Lake Washington/Cedar/Sammamish Watershed (WRIA 8)
Chinook Salmon Conservation Plan
10-year Update

PREPARED FOR
LAKE WASHINGTON/CEDAR/SAMMAMISH
WATERSHED SALMON RECOVERY COUNCIL

2017

FOREWORD

Chinook salmon are an icon of the Pacific Northwest and a vital cultural, economic, and environmental resource for our region. Salmon disappearing from our local waters would alter the fabric of our local communities and is an outcome we are not willing to accept. For the past 10 years, and the foreseeable future, the salmon recovery effort in the Lake Washington/Cedar/Sammamish Watershed (a.k.a., Water Resource Inventory Area [WRIA] 8) will continue working to keep salmon in our local streams. The WRIA 8 Chinook Salmon Recovery Council is an example of local governments working together regionally to deal with a problem that if not addressed will have long-term, wide-ranging consequences. Without increased habitat protection and restoration, as well as greater public awareness and support, we risk losing these valuable fish.

When the federal government listed Puget Sound Chinook salmon as threatened under the Endangered Species Act in 1999, local governments in WRIA 8 banded together to address the listing through a coordinated, bottom-up approach. Since 2000, the WRIA 8 Salmon Recovery Council, comprised of 28 local government partners and community groups, state and federal agencies, businesses, and citizens, has worked to implement the WRIA 8 Chinook Salmon Conservation Plan (Plan), driven by the shared goal of recovering sustainable, harvestable populations of Chinook salmon. This collaborative effort demonstrates the power of working together toward a common vision, investing in a cause that will not only benefit the region's salmon populations, but will also improve the quality of life for all people and wildlife in our watershed.

After more than 10 years of implementing the WRIA 8 Plan, we can say that we have made great headway, and our partnership remains strong. We have helped protect more than 1,500 acres of land, over 300 acres of floodplain, and nearly 12 miles of streambank. We have helped restore over 75 acres of floodplain, more than 325 acres of riparian area, and over a mile of lakeshore. We have removed invasive species from more than 500 acres of riparian areas. This is a great foundation from which to continue and accelerate our efforts on habitat protection and restoration.

However, salmon recovery is a long-term endeavor, and Chinook salmon populations remain far short of our goal of sustainable runs that enable tribal and recreational fishing. Over a century of development and modification in our region degraded salmon habitat and reduced populations to critically low levels. It will take us time and investment to restore our streams and rivers and recover salmon. Updating the Plan is an important step in keeping salmon recovery on track. Through this Plan Update, we set ambitious new habitat goals and developed a set of recovery strategies to guide implementation and ensure our salmon recovery efforts continue to be based on the most recent science, are informed by lessons learned, and are using limited resources wisely. This Plan Update also tells our salmon recovery story and explains to our partners, the public, and decision makers what is still needed to recover Chinook salmon.

As the most populous watershed in the state, WRIA 8 is the proving ground for whether salmon and people can live together. The 28 local government partners in WRIA 8 remain committed to recovering Chinook salmon. We serve as a model for how communities can effectively coordinate and rally

around a shared natural resource issue. By continuing to work together, even as our region grows, we can continue to have both a vibrant local economy and a healthy watershed with strong salmon runs returning each fall.

Working to recover salmon is about more than salmon – it is fundamentally about caring for our home and making our communities sustainable for the long-term. The strategies and actions called for in this Plan will protect and restore salmon habitat, but they will also improve water quality, reduce flood hazards, protect open space, improve stormwater management, sustain and improve our quality of life, and promote a proud legacy of stewardship for future generations. By taking action to recover Chinook salmon, we are taking a stand that extinction is not an option, that we want a healthy environment where we live, that meeting tribal treaty rights is imperative, and that future generations will continue to witness salmon returning to local streams.

On behalf of the WRIA 8 Salmon Recovery Council, we are pleased to share this update to the WRIA 8 Chinook Salmon Conservation Plan, and we strongly encourage everyone interested in salmon recovery and watershed health to assist in implementing this plan.

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City of Bothell

Chair, WRIA 8 Salmon Recovery Council

Mayor John Stokes

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ACRONYMS

2005 Plan	Lake Washington/Cedar/Sammamish Watershed (WRIA 8) Chinook Salmon Conservation Plan
2017 Plan	WRIA 8 Chinook Salmon Conservation Plan 10-Year Update
BMP	best management practice
CARA	critical aquifer recharge area
cfs	cubic feet per second
CMZ	channel migration zone
EIM	environmental information management
F	Fahrenheit
FEMA	Federal Emergency Management Agency
GMA	Growth Management Act
GSI	green stormwater infrastructure
HCP	Habitat Conservation Plan
HOS	hatchery-origin spawners
IC	WRIA 8 Implementation Committee
KCFCD	King County Flood Control District
ILA	interlocal agreement
LID	low impact development
MAP	monitoring and assessment plan
NOAA	National Oceanic and Atmospheric Administration
NOS	natural-origin spawners
NPDES	National Pollutant Discharge Elimination System
PAH	polycyclic aromatic hydrocarbons
PIT	passive inductance transponder
PHOS	proportion of hatchery-origin spawners
RM	river mile
SMA	Shoreline Management Act
SMP	shoreline master program
TC	WRIA 8 Technical Committee
UGA	urban growth area
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
VSP	viable salmonid population
WDFW	Washington Department of Fish and Wildlife
WQI	water quality index
WRIA	water resource inventory area

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EXECUTIVE SUMMARY

This document updates the *Lake Washington/ Cedar/Sammamish Watershed Chinook Salmon Conservation Plan* (2005 Plan; WRIA 8 Steering Committee, 2005). Since 2000, Lake Washington/ Cedar/Sammamish Watershed (a.k.a. Water Resource Inventory Area [WRIA] 8) partners have worked together to improve conditions for threatened Chinook salmon, with the goal of bringing naturally-produced Chinook salmon back to sustainable, harvestable levels. While the Plan focuses on recovering Chinook salmon, actions taken to improve conditions for Chinook also improve conditions for other salmon species and support improving overall watershed health.

The 2017 WRIA 8 Chinook Salmon Conservation Plan (2017 Plan) updates the 2005 Plan by drawing on current science to develop quantitative habitat goals for Chinook salmon, evaluate the negative impacts (or pressures) on Chinook salmon, update salmon recovery strategies to identify actions that address the highest priority pressures on salmon, and produce a Monitoring and Assessment Plan (MAP).

The 2017 Plan is an addendum to the 2005 Plan, but is also intended to serve as a stand-alone document. As an addendum, the 2017 Plan continues themes and content discussed in the 2005 Plan, provides information learned during the first 10 years of implementation, includes new habitat goals, and identifies new and updated strategies to meet salmon recovery goals. The 20 updated strategies are a valuable new tool to direct our work addressing the key factors limiting salmon recovery in our watershed. They are outlined in Section 4 of this document and spelled out in detail in Appendix E.

Over the past 10 years, we have learned more about the impacts humans have on Chinook salmon survival through empirical scientific research, studies, and formal and informal monitoring of implemented projects. While the 2005 Plan included measurable salmon population recovery goals, there were no measurable goals for habitat restoration. The 2017 Plan uses recent habitat monitoring efforts that establish baseline conditions to develop near-term (2025) and long-term (2055) quantifiable habitat recovery goals.

To produce a plan to achieve these goals, a conceptual model was developed to identify key life stages and important habitats that may limit Chinook salmon recovery. Human impacts that exert pressures on Chinook salmon and their habitat were evaluated for each life stage and geographic area of the watershed. This work formed the basis for developing the 20 recovery strategies to improve conditions that support Chinook salmon in WRIA 8.

One of the primary gaps identified in the 2005 Plan was the lack of methodology to measure progress towards the desired future status of habitat. While we have learned much from monitoring efforts to date, developing the MAP (Appendix A) allows us to better assess our progress and correct our course as we protect and restore salmon habitats and ecosystem processes. The MAP guides project sponsors in monitoring and reporting the progress of habitat restoration projects towards habitat and salmon recovery.

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Significant Changes to the WRIA 8 Plan Since 2005

2005 Plan Status	Change	Plan Update Reference
Focus on recovery of three populations (Cedar River, Issaquah Creek, and North Lake Washington Tributaries)	Combined Issaquah Creek and North Lake Washington populations into a single Sammamish River population	Page 6
Conceptual model	New, lifecycle-based conceptual model helps prioritize life stages to inform prioritization of actions, location, and timing	Pages 9-10
No habitat restoration goals	Numeric habitat goals for five key habitat elements	Page 9
Upper Cedar River Watershed, above Landsburg Diversion Dam designated Tier 2[1]	Area designated Tier 1 given regular, significant Chinook salmon spawning use since 2003 when construction of fish passage facilities allowed Chinook salmon to pass above Landsburg Diversion Dam	Section 1.2
Recovery strategies included	Twenty new and updated recovery strategies identified to guide implementation of recovery actions. Strategies based on new science, current conditions, and lessons learned.	Section 4
Comprehensive List of Site-Specific Projects (600+ projects) Start List of most important and ready-to-go projects, land use actions, and education and outreach actions to implement in the first 10 years	Revised and updated list of site-specific projects to improve project specificity, update definitions, reduce duplication, and add newly identified projects. Revised and updated lists of (1) recommended land use actions, and (2) education and outreach actions. All projects/actions are connected to the most relevant recovery strategies.	Pages 41-46 & Appendices F, H, and I
Monitoring and adaptive management framework	Monitoring and Assessment Plan guides monitoring and reporting on progress towards implementing recovery strategies and meeting habitat goals.	Pages 47-49 & Appendix A

[1]Recovery "tiers" are determined by watershed condition and fish use and denote the priority for recovery activities. Tier 1 areas are highest priority, followed by Tier 2, which are satellite spawning areas and are important for the spatial diversity of Chinook. Tier 3 areas see infrequent or no Chinook use but are important from a water quality perspective.

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Figure 1. Map of WRIA 8 Habitat Priority Tiers
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WRIA 8 Habitat Priority Tiers

- Tier 1
- Tier 2

- WRIA 8 boundary
- River
- Stream
- Major road
- Lake
- Incorporated area

N

0   2   4   6 Miles

July 2017

1. INTRODUCTION
PLAN UPDATE CONTEXT

This document updates the Lake Washington/ Cedar/Sammamish Watershed Chinook Salmon Conservation Plan (2005 Plan; WRIA 8 Steering Committee, 2005). Since 2000, Lake Washington/ Cedar/Sammamish Watershed (a.k.a. Water Resource Inventory Area [WRIA] 8) partners have worked together to improve conditions for threatened Chinook salmon, with the goal of bringing naturally-produced Chinook salmon back to sustainable, harvestable levels.

Concerned about the need to protect and restore Chinook salmon habitat for future generations and to maintain local control over recovery decisions and implementation, 27 local governments in WRIA 8, including King and Snohomish counties and 25 cities, signed an interlocal agreement (ILA) in 2001 to jointly fund the development of the 2005 Plan. The 2005 Plan was created with input from numerous stakeholders to provide a science-based roadmap for protecting and restoring spawning, rearing, and migratory habitat for Chinook salmon.

