Fish passage barriers in key Chinook streams

Southern Resident Killer Whale Task Force

Washington Department of FISH and WILDLIFE

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Introduction

At the direction of the Southern Resident Killer Whale (SRKW) task force Washington Department of Fish and Wildlife (WDFW) habitat biologists developed a list of known and potential passage barriers to Chinook salmon in Washington state. The project focused on streams used by Chinook stocks that were identified as priority prey sources for SRKW through the National Oceanic and Atmospheric Administration's "Southern Resident Killer Whale Priority Chinook Stocks Report," (NOAA, 2018). In total, 1,931 barriers were identified and categorized into three main groups: nearshore barriers, western barriers, and eastern barriers. The dividing line between western and eastern barriers is the White Salmon River. The list covers all systems with documented, presumed, potential, or historic presence of Chinook from all stocks identified by NOAA found within Washington. The list is not currently prioritized for barrier removals.

Project Framework and Implementation

WDFW biologists from western and eastern Washington completed the following objectives:

1. **Develop a list of priority stocks/runs/rivers to be assessed for Chinook barriers**
    a. Used the "Southern Resident Killer Whale Priority Chinook Stocks Report," (NOAA, 2018), WDFW's Salmon Conservation Reporting Engine, and contacted Tribal biologists and WDFW fisheries biologists to develop a list of all stream systems where priority Chinook stocks are known to, presumed to, or historically occurred (see Appendix A for table of stocks and associated stream systems).
    b. Completed a literature review of the latest, Washington-based, scientific studies related to Chinook habitat use. (See Appendix B for species use criteria).
2. **Compile a statewide list of known barriers within priority Chinook stream systems**
    a. Completed GIS analysis of WDFW's Fish Passage and Diversion Screening Inventory (FPDSI) database. Built a layer of all FPDSI site assessments within the priority stream systems that included Chinook as a potential species for the western and eastern site groups.
    b. Produced additional GIS layers using the Statewide Integrated Fish Distribution database (SWIFD) and multiple roads databases (WSDOT, city, county, federal). For SWIFD, stream segments within the priority systems that included Chinook salmon were used. Specifically, distribution types of documented, presumed, potential, or historic and use types of presence, rearing, or spawning. These stream segments were intersected with the roads databases to produce a second list of potential barriers for the western and eastern barrier groups.
    c. Conducted additional GIS analysis for nearshore barriers within western priority stream systems. Utilized distance buffers based off an extensive study completed by the Skagit River System Cooperative (Beamer, et al. 2013). A seven-kilometer buffer was placed around the confluence of every natal stream with tidal water. Within the buffer, all intersections with roads and streams were identified, then reduced to include only sites within 500 meters of tidal water (Figure 1).

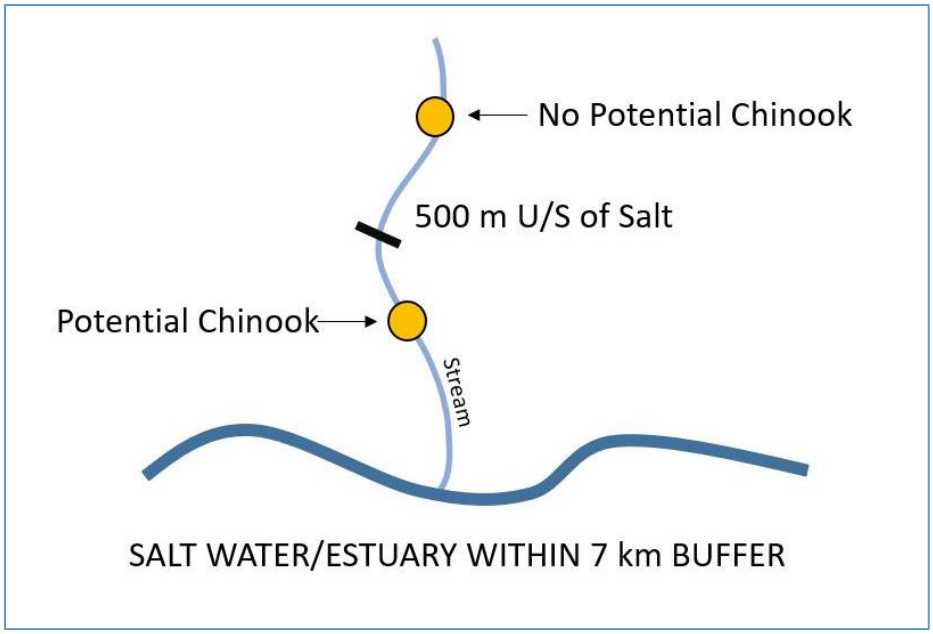

Figure 1. Diagram depicting nearshore site inclusion criteria (WDFW, unpublished)

d. Combined the nearshore, western, and eastern sets of potential barriers into one master layer of all barriers. Completed QA/QC of all potential barriers.

