.1	-13.9	0.1
Malaney	2,326	12.2	-45.1	0.6
Mill/ Gosnell Creeks	19,058	0.0	-292.7	0.2
Perry Creek	4,116	8.5	-354.3	0.3
Schneider Creek	4,631	0.1	-136.2	-0.1
Shelton Creek	2,085	58.7	-117.8	-0.1
Sherwood/Schumacher Creeks	21,174	24.8	-1613.4	1.2
Skookum Creek	12,437	78.9	-667.2	0.1
Snodgrass Creek	811	0.0	0.0	0.0
Uncle Johns Creek	1,136	0.0	0.0	0.0
All other watersheds	48,596	111.7	-1182.2	2.6
Total (acres)	**198,126**	**550.3**	**-8445.5**	**11.0**

[a] Data from NWIFC, 2016 Data sources: SSHIAP 2004; USFWS 2014, WADNR 2014a,b,c; WSDOT 2013; Ecology 1994, 2010, 2011a, 2013.

The land cover change data indicates that substantial development occurred within WRIA 14 from 2011 to 2016, resulting in an increase in developed area of 550 acres over the entire WRIA. This growth was concentrated around Shelton, with half of the increase (275 acres) occurring in Goldsborough and Shelton

Creeks. However, several other watersheds, including Skookum Creek and Sherwood/Schumacher Creeks, also had substantial development.

Of potentially equal or greater significance is the loss of forest within numerous WRIA 14 watersheds. Overall, there was a loss of approximately8,400 acres of forest land cover between 2006 and 2011. This is equivalent to over four percent of the total WRIA 14 land area and accounts for a reduction of forest cover by approximately seven percent. The Sherwood/Schumacher Creeks and Goldsborough Creek watersheds accounted for approximately 37 percent of the total loss, or 3,150 acres. Some of the forest loss is likely associated with a concurrent increase in developed land cover types, however the scale of forest loss is over 15 times greater than the increase in developed land cover types, indicating that the majority of forest land cover conversion may not be permanent, but associated with commercial timber harvest. A calculated increase of approximately 8,000 acres of the grassland land cover type was also noted, which may indicate the effects of logging and account for the majority of forest loss. Such an occurrence is also supported by the fact that for the total forest land cover type lost between 2006 and 2011, 94 percent was classified as evergreen forest (see Table A-11 in Appendix A).

The loss of wetlands does not appear to a primary threat within WRIA 14, as the analysis showed 11 additional acres of wetland in 2011 as compared to 2006, a very small proportion of the almost 9,000 acres of total wetland land cover type in WRIA 14.

4.2.6 Surface and Groundwater Diversions

Man-made diversions of surface waters and ground water can have negative effects on salmonid species and habitats, particularly if the water use is consumptive. Effects resulting from alterations of the natural hydrograph and can include reduction of flow volumes and result in reductions of stream baseflows. The pumping of aquifers with shallow or deep wells effects hyporheic flows, reducing the rate of groundwater recharge. The loss of flow and/or recharge can negatively affect salmonids by reducing the area of available habitat in the summer months, which can also limit fish passage by creating either low-flow or thermal barriers to fish migration. Lower summer flows also directly contribute to higher stream temperatures, which can be exacerbated by dewatering of cold-water aquifers that reduce the contribution of colder groundwater.

In order to assess the potential threats from water withdrawals, it is useful to examine the extent of surface and groundwater diversions in WRIA 14 watersheds. The Ecology data set of Water Device Points was utilized to examine three classes of the features by watershed (Table 12). However, the results are of somewhat limited usefulness, as the available data included only points for “Unmapped Water Device Points.” The Kennedy Creek watershed, with over 400 mapped withdrawals, accounts for nearly 90% of the available data.

Table 12. Surface and Groundwater Diversions[a] in WRIA 14 Watersheds

Watershed	Headworks Gravity Flow	Surface Water Pump	Well	Grand Total
Goldsborough Creek	4		11	**15**
Hiawata Creek			1	**1**
John's Creek			3	**3**
Kennedy Creek	67	348	2	**417**
Lynch Creek			1	**1**
Malaney Creek	1		1	**2**
Mill/Gosnell Creeks			1	**1**
Perry Creek			1	**1**
Schneider Creek			1	**1**
Sherwood/Schumacher Creeks			4	**4**
Skookum Creek			3	**3**
Grand Total	**77**	**348**	**58**	**483**

[a] Water Device Point Data from Ecology, 2019.

Note that the table does not include data for "Unmapped Water Device Points." This data layer, which maps surface and groundwater diversions including dams, is not publically available. However, the "Unmapped Water Device Points" layer contains substantially more data, although the points are geo-located in the center of the section or quarter section the feature is contained within.

Additional data on unmapped water withdrawals were retrieved from Ecology and will be analyzed and applied further in the next phase of work. The additional dataset includes 2,862 groundwater, 897 surface water, 12 reservoirs, and 28 undefined water withdrawals in WRIA 14.

4.3 Future Population Growth and Climate Change

As mentioned above, the list of pressures and stressors that have been identified as important to salmon recovery in various planning documents in WRIA 14 have largely focused on the legacy impacts or current impacts of pressures. In developing a robust freshwater habitat strategy, it is also important to consider future threats and what is most likely to cause impacts in the future. The two most likely factors that have the potential to cause major change and exacerbate pressures in WRIA 14 are population growth and climate change. While these can be considered pressures themselves, it is often helpful to consider them as overarching contributing factors that lead to the increased scope or severity of other pressures and stressors in the WRIA. Both population growth and climate change have different predictive scenarios that model where and how each is likely to play out on the landscape. These scenarios are helpful to review and consider as pressures are assessed and strategies are developed in later phases of the Freshwater Strategy Update in order to prevent future degradation and protect the most threatened geographies or habitats to get ahead of future impacts.

For population growth, the impacts will largely depend on location. If new residents stay within urban growth boundaries or stay within certain locations that are serviced by utilities, the impacts from conversion, water withdrawals, and impervious surfaces for example will be less than if residential growth occurs in areas that are currently rural working lands - agriculture or forestry. If the scenarios show new growth in rural working lands, the impacts are likely to include habitat conversion, higher road densities, increased impervious surface, more water withdrawals – which may be a more significant impact because they are much more difficult to reverse or restore once converted.

The Mason County Comprehensive Plan (2017) states that between 2016 and 2036, the population is projected to increase by 34% or 21,480 (growing from 62,320 in 2016 to 83,800 by 2036). The City of Shelton is expected to increase by 6,130 (61%); the Shelton UGA is expected to increase by 3,480 (93%); the Urban Growth Areas of Allyn and Belfair by 1,730 (58%); and the rural county is expected to increase by 10,140 (22%). While not all of this growth is within WRIA 14, the projections can provide important tools for considering how future growth patterns will look on the landscape and impact watersheds in different ways and to different degrees.

The Streamflow Restoration Act process that is currently underway in WRIA 14 may provide another tool to identify future rural growth and the estimated impact on streamflow specifically from permit exempt wells. The number and location of projected wells may be used in conjunction with the information available from Table 12 above that shows surface and groundwater diversions to provide a clear picture of how flow may be impacted by population in each watershed.

Climate change is another contributing factor that will change hydrology and exacerbate other pressures acting on salmonids and their habitats. The University of Washington's Climate Impacts Group reviewed climate scenarios and their likely impact in Puget Sound (Mauger et al., 2015), concluding that freshwater habitats will likely experience increased high flows associated with increased storm events and lower flows in the summer and increased air temperatures.

The University of Washington's Climate Impacts Group developed a "Tribal Climate Tool" to analyze scenarios to determine the localized impacts on Squaxin Island Tribe, including WRIA 14, and identified the following issues by 2040 (Krosby et al., 2018):

- Annual average daily temperatures will increase
- Average daily maximum summer temperatures will increase
- The number of days in which the average daily maximum is over 86°F will increase
- The number of days with the minimum daily temperature remains above freezing will increase
- The total annual precipitation will increase
- The total precipitation between October and March will increase
- The total precipitation between April and September will decrease.

Higher temperatures in the summer resulting in droughts and/or disconnected surface and groundwater are predicted to particularly impact the species in WRIA 14 that rear in freshwater over summer months or return to spawn during lower flow periods. Figure 22 overlays the life stages, seasonality and likely impacts from climate change on each focal species in WRIA 14. This framework was adapted from

Beechie et al. (2012) to include climate predictions for WRIA 14 to help conceptually understand the timing and relative impacts to each life stage and each species.

In addition to the direct impacts from climate change, there is likely to be an increase or shift in other pressures as humans adapt to climate change. The scale and timing of these are something to consider as part of the strategy update. The impacts could include more bank hardening to reduce erosion from major storms, increased growth in upland areas if sea level rise or increased flooding shifts the population out of the areas that more likely to be inundated, increased barriers to fish as culverts that were previously passable become impassable with a change in flows or increased sediment, or new or increased invasive species as the shift in temperatures and hydrological regime becomes more favorable to non-native species.

Figure 22. Timing of climate change impacts by life stage of each focal species

5 PRIORITY DATA GAPS

Through this analysis, three types of priority data gaps were identified. These were data gaps related to existing habitat conditions, fish populations in each watershed, and future threats. This section describes each type of data gap separately.

5.1 Data Gaps to Inform Existing Habitat Conditions

Priority data gaps related to characterizing existing habitat conditions were identified in the Existing Information and Data Gaps Technical Memorandum (ESA, 2019). These data gaps are summarized below, with a focus on the benefit of the filling the data gap to inform and strengthen the KEA analysis of existing conditions.

1. **Data on Sediment Size and Distribution KEA Relevant Indicators**

   The analysis of the Sediment Size and Distribution KEA relies almost exclusively on condition ratings presented in the Kuttel (2002) LFA. With the exception of the LFA, little to no data are available on sediment transport or deposition, including data on stream substrate composition, percent fines in spawning gravel, or substrate embeddedness, for almost all WRIA 14 streams. The filling of these data gaps would be beneficial in that it would allow a more accurate assessment of the existing conditions for the Sediment Size and Distribution KEA, which in turn would allow for a more accurate assessment of the impact of development pressures in the future.

2. **Data on Habitat Complexity KEA Relevant Indicators**

   Although the analysis of the Habitat Complexity KEA includes multiple studies on several streams that have occurred since the LFA analysis, the focus of such studies has primarily been on five larger watersheds within WRIA 14 and has been limited to specific reaches or portions of the watersheds. Twelve of the 17 watersheds analyzed in the KEA rating process completely lacked survey or summary data on instream habitat surveys in mainstem and tributaries, introducing uncertainty into the estimation of fish habitat quality. The collection of comprehensive data on each watershed (including LWD abundance, pool frequency and characteristics, the presence of man-made modifications to streambanks, and side channel connectivity) would provide data on those watersheds where no data exists and would assist in characterizing habitat quality in specific reaches or sub-basins of the larger watersheds. This would increase the accuracy and detail of the existing conditions for the Habitat Complexity KEA, which in turn would allow more accurate assessment of development pressures in the future.