When the WRIA 8 Salmon Recovery Council adopted the 2005 Plan, they established an initial 10-year implementation period and called for the plan to be reviewed and updated after that
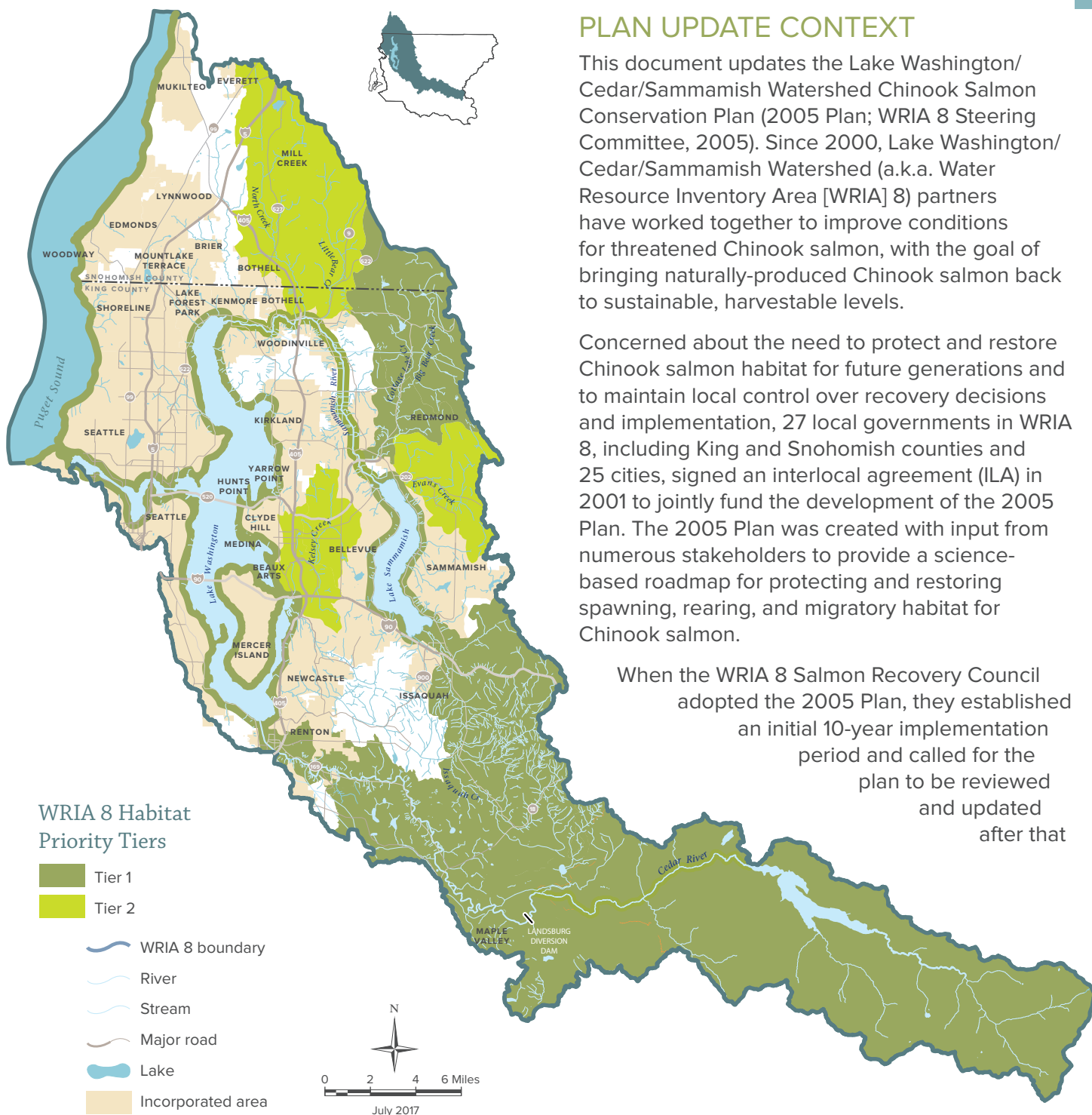
time. After 10 years, we have learned much about where more work is needed. The 2017 WRIA 8 Chinook Salmon Conservation Plan (2017 Plan) updates the 2005 Plan with new information and lessons learned over the last decade, and includes refined strategies and goals for the future. The full process for updating the 2017 Plan with Salmon Recovery Council input and approval is described in Appendix B.

In 2015, 28 local government partners in the watershed (the Town of Woodway joined the original 27 partners in 2014) renewed the ILA, recommitting themselves to coordinated salmon recovery for another 10 years. In so doing, partners recognized the habitat protection and restoration progress made over the past decade, the resulting benefits to local communities, and the efficiency of working collectively to make the watershed a place where salmon and people can live together.

RECOVERY CONTEXT

The Lake Washington/Cedar/Sammamish Watershed (WRIA 8), located in western Washington, comprises 692 square miles and includes two major river systems (the Cedar and Sammamish rivers) and three large lakes (Union, Washington, and Sammamish). It also includes the marine nearshore and numerous smaller sub-basins that drain directly to Puget Sound from West Point in the City of Seattle northward to Elliott Point in the City of Mukilteo. WRIA 8 is located predominantly in western King County and about 15 percent of the land area extends northward into Snohomish County. Over 53 percent of the marine shoreline is located within Snohomish County (Figure 1). A large portion of the upper Cedar River watershed is the municipal drinking water supply for the City of Seattle, and is managed under a Habitat Conservation Plan (HCP). Tribal treaty areas in WRIA 8 include usual and accustomed fishing places of the Muckleshoot, Snoqualmie, Tulalip, and Suquamish tribes. The human population of the watershed is approximately 1.4 million.

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Historically, the Lake Washington watershed drained south to the Black and Duwamish rivers. In 1916, the U.S. Army Corps of Engineers (USACE) constructed the Hiram M. Chittenden (a.k.a. Ballard) Locks (Locks) and excavated the Ship Canal to connect the Union Bay area in Lake Washington with Salmon Bay in Puget Sound. The surface of Lake Washington dropped 9 feet and exposed previously inundated shallow-water areas, decreasing the lake shoreline by 12.8 percent and draining many of the lake's wetlands. The decrease in lake elevation disconnected Lake Washington from the Duwamish River, and the Cedar River— which previously flowed into the Duwamish River via the Black River—was permanently rerouted to Lake Washington. As most of the Black River dried up and became impassable, salmon populations were forced to find a new route to their natal streams. The Sammamish River, which historically had a meandering channel through a large wetland complex, was also heavily modified, straightened, and drained in the early to mid-1900s to reduce flooding and support agricultural production in the Sammamish Valley. In subsequent years, salmon habitat was further impaired as upland and shoreline development removed more shallow-water habitat, reduced channel complexity in rivers and streams, and reduced forest cover along lake and channel shorelines. Today, all Chinook salmon enter and exit the watershed through the Ballard Locks and its associated fish passage facilities.

An estimated 31 populations of Chinook salmon once existed in Puget Sound. Annually, nearly 700,000 adults returned to Puget Sound watersheds to spawn. Since the late 1800s and early 1900s, human activities such as logging, overfishing, water withdrawals, and land development have caused the numbers of Chinook salmon to plummet to less than 10 percent of their historic levels (Figure 2). Nine populations have gone extinct, leaving only 22 populations in the Puget Sound. This drastic decline prompted the federal government to list Puget Sound Chinook salmon as threatened under the Endangered Species Act in 1999.

Chinook Salmon Recovery Timeline

WRIA 8 Wild Chinook Population

WRIA 8 Chinook Salmon recovery goals:

2025 (near-term) abundance goal = 2,763 returning natural-origin spawning adult fish

2055 (long-term) abundance goal range = 3,000 – 12,000 returning natural-origin spawning adult fish

Railroad 1870
Northern Pacific Railroad survey triggers land boom

Logging 1881
First splash dam built for logging in Washington

Population 1890
Seattle population **42,000**

Landsburg Diversion Dam on Cedar River
Constructed to supply drinking water to Seattle

Canneries 1913
Puget Sound canneries pack more than 2.5 million cases of Pacific salmon

Ballard Locks Built
Lake Washington drops 9 feet

Population 1950
Seattle **465,000**

WILD PUGET SOUND CHINOOK SALMON RUN SIZE

Puget Sound Wild Chinook Population

Population 2016
Seattle **689,000**

Puget Sound Chinook listed as threatened species

Why do the data on salmon abundance get better starting in 1975?
The quality of data on annual salmon population runs improves starting in 1975, when the Washington Department of Fisheries (predecessor to Washington Department of Fish and Wildlife) initiated data collection and began estimating annual salmon run size in response to the federal court mandate to develop and share annual abundance of salmon returning to individual rivers in Puget Sound.
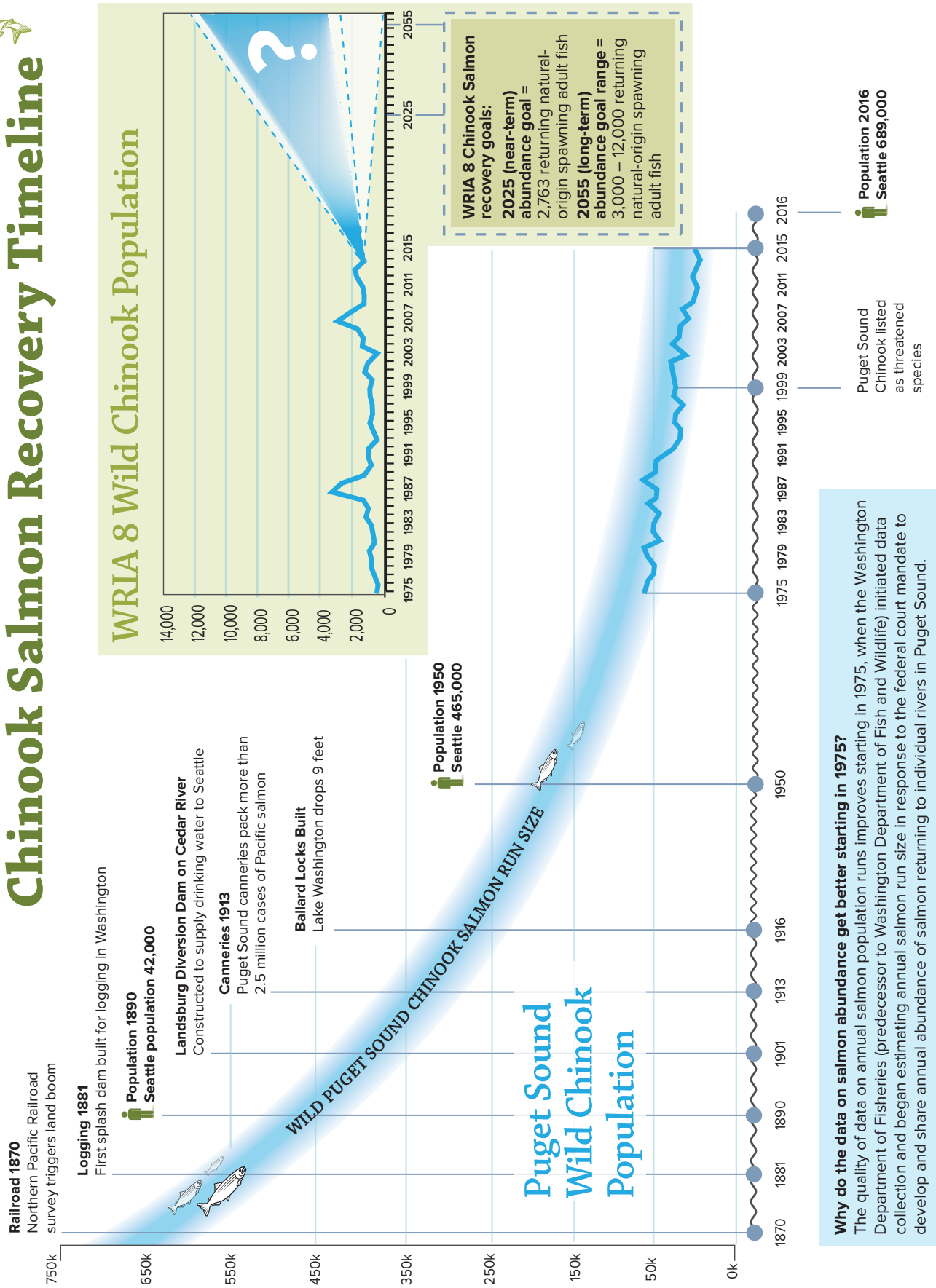
Figure 2. Puget Sound Chinook Population Decline and WRIA 8 Population Recovery
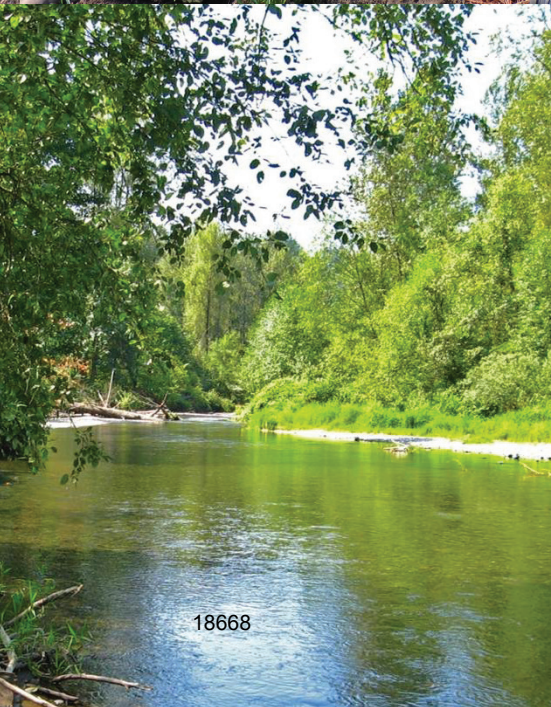
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WRIA 8 is home to two of the 22 Chinook salmon populations in Puget Sound: the Cedar population (Cedar River and tributaries) and the Sammamish population (Sammamish River, North Creek, Little Bear Creek, Bear/Cottage Lake Creek, Issaquah Creek, Kelsey Creek). Focusing on two populations reflects a change since adoption of the 2005 Plan. Originally, lacking certainty about genetic differences between populations, salmon recovery partners took a precautionary approach that identified three distinct Chinook salmon populations in WRIA 8. Genetic analyses performed after the 2005 Plan indicated that a two-population approach (Cedar River and Sammamish River populations) was appropriate. This approach was adopted by the WRIA 8 Salmon Recovery Council in 2010.