3. Solicited additional barriers from key partners

a. Created a barrier submittal form with project description, priority streams table, and qualifying criteria.

b. Developed a list of key external partners including, but not limited to, Tribes, regional fisheries enhancement groups, lead entities, WDFW habitat biologists, and conservation districts.

c. Engaged partners to explain the project and site submittal form and to answer questions and hear concerns.

d. Added qualifying barriers to the master list as they were submitted.

4. Combine all sites from western and eastern systems into a single list of known and potential barriers for key Chinook stocks

a. Completed final rounds of QA/QC. Assessed barriers for validity against qualifying criteria (see Appendix C for examples). Western and eastern barriers were combined into a single Excel table, GIS layer, and .KMZ file. The project package was sent to the WDFW Fish Passage and Screening Division Manager.

Results

Combining all sets of GIS query-based barriers and barriers submitted by partners resulted in a total of 13,443 known and potential barriers to Chinook from key stocks. Following the QA/QC process, which varied slightly between western and eastern site groups, removing duplicate sites, and sites that did not meet criteria, a final list containing 1,931 barriers was produced. This consisted of 364 nearshore barriers, 1,176 western barriers, and 391 eastern barriers. In terms of recovery regions, the western barriers were found in the Puget Sound, Hood Canal, Washington Coastal, and Lower Columbia regions. The eastern barriers were found in the Middle Columbia, Upper Columbia, and Snake River regions.

Candidate sites were removed from the initial list for the following reasons:

a. The barrier was not within the watershed utilized by a priority stock.

b. The barrier was a natural barrier.

c. The barrier was not a crossing feature. Many partners submitted levees and causeways as candidate sites and these types of barriers are not included in this project.

d. All duplicate sites. Frequently, an FPDSI site and a site produced by intersecting roads layers with stream layers were the same but due to the difference in field-based coordinates (FPDSI site) and mapped hydrology layers (SWIFD/roads intersect), two potential sites were produced for one.

e. The site was confirmed to be a non-barrier either through review of the FPDSI assessment or from review of orthophotography and light detection and ranging (LIDAR). The latter was most commonly used to discern if an unassessed site was a bridge (Figure 2).

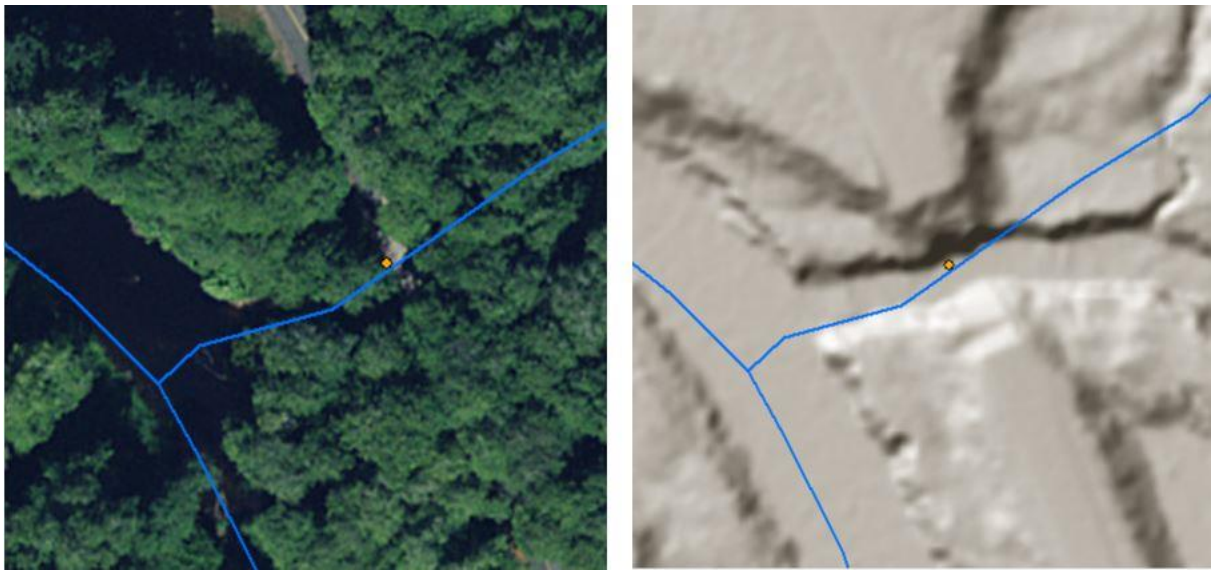

Figure 2. This is Salmon Creek at its confluence with North River. This site was produced as part of the intersect layer between SWIFD streams and roads. The orthoimage, above left, shows the stream path and the road but without an FPDSI assessment it is unclear that the crossing is a bridge until LIDAR is turned on. With LIDAR imagery the site is clearly a bridge, a non-barrier, and resulted in the site being removed from the list during QA/QC.

f. The site did not meet qualifying distance criteria and/or was in a headwaters system with multiple, downstream sites, having existing FPDSI assessments without Chinook included as a potential species (Figure 3).