3. **Data on the Water Temperature Regime and Ecology of Lakes in those Watersheds with Mid-line or Headwater Lakes.**

   Previous studies have indicated that solar radiation of midline or headwater lakes in several watersheds can cause sub-optimal or lethal water temperatures in the both lakes and in stream reaches downstream. These conditions can affect salmonid distribution, growth, and survival. In addition, warmer lake temperatures also support different biological communities, notably fish predators of salmon, which can cause survival bottlenecks for salmon moving through the lakes. While temperature data are available in some lake systems, it is recommended to collect additional temperature data (especially in summer) in lakes and in downstream reaches to understand the water temperature conditions of the watershed. This could be coupled with the collection of information to characterize the movement of juvenile salmon into and out of lakes in different seasons and to characterize predatory effects on juveniles from predation by warmwater species. This would inform an estimation of survival rates and would also inform the degree that predation or competition from non-native fish serve as a stressor.

5.2 Data Gaps in Fish Populations and Trends

Much of the spawning ground survey effort has been focused on Coho and Chum Salmon; therefore, the populations of species whose spawn timing is during other parts of the year are not as well documented. For example, Coastal Cutthroat Trout populations in the watersheds are not well studied despite their occurrence across the WRIA. Expanded spawning ground surveys to include late winter and spring spawning species would provide helpful information to increase our understanding of other salmonids in WRIA 14, especially Coastal Cutthroat Trout.

There is also a data gap on salmon use in the smaller tributaries of WRIA 14. WDFW and the Squaxin Island Tribe conduct spawning ground surveys in many creek systems in the WRIA, but there are other systems for which little information is known about species presence, abundance, and productivity.

5.3 Data Gaps to Inform Future Threats Analysis

Ecology data on surface and groundwater diversions were obtained and reported on in Section 4.2.6. Estimates of future water withdrawals are being developed by Water Restoration and Enhancement Committee. Those estimates should be incorporated into future threats analysis in a future project phase.

The pressures and stressors that had no data immediately available for analysis were extent of flood control structures like dikes and levees, and extent of bank hardening along mainstems, tributaries and lakes. In addition, the extending, location, and timing of both dredging and mining would be important datasets to acquire ahead of a formal pressures assessment. Invasive species should also be further explored to determine what species are of most concern in freshwater habitats, and gather or collect information on extent and location. Invasive species are likely to increase with both population growth and climate change as mentioned above.

6 RECOMMENDATIONS AND NEXT STEPS

This report summarizes the first phase of the update to the 2004 Salmon Habitat Protection and Restoration Plan for WRIA 14. Phase 1 of the strategy update consisted of a technical analysis of data collected since 2004 on the habitat conditions, salmonid distribution and abundance, the relationship between species life histories and key habitat elements (as KEAs), and on potential key stressors to the identified KEAs. The information in this report, potentially supplemented by the filling of additional data gaps identified in this report, will serve as the basis of Phase 2 of the Freshwater Habitat Strategy update, which will consist of prioritizing watersheds and reaches for restoration and protection. The framework of the technical analysis is based on firmly established salmonid restoration principles and will facilitate the identification of strategies and actions that will result in meaningful species restoration, as they will be based on established biological linkages on habitat usage and importance for all freshwater life history phases of the focal species for WRIA 14.

The following list identifies the recommended next steps and is followed by a more detailed description of each recommendation. The following steps are recommended to complete the Freshwater Habitat Strategy update. The steps are listed below, then described in more detail:

- Prioritize reaches for restoration and prioritization
- Fill data gaps for existing conditions and pressures
- Incorporate new data into a revised existing conditions (KEA) analysis and pressures analysis
- Complete a pressures assessment with stakeholders using the technical information from Phase 1, updated as described above
- Develop recovery strategies and actions and an adaptive management process

<u>Prioritization of Reaches for Restoration and Protection</u>

WRIA 14 is interested in a reach-scale prioritization of habitats for restoration and protection. Table 13 lists the reaches planned to be included in a reach prioritization.

Table 13. Prioritization Reaches for WRIA 14 Watersheds

Watershed	Reach Description
Campbell	entire watershed
County Line	entire watershed
Cranberry	downstream of Lake Limerick
	Lake Limerick
	reach between Lake Limerick and Cranberry Lake
	Cranberry Lake to headwaters
Deer	entire watershed
Elson	entire watershed

Watershed	Reach Description
Goldsborough	downstream of Coffee Creek
	Coffee Creek - new mouth to downstream of wetlands at RM 1.5
	Coffee Creek - wetlands at RM 1.5 upstream to headwaters
	from Coffee Creek to ~RM 6.1
	from ~RM 6.1 to confluence of North Fork and South Fork
	Lower North Fork Goldsborough, including Dayton Creek
	Winter Creek
	from confluence of North Fork and South Fork to RM 10.3
	RM 10.3 to 11.3
Johns	downstream of East Johns Creek Drive (RM 2.6)
	upstream of East Johns Creek Drive
Jones	entire watershed
Kennedy	downstream of barrier falls
	upstream of barrier falls
	Summit Lake
Lynch	entire watershed
Malaney	entire watershed
Mill/Gosnell	Mill Creek
	Isabella Lake
	Rock Creek
	Gosnell from lake to confluence of Mystery Creek (0033)
Perry	downstream of barrier falls
	Mystery Creek
	U/S of barrier falls
	Gosnell upstream of Mystery Creek confluence
Schneider	downstream of Hwy 101
	upstream of Hwy 101
Shelton	downstream of RM 1.3 (hospital)
	Canyon Creek
	upstream of RM 1.3
Sherwood/Schumacher	mouth of Sherwood Creek to D/S of Mason Lake
	Anderson Creek
	Mason Lake
	Schumacher Creek upstream of Mason Lake
Skookum	downstream of RM 6
	mouth of Little Creek to RM ~0.7
	Little Creek RM 0.7 U/S
	Tributaries between RM 4.3 and 6.0
	upstream of RM 6
Snodgrass	entire watershed
Uncle Johns	entire watershed

WRIA 14 is interested in a multi-species approach to recovery planning. To maximize the potential benefits that will result from the restoration strategy update developed in Phase 2, it is necessary to define whether all focal species or a subset will be the primary focus for the pressures assessment and formulation of restoration strategies. In our experience it is beyond the resources of any WRIA to truly develop a recovery plan for every salmonid in a basin, and well beyond the available restoration funding to implement projects; therefore, a subset of species is an approach often utilized. The subset selected can serve as proxies for other species due to similarities in life history and habitat requirements. Alternatively, an "umbrella species" is selected that covers a larger suite of habitat types or amount of time in freshwater. To assess pressures and to use that information to formulate restoration strategies, it is necessary to explicitly select the primary focal species (singular or plural). It will be important to state the justification for the primary focal species and assumptions upfront in a pressures assessment. This approach is still consistent with a multi-species approach, as the geographical overlap of species distribution can result in benefits that extend to all species within the geography. In addition, the strategies and actions in the plan can include details to identify what species most benefit from the project (primary and secondary benefitting).

A similar prioritization may be applied to the geography of WRIA 14 as well. The analysis and data in this report clearly demonstrate that the size, extent, and type of salmonid use, as well as the condition of the individual watersheds within the WRIA, vary substantially. Based on this information, and in conjunction with defining priority species, it is possible to define a list of priority watersheds to focus our restoration actions. Overall, clearly defining the restoration goal, including target species and geographic focus, will allow for the development of strategies that result in maximum benefit and allow for measurement of restoration effectiveness.

Fill Data Gaps

Section 5 identified a list of key data gaps both for the characterization of existing conditions and the evaluation of threats. Table 14 presents different approaches, based on a scale of level of effort, that could be used for collecting field data to fill some of the key data gaps, which would result in a more robust evaluation of existing KEA conditions and ratings. The reconnaissance-level survey is an alternate approach in place of the more intensive habitat surveys and sediment inputs investigation.

In addition to conducting field work to assess *in situ* conditions, the existing conditions analysis can be further scaled to smaller units of analysis, such as stream reaches within watersheds. Conducting additional GIS analysis on some existing condition data (such as riparian conditions, fish distribution, and spawning distribution) would allow for both better characterizations of some KEAs at a smaller scale and would be useful for the pressures analysis.

Likewise, a more detailed analysis of GIS data that informs potential threats is also recommended and would add substantial value to the pressures assessment. As with existing habitat conditions, this would include conducting analyses on key threats at a finer sub-basin scale, potentially including road density, barrier culverts, land cover, land use, and water diversions. In some cases, such as for water diversions, the acquisition of additional data sets would also inform the magnitude and location of such threats.

Incorporate New Data

Once existing condition data gaps are filled to the extent possible and practicable, the new data and analysis should be incorporated into the existing conditions analysis, as appropriate. It should be incorporated into the KEA analysis and the rating for each watershed updated, if necessary. Likewise, updated data relevant to the potential threats should be used as a primary source while conducting the pressures assessment.

Table 14. Potential Effort to Fill Selected Key Habitat Data Gaps

Data Gap	Lower Effort	Higher Effort
Habitat Surveys	Biologists systematically collect instream and riparian habitat data in a small subset of watersheds and reaches. Spreadsheet with data will be provided; findings documented in report.	Biologists systematically collect instream and riparian habitat data in more comprehensive set of watersheds and reaches. Spreadsheet with data provided; findings documented in report.
Sediment Inputs and Geomorphology Investigation	Abbreviated GIS analysis and field verification of channel unit type per WDNR guidelines; report describing methods and findings, as well as GIS layers.	GIS analysis and field verification of channel unit type per WDNR guidelines; report describing methods and findings, as well as GIS layers.
Combined Reconnaissance-Level Survey to Inform Habitat and Sediment Input Data Gaps (*this is an alternative approach to addressing the two data gaps listed above*)	Biologists and geomorphologists walk parts of creek systems to observe instream/ floodplain/ riparian conditions and observe sediment input and geomorphological conditions. Observations applied in analysis but no separate report.	Biologists and geomorphologists walk parts of creek systems to observe instream/ floodplain/ riparian conditions and observe sediment input and geomorphological conditions. Observations report provided.

Conduct Pressures Assessment

To prepare for a full pressures assessment that determines the scope, severity, and irreversibility of each pressure, it is helpful to generate maps to determine the location and extent of the pressure. While the tables above are useful for determining the amount and the relative proportions of a pressure by watershed, the location of a pressure is important to identify and understand to determine how much of a threat it poses to each species. A small percentage of a watershed may be impacted, but if it occurs in a critical location for a given species, it will rate as a pressure of higher importance than one that may represent the same percentage of the watershed but in a less critical location. The process of developing a full pressures assessment is best done with representatives across technical and policy backgrounds in the WRIA to document assumptions and set the groundwork for collective agreement on what pressures and stressors to address for each species.