The contribution of WRIA 8 partners to the overall goal of increasing WRIA 8 natural-origin Chinook salmon to sustainable and harvestable levels is to protect high-quality habitat, as well as to reduce existing pressures and restore additional habitat needed by salmon at specific life history stages in the watershed. To prioritize implementation of restoration strategies, the watershed has been classified into functional "tiers" based on watershed condition and fish use (Figure 1). Tier 1 areas are the highest priority habitats for protection/restoration, and include primary spawning areas, as well as migratory and rearing corridors. The Cedar and Sammamish rivers, Bear and Issaquah creeks, shores of lakes Sammamish, Union, and Washington (including the Ship Canal), and the marine nearshore (including bluff-backed beaches and pocket estuaries) are classified as Tier 1. The Cedar River is considered the highest priority Tier 1 area because it includes spawning and rearing areas for the Cedar population, which supports the largest number of natural-origin Chinook salmon in the watershed. With its tributaries, it is also the sole spawning area for the Cedar population. The marine nearshore is a Tier 1 area because it is important as migratory and rearing habitat for WRIA 8 Chinook populations and those from other Puget Sound watersheds.

Tier 2 areas are a secondary priority and include areas less frequently used by Chinook salmon for spawning, but that contribute to the overall spatial diversity of salmon populations in the watershed. Tier 2 systems include North, Little Bear, Kelsey, and Evans creeks. Upland areas associated with Tier 1 and Tier 2 streams assume the tier designation for the waterbody the upland area supports.

Tier 3 areas (all areas not Tier 1 or Tier 2) contain streams that are infrequently or never used by Chinook salmon, but are still important for other species of salmon and resident fish, water quality, flow management, and overall watershed health. Coal and May creeks were classified as Tier 3 streams in the 2005 Plan. Recently, these creeks have experienced an increase in use by spawning Chinook salmon, and contain areas with somewhat higher quality habitat compared to some other Tier 2 areas. The WRIA 8 Technical Committee (TC) plans to monitor their status and to consider upgrading these streams to Tier 2 if adult returns continue to increase.

In addition to prioritizing geographic areas by tiers, the 2017 Plan further prioritizes actions by life stage, using an updated conceptual model developed by the WRIA 8 TC during the 2017 Plan update process. This conceptual model is described in more detail in Section 2.2.

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2. RECOVERY GOALS

As part of the 2005 Plan update process, the WRIA 8 Technical Committee (TC) reviewed the Chinook salmon population recovery goals established in the 2005 Plan and determined that they remain appropriate and relevant. Upon the recommendation of the TC, the WRIA 8 Salmon Recovery Council approved carrying them forward in the 2017 Plan.

Noting that the 2005 Plan did not include quantifiable habitat goals, the TC used an assessment of pressures on Chinook salmon, a new conceptual model, existing monitoring data, limiting factor assessments, and available scientific studies to develop and articulate a focused set of near-term (2025) and long-term (2055) Chinook salmon habitat goals. These habitat goals provide targets for the most important Chinook salmon habitat elements in the watershed, and give us a roadmap for measuring progress.

CHINOOK SALMON RECOVERY GOALS

Chinook salmon population recovery goals were determined using the Viable Salmonid Population (VSP) concept and the recommendations identified in WRIA 8's "H-Integration" process to address impacts from habitat degradation, hatchery production, and harvest. A "viable" population is one that has a negligible risk of extinction in its native habitat over a 100-year time frame. Recovery goals are set for both a near-term (2025) and a long-term (2055) time frame for each VSP parameter to support sustainable Chinook salmon populations (Table 1). The 2025 and 2055 goals described for the Chinook salmon recovery goals in this section are the same as the short-term and long-term goals from the 2005 Plan.

The 2005 Plan included Chinook salmon population recovery goals that are based on recovery planning targets provided by the Washington Department of Fish and Wildlife (WDFW) and the National Oceanic and Atmospheric Administration's (NOAA) Population Viability Analysis, which the TC further elaborated in 2009 as part of the H-Integration process. The TC reviewed these goals as part of updating the 2005 Plan, and recommended no changes for the 2017 Plan, which the Salmon Recovery Council approved. For more information on the Chinook salmon population recovery goals, see Chapter 3 of the 2005 Plan.

Adult spawner ("fish-in") and juvenile outmigration ("fish-out") monitoring has occurred in the watershed since 1998, at significant expense to watershed partners. The TC recognizes the value of these data and recommends continuing this work. However, the TC notes that future priorities may require directing limited monitoring funds toward other priorities over the next 10-year implementation cycle.

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WRIA 8 Chinook Salmon Population Goals

VSP[a] Parameter	Historical Conditions[b]	2025 Goals	2055 Goals
CEDAR POPULATION			
Abundance	>15,000 spawner capacity	1,680 natural-origin spawners (NOS)	2,000 to 8,000 natural-origin spawners; consistent with tribal treaty rights and recreational harvest
Productivity	Unknown	≥2 returns per spawner 2-4 years out of 10; ≥13.8% egg-to-migrant survival rate	12-20% egg-to-migrant survival rate
Spatial distribution	Proportional use by river mile and lake residency[c]	Convert one satellite subarea to core (Tier 1); expand spawning area distribution	Recapture historical distribution; fully exploit available habitat
Diversity	Assume >50% parr rearing life history; low stray rate from other systems	Increase Cedar River instream rearing trajectory	Increase Cedar River instream rearing trajectories to 50%
SAMMAMISH POPULATION			
Abundance	Unknown, estimated at ~8,500 spawners	Maintain base period average of 1,083 naturally spawning adults	1,000 to 4,000 natural-origin spawners; tribal treaty and sport fishing occur on a consistent basis
Productivity	Unknown	Adult productivity ≥1.0; ≥2 returns per spawner 2 4 years out of 10; ≥4.4% egg-to-migrant survival rate	≥ 10% egg-to-migrant survival rate
Spatial distribution	Spawning distribution assumed to be broad, but more concentrated in larger streams	Convert one satellite subarea to core; expand spawning area distribution	Consistent use of north Lake Washington tributaries (in addition to Bear Creek) for spawning
Diversity	Historical diversity assumed to be greater than that at present	Improve Sammamish River habitat rearing conditions to support eventual parr rearing	Maintain and increase duration of natural spawning in the basin

Note: Current population status is discussed in Section 3

[a] VSP – viable salmon population, one with a negligible risk of extinction over a 100-year time frame.

[b] Historical conditions are estimates of presettlement or "template" conditions provided by NOAA and WDFW.

[c] Lake residency is considered a template condition, even though lake residency is not a historical condition. See 2005 Plan for more information.

Table 1. WRIA 8 Chinook Salmon Population Goals

For more information on the VSP Framework and how the Chinook salmon recovery goals were developed, see Appendix C-1 in the 2005 Plan.

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HABITAT GOALS

The relationships between habitat conditions and Chinook salmon growth and survival are known to be multifaceted and complex. They operate at many spatial and temporal scales. The response of Chinook salmon populations to even large-scale habitat improvements may not be detectable for years, and may be confounded by improvements or declines elsewhere in the watershed or in the marine environment. Nevertheless, known linkages exist between freshwater habitat conditions and salmon, supported by decades of scientific research.

> **Important: Not all of the key constraints to Chinook salmon recovery in WRIA 8 can be alleviated by capital actions that protect and restore habitat. As described in the discussion of the WRIA 8 conceptual life stage model that follows, key constraints such as predation and high water temperatures will require other recovery strategies. These strategies are discussed in Section 4.**

During the 2017 Plan update process, the TC reviewed new information about Chinook salmon needs and limiting factors in WRIA 8. This review culminated in a conceptual life stage model of WRIA 8 Chinook salmon that considers the habitat needs and pressures facing Chinook salmon at each specific time and place in their lifecycle. The conceptual model allowed the TC to rank the pressures affecting Chinook salmon in the watershed, thereby helping ensure that strategies were developed to address the most pressing issues. This process allowed the TC to focus protection and recovery recommendations where they will be most effective and cost-efficient.

WRIA 8 conceptual life-stage model

Chinook salmon occupy different and unique habitats at each stage of their lives. Each of these habitat types becomes significant to salmon for the specific periods it is occupied (or traversed) by Chinook salmon. Environmental conditions

vary across space and time; stresses vary in their significance by geography, season, and life stage. The life stage conceptual model for WRIA 8 Chinook salmon (Figure 3) attempts to describe these local stresses and illustrate the factors with the most important impacts. The following section summarizes the key factors affecting each life stage at the most significant places and times. More information can be found online at http://www.govlink.org/watersheds/8/reports/default.aspx#fishecol.

Adult migration occurs from June through September from Salmon Bay through the Ballard Locks and Ship Canal to Lake Washington, and from Lake Washington either north to the Sammamish River and its tributaries, or south to the Cedar River or south Lake Washington tributary streams (Kelsey, May and Coal creeks). Significant stresses identified for adult migrants include thermal and dissolved oxygen barriers at the Locks and Ship Canal, and physical passage through the Locks and fish ladder. The Sammamish River can pose significant thermal stress to Chinook salmon returning to Bear/Cottage Lake and Issaquah creeks, as well as to Chinook salmon returning to the Issaquah Salmon Hatchery. **Lethal and sublethal temperatures in the Ship Canal and Sammamish River during adult migration are considered a key constraint on recovery.**

Harvest in terminal or freshwater areas (including bycatch) is currently minimal, and is managed to protect Cedar River Chinook salmon as stipulated in the Puget Sound Chinook Harvest Management Plan (Puget Sound Indian Tribes and WDFW, 2010).

Stream flows on the Cedar River are managed by Seattle Public Utilities to support fall migration and spawning needs. Elsewhere, low flows early in the migration period could potentially impede migration. The sockeye broodstock collection facility on the lower Cedar River has the potential to delay passage and alter spawning patterns (facility is monitored and managed to minimize delays and is undergoing redesign). Predation on migrating adults occurs at the Locks, but is not
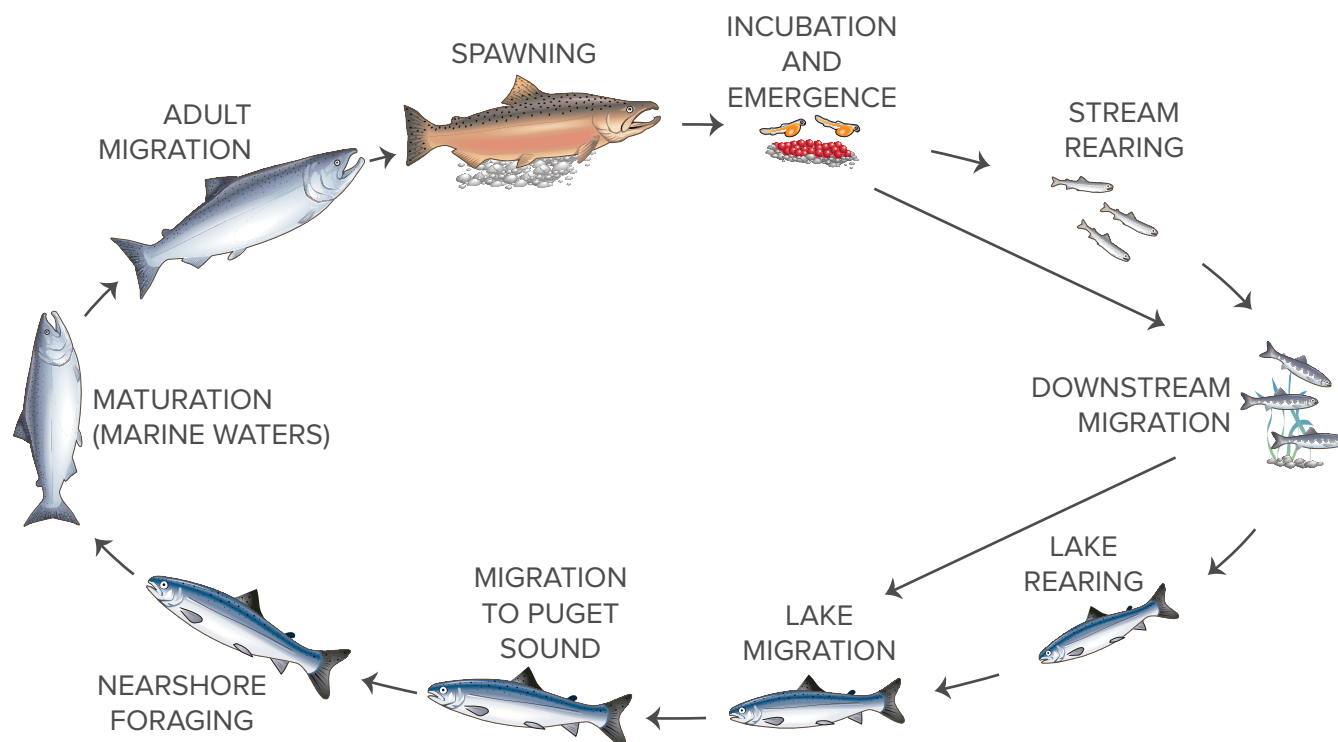
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Figure 3. Life Stage Conceptual Model of WRIA 8 Chinook Salmon

consistently significant. Disease or parasites on Chinook salmon do not appear to be a significant issue at this time.