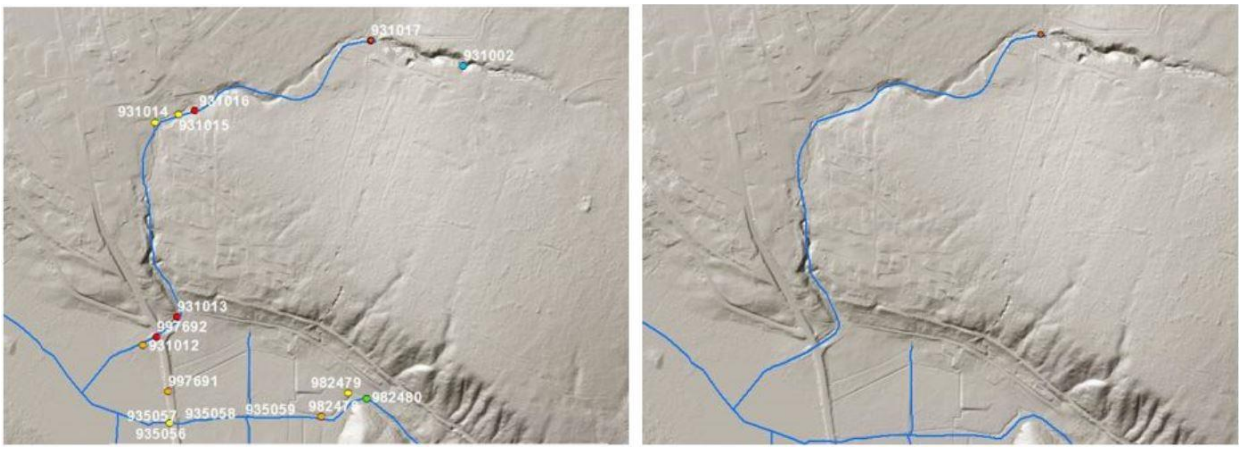

Figure 3. The above depicts an unnamed stream that flows into Jones Lake in WRIA 9. Of the eight FPDSI assessments shown on this stream, above left, 931017 was the only one with Chinook indicated as a potential species. As such, it was initially included on the list following GIS analysis, above right. Also note that this stream has no SWIFD record of Chinook use. As a result, site 931017 was removed during QA/QC.

g. For culverted crossings, if the site had been assessed in the field within the last ten years and was determined to be fully passable it was removed from the list.

A sortable Excel spreadsheet containing the 1,931 barriers was produced with information on barrier type, passability, ownership, and location for each site. The spreadsheet is organized by WRIA number. In addition to the Excel table, a GIS layer and a .kmz file were created of all sites to allow the list to be viewed cartographically and for it to be readily viewable by partners and the public.

Discussion

Of the 1,931 sites, 966 have an unknown barrier status because a barrier determination could not be made based on orthophotography and LIDAR, or because the barriers require additional analysis (e.g., Level B analysis, engineering review). Level B analysis is a common requirement of larger streams, which many these barriers are on since Chinook typically use larger stream systems. Completing the additional field assessments for these barriers and determining a barrier status/passability rating would result in a refined barrier list.

Confidence in capturing certain barrier types or groups of barriers is variable. While the nearshore sites were derived using best available science (Beamer, et al. 2013) and the most up-to-date imagery, LIDAR, roads layers, parcel maps, and hydrology layers, the listed barriers are likely only a modest percentage of the actual number of nearshore sites that would qualify. Many of these barriers are on privately-owned, agricultural use only, roads which were not captured in the GIS analysis as there is no agricultural use road layer for western Washington. In addition, many more of these sites are associated with non-road crossings and convey tidal flux through levees and dikes. Unless these features had a pre-existing FPDSI assessment, or were submitted by partners, they were not captured in this analysis. Further, the regulatory

classification of many of these sites is not definitive (e.g., drainage ditch versus historical tidal distributary channel). Lastly, many tidal channels and distributary channels that may be used by juvenile salmonids are small and delineating potential barriers using orthoimagery or LIDAR would come with a high level of inaccuracy.