Additional Steps to Update the WRIA 14 Freshwater Habitat Strategy

Following a pressures assessment, priority strategies and actions are identified to address each priority pressure. This may include restoration to address legacy pressures, as well as protection, mitigation, and policy changes to address both current and future pressures. A full strategy update should also include elements such as the identification of an adaptive management approach so there is a clarity on the process for incorporating new information in the WRIA from monitoring and research as it becomes available.

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APPENDIX A: Additional Data Tables

Table A- 1. WRIA 14 Coho Salmon Distribution Data

Subwatershed	Total Distribution	Spawning	Documented Presence	Presumed Presence	Percent of Total Distribution Stream Length in WRIA 14	Percent of Spawning Distribution Stream Length in WRIA 14
Campbell Creek	1.8		1.8		1%	0%
County Line Creek	0.7		0.7		0%	0%
Cranberry Creek	8.0	4.6	3.4		5%	8%
Deer Creek	10.4	7.9	2.5		7%	14%
Goldsborough Creek	23.2	9.8	11.1	2.2	15%	18%
Hiawata Creek	0.5		0.5		0%	0%
Johns Creek	9.1	3.6	4.6	1.0	6%	6%
Kennedy Creek	3.8	2.4	1.4		2%	4%
Lynch Creek	2.9	1.0	1.9		2%	2%
Malaney Creek	2.6		0.4	2.2	2%	0%
Mill/Gosnell Creeks	26.2	10.5	15.7		17%	19%
Perry Creek	1.6		1.1	0.6	1%	0%
Schneider Creek	4.6		4.6		3%	0%
Shelton Creek	2.7		2.7		2%	0%
Sherwood/Schumacher	24.3	11.2	12.4	0.7	16%	20%
Skookum Creek	17.3	3.8	13.5		11%	7%
Snodgrass Creek	0.6		0.6		0%	0%
Uncle Johns Creek	1.9		1.0	0.9	1%	0%
All other sub-watersheds	13.6	1.0	12.5		9%	2%
Total	**155.6**	**55.7**	**92.5**	**7.4**	**100%**	**100%**

Source: WDFW (2019a) SWIFD.

Table A- 2. WRIA 14 Fall Chum Salmon Distribution Data

Subwatershed	Total Distribution	Spawning	Documented Presence	Presumed Presence	Percent of Total Distribution Stream Length in WRIA 14	Percent of Spawning Distribution Stream Length in WRIA 14
Campbell Creek	0.9		0.9		1%	0%
County Line Creek	0.6		0.6		0%	0%
Cranberry Creek	11.1	7.9	3.2		8%	14%
Deer Creek	3.0	2.7	0.2	0.1	2%	5%
Goldsborough Creek	10.6	2.1	5.1	3.5	8%	4%
Hiawata Creek	0.5		0.5		0%	0%
Johns Creek	7.9	7.2	0.4	0.4	6%	13%
Kennedy Creek	3.1	2.7	0.4		2%	5%
Lynch Creek	2.1	1.5	0.6		2%	3%
Malaney Creek	2.6		0.4	2.2	2%	0%
Mill/Gosnell Creeks	17.9	10.5	7.3		13%	19%
Perry Creek	1.5		1.1	0.4	1%	0%
Schneider Creek	4.2		4.2		3%	0%
Shelton Creek	3.4	1.7	1.7		3%	3%
Sherwood/Schumacher	32.2	8.3	21.1	2.8	24%	15%
Skookum Creek	17.2	5.6	11.6		13%	10%
Snodgrass Creek	0.6	0.6			0%	1%
Uncle Johns Creek	1.0		1.0		1%	0%
All other sub-watersheds	12.5	1.6	10.0	0.8	9%	3%
Total	**132.8**	**52.5**	**70.2**	**10.1**	**100%**	**94%**

Source: WDFW (2019a) SWIFD.

Table A- 3. WRIA 14 Summer Chum Salmon Distribution Data

Subwatershed	Total Distribution	Spawning	Documented Presence	Presumed Presence	Percent of Total Distribution Stream Length in WRIA 14	Percent of Spawning Distribution Stream Length in WRIA 14
Campbell Creek						
County Line Creek						
Cranberry Creek	5.5	4.0	1.5	0.0	21%	31%
Deer Creek	1.5	1.3	0.0	0.1	6%	10%
Goldsborough Creek						
Hiawata Creek						
Johns Creek	4.0	3.6	0.0	0.4	15%	28%
Kennedy Creek						
Lynch Creek						
Malaney Creek						
Mill/Gosnell Creeks						
Perry Creek						
Schneider Creek						
Shelton Creek						
Sherwood/Schumacher	15.6	3.9	10.0	1.7	59%	30%
Skookum Creek						
Snodgrass Creek						
Uncle Johns Creek						
All other sub-watersheds						
Total	**26.5**	**12.8**	**11.5**	**2.2**	**100%**	**100%**

Source: WDFW (2019a) SWIFD.

Table A- 4. WRIA 14 Steelhead Distribution Data

Subwatershed	Total Distribution	Spawning	Documented Presence	Presumed Presence	Percent of Total Distribution Stream Length in WRIA 14	Percent of Spawning Distribution Stream Length in WRIA 14
Campbell Creek	2.6			2.6	2%	0%
County Line Creek					0%	0%
Cranberry Creek	8.5		4.0	4.4	8%	0%
Deer Creek	8.3		8.3		8%	0%
Goldsborough Creek	20.3	6.3	13.5	0.5	19%	27%
Hiawata Creek					0%	0%
Johns Creek					0%	0%
Kennedy Creek	3.6		2.8	0.8	3%	0%
Lynch Creek	2.0		2.0		2%	0%
Malaney Creek	2.6			2.6	2%	0%
Mill/Gosnell Creeks	23.5	10.3	11.2	1.9	21%	43%
Perry Creek	1.2		1.2		1%	0%
Schneider Creek	5.2		5.2		5%	0%
Shelton Creek	1.7	1.4	0.3		2%	6%
Sherwood/Schumacher	16.8	1.3	14.8	0.7	15%	6%
Skookum Creek	11.9	4.4	6.5	1.1	11%	18%
Snodgrass Creek					0%	0%
Uncle Johns Creek	0.5			0.5	0%	0%
All other sub-watersheds	0.5			0.5	0%	0%
Total	**109.2**	**23.7**	**69.7**	**15.8**	**100%**	**100%**

Source: WDFW (2019a) SWIFD.

Table A- 5. Specific Data Sources for the WRIA 14 Strategy Update and How Data Was Utilized in Analysis

Citation	Full Reference	Data Utilization
ASEG, 2002	ASEG (Allyn Salmon Enhancement Group).2002. 2000-2002. Sherwood Creek Baseline Salmon Habitat Study.	Existing habitat condition data for sediment condition, pool frequency, LWD frequency, and stream temperature in Sherwood Creek
Brakensiek, 2008	Brakensiek. K. 2008. Further Field Investigations on Factors Limiting the Abundance of Juvenile Coho Salmon in the Sherwood – Schumacher Creek basin, South Puget Sound, Washington, Year 2008. Prepared for the Squaxin Island Tribe and The South Puget Sound Salmon Enhancement Group	Existing habitat condition data for pool frequency and stream temperature in Sherwood – Schumacher Creek.
Caldwell, 2014	Caldwell, J. 2014. Skookum Creek Watershed Limiting Factors & Available Information: Discussion Paper. Prepared for the Squaxin Island Tribe	Existing habitat condition data for off-channel habitat and stream temperature in Skookum Creek.
Caldwell, 2015	Caldwell, J. Skookum Creek Watershed Limiting Factors, Gaps & Available Information. 2015. Prepared for the Squaxin Island Tribe.	Existing habitat condition data for stream temperature, sediment quality, and LWD frequency in Skookum Creek.
Ecology, 2007	Ecology (Washington Department of Ecology). 2007. Tributaries to Totten, Eld and Little Skookum Inlets- Fecal Coliform Bacteria and Temperature Total Maximum Daily Load Water Quality Implementation Plan. https://fortress.wa.gov/ecy/publications/documents/0710071.pdf	Existing habitat condition data for stream temperature in Skookum Creek
Ecology, 2018	Ecology (Washington Department of Ecology). Cranberry, Johns, and Mill Creeks Temperature Characterization Study: Three Creeks in Mason County, June 2018, Publication No. 18-10-022. https://fortress.wa.gov/ecy/publications/documents/1810022.pdf	Existing habitat condition data for stream temperature in Cranberry, Johns, and Mill Creeks
GeoEngineers and Reid Middleton, 2015	GeoEngineers and Reid Middleton. 2015. Railroad Culvert Assessment for Fish Passage Shelton-Bangor-Bremerton Railroad. Prepared for the Naval Facilities Engineering Command. June 14, 2015. N44255?10?D?5000/0033.	Existing habitat condition data for fish passage and in threats analysis.
Kuttel, 2002	Kuttel Jr, M. 2002. Salmonid Habitat Limiting Factors: Water Resource Inventory Area 14, Kennedy-Goldsborough Basin. Washington State Conservation Commission.	"Historic" existing habitat condition data for all watersheds and most indicators.
Marbet, 2015a	Marbet, E. 2015a. Preliminary Analysis of Lake Limerick and Cranberry Creek Temperature and Flow. Squaxin Island Tribe	Existing habitat condition data for stream temperature in Cranberry Creek
Marbet and Caldwell, 2015	Marbet, E. and J. Caldwell. 2015. Mill Creek Water Temperatures and Lake Isabella Water Quality Investigations. Prepared for the Squaxin Island Tribe.	Existing habitat condition data for stream temperature in Mill Creek
MCD, 2016a	MCD (Mason Conservation District). 2016a. Data Summary for Japanese Knotweed Surveys in Mill and Goldsborough Creek.	Data will be used to inform Phase 2 (Project Action Development) in Mill and Goldsborough Creeks
MCD, 2016b	MCD (Mason Conservation District). 2016b. WRIA 14 Riparian Assessment.	Existing habitat condition data for stream temperature in most sub-watersheds
May, et al. 2004	May, C.W., M.C. Miller, and J.A. Southard. 2004. An Analysis of Stream Culvert Fish Passage on the Navy Railroad Line between Bremerton and Shelton, Washington. Prepared for the Puget Sound Naval Shipyard and Intermediate Maintenance Facility	Existing habitat condition data for fish passage and in threats analysis.
Mobrand, 2004	Mobrand Biometrics. 2004. EDT Analysis of Habitat Potential and Restoration Opportunities.	Existing habitat condition data/limiting factors for Goldsborough, Johns, and Skookum Creeks
Mueller, 1997	Mueller, K. W. 1997. Mason Lake Survey: The Warmwater Fish Community of a Lake Dominated by Non-Game Fish. Prepared for Washington Department of Fish and Wildlife.	Existing fish conditions (non-native species) for Schumacher-Sherwood Creeks
Pierce, 2015	Pierce, K. 2015. High Resolution Land Cover Data. Washington Department of Fish and Wildlife	Existing habitat condition data to inform analysis of stream temperature in all sub-watersheds
Squaxin Island Tribe, 2009a	Squaxin Island Tribe. 2009a. Timber Fish and Wildlife Survey Data Forms for 2009 surveys of the mainstem and South Fork Goldsborough Creek and Coffee Creek. Conducted by Squaxin Tribal staff	Existing habitat condition data for sediment condition and pool frequency
Squaxin Island Tribe, 2009b	Squaxin Island Tribe Natural Resources Department. 2009b. Goldsborough Creek Action Plan.	Information will be used to inform Phase 2 (Project Action Development) in Goldsborough Creeks
Squaxin Island Tribe, 2009c	Squaxin Island Tribe. 2009c. Recommendations for restoration and/or preservation of the biological resources in Johns Creek.	Existing habitat condition data for stream temperature, sediment quality, and LWD frequency in Johns Creek.
Squaxin Island Tribe, et al., 2014	Squaxin Island Tribe, Mason County, and WSU Extension. 2014. Update Report for Mason County Pollution Inventory and Correction Program. Prepared for the Washington State Department of Health. March 7, 2014.	Information will be included in Pressures Assessment, to classify areas with degraded water quality
Squaxin Island Tribe, 2015a	Squaxin Island Tribe. 2015a. Mill Creek Action Plan. Prepared by Squaxin Island Tribe Natural Resources Department	Information will be used to inform Phase 2 (Project Action Development) in Mill Creek
Squaxin Island Tribe, 2015b	Squaxin Island Tribe. 2015b. 2013 to 2015 Mill Creek Mill Creek Habitat and Snorkel Survey Results	Existing habitat condition data for pool frequency
Squaxin Island Tribe and Mason County, 2015	Squaxin Island Tribe and Mason County. 2015. Update Report for Mason County Pollution Inventory and Correction Program. Prepared for the Washington State Department of Health. February 2, 2015.	Information will be included in Pressures Assessment, to classify areas with degraded water quality