Spawning in WRIA 8 occurs from September through November in the Cedar River, Bear/Cottage Lake Creek, Issaquah Creek (below and above the Issaquah Salmon Hatchery), Little Bear Creek, North Creek, and Kelsey Creek. May and Coal creeks and a few other streams in the basin also see intermittent use by small numbers of Chinook salmon. Monitoring on the Cedar River and on Bear/Cottage Lake Creek indicates that these streams have sufficient spawning habitat at current abundance levels. Limitations in other creeks are unknown but are assumed to be present inside the Urban Growth Area (UGA). Potential spawning stresses include habitat limitations (gravel quantity and quality, inadequate cover), hatchery interactions, and low streamflow and high temperatures early in the spawning season. In addition, disturbance or harassment by humans or their pets, or human infrastructure (e.g., artificial light) could affect spawning success, especially in urban areas.

Incubation and emergence occurs from September through March in the Cedar River, Bear/Cottage Lake Creek, Issaquah Creek (below and above the hatchery), Little Bear Creek, North Creek, and Kelsey Creek. Potential stresses

include habitat limitations through excessive fine sediments, abnormally high or low streamflow, high temperature, and possible water quality concerns, especially during early fall freshets (urban stormwater has been shown to affect salmon embryo development). Monitoring on Cedar River and Bear Creek indicates those areas are not limited at this life history stage at current abundance levels (WRIA 8 TC, unpublished data). Habitat quality/quantity limitations on other creeks are unknown but likely high, except perhaps upper Issaquah Creek where human impacts are lower. Streamflow on the Cedar River is regulated to support Chinook salmon incubation through an HCP, and is managed during redd incubation to avoid, if possible, redd scour due to flows above about 2,200 cfs. Flow management on the Cedar River also supplements minimum flows to prevent redd dewatering during low flow periods. It is important to note that flow management can be limited due to the relatively small size of the water supply dams on the Cedar River, which were not designed as flood control facilitates. Elsewhere, high- or low-flow events may affect success through scouring or dewatering redds. Temperature during incubation influences time of emergence – warmer temperatures speed embryo development and result in earlier emergence dates, which could affect survival if fry emerge before prey or during high winter flows.

Stream rearing occurs from January through July, and a very small fraction of the population remains in the system as yearlings. Stream rearing occurs in the Cedar River, Bear/Cottage Lake Creek, Issaquah Creek (below and above the hatchery), Little Bear Creek, North Creek, and Kelsey Creek. Potential stresses include streamflow, habitat limitations (quantity and quality of instream habitat, cover, flood refugia, and large woody debris), predation, prey resources, and water quality. **A key constraint on Chinook salmon recovery in WRIA 8 is insufficient instream rearing and refuge habitat, due to habitat simplification, loss of floodplains and side channels/off-channel rearing, and lack of large woody debris.** Evidence from annual juvenile outmigrant trapping indicates this life stage is limited in the Cedar River and Bear/Cottage Lake Creek. It is likely that this life stage is limited by lack of instream rearing and refuge habitat throughout the watershed, though little data exist on Chinook salmon productivity in other WRIA 8 streams. (Habitat monitoring confirms lack of quality rearing/refuge habitat.) Streamflow issues vary from year to year. Peak storm flows may wash fry downstream if floodplain refuge habitat is insufficient; base flows are usually adequate during the period that Chinook salmon rear in the stream (although unusually low base flows in spring 2015 could become more common under climate change scenarios). Predation by cutthroat trout (*Oncorhynchus clarkii*) and other predators may be a factor. Prey abundance and its potential limitation during the stream rearing stage is unknown, although prey abundance may be considered low in areas with low concentrations of macroinvertebrates (as measured by the Benthic Index of Biotic Integrity, or B-IBI). Poor water quality may affect Chinook salmon survival in areas with high volumes of storm runoff.

Downstream migration occurs from January through July, with fry migrants moving downstream from January through April, and parr migrants moving downstream from April through July. Potential stresses include streamflow, habitat limitations (quantity and quality of cover), and predation. Predation on migrating juvenile Chinook salmon by resident trout and other fish, including some non-natives, may present localized bottlenecks, and is likely a key pressure at this life stage.

Lake rearing and migration occur from January through July, with small numbers of Chinook salmon remaining year-round in Lake Washington and Lake Union, either by choice or due to late-season thermal barriers to outmigration at the Ballard Locks. Lake Washington is a unique feature across Puget Sound Chinook populations, and functions much like an estuary for WRIA 8 Chinook salmon fry. Rearing in Lake Washington begins in the southern end near the outlet of the Cedar River (January through March) and shifts northward toward Union Bay and the Ship Canal in later months, as juveniles move toward eventual outmigration (May through July). Prey resources do not appear to be limiting. During January through to early April, fry are shoreline-oriented and feed primarily on chironomids in shallow waters. Chinook salmon fry become less shoreline-oriented and occupy deeper water as they grow and migrate northward, and shift to *Daphnia spp*. as their preferred prey after the spring phytoplankton bloom and daphnia emergence. Information on the behavior of naturally produced Chinook salmon in Lake Sammamish is limited, but it is likely that fry exhibit similar behavior.

Potential stresses during lake rearing and migration include predation, habitat limitations (quantity and quality of refuge habitat, cover), inadequate prey resources, high temperatures, and poor water quality. Shoreline habitat, including stream mouths, has greater importance at the southern ends of Lake Washington and Lake Sammamish when

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Chinook salmon are smaller; good lake shoreline habitat is generally lacking throughout both lakes. Early-season predation on Chinook salmon is assumed to be focused on the southern shorelines, with a shift northward and offshore as Chinook salmon grow. Early-season water temperatures likely hinder significant predation by warmwater fish, but predation by cutthroat trout and northern pikeminnow (*Ptychocheilus oregonensis*) could affect a large proportion of the Chinook salmon population. Recent captures of walleye (*Sander vitreus*), a non-native warm-water lake fish common to the Midwest, in both lakes raise concerns that this low-light predator could adversely affect overall survival rates in the future if their numbers grow. There is little research on avian predation in Lake Washington. **Predation by fish in Lake Washington and the Ship Canal, while not yet adequately quantified, appears likely to be a key constraint on juvenile rearing and migration.** Predation is likely to be exacerbated by artificial nighttime lighting in urban areas. Poor water quality may have sublethal effects on Chinook salmon survival, especially near stormwater outfalls and in the Ship Canal and Lake Union. Recent analyses showed no evidence of polychlorinated biphenyl (PCB) contamination of juvenile Chinook salmon leaving the Lake Washington system, although the issue is known to be significant elsewhere in Puget Sound (Meador, 2013).

Migration to Puget Sound occurs from April through August. The key geography for this life stage includes the Lake Washington Ship Canal, Ballard Locks, and the Salmon Bay estuary. Potential stresses include abrupt temperature and salinity transitions, predation, habitat limitations (quantity and quality of refuge habitat, cover), high temperatures, poor water quality, and lack of prey resources (though ample zooplankton prey are available in the inner bay just downstream of the Locks (Simenstad et al., 2003). Predation by warmwater predators is likely significant because

of the concentration of predators and timing of migration. Recent surveys have documented smallmouth bass (*Micropterus dolomieu*), largemouth bass (*M. salmoides*), rock bass (*Ambloplites rupestris*), and yellow perch (*Perca flavescens*) as predators on juvenile Chinook salmon in the Ship Canal. The Ballard Locks pose a migration barrier hazard as exit pathways may physically harm Chinook salmon, delay their volitional passage, or cause other sublethal effects.

Nearshore foraging occurs primarily from April through August in the Puget Sound nearshore, but Chinook are found in the nearshore throughout the year (Brennan et al., 2004). Data from beach seining in 2001 and 2002 showed that juvenile Chinook (<150mm) caught within WRIA 8's nearshore consumed higher amounts of crab larvae and terrestrial insects than two areas in WRIA 9 (Brennan et al., 2004). It also showed that as juvenile Chinook get larger than 150mm, they predominately feed on other fish. Potential impacts include lack of rearing habitat and disconnected habitat, predation, lack of or competition for prey resources, and poor water quality. Since WRIA 8 lacks a true estuary, Chinook fry tend to rear in Lake Washington and enter Puget Sound at approximately the same size as WRIA 8 parr migrants. The nearshore is a shared resource that offers regional benefits for Chinook migrating along the shoreline from WRIA 8 as well as from other watersheds.

Maturation (marine waters). Chinook salmon spend 1 to 5 years in Puget Sound and the Pacific Ocean before returning to fresh water to spawn, with the majority of WRIA 8 Chinook salmon returning at age 3 or 4. Shifts in ocean conditions such as those related to El Niño and Pacific Decadal Oscillation patterns or climate change (e.g., ocean acidification) have been shown to affect ocean survival rates and therefore Chinook salmon abundance. Approximately 58 percent of

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WRIA 8 adult Chinook salmon caught in marine fisheries (1973-1985) were recovered within Puget Sound, while 15 percent were recovered off southwest Vancouver Island (Quinn et al., 2005). Marine harvest of Chinook salmon is governed by international treaty and by state, federal, and tribal fishery managers.

HABITAT GOALS SUMMARY

During development of the 2017 Plan, the TC developed a short list of near-term (2025) and long-term (2055) goals (Table 2) that focus on the key elements affecting Chinook salmon within the watershed, as determined by scientific research (including new and emerging scientific information), the WRIA 8 Chinook salmon conceptual model, and assessment of the human pressures on Chinook salmon survival in WRIA 8 (Section 3.3). The 2025 goals selected by the TC focus on the most important habitat elements for conservation and recovery of Chinook salmon in the watershed and are based on local data, the unique constraints placed on rivers and streams in the WRIA 8 watershed, and the pace of implementation

progress in the last 10 years. These goals are intended to be feasible and achievable, and are proxies for a larger set of habitat processes that the TC hypothesizes will be improved if these goals are met. The 2055 goals represent desired future conditions, which in some cases are a qualitative description rather than a quantitative measure. The WRIA 8 Salmon Recovery Council approved the goals during development of the 2017 Plan.