The SWIFD and FPDSI databases were integral to developing this list given the short timeframe, but both present challenges. SWIFD has not been updated in several years and locally-based partners made frequent note of SWIFD either not capturing the full range of a priority salmon stock or over capturing the potential range. This was partially addressed by removing all 'gradient accessible' SWIFD Chinook stream segments from the GIS analysis. Furthermore, the Excel table can quickly be sorted to show, for example, only the barriers on stream segments with documented spawning. WDFW fisheries biologists and Tribal biologists were consulted and asked to review and comment on the draft table of priority stream systems (Appendix A).

In addition, the FPDSI database consists of tens of thousands of site assessments, collected over 25 years, from a multitude of entities with various levels of training and knowledge of salmonid ecology and life history. Figure 3 provides a good example of Chinook being incorrectly included. Anecdotally, species determination by assessment becomes more refined and aligns with SWIFD more closely in more recent assessments. The majority of FPDSI barriers with Chinook listed as a potential species that were removed from the list were assessed between 1999 and 2005.

Finally, it should be noted that assumptions on Chinook stock importance to SRKW are based on the NOAA paper as recommended by the SRKW Task Force.

The next step in the SRKW Chinook Barrier list is likely to include prioritization. While the NOAA report provides a single-scoring metric that can easily be applied to the Excel spreadsheet, there are other considerations that should be included. Incorporating individual stock health, run type, population size, population trend, average escapement rates, stock type (natural, hatchery, composite), habitat quality and quantity within the stock's watershed, and feasibility of barrier corrections for a specific stock's watershed should all be included. This, in addition to field assessments of all crossings with unknown barrier status, would result in a defensible, prioritized list.

Barring the above, the SRKW Chinook Barrier list provides immediate potential for narrowing the list from 1,931 which may be more pragmatic given the triage nature of the SRKW task force's recommendations. For example, after sorting for only sites with: a known feature type that are confirmed barriers; a passability rating (i.e. have had a field assessment); a SWIFD 'Distribution Type' of Nearshore or Documented and a 'Use Type' of Nearshore, Presence, Rearing, or Spawning, the list decreases to 140 sites statewide. This much more manageable figure represents a valuable starting point for restoring passage to Chinook from key SRKW prey stocks.

Conclusion

This barrier list is meant to be dynamic and adaptive. Restoration projects are in progress statewide to remove known barriers and new barriers to salmonid passage are found weekly. The Excel spreadsheet provides an easy template to add or remove sites as existing barriers are removed or as new barriers are discovered and assessed.

References

Beamer, E.M., W.T. Zackey, D. Marks, D. Teel, D. Kuligowski, and R. Henderson. 2013. *Juvenile Chinook salmon rearing in small non-natal streams draining into the Whidbey Basin*. Skagit River System Cooperative, LaConner, Washington.

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Appendix A

This table shows all SRKW priority stocks in Washington state and which specific systems within WRIAs are used for spawning.

Population Name (SCoRE)	Run Type (SWIFD, SalmonScape)	Production Type (SCoRE)	ESU Stock/Group (NOAA categories)	River(s): Spawning (SCoRE and AFBs)	WRIA (SCoRE)
North Fork Nooksack Chinook (including Middle Fork Nooksack River)	Spring	Composite	Northern Puget Sound	North Fork Nooksack, Canyon, Racehorse, Boulder, Maple, Cornell, Deadhorse, Thompson and Boyd creeks, Middle Fork Nooksack, Canyon Lake Creek	1
South Fork Nooksack Chinook	Spring	Wild	Northern Puget Sound	South Fork Nooksack, Hutchinson, Skookum, Deer and Plumbago creeks	1
Lower Skagit Chinook	Fall	Wild	Northern Puget Sound	Lower Skagit Mainstem and tributaries (Finney, Day, Pressentin, Alder, Jones, Jackman, Grandy, and East Fork Nookachamps Creeks.	3
Upper Skagit Chinook	Summer	Composite	Northern Puget Sound	(To Newhalem) Skagit, Sauk River, lower Cascade river, Illabot, Diobsud, Bacon, Falls, and Goodell Creeks	4
Cascade Chinook	Spring	Composite	Northern Puget Sound	Upper Cascade River, NF Cascade, Suiattle, Marble, Found, and Kindy Creek	4
Lower Sauk Chinook	Spring	Composite	Northern Puget Sound	Sauk River up to Darrington Bridge	4
North Fork Stillaguamish Chinook	Summer (Summers and Falls spawn in both forks of the Stilly; work is in progress to parse them genetically.)	Composite	Northern Puget Sound	North Fork Stillaguamish River, Boulder River, Grant, Deer, Brooks, French, Segelson, Squire, Ashton, and Brown Creeks	5
South Fork Stillaguamish Chinook	Fall (Summers and Falls spawn in both Forks of the Stilly; work is in progress to parse them genetically.)	Composite	Northern Puget Sound	Mainstem and South Fork Stillaguamish and in Canyon, Jim, Siberia, and Pilchuck creeks	5
Skykomish Chinook (Snohomish watershed)	Summer	Composite	Northern Puget Sound	Snoh-Sky (Mainstems), NF Skykomish River, SF Sky (Sunset Falls), Pilchuck River, Wood Creek, Elwell Creek, Sultan River, Wallace River, Olney Creek, Proctor Creek, Bridal Veil creek	7
Snoqualmie Chinook	Fall	Wild	Northern Puget Sound	Snoqualmie River (RM 0.0-40.0), Cherry Creek, Tolt River, North Fork Tolt River, SF Tolt River, Raging River, Tokul Creek	7
Cedar Chinook	Fall	Wild	Northern Puget Sound	Cedar River, Taylor Creek	8
Sammamish Chinook	Fall	Composite	Northern Puget Sound	Issaquah, Bear, Cottage Lake Creeks	8
Elwha Chinook	Spring	Wild	Northern Puget Sound	Elwha River, Indian Creek, Little River	18
Elwha Chinook	Summer/Fall	Composite	Northern Puget Sound	Elwha River, Indian Creek, Little River	18
Dungeness Chinook	Spring/Summer	Composite	Northern Puget Sound	MS Dungeness, Gray Wolf River	18