Citation	Full Reference	Data Utilization
Squaxin Island Tribe, 2016	Squaxin Island Tribe Natural Resources Department. 2016. 2016 Skookum Creek Snorkel Survey Results.	Report will include information on relationship between juvenile Coho Salmon presence and cool stream temperatures (existing conditions) and will be also used to inform Phase 2 (Project Action Development) in Skookum Creek
Squaxin Island Tribe, 2017	Squaxin Island Tribe Natural Resources Department. 2017. 2017 Skookum Creek Snorkel Survey Results.	Report will include information on relationship between juvenile Coho Salmon presence and cool stream temperatures (existing conditions) and will be also used to inform Phase 2 (Project Action Development) in Skookum Creek
Squaxin Island Tribe, 2018a	Squaxin Island Tribe Natural Resources Department. 2018a. 2018 Skookum Creek Snorkel Survey Results.	Report will include information on relationship between juvenile Coho Salmon presence and cool stream temperatures (existing conditions) and will be also used to inform Phase 2 (Project Action Development) in Skookum Creek
Squaxin Island Tribe, 2018b	Squaxin Island Tribe Natural Resources Department. 2018b. Skookum Watershed Fish and Wildlife/ Riparian Habitat Acquisition and Protection Plan.	Information will be used to inform Phase 2 (Project Action Development) in Goldsborough Creeks
Stillwater, 2007	Stillwater Sciences. 2007. An Analysis of Potential Factors Limiting Coho Salmon Populations in Mill and Sherwood Creeks, South Puget Sound, Washington.	Existing habitat condition data for stream temperature and canopy cover in Mill and Sherwood Creeks
Stillwater, 2008	Stillwater Sciences. 2008. Further Field Investigations on Factors Limiting the Abundance of Juvenile Coho Salmon in the Sherwood - Schumacher Creek basin, South Puget Sound, Washington.	Existing habitat condition data for stream temperature and canopy cover in Sherwood Creek
Stevie, 2004	Stevie, M. 2004. Large Woody Debris/Habitat Restoration Project, in Tributaries of Goldsborough and Skookum Creeks. Prepared for the Squaxin Island Tribe.	Existing habitat condition data for stream temperature, pool frequency, and LWD frequency in Goldsborough and Skookum Creeks
WDFW, 2019a	Washington Department of Fish and Wildlife. 2019a. Statewide Washington Integrated Fish Distribution (SWIFD) database.	Used database to determine distribution of documented salmonids, including documented spawning and rearing, in the project area, as well as the amount of mapped potential habitat. Used to classify existing conditions for salmonids.
WDFW, 2019b	Washington Department of Fish and Wildlife. 2019b. WRIA 14 Spawning Survey Database.	Used database to determine distribution and populations of spawning salmonids in the project area.
WDFW, 2019c	Washington Department of Fish and Wildlife and Washington Department of Transportation. 2019c. Fish Passage Barrier Inventory GIS Database.	Analyzed database to determine number of full and partial barriers in each sub-watershed
Watershed Sciences, Inc., 2004	Watershed Sciences, Inc. 2004. Aerial Survey of Mill, Cranberry and Johns Creeks. Thermal Infrared and Color Videography. Prepared for the Squaxin Island Tribe.	Existing habitat condition data for stream temperature in Mill, John, and Cranberry Creeks. Information may also be used to inform Phase 2 (Project Action Development) for riparian/groundwater input restoration projects.
Watershed Sciences, Inc., 2005	Watershed Sciences, Inc. 2005. Aerial Survey of Skookum and Goldsborough Creeks, WA. Thermal Infrared and Color Videography. Prepared for the Squaxin Island Tribe.	Existing habitat condition data for stream temperature in Skookum and Goldsborough Creeks. Information may also be used to inform Phase 2 (Project Action Development) for riparian/groundwater input restoration projects.
WFC, 2019	WFC (Wild Fish Conservancy). 2019. Stream Typing Data from WRIA 14.	Used database to determine distribution stream segments that are Type F, and that either support fish or are capable of supporting fish based on stream physical characteristic (slope and BFW)
WSDOT (2019)	WSDOT (Washington Department of Fish and Wildlife). 2019. WSDOT Fish Passage Inventory Online Mapper. Available at: https://www.wsdot.wa.gov/data/tools/geoportal/?config=fish-passage-barriers	Analyzed database to determine number of full and partial barriers in each sub-watershed. Information will also be used to inform Phase 2 (Project Action Development) for fish passage actions.
Zaniewski, 2019	Zaniewski, S. 2016-2018. Summary Reports from Skookum Creek Snorkel Survey Efforts	Existing habitat condition data for stream temperature in Skookum Creek

Table A-6. Existing Condition Analysis[a] and KEA Rating of WRIA 14 Subwatersheds by Key Ecological Attributes

Stream Temperature KEA	Data Source	Subwatershed							
		Campbell Creek	County Line Creek	Cranberry Creek	Deer Creek	Goldsborough Creek	Gosnell Creek	Mill Creek (including Isabella Lake)	Johns Creek
Indicators		Poor (DG)	Fair (DG)	Poor	Poor	Fair	Good	Poor	Fair
Cat 5 303(d) Temperature and DO Listings	1	Temperature (Listing ID# 48745)	No	Temperature (Listing ID# 72644)	Temperature (Listing ID# 23756) & DO (Listing ID# 9443)	Temperature (lower 0.8 mi only) (Listing ID# 10900)	No	Temperature (Listing ID# 9446, 40597, 40598, 40599, & 48737) & DO (Listing ID# 78083)	Temperature (Listing ID# 23751)
Stream Temperature (Misc. Data Sources)	2	Poor (Squaxin Island Tribe, 2019 - monthly sampling)		Poor (Watershed Sciences, Inc., 2004; Marbet, 2015a; Ecology, 2018)	Good (Squaxin Island Tribe, 2019 - spot check)	Fair (Watershed Sciences, Inc., 2005) Good (USGS - Provisional Data, 2019)	Good (Watershed Sciences, Inc., 2004; Stillwater, 2007; Marbet and Caldwell, 2015; Ecology, 2018)	Poor (Watershed Sciences, Inc., 2004; Stillwater, 2007; Marbet and Caldwell, 2015; Ecology, 2018)	
Canopy Cover (Misc. Data Sources)	3					Good (Squaxin Island Tribe, 2009a)		Fair (Marbet and Caldwell, 2015)	
Major Lakes (basin position)*	4	Phillips Lk and Timber Lk (headwaters)		Cranberry Lk (upper-mid basin) & Lk Limerick (mid-basin)	Benson Lk (limited surface connection) and Mason Lk (contributes groundwater flow to stream but no surface connection)			Isabella Lk (headwaters)	Johns Lk (headwaters)
Percent Forest in Riparian Buffer	5	73%	81%	49%	56%	73%	83%	65%	40%
Canopy Height (% low canopy from MCD, 2016b)	6	33% lc	35% lc	37% lc	40% lc	43% lc	39% lc	39% lc	Gap
Stream Flow Rule Adherence (% of summer numerical rule not met)*	7	Gap (seasonal closure and numerical rule)	n/a (no numerical rule)	56% rnm	Gap (seasonal closure and numerical rule)	68% rnm	Gap (numerical rule)	87% rnm	50% rnm
Stream Temperature (from LFA)*	8	Poor	Gap	Poor	Gap	Good	Good	Good	Poor
Canopy Closure (from LFA)	9	Poor	Poor	Good	Poor	Poor	Poor	Poor	Poor
Stream Flow/Low Flow (from LFA)*	10	Gap	Gap	Poor	Gap	Poor	Gap	Gap	Poor

Sediment Condition KEA	Data Source	Sub-watershed							
		Campbell Creek	County Line Creek	Cranberry Creek	Deer Creek	Goldsborough Creek	Gosnell Creek	Mill Creek (including Isabella Lake)	Johns Creek
Indicators		Fair (DG)	Fair (DG)	Fair (DG)	Fair (DG)	Fair	Fair	Fair (DG)	Fair (DG)
Sediment Size and Distribution (Misc. Data Sources)	11					Good (Squaxin Island Tribe, 2009a)	Fair to Good (Squaxin Island Tribe, 2015a)		Fair to Poor (Squaxin Island Tribe, 2009c)
Embeddedness (Misc. Data Sources)	12					Good (Squaxin Island Tribe, 2009a)			
Embeddedness (from LFA)	13	Fair	Fair	Fair	Good	Fair	Fair	Fair	Fair
Changes in Flow Regime (high flow) (from LFA)*	14	Gap	Fair	Poor	Gap	Poor	Gap	Gap	Gap
Stream Bank Condition (from LFA)	15	Fair	Gap	Gap	Poor	Poor	Fair to Poor	Fair to Poor	Fair

[a] Note that ror the assessments of indicators by watershed, the good, fair, poor rating is the authors best professional judgement on the rating of the idicator, based on the data source and is not an assessment of data quality.