Monitoring is necessary to track progress towards achieving these goals. To align with other planning horizons and remain ecologically meaningful, we recommend that adaptive management course corrections occur in 5-year intervals, at which time the goals will be assessed and adjusted as necessary, and the next adaptive management planning horizon will be set. The WRIA 8 TC will oversee monitoring efforts in the intervening periods and recommend changes if warranted by interim results. (see Appendix A: Monitoring and Assessment Plan)

WRIA 8 Habitat Goals

Habitat Component	2025 Goals	2055 Goals
Cedar River	Total connected floodplain acres between Lake Washington and Landsburg Diversion Dam will be 1,170 acres (reconnect an additional 130 acres) by 2025. Average wood volume will quadruple over current basin conditions to 42 m^3/100 m (RM 4 to Landsburg Diversion Dam) by 2025.	Total connected floodplain acres between Lake Washington and Landsburg Diversion Dam will be at least 1,386 acres by 2055 (reconnect on additional 346 acres). Average wood volume between RM 4 and Landsburg Diversion Dam will be 93 m^3/100 m by 2055 (the median standard wood volume for streams over 30 m bankfull width – Fox and Bolton, 2007).
Sammamish River	Areas of river will be cool enough to support Chinook salmon migration and survival (increase riparian cover by at least 10% and add two thermal refugia) by 2025.	Riparian forest cover and thermal refugia along the river will help keep it cool enough to support Chinook salmon migration and survival by 2055.
Streams (Bear/Cottage Lake, Issaquah, Evans, Kelsey, Little Bear, North creeks)	Area of riparian cover in each Tier 1 and Tier 2 stream will increase by 10% over 2015 conditions by 2025. Average wood volume will double over current basin conditions by 2025.	Riparian areas along Tier 1 and Tier 2 streams will be of sufficient size and quality to support sustainable and harvestable Chinook salmon populations in the watershed by 2055. Each Tier 1 and Tier 2 stream system will meet appropriate regional instream wood-loading standards by 2055.
Lakes	Natural lake shoreline[1] south of I-90 (Lake Washington) and throughout Lake Sammamish will double over 2015 conditions by 2025. Natural riparian vegetation within 25 feet of shoreline south of I-90 (Lake Washington) and throughout Lake Sammamish will double over 2015 conditions by 2025.	Natural lake shoreline south of I-90 on Lake Washington and throughout Lake Sammamish will be restored adequately to support juvenile rearing and migration by 2055. Natural vegetation within 25 feet of the shoreline south of I-90 (Lake Washington) and throughout Lake Sammamish is restored adequately to support juvenile rearing and migration by 2055.
Nearshore (Pocket Estuaries)	Pocket estuaries along WRIA 8 shoreline will support juvenile Chinook salmon for rearing and migration (reconnect two stream mouth pocket estuaries) by 2025.	Same as 2025 goal.

[1] "Natural lake shoreline" is defined by the WRIA 8 Technical Committee as without bulkhead, with slope and substrate matching historic lakeshore contours for the area under consideration.

RM = River Mile

Table 2. WRIA 8 Habitat Goals

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RESEARCH AND DATA NEEDS

In 2015, WRIA 8 hosted a technical forum assembling fisheries scientists and technical experts on salmon recovery in the watershed. Participants proposed the following priority-level rankings of limiting factors to recovery. These constitute an outline for a prioritized list of research and data needs to advance recovery and support implementation of the 2017 Plan. (A full summary of the forum and presentations can be found online at http://www.govlink.org/watersheds/8/committees/15TechFrm/default.aspx).

First-tier priorities:

- Ballard Locks and Ship Canal operations – What are feasible solutions to improve conditions related to high temperature, low dissolved oxygen, and concomitant decreased resistance of salmonids to disease/parasites?

- Rearing and refuge – What are the effects of a lack of woody debris and floodplain connectivity (levees, revetments) and other features of adequate instream rearing habitat?

- Lake survival – What are the effects of artificial light and predation in Lake Washington, Lake Sammamish, and the Ship Canal (predation in Ship Canal may be a key limiting factor)?

- High water temperature – What are the effects of high water temperature in the Ship Canal and Sammamish River?

Other important priorities:

- Water quality – What are the effects of stormwater on Chinook salmon, including toxic loading of chemicals and contaminants? Are current stormwater regulations and treatment standards adequate? How can the pace of retrofits be increased?

- Streamflows – What are the effects of low summer flows and "flashy" winter flows?

- Invasive aquatic vegetation – What are the effects of invasive aquatic vegetation on salmon migration and survival?

Other limiting factors with potentially large impacts:

- Piers and docks – What are the effects of overwater structures on salmon migration and survival?

- Genetic introgression or other issues related to hatchery operations – What are the effects of hatcheries on the genetic fitness of natural origin salmon?

In addition, the WRIA 8 TC identified the following critical monitoring needs to track indicators associated with key recovery goals. Juvenile outmigrant trapping and adult spawner surveys are currently funded in part by competitive grants; other critical monitoring needs are unfunded.

- Juvenile outmigrant trapping

- Adult spawner surveys

- Wood volume surveys on all Tier 1 and Tier 2 streams

- Lakeshore surveys: length of natural bank profile, bulkheads, overwater structures

- Remote sensing: high-resolution land cover mapping of forest cover and impervious surfaces

- Assessment of accessibility and habitat quality of pocket estuaries and coastal streams entering Puget Sound

Monitoring needs are outlined in more detail in the Monitoring and Assessment Plan, Appendix A.

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3. CURRENT STATUS

CHINOOK SALMON STATUS

The general approach to determine the conservation status of Chinook salmon in the Puget Sound region is based on the viable salmonid population (VSP) concept. A VSP is defined as an independent population with a negligible (less than 5 percent) risk of extinction in their natural habitat over a 100-year period (McElhany et al. 2000). The attributes used to evaluate the status of Chinook salmon are abundance, population productivity, spatial distribution, and diversity.

ABUNDANCE

Adult abundance is the number of adult Chinook salmon returning to WRIA 8 streams to spawn. In WRIA 8, abundance is monitored by surveying each Tier 1 and Tier 2 stream for salmon redds during the spawning season. Carcasses are surveyed for the presence or absence of an adipose fin: the absence of an adipose fin indicates hatchery origin. Abundance goals for Chinook salmon in WRIA 8 were set by the state and tribal Co-Managers and adopted in the WRIA 8 Plan in 2005. The 10-year WRIA 8 abundance goal for the Cedar River population was 1,680 natural-origin spawners (NOS). Average return for the Cedar River population (2006-2015) was 1,012 NOS (Figure 4). The 10-year abundance goal for the Sammamish River population (measured on Bear/Cottage Lake Creek) was 350 NOS. Average spawner abundance for Bear/Cottage Lake Creek (2006-2015) was 47 NOS (Figure 5). A second 10-year WRIA 8 goal for the Sammamish River population (measured on Bear/Cottage Lake and Issaquah creeks) was to maintain the base period average escapement of 1,083 adults (combined hatchery-origin and natural-origin spawners). Average return for the Sammamish River population (2006-2015) was 1,269 adults (including HOS).

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WRIA 8 Chinook Salmon Population Status

VSP Parameter	10-year average results (2006-2015)	2025 Goals
CEDAR POPULATION		
Abundance	1,012 natural-origin spawners (NOS)	1,680 NOS
Productivity	Positive trend (see text)	≥2 returns per spawner 2-4 years out of 10
	24.0% egg-to-migrant survival	≥13.8% egg-to-migrant survival rate
Spatial distribution	Cedar River above Landsburg converted to Tier 1	Convert one satellite subarea to core (Tier 1)
	Spawning area distribution includes Cedar River from Landsburg to Cedar Falls (natural upstream barrier)	Restore historic spatial distribution
Diversity	Average instream rearing (parr): 8%	Increase Cedar River instream rearing to 40%
	Hatchery-origin spawners (HOS) 20%	HOS <20%
SAMMAMISH POPULATION		
Abundance	47 NOS	350 NOS—Bear/ Cottage Lake index
	1,337 naturally spawning adults (includes HOS)	Maintain base period average of 1,083 naturally spawning adults
Productivity	Productivity < 1.0	Adult productivity ≥1.0; ≥2 returns per spawner 2 4 years out of 10;
	8.8% egg-to-migrant survival	≥4.4% egg-to-migrant survival rate
Spatial distribution	Restored access to Issaquah Creek above hatchery intake diversion	Restore historic spatial distribution
	No detectable change in spawning distribution	Expand spawning area distribution in North Lake Washington tributaries
Diversity	No improvement	Sammamish River habitat on trajectory to support parr rearing
	Hatchery origin spawners (HOS) average: 90% (status quo)	Hatchery-origin spawners status quo or decrease

Table 3. Summary of the Current Status of Chinook Salmon in WRIA 8

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Number of Natural-Origin Spawners

10 Year Goal

Source: WDFW

Return Year
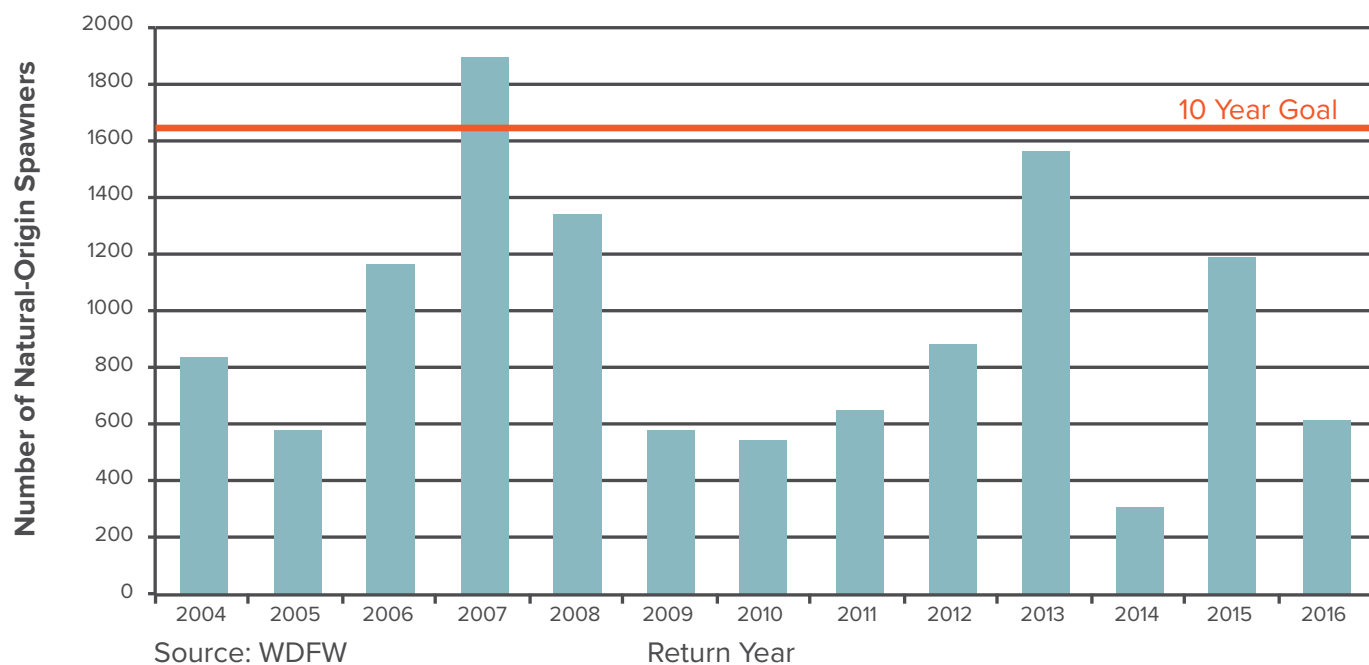
Figure 4. Cedar River Chinook Salmon Abundance: Natural-Origin Spawners (NOS), 2004-2016