Population Name (SCoRE)	Run Type (SWIFD, SalmonScape)	Production Type (SCoRE)	ESU Stock/Group (NOAA categories)	River(s): Spawning (SCoRE and AFBs)	WRIA (SCoRE)
Green River (Duwamish) Chinook	Fall	Composite	Southern Puget Sound	MS Green River, Soos Creek, Newaukum creek	9
Mid Hood Canal Chinook	Fall	Composite	Southern Puget Sound	Hamma Hamma, Duckabush, Dosewallips Rivers	16
Skokomish Chinook	Fall	Composite	Southern Puget Sound	North and South Fork Skokomish River, MS Skokomish, Purdy, Vance, Hunter Creeks	16
Skokomish Chinook	Spring	Composite	N/A (new stock being introduced)	Skokomish River, North Fork	16
Puyallup Chinook	Fall	Composite	Southern Puget Sound	South Prairie Creek, Puyallup MS, Carbon MS, lower White River	10
White River Chinook	Spring	Composite	Southern Puget Sound	MS White River, WF White, Clearwater R, Greenwater R, Lower Huckleberry	10
Nisqually Chinook	Fall	Composite	Southern Puget Sound	MS Nisqually, Mashel River, Ohop Creek, 25 mile, Yelm, Horn, and Muck Creeks	11
Chehalis Fall Chinook	Fall	Wild	Washington Coastal	MS SF Chehalis, Black River, Skookumchuck, Newaukum, SF NF Newaukum, Cloquallum, Wildcat, Porter, Cedar, Waddell, Stillman, Elk, Big and Jones creeks	22,23
Chehalis Spring Chinook	Spring	Wild	Washington Coastal	MS SF Chehalis, Black River, Skookumchuck River, Newaukum MS NF, Stillman Creek, Elk Creek	22,23
Hoquiam Fall Chinook	Fall	Wild	Washington Coastal	EF WF MF Hoquiam River, Davis Creek	22
Humptulips Fall Chinook	Fall	Wild	Washington Coastal	MS EF WF Humptulips, Big, Stevens, Donkey, O`Brien, Newberry, Rainbow, Brittain and Grouse creeks	22
Satsop Fall Chinook	Fall	Composite	Washington Coastal	MS EF WF Satsop, Canyon River, Bingham, Decker and Black creeks as well as unnamed tributaries 22.0366 and 22.0372	22
South Bay Fall Chinook	Fall	Wild (non-native stock)	Washington Coastal	Johns River	22
Wishkah Fall Chinook	Fall	Wild	Washington Coastal	MS EF WF Wishkah River	22
Wynoochee Fall Chinook	Fall	Wild	Washington Coastal	MS Wynoochee, Carter, Schafer, Helm, Big, Anderson Creeks	22
Hoh Fall Chinook	Fall	Wild	Washington Coastal	MS SF Hoh River, Nolan, Anderson, Winfield, Elk, Alder, Willoughby, Lindner, Braden, Lost, Pole, Spruce, Owl, Iron Maiden, Shelter, Camp, Twin, Hoh creeks and unnamed tributary 20.0511	20
Hoh Spring/Summer	Spring/Summer	Wild	Washington Coastal	MS N S Hoh River, Winfield, Owl, Mount Tom Creeks	20
Quillayute/Bogachiel Fall Chinook	Fall	Wild	Washington Coastal	MS Bogachiel, Bear Creek, MS Quillayute River	20
Quillayute/Bogachiel Summer Chinook	Spring/Summer	Wild	Washington Coastal	MS Bogachiel River	20
Queets Spring/Summer Chinook	Spring/Summer	Wild	Washington Coastal	MS Queets, Tshletsky and Matheny Creek, Sams River	21
Queets Fall Chinook	Fall	Wild	Washington Coastal	MS Queets, Tshletsky and Matheny Creek, Sams River, Salmon River	21