Gray shading indicates older data source (e.g., 2002 Limiting Factors Analysis)

CONDITION BIN KEY

Good = KEA is properly functioning throughout majority of subwatershed , providing or supporting most relevant habitat elements required by all salmonids and life history stages	Fair = KEA is properly functioning throughout some portion of subwatershed or is of moderate function through majority of subwatershed, providing or supporting some relevant habitat elments required by all salmonids and life history stages	Poor = KEA is not properly functioning throughout all or most of subwatershed , providing or supporting few relevant habitat elments required by all salmonids and life history stages. Likely a limiting factor to salmonid production.

Stream Temperature KEA	Sub-watershed								
	Kennedy Creek	Malaney Creek	Perry Creek	Schneider Creek	Schumocher-Sherwood Creeks	Shelton Creek	Skookum Creek	Snodgrass Creek	Uncle John's Creek
Indicators	Fair	Poor (DG)	Good	Fair	Poor	Good	Poor	Fair (DG)	Poor (DG)
Cat 5 303(d) Temperature and DO Listings	DO (Listing ID# 41467)and TMDL for Temperature (Listing ID# 23545)	Temperature (Listing ID# 48741)	DO - lower 0.3 mi only (Listing ID# 41437)	DO (Listing ID# 78074)	No	No	DO	No	Temperature (Listing ID# 73408)
Stream Temperature (Misc. Data Sources)	Fair (Thurston County, 2019)		Good (Thurston County, 2019)	Fair (Thurston County, 2019)	Poor (ASEG, 2002; Stillwater, 2007, 2008; Brakensiek, 2008; Zaniewski, 2018)	Good (Squaxin Island Tribe, 2019 - spot check)	Poor (Watershed Sciences, Inc., 2005; Ecology, 2007; Caldwell, 2014, 2015)		Poor (Squaxin Island Tribe, 2019 - spot check)
Canopy Cover (Misc. Data Sources)					Poor (Stillwater, 2007. 2008)				
Major Lakes (basin position)*	Summit Lk (headwaters)	Spencer Lk (headwaters)			Mason Lk (mid-basin)				
Percent Forest in Riparian Buffer	73%	53%	77%	79%	68% (Sherwood) 48% (Schumacher)	48%	75%	80%	73%
Canopy Height (% low canopy from MCD, 2016b)	38% lc	Gap	Gap	40% lc	31% lc	48% lc	43% lc	34% lc	44% lc
Stream Flow Rule Adherence (% of summer numerical rule not met)*	Gap (seasonal closure and numerical rule)	n/a (no numerical rule)	Gap (seasonal closure and numerical rule)	Gap (closure)	42% rnm (Sherwood only)	Gap (closure)	58% rnm	n/a	Gap (closure)
Stream Temperature (from LFA)*	Gap	Gap	Gap	Gap	Poor	Gap	Gap	Gap	Poor
Canopy Closure (from LFA)	Poor	Poor	Poor	Poor	Gap	Poor	Poor	Gap	Gap
Stream Flow/Low Flow (from LFA)*	Gap	Gap	Gap	Fair	Good	Poor	Poor	Gap	Gap

Sediment Condition KEA	Sub-watershed								
	Kennedy Creek	Malaney Creek	Perry Creek	Schneider Creek	Schumocher-Sherwood Creeks	Shelton Creek	Skookum Creek	Snodgrass Creek	Uncle John's Creek
Indicators	Fair (DG)	Fair (DG)	Fair (DG)	Fair (DG)	Fair (DG)	Poor (DG)	Poor	Poor (DG)	Poor (DG)
Sediment Size and Distribution (Misc. Data Sources)					Poor (Sherwood) (ASEG, 2002)		Poor (Stevie, 2004; Caldwell, 2015)		
Embeddedness (Misc. Data Sources)					Poor (Sherwood) (ASEG, 2002)		Poor (Caldwell, 2015)		
Embeddedness (from LFA)	Good	Fair	Gap	Fair	Poor	Poor	Fair	Poor	Poor
Changes in Flow Regime (high flow) (from LFA)*	Fair	Gap	Fair	Fair	Fair	Poor	Gap	Gap	Gap
Stream Bank Condition (from LFA)	Poor	Poor	Fair to Poor	Fair	Fair	Poor	Poor	Gap	Poor

[a] Note that ror the assessments of indicators by watershed, the good, fair, poor rating is the authors best professional judgement on the rating of the indicator, based on the data source and is not an assessment of data quality.

Gray shading indicates older data source (e.g., 2002 Limiting Factors Analysis)

CONDITION BIN KEY

Good = KEA is properly functioning throughout majority of subwatershed , providing or supporting most relevant habitat elements required by all salmonids and life history stages	Fair = KEA is properly functioning throughout some portion of subwatershed or is of moderate function through majority of subwatershed, providing or supporting some relevant habitat elments required by all salmonids and life history stages	Poor = KEA is not properly functioning throughout all or most of subwatershed , providing or supporting few relevant habitat elments required by all salmonids and life history stages. Likely a limiting factor to salmonid production.

Stream Complexity KEA	Data Source	Sub-watershed							
		Campbell Creek	County Line Creek	Cranberry Creek	Deer Creek	Goldsborough Creek	Gosnell Creek	Mill Creek (including Isabella Lake)	Johns Creek
Indicators		Fair (DG)	Poor (DG)	Fair to Good (DG)	Good (DG)	Fair (DG)	Fair	Fair	Fair (DG)
Pool Frequency (Misc. Data Sources)	16					Good (Squaxin Island Tribe, 2009a)		Fair (Squaxin Island Tribe, 2015b)	
Off-channel Habitat (Misc. Data Sources)	17						Good (Squaxin Island Tribe, 2015a)		
LWD Frequency (Misc. Data Sources)	18					Fair to Poor (South Fork) (Stevie, 2004)		Fair to Poor (Marbet and Caldwell, 2015)	Fair to Poor (Squaxin Island Tribe, 2009c)
Habitat Limiting Factors From Recent Reports	19					Lack of habitat diversity and lack of channel stability (Mobrand, 2004)		Poor instream habitat complexity (Squaxin Island Tribe, 2015a)	Loss of habitat quantity, reflecting channelization, roads and other factors narrowing stream (Mobrand, 2004)
Pool Frequency (from LFA)	20	Fair	Fair	Fair	Good	Fair	Fair	Fair	Fair
Pool Quality (from LFA)	21	Good	Good	Good	Good	Good	Fair	Fair	Poor
Off-channel Habitat (from LFA)	22	Good	Gap	Good	Good	Good	Good	Good	Good
LWD Frequency (from LFA)	23	Fair to Poor	Poor	Fair to Good	Fair	Good to Poor	Fair	Fair	Good to Poor
LWD Key Pieces (from LFA)	24	Fair to Poor	Poor	Fair	Poor	Fair to Poor	Fair	Fair to Poor	Poor
Floodplain Connectivity (from LFA)	25	Good	Gap	Fair	Good	Good to Poor	Fair	Fair	Good

Aquatic Habitat Connectivity KEA	Data Source	Sub-watershed							
		Campbell Creek	County Line Creek	Cranberry Creek	Deer Creek	Goldsborough Creek	Gosnell Creek	Mill Creek (including Isabella Lake)	Johns Creek
Indicators		Fair	Poor	Poor	Fair	Fair	Poor	Fair	Poor
Distribution of Anadromous and Resident Salmonid Stream Habitat Miles in Relation to Fish Passage Barriers (WDFW, 2019a) (See Figures B-1 and B-2 in Appendix B for graphical representation)	26	2.6 miles of anadromous habitat downstream of all barriers; 0 miles of anadromous habitat upstream of barriers; 5.4 miles of cutthroat trout habitat upstream of anadromous zone	0.1 miles of anadromous habitat downstream of all barriers; 0.6 miles of anadromous habitat upstream of barriers; 1.5miles of cutthroat trout habitat upstream of anadromous zone	0.1 miles of anadromous habitat downstream of all barriers; 0.6 miles of anadromous habitat upstream of barriers; 1.5 miles of cutthroat trout habitat upstream of anadromous zone	8.8 miles of anadromous habitat downstream of all barriers; 1.6 miles of anadromous habitat upstream of barriers; 10.5 miles of cutthroat trout habitat upstream of anadromous zone	17.5 miles of anadromous habitat downstream of all barriers; 5.9 miles of anadromous habitat upstream of barriers; 34.4 miles of cutthroat trout habitat upstream of anadromous zone	13.1 miles of anadromous habitat downstream of all barriers; 13.2 miles of anadromous habitat upstream of barriers; 20.5 miles of cutthroat trout habitat upstream of anadromous zone		0.5 miles of anadromous habitat downstream of all barriers; 8.8 miles of anadromous habitat upstream of barriers; 1.7 miles of cutthroat trout habitat upstream of anadromous zone
Connectivity (low flow and temp) - from Temp KEA	27	Poor (DG)	Fair (DG)	Poor	Poor	Fair	Good	Poor	Fair
Fish Passage at Water Crossings (from LFA)*	28	Fair	Fair	Fair	Fair	Fair	Fair	Good	Fair

[a] Note that ror the assessments of indicators by watershed, the good, fair, poor rating is the authors best professional judgement on the rating of the idicator, based on the data source and is not an assessment of data quality.

Gray shading indicates older data source (e.g., 2002 Limiting Factors Analysis)

CONDITION BIN KEY

Good	Fair	Poor
Good = KEA is properly functioning throughout majority of subwatershed , providing or supporting most relevant habitat elements required by all salmonids and life history stages	Fair = KEA is properly functioning throughout some portion of subwatershed or is of moderate function through majority of subwatershed, providing or supporting some relevant habitat elments required by all salmonids and life history stages	Poor = KEA is not properly functioning throughout all or most of subwatershed , providing or supporting few relevant habitat elments required by all salmonids and life history stages. Likely a limiting factor to salmonid production.