Number of Natural-Origin Spawners

10 Year Goal

Source: WDFW
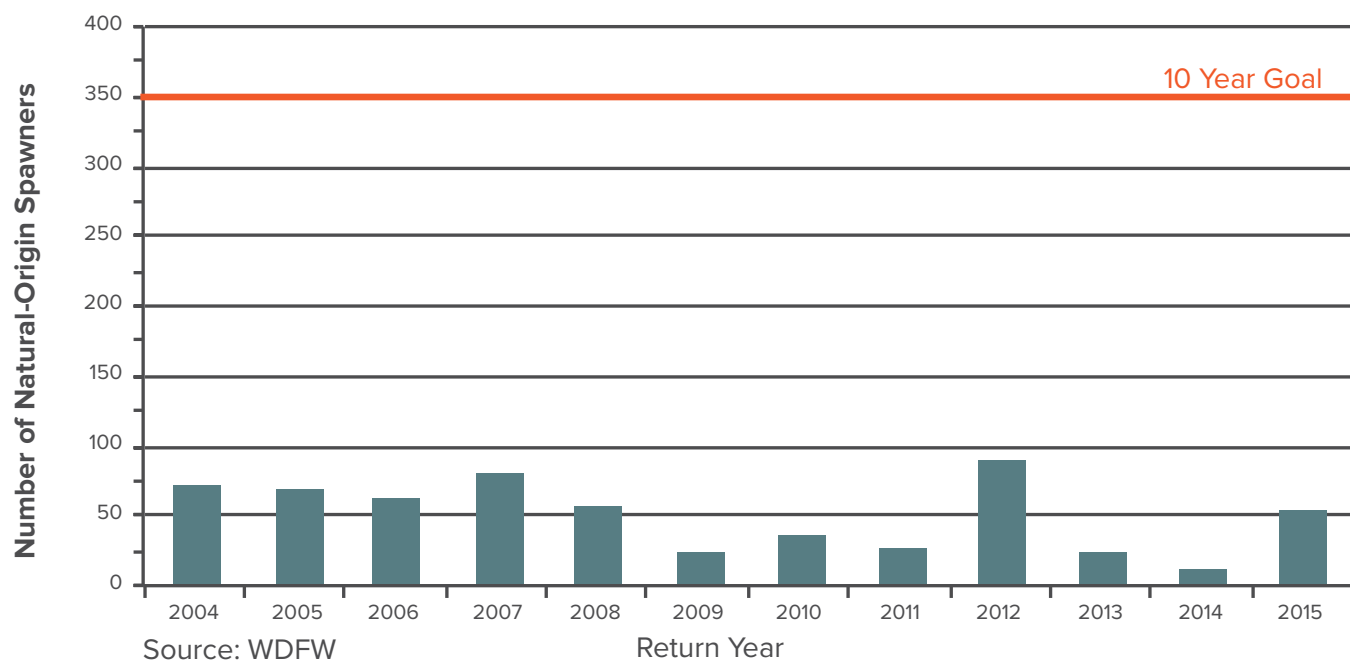
Return Year

Figure 5. Bear Creek/Cottage Lake Creek Chinook Salmon Abundance: Natural-Origin Spawners (NOS), 2004-2015

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While WRIA 8 has no quantitative goals for juvenile Chinook salmon abundance, the watershed funds juvenile abundance monitoring through outmigrant trapping on the Cedar River and Bear Creek. Juvenile Chinook salmon abundance has significantly increased in recent years (Figure 6 and Figure 7).

PRODUCTIVITY

Productivity indicates whether a population is growing or shrinking over time. Given the very low overall abundance of Chinook salmon in WRIA 8, high productivity is necessary to restore the population to historical levels. Overall Chinook salmon productivity is influenced by factors throughout the full salmon lifecycle, including elements outside the control of WRIA 8 partners, such as marine survival. Juvenile productivity, however, mostly reflects habitat factors within the control of WRIA 8 partners, such as watershed hydrology and juvenile rearing habitat quantity and quality. For this reason, WRIA 8 focuses on juvenile productivity as a key indicator of progress.

Adult productivity is assessed and reported by the NOAA Northwest Fisheries Science Center at five-year intervals. The most recent review was published in 2015, and reported on Chinook salmon status through 2011 (NWFSC, 2015). Fifteen-year trends in

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Source: WDFW Brood Year
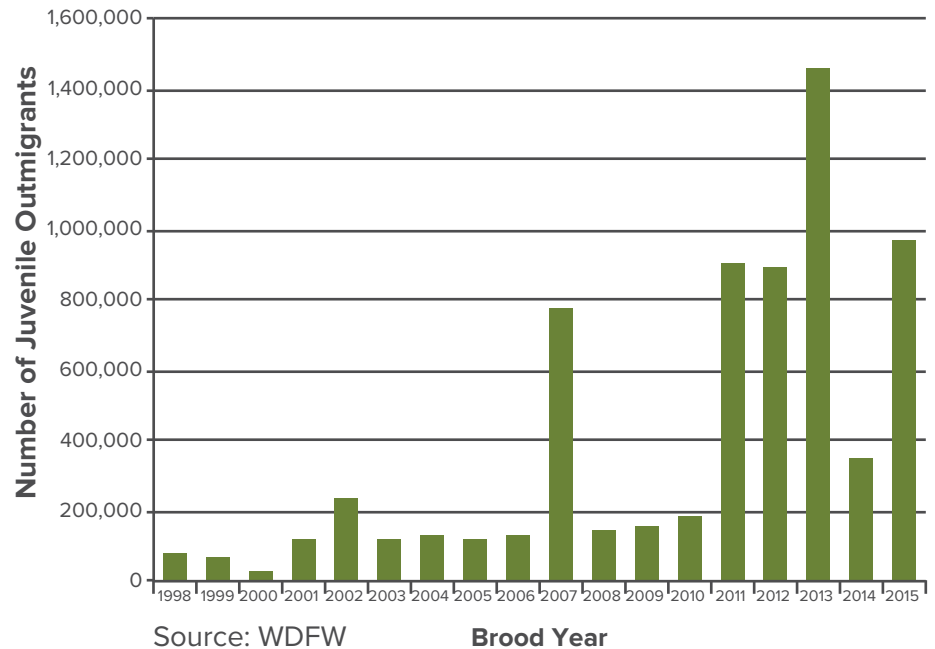
Figure 6. Juvenile Chinook Salmon Abundance (Cedar River)

Source: WDFW Brood Year
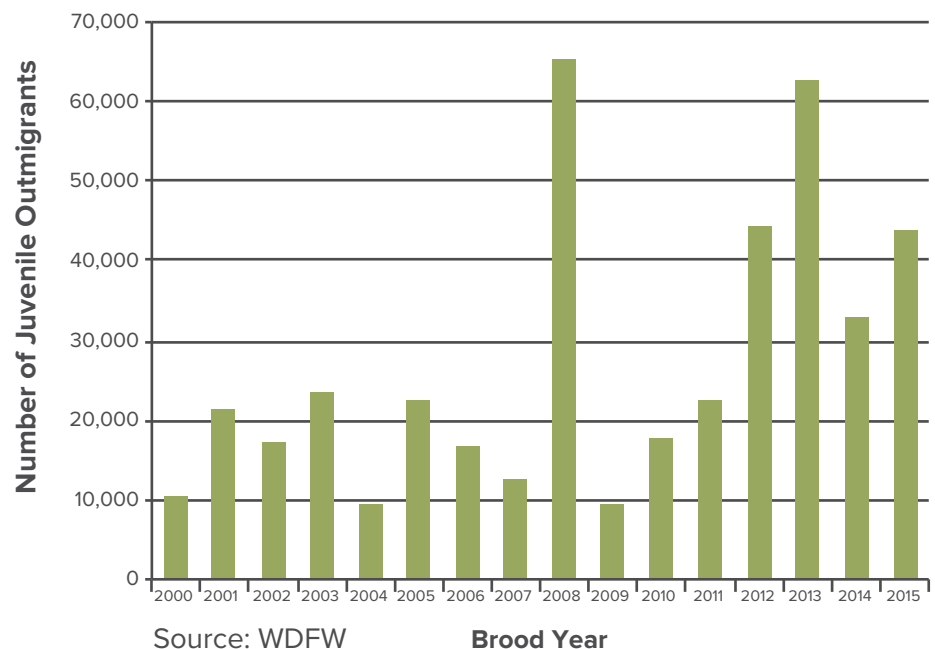
Figure 7. Juvenile Chinook Salmon Abundance (Bear Creek/Cottage Lake Creek)

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productivity are reported by a method where a number above zero indicates positive productivity, while a number below zero indicates a population that is not replacing itself (NWFSC, 2015). Data through 2011 indicated that the Cedar River population has shown a positive productivity trend. The Sammamish population displays a negative trend through 2011.

Adult spawner surveys and juvenile outmigrant trapping allows the watershed to estimate juvenile productivity. WRIA 8 uses egg-to-migrant survival as its indicator of juvenile productivity. The 10-year juvenile survival rate goals in the 2005 Plan for WRIA 8 Chinook salmon from egg deposition to the trapping location were 13.8 percent and 4.4 percent for the Cedar and Bear populations, respectively.[2] The average survival rates for the last 10 years (brood years 2004-2013) are 22.2 percent for the Cedar population and 7.64 percent for the Bear population.

SPATIAL DISTRIBUTION

The distribution of a population throughout a landscape provides an insurance policy against isolated catastrophes, such as floods or landslides that affect only a small geographic area. WRIA 8 salmon populations possess a greater chance of long-term survival if they are able to spawn and rear successfully throughout the landscape. During times of high abundance, salmon are more likely to spread out and use less ideal habitats, and colonize nearby streams and basins. During periods of low abundance, spawning salmon spatial distribution is more likely to contract to prime spawning areas.

In WRIA 8, the 10-year goal in the 2005 Plan was to maintain and, where opportunities existed, increase the spawning and rearing distribution of Chinook salmon throughout the watershed. Annual spawning ground surveys indicate increasing use of the Cedar River above the Landsburg Diversion Dam since creation of a fish passage facility there in 2003. Similarly, recent construction of a fish passage project at the hatchery intake diversion on Issaquah Creek will likely increase Chinook use of the upper creek.

[2]Juvenile survival is an indicator of freshwater production above the trapping location. In WRIA 8, those locations are in the lower Cedar River and lower Bear Creek. Survival from the trapping location to the eventual exit of the WRIA 8 system at the Ballard Locks can be estimated through the use of passive inductance transponder (PIT) tag readers. Measured at the Locks, juvenile survival integrates overall survival through Lake Washington and (for the Bear Creek migrants) through the Sammamish River. Currently, the complex nature of the passage options for juvenile Chinook salmon through the Locks makes estimating overall survival problematic. In 2016, an additional PIT tag array in one of the lock-filling culverts should improve our ability to estimate the survival of juvenile Chinook salmon to the Locks.

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WRIA 8 Chinook Salmon Redd Survey Results, 1999-2015

Creek	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Bear	137	30	42	25	24	25	40	12	20	44	9	1	17	41	16	5	60
Cottage	171	103	96	102	120	96	82	119	69	88	39	59	38	106	32	55	78
EF Issaquah	NS	NS	NS	0	3	25	11	3	30	13	19	29	18	15	28	31	12
Little Bear	1	1	1	3	3	1	0	0	5	1	1	0	0	0	NS	NS	7
North Creek	2	4	6	10	1	5	4	9	3	5	7	3	5	14	NS	NS	4
Kelsey Creek	76	8	4	5	0	7	14	93	77	10	5	0	0	0	0	0	0
May Creek	0	1	3	NS	5	9	1	0	12	5	2	1	1	2	NS	NS	0
Rock Creek (Lower)	0	0	0	0	0	0	0	0	0	0	0	3	0	2	7	0	0
Taylor Creek	0	0	7	12	11	8	7	1	30	0	0	1	2	11	9	5	4
Peterson Creek	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Walsh Creek	0	0	1	0	6	12	0	0	10	0	0	X	X	X	X	X	X
Cedar River Mainstem (and tribs above L'burg)	182	53	390	269	319	490	331	587	859	599	285	262	322	420	724	227	713

Source: WDFW, Seattle Public Utilities, City of Bellevue
Note: "X" denotes an artificial tributary that no longer supports spawning. "NS" denotes No Survey.

Table 4. WRIA 8 Chinook Salmon Redd Survey Results, 1999-2015

DIVERSITY

WRIA 8 partners monitor diversity through assessments of the age of returning adults, the proportion of juvenile salmon migrating as fry (early) or parr (later), and the proportion of hatchery fish on the spawning grounds. WRIA 8 goals are to increase the proportion of parr migrants on the Cedar River, and decrease the proportion of hatchery-origin Chinook salmon spawning with natural-origin fish.

The number of parr migrants has not increased consistently (Figure 8). Fry migrants have driven the overall increase in juvenile migrants in recent years (Figure 6 and Figure 7). This and other data indicate that freshwater rearing and refuge habitat continues to limit the production of parr migrants. This information confirms that our primary goal of increasing freshwater rearing and refuge habitat is still a priority. We expect that over time, as more rearing and refuge habitat is restored, the number of parr migrants will increase.