Population Name (SCoRE)	Run Type (SWIFD, SalmonScape)	Production Type (SCoRE)	ESU Stock/Group (NOAA categories)	River(s): Spawning (SCoRE and AFBs)	WRIA (SCoRE)
Bear River Fall Chinook	Fall	Wild	Washington Coastal	MS Bear River	24
Naselle Fall Chinook	Fall	Composite	Washington Coastal	MS N Fork S Fork Naselle River, Alder and Brock Creek	24
Nemah Fall Chinook	Fall	Composite	Washington Coastal	Williams Creek, N Middle S Forks Nemah	24
North River/Smith Creek Fall Chinook	Fall	Wild	Washington Coastal	MS North River, Fall River, Smith and Raimie Creeks	24
Palix Fall Run	Fall	Wild	Washington Coastal	Canon River	24
Willapa Fall Chinook	Fall	Composite	Washington Coastal	MS SF Willapa Rivers, Trap Creek, Rue, Mill, Half Moon and Garbage Dump creeks	24
Kalama Fall (Tule) Chinook	Fall	Composite	Lower Columbia	MS Kalama to Lower Kalama Falls (Hatchery fish released above falls)	27
Kalama Spring Chinook	Spring	Composite	Lower Columbia	Fallert Cr Hatchery to lower Kalama Falls. Also, from Kalama Falls Hatchery to MS RM 20	27
Lewis River Fall (Tule) Chinook	Fall	Composite	Lower Columbia	EF Lewis River primarily. Some NF	27
Lewis River Late Fall (Bright) Chinook	Late Fall	Wild (legacy stock)	Lower Columbia	EF Lewis River primarily. Some NF	27
North Fork Lewis River Spring Chinook	Spring	Composite	Lower Columbia	MS Lewis to Merwin Dam. Limited EF Lewis River	27
Coweeman Fall (Tule) Chinook	Fall	Wild	Lower Columbia	MS Coweeman from Jeep Club Bridge to Mullholland Cr	26
Lower Cowlitz Fall (Tule) Chinook	Fall	Composite	Lower Columbia	MS Cowlitz to Mayfield Dam (Historically up MS and Tribs up to Ohanapecosh and Tilton Rivers	26
Toutle Fall (Tule) Chinook	Fall	Composite	Lower Columbia	Lower Green River, SF Toutle River (impacted by St Helens)	26
Upper Cowlitz Fall (Tule) Chinook	Fall	Composite	Lower Columbia	Historically upper watershed. Currently Tilton River	26
Upper Cowlitz and Cispus Spring Chinook	Spring	Composite	Lower Columbia	Cispus River bw Iron and East Canyon Creek (historically)	26
Big White Salmon River Fall (Tule) Chinook	Fall	Composite	Lower Columbia	MS White Salmon	29
Elochoman/Skamokawa Fall (Tule) Chinook	Fall	Composite	Lower Columbia	MS Elochoman, Skamakowa Cr	25
Grays/Chinook Fall (Tule) Chinook	Fall	Wild	Lower Columbia	MS WF Grays River	25
Mill/Abernathy/Germany Creeks Fall (Tule) Chinook	Fall	Composite	Lower Columbia	MS Mill, Abernathy, Germany creeks	25
Washougal Fall (Tule) Chinook	Fall	Composite	Lower Columbia	MS Washougal River	28