Stream Complexity KEA	Sub-watershed								
	Kennedy Creek	**Malaney Creek**	**Perry Creek**	**Schneider Creek**	**Sherwood - Schumacher Creeks**	**Shelton Creek**	**Skookum Creek**	**Snodgrass Creek**	**Uncle John's Creek**
Indicators	Good (DG)	Fair to Good (DG)	Poor (DG)	Fair (DG)	Good (Sherwood) Fair (Schumocher) (DG)	Poor (DG)	Poor (DG)	Poor (DG)	Poor (DG)
Pool Frequency (Misc. Data Sources)					Good (Sherwood), Fair (Schumocher) (Brakensiek, 2008) Good (Sherwood) (ASEG, 2002)		Poor (Reitdorf Crk) (Stevie, 2004) Poor (mainstem) (Caldwell, 2015)		
Off-channel Habitat (Misc. Data Sources)							Poor (Caldwell, 2014)		
LWD Frequency (Misc. Data Sources)					Good (Sherwood) (ASEG, 2002)		Poor (Reitdorf Crk) (Stevie, 2004)		
Habitat Limiting Factors From Recent Reports							Disconnection from wetlands and floodplains (Caldwell, 2014) Lack of habitat diversity and decreasing habitat quantity (Mobrand, 2004)		
Pool Frequency (from LFA)	Good	Fair	Gap	Fair	Poor	Poor	Fair	Poor	Poor
Pool Quality (from LFA)	Good	Good	Gap	Good	Gap	Poor	Poor	Gap	Poor
Off-channel Habitat (from LFA)	Gap	Good	Gap	Gap	Good	Poor	Gap	Gap	Fair
LWD Frequency (from LFA)	Good to Fair	Fair to Poor	Good to Poor	Good to Poor	Good (Sher) Gap (Schum)	Poor	Good	Poor	Poor
LWD Key Pieces (from LFA)	Poor to Fair	Fair	Poor	Poor	Good (Sher) Gap (Schum)	Poor	Poor	Poor	Poor
Floodplain Connectivity (from LFA)	Gap	Fair	Poor	Fair	Fair (Sher) Good (Shum)	Poor	Poor	Gap	Poor

Aquatic Habitat Connectivity KEA	Sub-watershed								
	Kennedy Creek	**Malaney Creek**	**Perry Creek**	**Schneider Creek**	**Sherwood - Schumacher Creeks**	**Shelton Creek**	**Skookum Creek**	**Snodgrass Creek**	**Uncle John's Creek**
Indicators	Good	Good	Good	Fair	Fair	Poor	Poor	Good	Poor
Distribution of Anadromous and Resident Salmonid Stream Habitat Miles in Relation to Fish Passage Barriers (WDFW, 2019a) (See Figures B-1 and B-2 in Appendix B for graphical representation)	3.8 miles of anadromous habitat downstream of all barriers; 0 miles of anadromous habitat upstream of barriers; 32.8 miles of cutthroat trout habitat upstream of anadromous zone	3.0 miles of anadromous habitat downstream of all barriers; 0 miles of anadromous habitat upstream of barriers; 2.3 miles of cutthroat trout habitat upstream of anadromous zone	1.6 miles of anadromous habitat downstream of all barriers; 0 miles of anadromous habitat upstream of barriers; 4.2 miles of cutthroat trout habitat upstream of anadromous zone	3.4 miles of anadromous habitat downstream of all barriers; 2.1 miles of anadromous habitat upstream of barriers; 3 miles of cutthroat trout habitat upstream of anadromous zone	21.3 miles of anadromous habitat downstream of all barriers; 3 miles of anadromous habitat upstream of barriers; 11.5 miles of cutthroat trout habitat upstream of anadromous zone	1.7 miles of anadromous habitat downstream of all barriers; 1.7 miles of anadromous habitat upstream of barriers; 1.0 miles of cutthroat trout habitat upstream of anadromous zone	13.7 miles of anadromous habitat downstream of all barriers; 3.6 miles of anadromous habitat upstream of barriers; 15.7 miles of cutthroat trout habitat upstream of anadromous zone	0.6 miles of anadromous habitat downstream of all barriers; 0 miles of anadromous habitat upstream of barriers; 2.2 miles of cutthroat trout habitat upstream of anadromous zone	1.9 miles of anadromous habitat downstream of all barriers; 0 miles of anadromous habitat upstream of barriers; 0.7 miles of cutthroat trout habitat upstream of anadromous zone
Connectivity (low flow and temp) - from Temp KEA	Fair	Poor (DG)	Good	Fair	Poor	Good	Poor	Fair (DG)	Poor (DG)
Fish Passage at Water Crossings (from LFA)*	Fair to Poor	Poor	Poor	Fair	Fair	Poor	Fair	GAP	Poor

[a] Note that ror the assessments of indicators by watershed, the good, fair, poor rating is the authors best professional judgement on the rating of the idicator, based on the data source and is not an assessment of data quality.

Gray shading indicates older data source (e.g., 2002 Limiting Factors Analysis)

CONDITION BIN KEY

Good = KEA is properly functioning throughout majority of subwatershed , providing or supporting most relevant habitat elements required by all salmonids and life history stages	Fair = KEA is properly functioning throughout some portion of subwatershed or is of moderate function through majority of subwatershed, providing or supporting some relevant habitat elements required by all salmonids and life history stages	Poor = KEA is not properly functioning throughout all or most of subwatershed , providing or supporting few relevant habitat elments required by all salmonids and life history stages. Likely a limiting factor to salmonid production.

Table A- 7. Data Source Detail for All KEA Indicators

KEA and Indicator	Data Source	Data Source Details and Notes
Stream Temperature		
Category 5 303(d) Temperature and DO Listings	1	Highest priority indicator for stream temperature using current data on location and extent of 303d listed reaches listed for temperature and DO (Ecology, 2008).
Stream Temperature	2	Multiple Data Sources – High priority indicator utilizing available reports and data on stream temperature, in watersheds where available. Includes Squaxin Island Tribe water quality monitoring data and summary reports, USGS monitoring data, aerial FLIR data, and fish specific studies where temperature was assessed. Applied best professional judgement to translate data results into ratings (good, fair, poor) based on general temperature requirements for salmonid focal species, as summarized by Washington State Water Quality standards for salmonids.
Canopy Cover (Multiple Data Sources)	3	Multiple Data Sources – Medium-high priority indicator utilizing available reports and data on percent canopy cover, where data was available. Includes data from Squaxin Island Tribe and others. Applied best professional judgement to translate data results into ratings (good, fair, poor) based on the established general relationship between stream shading and stream temperatures;
Major Lakes (basin position)	4	Medium priority indicator, based on presence or absence of headwater and mid-basin lakes. This indicator is based on a wide-variety of literature that ties the presence of large, open-water bodies in WRIA 14 with increased stream temperatures within the water feature and downstream.
Percent Forest in Riparian Buffer	5	Medium priority indicator, based on the percent of forested land cover within a 150-foot stream buffer. This data was derived from an ESA GIS analysis using 2015 WDFW high resolution land cover data (Pierce, 2015) within the defined buffer (results in Appendix Table A-9). This indicator is analogous to canopy cover, as there is an established link between the buffer composition and stream shading, which ultimately influences water temperature. Percent forest cover greater than 70% generally represent buffer areas that have fair to good stream shading, while those with forest cover of less than 50 percent generally have poor stream shading.
Canopy Height (% low canopy from MCD, 2016b)	6	Medium priority indicator, based on a GIS analysis on percent of low forest canopy height (0 to 10 feet) land cover within a 180-foot stream buffer by MCD (2016b) WRIA 14 riparian assessment. This indicator provides some information on buffer condition which is degraded as to shade provision functions, due to the low canopy height, however the analysis does not differentiate between mainstem and tributary areas and does not include the amount of medium or high canopy height. In general, a higher percentage of low canopy height buffer indicates increased likelihood of poor riparian conditions.
Stream Flow Rule Adherence (% of summer numerical rule not met)	7	Medium-low priority indicator utilizing flow data from Squaxin Island Tribe and USGS. Indicator applies to those watersheds where there is 1) a numerical rule established for summer low flows by Ecology, and 2) stream gage data is available. Where applicable, the calculated indicator is presented as the percent of the summer low flow period that the numeric criteria are not met. The use of the indicator is based on the relationship between low flow and higher temperatures, however its low priority is based on the variability of the numeric criteria, which in many cases was not based on gage data and may therefore not represent "natural conditions".
Stream Temperature	8	From Kuttel (2002) LFA analysis and based on a combination of qualitative and quantitative data. Where quantitative data exists, the resultant rating in the LFA (good or poor) was based on exceeding maximum State standards for water quality (see Table A-10 in Appendix A for specific criteria).
Canopy Closure	9	From Kuttel (2002) LFA analysis and based on a combination of qualitative and quantitative data. The resultant rating in the LFA (good or poor) was based on professional judgement on whether canopy closure will maintain State standards for temperature (see Table A-10 in Appendix A for specific criteria).
Stream Flow/Low Flow	10	From Kuttel (2002) LFA analysis and based on a combination of qualitative and quantitative data. The resultant rating in the LFA (good, fair, or poor) was based on professional judgement on whether low flows are adequate for all salmonid life stages (see Table A-10 in Appendix A for specific criteria).
Sediment Condition		
Sediment Size and Distribution	11	Multiple Data Sources – High priority indicator utilizing available reports and data on sediment size and distribution in watersheds where available. Includes Squaxin Island Tribe and other available habitat monitoring data and summary reports. Applied best professional judgement to translate data results into ratings (good, fair, poor) based on quality and quantity of sediment sizes to provide adequate spawning habitat for salmonids.
Embeddedness	12	Multiple Data Sources – Medium-high priority indicator utilizing available reports and data on substrate embeddedness and percent fines in watersheds where available. Includes Squaxin Island Tribe and other available habitat monitoring data and summary reports. Applied best professional judgement to translate data results into ratings (good, fair, poor) based on the relationship of spawning gravel percent fines and spawning and incubation success for salmonids.
Embeddedness	13	From Kuttel (2002) LFA analysis and based on a combination of qualitative and quantitative data. Where quantitative data exists, the resultant rating in the LFA (good, fair, poor) was based on the measured or estimated percent fines in spawning gravel (see Table A-10 in Appendix A for specific criteria).
Changes in Flow Regime (high flow)	14	From Kuttel (2002) LFA analysis and based on a combination of qualitative and quantitative data. The resultant rating in the LFA (good, fair, poor) was based on comparing the target watershed peak flow, base flow and flow timing characteristics to a undisturbed reference watershed of similar size, to detect changes from reference conditions (see Table A-10 in Appendix A for specific criteria).