WRIA 8 goals in the 2005 Plan were to see a decrease in the proportion of hatchery-origin spawners to below 20 percent for the Cedar population and to increase the proportion of natural-origin spawners in the Sammamish population. For the Cedar population, the proportion of hatchery-origin spawners was below 20 percent between 2007 and 2013, but has recently increased (Figure 9). We speculate that recent high temperatures during the late summer/early fall migration period have induced more hatchery-origin Chinook salmon to migrate to the Cedar River, rather than return through the much warmer Sammamish River to the Issaquah hatchery. The proportion of hatchery-origin spawners is consistently high (over 70 percent) for the Sammamish population (Figure 9).
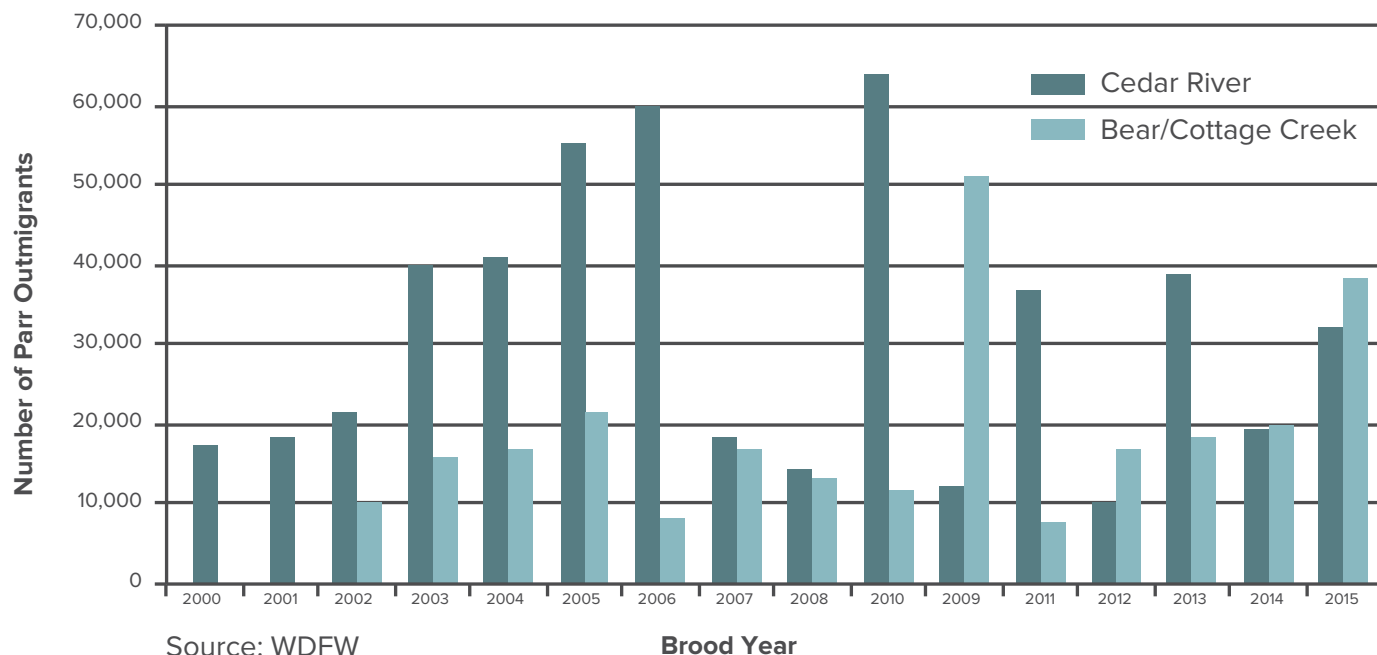
Lake Washington/Cedar/Sammamish Watershed (WRIA 8) Chinook Salmon Conservation Plan | 10-YEAR UPDATE | 2017

Source: WDFW

Figure 8. Number of Parr Migrants from the Cedar River and Bear Creek/Cottage Lake Creek, Brood Years 2000-2015
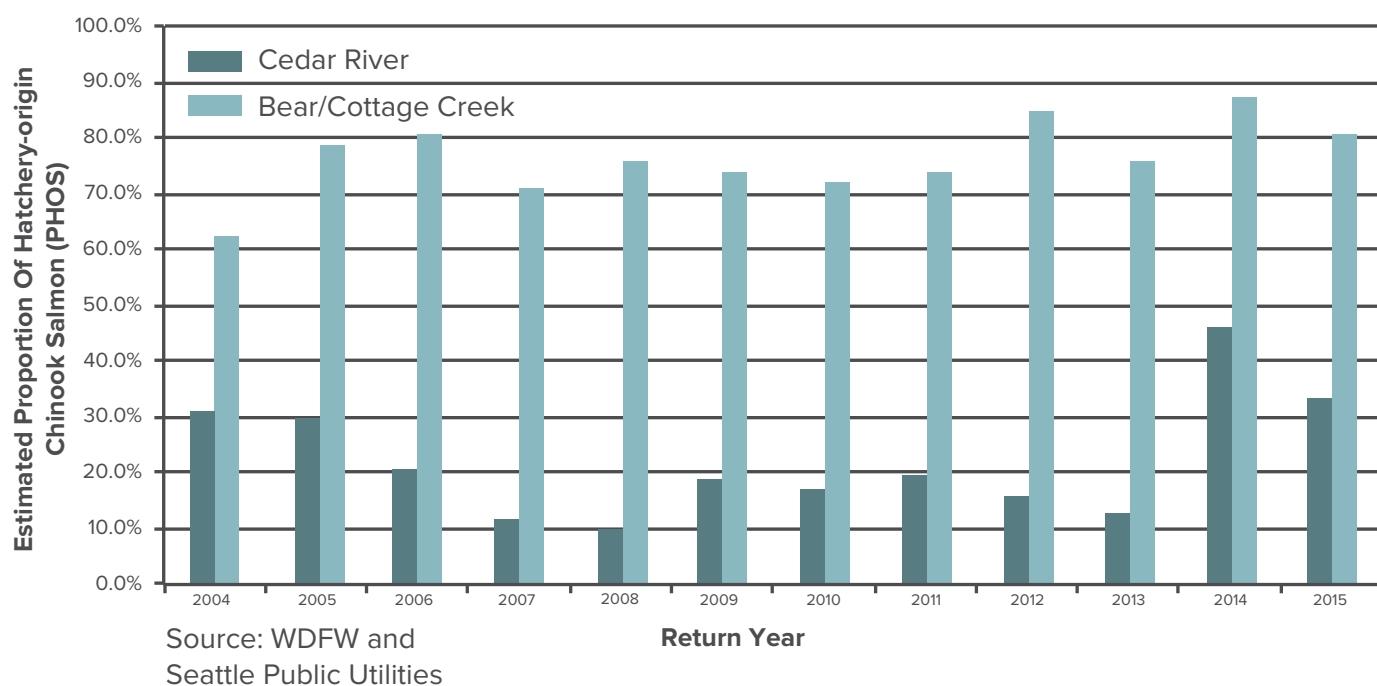

Source: WDFW and
Seattle Public Utilities

Figure 9. Estimated Proportion of Hatchery-Origin Chinook Salmon (PHOS) Detected in Cedar River and Bear Creek/Cottage Lake Creek Spawning Surveys Since 2004

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CHINOOK SALMON HABITAT STATUS

The condition of the watershed varies between lower elevations that have been intensively developed and higher elevations that are more pristine. Current stream habitat conditions in most areas inside the UGA boundary in WRIA 8 are degraded, largely because of land conversion and associated effects of human activities. Data on habitat status since 2005 includes a forest cover analysis (Vanderhoof et al., 2011) and a wadeable streams status and trends monitoring project (King County, 2015), as well as ongoing annual monitoring of water quality and macroinvertebrates (indirect indicators of habitat quality) conducted by King County and other jurisdictions. The wadeable streams project collected data on pools, wood in streams, sediment, riparian canopy cover, and many other metrics. Other studies in the watershed that provide valuable information on habitat status include a U.S. Geological Survey (USGS) longitudinal profile of the Cedar River (Konrad et al., in press), Bear Creek watershed planning research (King County, 2017), and high-resolution land cover mapping by NOAA using 2015 aerial photography (NOAA, 2017).

Important locations lacking in recent data include the lake shorelines, where information on bulkheads, docks, and lakeshore conditions is necessary to track improvements or degradation. Other habitat status and trends monitoring needs are outlined in the Monitoring and Assessment Plan (Appendix A).

RIVERS AND STREAMS

Cedar River and Tributaries (Tier 1)

The Cedar River contains the highest priority spawning and rearing areas in WRIA 8 and (with its tributaries) is the sole spawning and rearing stream for the Cedar River Chinook salmon population. The river supports the largest number of natural-origin Chinook salmon in the basin, and contains the primary spawning areas for Lake Washington

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sockeye and steelhead. A fish passage facility installed at the Landsburg water supply diversion dam in 2003 substantially increased the extent of Chinook salmon spawning and rearing habitat by over 17 miles in the watershed, and reconnected the full historical extent of migratory habitat. The river upstream of the Landsburg Diversion Dam is protected by a 50-year HCP administered by Seattle Public Utilities, and is used annually by a substantial proportion of Chinook salmon returning to the watershed. The river upstream from Landsburg Diversion Dam to the natural barrier at Cedar Falls was reclassified to Tier 1 habitat status in 2017. Aside from some service roads, this area is unconfined by levees or other artificial structures, and the riparian zone is dominated by second-growth conifer forest.

Of the 1,419 acres in the moderate CMZ below Landsburg Diversion Dam as of 2015, approximately 380 acres (26 percent) are behind levees, revetments, or other hard structures. (WRIA 8 uses the moderate CMZ as a proxy for its floodplain metric.) Between 2005 and 2015, approximately 65 acres of floodplain were reconnected through levee setbacks and floodplain restoration.

Using a recent remote-sensing product (NOAA, 2015), the TC estimates the instream area of woody debris in the Cedar River between RM 4 and Landsburg as 5.2 m^2/100 m. If the typical jam is assumed to be 2 meters tall, the estimated wood volume would be 10.4 m^3/100 m (WRIA 8 TC, unpublished GIS data; King County, 2015). This value is substantially below regional benchmarks for rivers of this size (Fox and Bolton, 2007) and the TC considers this value to reflect poor condition (well below the 25th percentile for rivers 30 meters bankfull width or greater).

Using a high-resolution (1 meter) land cover product (NOAA, 2017), the WRIA 8 TC estimated the 2015 forest cover within 200 feet of the channel centerline as 70 percent outside the UGA boundary and 39 percent inside the UGA (WRIA 8 TC, unpublished data). Impervious cover extent was estimated at 4 percent outside the UGA and 18 percent inside.

Sammamish River (Tier 1)

The Sammamish River is a low-gradient waterbody connecting Lake Sammamish and Lake Washington, and is the migratory pathway to and from Lake Washington for salmon originating in the Issaquah and Bear Creek/Cottage Lake Creek systems, as well as for Chinook and coho salmon produced at the Issaquah salmon hatchery. The Sammamish River valley was heavily modified in the 20th century, and the river is channelized and armored along its entire length. The Sammamish River is classified as a flood conveyance facility by the USACE; opportunities for levee setback projects are minimal. King County designated a portion of the Sammamish Valley as an agricultural production district (APD), to preserve agricultural production. While development pressure is reduced in the APD, efforts to restore habitat in this area may be limited and will need to consider these agricultural designations and work closely with agricultural preservation interests.

A recent remote-sensing product (NOAA, 2015) detected zero incidence of large wood in the Sammamish River (WRIA 8 TC, unpublished GIS data). However, constructed logjams are known to be present in the Sammamish River in and near Redmond. Notwithstanding the few known logjams, the TC considers the Sammamish River to reflect poor condition for wood volume.

Using a high-resolution (1 meter) land cover product (NOAA, 2017), the WRIA 8 TC estimated the 2015 forest cover within 200 feet of the Sammamish River channel centerline as 16 percent outside the UGA boundary and 32 percent inside the UGA (WRIA 8 TC, unpublished data). Impervious cover extent within the 200-foot area was estimated at 6 percent outside the UGA and 15 percent inside.

Bear Creek/Cottage Lake Creek (Tier 1)

The Bear Creek/Cottage Lake Creek system is the primary spawning tributary for the naturally produced portion of the Sammamish River Chinook salmon population. The lower reaches of the Bear Creek/Cottage Lake system are heavily urbanized in Redmond near the confluence with the Sammamish River. Farther upstream, rural/suburban land uses predominate.

Using a high-resolution (1 meter) land cover product (NOAA, 2017), the WRIA 8 TC estimated the 2015 forest cover within 200 feet of the Bear Creek channel centerline as 69 percent outside the UGA boundary and 35 percent inside the UGA (WRIA 8 TC, unpublished data). Cottage Lake Creek forest cover (all outside the UGA) was estimated at 39 percent. Impervious cover within the 200-foot area was estimated at 4 percent outside the UGA and 19 percent inside for Bear Creek, and 10 percent for Cottage Lake Creek.