Population Name (SCoRE)	Run Type (SWIFD, SalmonScape)	Production Type (SCoRE)	ESU Stock/Group (NOAA categories)	River(s): Spawning (SCoRE and AFBs)	WRIA (SCoRE)
Okanogan Summer Chinook	Summer	Composite	Upper Columbia	Okanogan, Similkameen	49
Methow Spring Chinook	Spring	Composite	Upper Columbia	Methow, Twisp, Chewuch, Lost, Early Winters ck, Wolf ck, Hancock ck, Lake ck, Eightmile ck, Gold ck.	48
Methow Summer Chinook	Summer	Composite	Upper Columbia	Methow mainstem	48
Entiat Spring Chinook	Spring	Composite	Upper Columbia	Entiat mainstem	46
Wenatchee Spring Chinook	Spring		Upper Columbia	White River, Little Wenatchee, Chiwawa	45
Wenatchee Summer Chinook	Summer	Composite	Upper Columbia	Wenatchee mainstem	45
Upper Yakima River Spring Chinook	Spring	Composite	Middle Columbia	Yakima mainstem, Cle Elum River	39
American River Spring Chinook	Spring	Wild	Middle Columbia	American River mainstem	38
Naches Spring Chinook	Spring	Wild	Middle Columbia	Upper Naches, Bumping, Little Naches, Rattlesnake ck.	38
Marion Drain Fall Chinook	Fall	Wild	Middle Columbia	Marion Drain	37
Yakima River Bright Fall Chinook	Fall	Composite	Middle Columbia	Yakima mainstem	37
Asotin Creek Spring Chinook	Spring	Wild	Snake River	North fork Asotin ck, upper mainstem	35
Snake Fall Chinook	Fall	Composite	Snake River	Snake River mainstem, lower Tucannon, Palouse, Grand Ronde	35
Tucannon Spring Chinook	Spring	Composite	Snake River	Tucannon mainstem, Asotin ck.	35
Wenaha Spring Chinook	Spring		Snake River	Wenaha mainstem & North fork	35

Appendix B

The list of criteria below is adapted from the site submittal form which was sent to key stakeholders. The criteria were derived from the literature review. For a new site to be considered for the barrier list at least one of these conditions needed to be met and it is recommended that any future sites adhere to these criteria.

Criteria for inclusion on the SRKW CK Barrier List:

- Site is within documented Chinook spawning area for one of the identified priority populations.
- Site is in a documented Chinook rearing area within a stream system (watershed) of one of the identified priority populations.
- Site is on a non-natal stream within 500 meters of a documented spawning area for one of the identified priority populations.
- Site is on a non-natal stream within 500 meters of its confluence with tidal water and within 7 kilometers of a natal stream for one of the identified priority population.

Note that there are sites on the current list that do not meet any of these criteria. These are sites that have had at least one field-based site assessment and were kept because the circumstances of the decision to include Chinook as a potential species could be based on local knowledge or made for other, unknown reasons. For example, Double Ditch Creek in WRIA 1 does not have a SWIFD Distribution Type or Use Type for Chinook but there are 39 existing site reports collected from 2004 to 2018 by tens of environmental professionals, all which list Chinook as a potential species. As such, none of these were removed from the barrier list.

Appendix C

The figures and images below are meant to serve as clarifying examples of when a site was removed or included in the barrier list. A depiction of the nearshore buffer layer is provided as well.