KEA and Indicator	Data Source	Data Source Details and Notes
Stream Bank Condition	15	From Kuttel (2002) LFA analysis and based on a combination of qualitative and quantitative data. The resultant rating in the LFA (good, fair, poor) was based on the measured or estimated percent of natural streambank stability in the watershed (see Table A-10 in Appendix A for specific criteria).
Stream Complexity		
Pool Frequency	16	Multiple Data Sources – High priority indicator utilizing available reports and data on pool frequency. Includes Squaxin Island Tribe and other data. Applied best professional judgement to translate data results into ratings (good, fair, poor) based on general relationship of pool frequency and pool-riffle ratio to salmonid spawning and rearing habitat availability.
Off-channel Habitat	17	Multiple Data Sources – High priority indicator utilizing available reports that address off-channel habitats, including floodplains, side-channels, hydrologically connected riverine wetlands and other off-channel habitats. Includes Squaxin Island Tribe and other data. Applied best professional judgement to translate data results into ratings (good, fair, poor) based on the general relationship of off-channel habitats to rearing habitat quality and quantity.
LWD Frequency	18	Multiple Data Sources – High priority indicator utilizing available reports and data on LWD frequency. Includes Squaxin Island Tribe and other data. Applied best professional judgement to translate data results into ratings (good, fair, poor) based on general relationship of instream LWD frequency to habitat quality, quantity, and habitat forming ecological
Habitat Limiting Factors From Recent Reports	19	Medium priority indicator based on qualities assessments of habitat limiting factors for stream complexity. Includes assessments by Squaxin Island Tribe and others. Listed specific identified limiting factors that affect Habitat Complexity.
Pool Frequency	20	From Kuttel (2002) LFA analysis and based on a combination of qualitative and quantitative data. Where quantitative data exists, the resultant rating in the LFA (good, fair, poor) was based on the measured or estimated percent pool frequency on a channel widths per mile basis (see Table A-10 in Appendix A for specific criteria).
Pool Quality	21	From Kuttel (2002) LFA analysis and based on a combination of qualitative and quantitative data. Where quantitative data exists, the resultant rating in the LFA (good, fair, poor) was based on the measured or estimated pool quality as indicated by mean residual pool depth and amount of pool surface area (see Table A-10 in Appendix A for specific criteria).
Off-channel Habitat	22	From Kuttel (2002) LFA analysis and based on a combination of qualitative and quantitative data. Where quantitative data exists, the resultant rating in the LFA (good, fair, poor) was based on the measured or estimated area within the channel migration zone (see Table A-10 in Appendix A for specific criteria).
LWD Frequency	23	From Kuttel (2002) LFA analysis and based on a combination of qualitative and quantitative data. Where quantitative data exists, the resultant rating in the LFA (good, fair, poor) was based on the measured or estimated percent LWD pieces per channel lengths (see Table A-10 in Appendix A for specific criteria).
LWD Key Pieces	24	From Kuttel (2002) LFA analysis and based on a combination of qualitative and quantitative data. Where quantitative data exists, the resultant rating in the LFA (good, fair, poor) was based on the measured or estimated percent key LWD pieces per channel lengths (see Table A-10 in Appendix A for specific criteria).
Floodplain Connectivity	25	From Kuttel (2002) LFA analysis and based on a combination of qualitative and quantitative data. Where quantitative data exists, the resultant rating in the LFA (good, fair, poor) was based on the estimated amount of hydrologic connectivity between off-channel, wetland, floodplain, and riparian areas (see Table A-10 in Appendix A for specific criteria).
Aquatic Habitat Connectivity		
Distribution of Anadromous and Resident Salmonid Stream Habitat Miles in Relation to Fish Passage Barriers (WDFW, 2019c)	26	High priority indicator, based on the location and extent of anadromous fish habitat above identified fish passage barrier and below the barriers, as well as the amount of resident fish habitat upstream of anadromous fish habitat. The was derived from an overlay of the WDFW (2019c) fish passage database and fish distribution data (WDFW 2019a). This indicator directly quantifies the extent of salmonid habitat affected by one or more man-made fish passage barriers.
Connectivity (low flow and temp) - from Temperature KEA	27	Medium-low priority indicator which consist of the overall rating of temperature KEA. This use of this indicator is based on the observed incidences of high stream temperatures in some WRIA 14 watersheds acting as a migration barrier during the summer months, limiting the movement and distribution of rearing salmonids.
Fish Passage at Water Crossings	28	From Kuttel (2002) LFA analysis and based on a combination of qualitative and quantitative data. Where quantitative data exists, the resultant rating in the LFA (good, fair, poor) was based on the presence or absence of manmade barriers that restrict fish movement upstream and downstream (see Table A-10 in Appendix A for specific criteria).

Table A- 8. Land Cover Types in WRIA 14 Watershed by Percentages

Watershed	Total Area (acres)	Land Cover Type						
		Developed	Forest	Bare Dirt	Grass/ Pasture	Shrub	Water	Unclassified
Campbell Creek	2,954	3.0	60.3	5.2	18.3	5.5	6.6	1.1
County Line Creek	929	2.1	73.7	2.4	16.4	3.7	0.4	1.2
Cranberry Creek	8,978	3.9	51.4	6.3	17.2	15.6	3.4	2.3
Deer Creek	9,537	2.3	48.7	8.1	23.6	15.4	1.1	0.8
Goldsborough Creek	38,241	3.3	60.7	6.1	16.6	10.2	1.0	2.1
Hiawata Creek	871	1.5	81.9	3.5	6.7	2.9	1.9	1.6
Johns Creek	6,651	6.6	40.4	9.6	25.9	11.4	1.9	4.3
Kennedy Creek	12,766	2.3	67.7	2.6	16.2	4.2	4.2	2.8
Lynch Creek	830	7.9	52.9	6.4	15.3	7.4	7.2	2.8
Malaney Creek	2,326	4.0	56.6	6.2	15.3	7.2	9.4	1.2
Mill/ Gosnell Creeks	19,058	2.4	70.8	3.9	13.1	6.0	1.8	1.9
Perry Creek	4,116	3.3	72.1	3.6	13.8	4.3	0.3	2.5
Schneider Creek	4,631	3.2	71.0	5.6	13.8	4.3	0.4	1.7
Shelton Creek	2,085	20.7	32.0	14.4	20.4	9.1	1.1	2.3
Sherwood/Schumacher Creeks	21,174	2.9	49.4	6.7	20.7	13.7	5.6	1.0
Skookum Creek	12,437	2.5	72.4	3.2	16.6	3.7	0.3	1.4
Snodgrass Creek	811	1.3	69.5	2.6	11.3	13.5	1.0	0.8
Uncle Johns Creek	1,136	2.1	77.2	6.0	9.6	3.5	0.2	1.4
All other sub-watersheds	48,596	4.6	67.9	5.9	13.0	6.6	0.8	1.2
Total/Basin-wide Average	**198,126**	**3.6**	**62.1**	**5.7**	**16.3**	**8.6**	**2.0**	**1.7**
Maximum	**48,595.6**	**20.7**	**81.9**	**14.4**	**25.9**	**15.6**	**9.4**	**4.3**
Minimum	**810.5**	**1.3**	**32.0**	**2.4**	**6.7**	**2.9**	**0.2**	**0.8**
Average	**10,427.7**	**4.2**	**61.9**	**5.7**	**16.0**	**7.8**	**2.6**	**1.8**
Standard Deviation	**13,258.1**	**4.3**	**13.3**	**2.9**	**4.6**	**4.3**	**2.8**	**0.9**

Table A- 9. Land Cover Types in WRIA 14 Watershed Stream Buffers (150-foot-buffer) by Percentages

Watershed	Total Acres of Riparian Buffer	Developed	Forest	Bare Dirt	Grass/ Pasture	Shrub	Water	Unclassified
Campbell Creek	340	0.8	72.9	1.3	9.5	3.4	11.1	1.0
County Line Creek	193	1.7	80.7	1.8	11.6	2.5	0.4	1.2
Cranberry Creek	1,419	2.6	49.3	4.2	18.7	12.7	10.0	2.6
Deer Creek	1,266	1.5	56.4	4.4	17.5	16.4	2.7	1.0
Goldsborough Creek	4,223	1.4	72.5	2.5	12.5	7.9	1.9	1.4
Hiawata Creek	136	1.0	79.6	1.7	5.0	2.7	9.0	1.0
Johns Creek	720	2.7	39.7	6.5	27.4	10.9	4.6	8.2
Kennedy Creek	2,977	2.4	73.1	1.7	9.9	3.7	5.8	3.3
Lynch Creek	151	4.4	59.3	3.9	6.1	5.2	19.0	2.1
Malaney Creek	215	1.1	52.6	1.9	11.2	3.9	28.2	1.1
Mill/ Gosnell Creeks	3,174	1.1	76.5	1.7	11.4	5.4	2.6	1.3
Perry Creek	781	2.9	77.2	2.4	10.2	3.9	0.5	2.9
Schneider Creek	824	2.3	78.7	2.9	11.2	3.0	0.5	1.4
Shelton Creek	178	21.3	48.4	10.1	8.5	7.6	1.5	2.6
Sherwood/Schumacher Creeks	2,912	2.0	53.6	4.3	15.7	13.1	10.0	1.3
Skookum Creek	2,176	1.8	75.4	2.0	15.7	3.4	0.5	1.2
Snodgrass Creek	150	0.4	79.7	0.4	6.0	10.4	2.5	0.7
Uncle Johns Creek	114	2.4	73.3	4.6	14.2	3.6	0.4	1.4
All other sub-watersheds	4,804	2.1	77.4	2.8	9.4	5.3	1.8	1.2
Total/Basin-wide Average	**26,753**	**2.0**	**69.3**	**2.8**	**12.8**	**7.2**	**4.1**	**1.8**
Maximum	**4,804**	**21.3**	**80.7**	**10.1**	**27.4**	**16.4**	**28.2**	**8.2**
Minimum	**114**	**0.4**	**39.7**	**0.4**	**5.0**	**2.5**	**0.4**	**0.7**
Average	**1,408**	**2.9**	**67.2**	**3.2**	**12.2**	**6.6**	**5.9**	**1.9**
Standard Deviation	**1,511**	**4.5**	**13.2**	**2.2**	**5.3**	**4.2**	**7.3**	**1.7**

Table A-10. Table of Salmonid Habitat Rating Condition Criteria for WRIA 14 Limiting Factor Analysis (from Kuttel, 2002)

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Fish Passage	Man-made physical barriers (address subsurface flows or dewatering where they impede fish passage under water quantity attributes)	All	Man-made barriers present in the reach restrict upstream and/or downstream fish passage at a range of flows.	Man-made barriers present in the reach restrict upstream and/or downstream fish passage at base/low flows.	Man-made barriers present in the reach allow adequate upstream and downstream fish passage at all flows.	USFWS Guidelines
Riparian Condition	(1) Riparian buffer width (measured horizontally from the channel migration zone on each side of the stream) (2) Riparian composition	Type 1-3 and untyped salmonid streams >5 feet wide	(1) <75' or <50% of site potential tree height (whichever is greater) OR (2) Dominated by hardwoods, shrubs, or nonnative species (<30% conifer) unless these species were dominant historically	(1) 75'-150' or 50-100% of site potential tree height (whichever is greater) AND (2) Dominated by conifers or a mix of conifers and hardwoods (≥30% conifer) of any age unless hardwoods were dominant historically.	(1) >150' or site potential tree height (whichever is greater) AND (2) Dominated by mature conifers (≥70% conifer) unless hardwoods were dominant historically	WCC/WSP
	(1) Buffer width (2) Riparian composition	Type 4 and untyped perennial streams <5' wide	(1) <50' (2) Same as above	(1) 50'-100' (2) Same as above	(1) >100' (2) Same as above	WCC/WSP
	(1) Buffer width (2) Riparian composition	Type 5 and all other untyped streams	(1) <25' (2) Same as above	(1) 25'-50' (2) Same as above	(1) >50' (2) Same as above	WCC/WSP
Riparian Canopy Closure	Percent riparian canopy closure needed based on State water quality classification and stream elevation	All	Riparian canopy closure less than the value needed to maintain State water quality standard	Not applicable	Riparian canopy closure greater than or equal to the value needed to maintain State water quality standard	WAC-222-30-040 (Washington Forest Practices Board 2000)

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Streambank Condition	% of stream reach in stable natural condition	All	<80% natural stability	80-90% natural stability	>90% natural stability	NMFS/WSP
Floodplain Connectivity	Stream and off-channel habitat length with lost floodplain connectivity due to incision, roads, dikes, flood protection, or other	All	Severe reduction in hydrologic connectivity between off-channel, wetland, floodplain and riparian areas; wetlands extent drastically reduced and riparian vegetation/succession altered significantly.	Reduced linkage of wetland, floodplains and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function and riparian vegetation/succession.	Off-channel areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession.	USFWS Guidelines
Width/Depth Ratio	Ratio of bankfull width to average bankfull depth (Rosgen 1996) (i.e. width divided by average depth)	All	Width/depth ratio varies depending upon channel morphology. A stream typically exhibits several channel morphologies over its length depending upon gradient, geology, vegetative cover, etc (Rosgen 1996). While width/depth ratios are described in the narrative, the TAG did not feel it was appropriate to rate this parameter as good, fair, or poor for an entire stream.			TAG 2002
Substrate Embeddedness	Fines <0.85 mm in spawning gravel	All-Western Washington	>17%	11-17%	≤11%	WSP/WSA/NMFS/ Hood Canal
Large Woody Debris	Pieces/meter channel length	≤4% gradient, <15 meters wide	<0.2	0.2-0.4	>0.4	Hood Canal/Skagit
	Use Watershed Analysis piece and key piece standards listed below when data are available.					
	Pieces/channel width	<20 m wide	<1	1-2	2-4	WSP/WSA
	Key pieces/channel width*	<10 m wide	<0.15	0.15-0.30	>0.30	WSP/WSA
	Key pieces/channel width*	10-20 m wide	<0.20	0.20-0.50	>0.50	WSP/WSA
	* Minimum size to qualify as a key piece:	Bankfull width (meters)	Diameter (meters)	Length (meters)		
		0-5	0.4	8		
		6-10	0.55	10		
		11-15	0.65	18		
		16-20	0.7	24		

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Percent Pool	% pool by surface area	<2% gradient, <15 meters wide	<40%	40-55%	>55%	WSP/WSA
	% pool by surface area	2-5% gradient, <15 meters wide	<30%	30-40%	>40%	
	% pool by surface area	>5% gradient, <15 meters wide	<20%	20-30%	>30%	
	% pool by surface area	>15 meters wide	<35%	35-50%	>50%	Hood Canal
Pool Frequency	Channel widths per pool	<15 meters wide	>4	2-4	<2	WSP/WSA
Off-channel Habitat	Area within the channel migration zone.	Reaches with average gradient <2%	Reach has no ponds, oxbows, backwaters, or other off-channel areas	Reach has <5 ponds, oxbows, backwaters, and other off-channel areas with cover per mile; but side-channel areas are generally high energy areas	Reach has >5 ponds, oxbows, backwaters, and other off-channel areas with cover per mile; and side-channels are low energy areas	USFWS Guidelines TAG 2002

<table>
<tr><th>Habitat Factor</th><th>Parameter</th><th>Channel Type</th><th colspan="2">Poor</th><th>Fair</th><th colspan="2">Good</th><th>Source</th></tr>
<tr><td rowspan="3">Temperature</td><td rowspan="3">Degrees Celsius
(Degrees Fahrenheit)</td><td rowspan="3">All</td><td colspan="2">Maximum water temperatures exceed State Standard</td><td rowspan="3">Not applicable</td><td colspan="2">Maximum water temperatures meet State Standard</td><td rowspan="3">WAC 173-201A-030 (State of Washington 1992)</td></tr>
<tr><td>Class A</td><td>Class AA</td><td>Class A</td><td>Class AA</td></tr>
<tr><td>>18ºC
(64.4ºF)</td><td>>16ºC
(60.8ºF)</td><td>≤18ºC
(64.4ºF)</td><td>≤16ºC
(60.8ºF)</td></tr>
<tr><td rowspan="3">Dissolved Oxygen</td><td rowspan="3">mg/L</td><td rowspan="3">All</td><td colspan="2">Dissolved oxygen levels below State Standard</td><td rowspan="3">Not applicable</td><td colspan="2">Dissolved oxygen levels meet or exceed State Standard</td><td rowspan="3">WAC 173-201A-030 (State of Washington 1992)</td></tr>
<tr><td>Class A</td><td>Class AA</td><td>Class A</td><td>Class AA</td></tr>
<tr><td><8 mg/L</td><td><9.5 mg/L</td><td>≥8 mg/L</td><td>≥9.5 mg/L</td></tr>
<tr><td>Water Quantity/ Dewatering</td><td>Presence/absence in a stream reach</td><td>All</td><td colspan="2">No flows during some portion of the year or inadequate for all lifestages</td><td>Inadequate flows for some lifestages during some portion of the year</td><td colspan="2">Adequate flows for all lifestages present year-round</td><td>TAG 2002</td></tr>
<tr><td>Change in Flow Regime</td><td>Change in Peak/Base Flows</td><td>All</td><td colspan="2">Pronounced changes in peak flow, base flow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography</td><td>Some evidence of altered peak flow, base flow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography</td><td colspan="2">Watershed hydrograph indicates peak flow, base flow and flow timing characteristics comparable to an undisturbed watershed of similar size, geology and geography</td><td>USFWS Guidelines</td></tr>
<tr><td>Biological Processes</td><td>Lack of nutrient input from anadromous spawners, exotic animal species present, etc.</td><td>All</td><td colspan="2">No anadromous carcasses and there is likely exotic species competition</td><td>Few anadromous carcasses or there is exotic species competition</td><td colspan="2">Many anadromous carcasses and no exotic species competition</td><td>TAG 2002</td></tr>
</table>

Table A- 11. Changes (acres) in Developed, Forested, and Freshwater Wetland Land Cover Types from 2006 to 2011 in WRIA 14 Watershed

		Change in Development Area (acres)					Change in Forest Area (acres)				Freshwater Wetland Area (acres)			
Sub-watershed	Sub-watershed Area (acres)	High Intensity Developed	Medium Intensity Developed	Low Intensity Developed	Open Space Developed	Total Developed	Deciduous Forest	Evergreen Forest	Mixed Forest	Total Forest	Palustrine Forested Wetland	Palustrine Scrub/Shrub Wetland	Palustrine Emergent Wetland	Total Freshwater Wetland
Campbell Creek	2,954	0.0	0.0	0.0	0.0	**0.0**	-1.7	-179.6	-5.1	**-186.4**	-9.0	0.1	8.8	**-0.1**
County Line Creek	929	0.0	0.0	0.1	0.0	**0.1**	2.0	-10.7	-0.2	**-8.8**	0.0	0.0	0.0	**0.0**
Cranberry Creek	8,978	0.0	0.0	0.2	0.0	**0.2**	4.4	-158.3	0.2	**-153.7**	3.6	2.0	-0.7	**4.9**
Deer Creek	9,537	0.0	0.0	0.6	0.0	**0.6**	2.1	-949.2	-47.3	**-994.4**	11.5	-1.1	-10.0	**0.4**
Goldsborough Creek	38,241	18.1	50.1	85.2	63.0	**216.4**	-5.1	-1448.2	-86.5	**-1539.8**	-5.0	-7.6	12.8	**0.2**
Hiawata Creek	871	0.0	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**
Johns Creek	6,651	0.9	3.2	11.9	21.7	**37.8**	2.1	-255.3	-1.5	**-254.7**	-3.4	-0.5	4.9	**1.0**
Kennedy Creek	12,766	0.0	0.1	0.4	0.0	**0.4**	-36.2	-713.4	-135.3	**-885.0**	-1.2	0.4	0.6	**-0.2**
Lynch	830	0.0	0.0	-0.1	0.0	**-0.1**	-1.2	-12.1	-0.7	**-13.9**	0.3	-0.5	0.3	**0.1**
Malaney	2,326	0.0	0.6	9.3	2.3	**12.2**	0.5	-44.4	-1.2	**-45.1**	-0.8	0.0	1.4	**0.6**
Mill/ Gosnell Creeks	19,058	0.0	0.0	0.0	0.0	**0.0**	-3.4	-258.8	-30.5	**-292.7**	-0.4	1.4	-0.8	**0.2**
Perry Creek	4,116	0.0	0.3	4.1	4.0	**8.5**	-17.2	-325.1	-12.0	**-354.3**	0.0	0.4	-0.1	**0.3**
Schneider Creek	4,631	0.0	0.0	0.1	0.0	**0.1**	-1.8	-122.1	-12.3	**-136.2**	0.0	-2.6	2.5	**-0.1**
Shelton Creek	2,085	6.7	5.9	34.3	11.9	**58.7**	-2.3	-112.5	-3.0	**-117.8**	-0.4	0.0	0.3	**-0.1**
Sherwood/Schumacher Creeks	21,174	0.0	0.2	22.0	2.7	**24.8**	10.6	-1615.7	-8.3	**-1613.4**	-1.7	-4.6	7.6	**1.2**
Skookum Creek	12,437	6.4	16.1	12.3	44.2	**78.9**	-1.6	-609.5	-56.1	**-667.2**	0.4	-1.0	0.7	**0.1**
Snodgrass Creek	811	0.0	0.0	0.0	0.0	**0.0**	1.9	-1.6	-0.3	**0.0**	0.0	0.0	0.0	**0.0**
Uncle Johns Creek	1,136	0.0	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**
All other sub-watersheds	48,596	1.0	4.4	59.6	46.7	**111.7**	3.5	-1118.3	-67.5	**-1182.2**	-4.3	-5.1	12.1	**2.6**
Grand Total	**198,126**	**33.1**	**80.9**	**240.0**	**196.4**	**550.3**	**-43.2**	**-7934.6**	**-467.6**	**-8445.5**	**-10.5**	**-18.9**	**40.5**	**11.0**