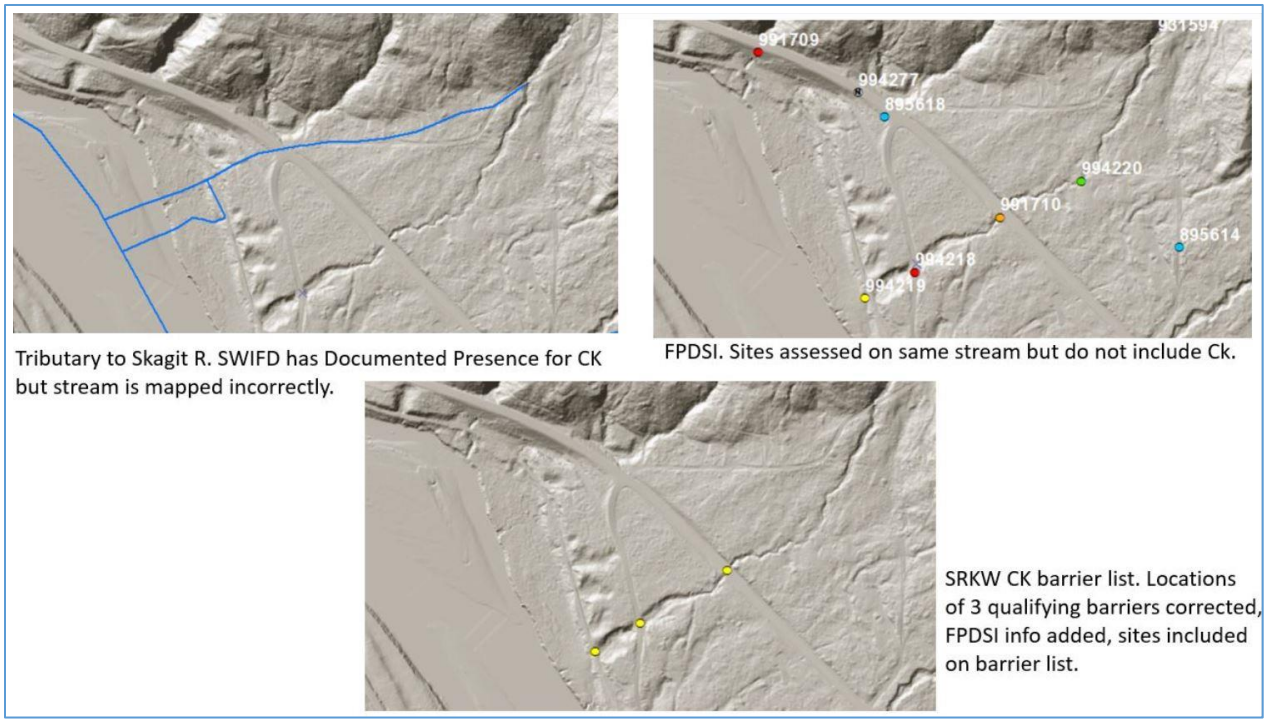

Figure 4. This series shows the iterative QA/QC process at work. In this case combining information from roads layers, SWIFD stream layers, FPDSI, and LIDAR provides the complete picture.

Figure 5. This is an example of a culvert that was assessed as fully passable more than ten years ago. In this case, the stream appears to have an active bedload and the clearance 11 years ago was minimal. It's possible that since 2009 this clearance has decreased enough for this site to be reassessed as a barrier. Site ID 930618. West Fork Kelsey Creek. WRIA 8.

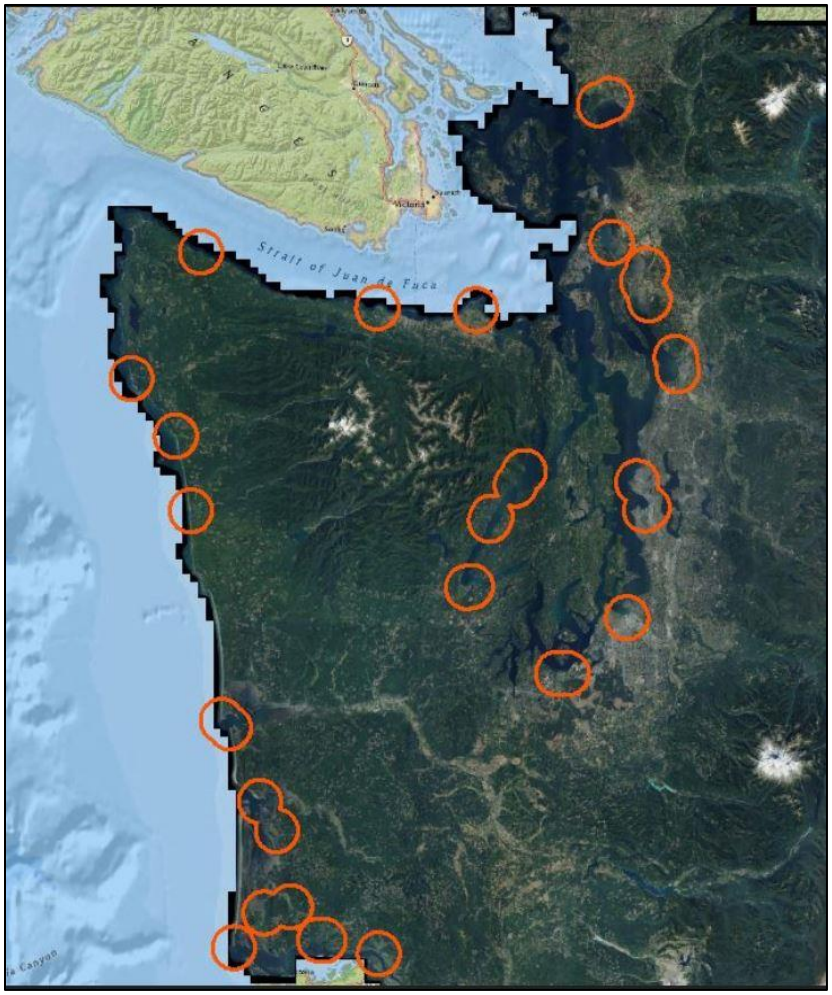

Figure 6. This map shows the 7km buffer that was put at the tidalwater confluence of every watershed included in the barrier list project. A GIS layer of all stream/road intersections within those buffers were reviewed for proximity to tidalwater (if not within 500 meters they were removed), passability (any bridges or passable culverts with assessments done within the last ten years were removed) or excessive gradients (using the synthetic stream network, any systems with slopes over 12.0% were scrutinized and any with slopes over 20% were immediately removed from the list).