Wood volume for seven sites sampled annually in the Bear Creek/Cottage Lake Creek basin between 2010 and 2013 averaged 22.8 m^3/100 m (WRIA 8 TC, unpublished data; King County, 2015). This value is slightly below the 25th percentile of the distribution of wood volume for unmanaged western Washington streams less than 30 meters bankfull width (Fox and Bolton, 2007). The TC considers this value to reflect poor condition for wood, though more sites should be sampled to characterize the overall stream system with greater confidence.

Issaquah Creek (Tier 1)

Issaquah Creek is a potentially significant spawning area for Chinook salmon in WRIA 8. A fish passage facility installed at the Issaquah salmon hatchery water supply diversion dam in 2013 opened up 11 miles of Chinook salmon spawning and rearing habitat in the watershed, and reconnected the hypothesized extent of historical migratory habitat. The lower reaches of Issaquah Creek are heavily urbanized in Issaquah near the confluence with Lake Sammamish, though the bottom-most reaches flow through Lake Sammamish State Park. Farther upstream, rural/suburban, recreation, and forestry land uses predominate.

Using a high-resolution (1 meter) land cover product (NOAA, 2017), the WRIA 8 TC estimated the 2015

forest cover within 200 feet of the Issaquah Creek channel centerline as 82 percent outside the UGA boundary and 60 percent inside the UGA (WRIA 8 TC, unpublished data). Impervious cover extent within the 200-foot area was estimated at 3 percent outside the UGA and 15 percent inside.

Wood volume for 13 sites sampled annually in the Issaquah Creek basin (including Carey, Holder, and East Fork Issaquah creeks) between 2010 and 2013 averaged 30.7 m^3/100 m (WRIA 8 TC, unpublished data; King County, 2015). This value is above the 25th percentile of the distribution of wood volume for unmanaged western Washington streams less than 30 meters bankfull width (Fox and Bolton, 2007). The TC considers this value to reflect overall fair condition for wood in the Issaquah Creek system, though the wood volume in much of the lower extent is low or very low.

Little Bear Creek (Tier 2)

Little Bear Creek is a tributary to the Sammamish River, joining the Sammamish River at Woodinville. Most of the upper reaches are rural/suburban. Spawning by Chinook salmon in Little Bear Creek is intermittent, though sockeye salmon regularly spawn in the lower reaches.

Using a high-resolution (1 meter) land cover product (NOAA, 2017), the WRIA 8 TC estimated the 2015 forest cover within 200 feet of the Little Bear Creek channel centerline as 83 percent outside the UGA boundary and 44 percent inside the UGA (WRIA 8 TC, unpublished data). Impervious cover extent within the 200-foot area was estimated at 5 percent outside the UGA and 44 percent inside.

Wood volume was sampled annually at two sites in Little Bear Creek between 2010 and 2013, and averaged 5.3 m^3/100 m (WRIA 8 TC, unpublished data; King County, 2015). This value is significantly below the 25th percentile of the distribution of wood volume for unmanaged western Washington streams less than 30 meters bankfull width (Fox and Bolton, 2007). The TC considers this value to

reflect very poor condition for wood in Little Bear Creek, though more sites should be sampled to characterize the overall stream system with greater confidence.

North Creek (Tier 2)

North Creek is a tributary to the Sammamish River, joining the Sammamish at Bothell. Spawning by Chinook salmon in North Creek is intermittent. The entire North Creek basin is inside the UGA.

Using a high-resolution (1 meter) land cover product (NOAA, 2017), the WRIA 8 TC estimated the 2015 forest cover within 200 feet of the North Creek channel centerline as 70 percent (WRIA 8 TC, unpublished data; King County 2015). Impervious cover extent within the 200-foot area was estimated at 14 percent.

Wood volume was sampled annually at four sites in the North Creek basin between 2010 and 2013, and averaged 22.7 m^3/100 m (WRIA 8 TC, unpublished data; King County, 2015). This value is below the 25th percentile of the distribution of wood volume for unmanaged western Washington streams less than 30 meters bankfull width (Fox and Bolton, 2007). The TC considers this value to reflect overall poor condition for wood in North Creek, though more sites should be sampled to characterize the overall stream system with greater confidence.

Kelsey Creek (Tier 2)

Kelsey Creek is a tributary to Lake Washington, draining into Lake Washington through Bellevue. Spawning by Chinook salmon in Kelsey Creek is intermittent. The entire Kelsey Creek basin is inside the UGA.

Using a high-resolution (1 meter) land cover product (NOAA, 2017), the WRIA 8 TC estimated the 2015 forest cover within 200 feet of the Kelsey Creek channel centerline at 56 percent (WRIA 8 TC, unpublished data). Impervious cover extent within the 200-foot area was estimated at 16 percent.

Wood volume was sampled annually at four sites in the Kelsey Creek basin between 2010 and 2013, and averaged 18.3 m^3/100 m (WRIA 8 TC,

unpublished data; King County, 2015). This value is below the 25th percentile of the distribution of wood volume for unmanaged western Washington streams less than 30 meters bankfull width (Fox and Bolton, 2007). The TC considers this value to reflect overall very poor condition for wood in Kelsey Creek, though more sites should be sampled to characterize the overall stream system with greater confidence.

Other Chinook Salmon Creeks in WRIA 8 (Tier 3)

Regular Chinook salmon spawner surveys occur in May and Coal creeks, both tributaries to Lake Washington a few miles north of the Cedar River. Spawning by Chinook salmon in these creeks is intermittent. Other Tier 3 streams in WRIA 8 are not regularly surveyed for Chinook spawning.

Forest cover within 200 feet of the Coal Creek channel centerline in 2015 was estimated at 100 percent outside the UGA and 84 percent inside (WRIA 8 TC, unpublished data; King County, 2015). Impervious cover extent within the 200-foot buffer was estimated at 0 percent outside the UGA, and 7 percent inside. For May Creek, the 2015 forest cover within 200 feet of the channel centerline was estimated at 48 percent outside the UGA and 81 percent inside (WRIA 8 TC, unpublished data; King County, 2015). Impervious cover extent within the 200-foot area was estimated at 5 percent outside the UGA and 8 percent inside.

Wood volume was sampled at one site in the May Creek basin and two in the Coal Creek basin annually between 2010 and 2013. Wood volume averaged 64.0 m^3/100 m at May Creek and 40.6 m^3/100 m in Coal Creek (WRIA 8 TC, unpublished data; King County, 2015). The May Creek site exceeded the median and the Coal Creek sites averaged slightly below the median of the distribution of wood volume for unmanaged western Washington streams less than 30 meters bankfull width (Fox and Bolton, 2007). The TC considers these values to reflect overall fair condition for wood, though more sites should be sampled to characterize the overall stream systems with greater confidence.

LAKE WASHINGTON AND LAKE SAMMAMISH SHORELINE (TIER 1)

Lake shoreline habitats in both Lake Washington and Lake Sammamish are important for outmigrating and lake-rearing juvenile Chinook salmon. Juvenile salmon use shallow-water lake shoreline areas to escape predators and to feed as they enter the lakes as fry. Shoreline conditions were initially degraded by the lowering of Lake Washington during construction of the Ballard Locks, and impacts from urbanization and shoreline development have further degraded shoreline conditions. The majority of lake shorelines are in private residential ownership, with landscaped yards and bulkheads or other shoreline armoring. Earlier studies indicated that approximately 75 percent of Lake Washington's shoreline has a bulkhead or other form of shoreline armoring (Toft et al., 2003). These conditions have altered or eliminated much of the shallow-water habitat around the lake, reduced emergent and riparian vegetation, reduced the amount of large wood, and changed sediment dynamics.

Using a high-resolution (1 meter) land cover product (NOAA 2017), the WRIA 8 TC estimated the 2015 forest cover within 200 feet of the shoreline as 38% (Lake Washington) and 36% (Lake Sammamish) (WRIA 8 TC, unpublished data). Impervious cover extent within the 200-foot area was estimated at 28% (Lake Washington) and 36% (Lake Sammamish).

Recent information on bulkheads, docks, and lakeshore conditions is lacking, but necessary to track improvements or degradation.

MARINE NEARSHORE

The marine nearshore portion of WRIA 8 encompasses approximately 24 miles of shoreline, from West Point north to Elliot Point in Snohomish County. The nearshore is of primary importance for juvenile salmon for rearing and migration as they make their way through Puget Sound to the ocean. In particular, areas where small coastal

streams enter Puget Sound have been identified as important for juvenile salmon rearing and refuge during migration (Beamer et al., 2013).

With a few notable exceptions, recent status information is not available for the WRIA 8 marine nearshore. The BNSF railroad along most of the shoreline disconnects upland habitats from the nearshore and interrupts natural beach creation and erosion processes; this condition is not likely to change without engagement with and support from BNSF. For information on the status of marine shorelines prior to 2005, see the 2005 Plan and Kerwin (2001).

PRESSURES ASSESSMENT

During development of the 2017 Plan, the WRIA 8 TC assessed the primary human-induced impacts on Chinook salmon and their habitat through a systematic "pressures assessment." This exercise evaluated the various impacts—or pressures—faced by Chinook salmon during each of the life stages represented in the conceptual model. Since each life stage relies on specific habitat types at particular locations and at certain times of year, evaluating pressures on certain life stages takes into account location in the watershed, use of habitat, and the timing of that use. The pressures assessment used a regionally standardized list of pressures and rated each according to its scope, severity, and irreversibility at each life stage. The WRIA 8 TC used their knowledge of local conditions, local monitoring and scientific studies, and other studies from the scientific literature as the basis for their assessment. The pressures assessment process and results are further described in Appendix C.

Priority pressures

The most significant pressures in WRIA 8 are hypothesized to be land conversion, existing levees and revetments, shoreline armoring (marine nearshore, lakes and Ship Canal), altered peak flows, increased water temperatures, predation, and pressures associated with migration through the Ballard Locks. Many of these pressures are interconnected and one may exacerbate another (for example, increased water temperatures are likely to increase the efficiency of warm water predators such as bass in the Ship Canal). These seven most significant pressures are described below, based on the definitions of the Puget Sound Partnership and modified slightly to be most relevant to WRIA 8. The assessment considered climate change not as a separate pressure but through its exacerbating effects on the other pressures in the Lake Washington/Cedar/Sammamish Watershed.

The WRIA 8 TC has documented its rating of the full list of pressures that threaten the recovery of Chinook salmon in WRIA 8. These pressures are described in Appendix C. The impacts of these pressures in WRIA 8 are assumed based on studies and data from other watersheds, but these pressures are well known in general (WDFW, 2009). The specific empirical data associated with these pressures is not included in this document.

Land conversion. Land conversion is the conversion of land from natural cover to one dominated by residential, commercial, and/or industrial development or one dominated by agriculture. Land conversion reduces the extent and quality of habitat. Related pressures such as pollution, shoreline hardening, and other cascading effects of land conversion are assessed separately. Note that conversion is often a step-wise process. Some areas of WRIA 8 have converted from natural cover to agriculture, while others have then converted from agriculture to urban or suburban development. Compared to other Puget Sound watersheds, development pressure and the rate of urbanization have been and continue to be very high in WRIA 8. This pressure includes the legacy effects of past conversion and ongoing degradation from continued development.

Levees and revetments.[3] Levees and revetments are structures, often originally intended for flood control, that block or restrict movement of water, sediment, or debris flow in the river or stream channel and consequently change sediment and debris delivery. These structures may also be barriers to movement of species. The structures built along the Cedar and Sammamish rivers in WRIA 8 block habitat connectivity within the floodplain, prevent inundation of off-channel habitat, and keep fish from accessing what refuge habitat might remain behind the levees. Relative to the Sammamish River system, the Cedar River system has more opportunity for setting back levees and re-creating habitat with some additional constraints to consider, such as flood protection, trails, and regional fiber-optic lines located underneath the Cedar River Trail along much of its length.

Shoreline armoring. Shoreline armoring changes shoreline features in a manner that reduces habitat extent and/or disrupts shoreline processes. The primary source of this impact is the construction of shoreline infrastructure, often as part of land conversion activities, that produces a hard linear surface along the beach or streambank intended to reduce erosion. In WRIA 8, natural shallow shoreline and creek mouths in Lake Washington and Lake Sammamish have been changed by shoreline hardening. In addition, the BNSF track running along most of the WRIA 8 marine shoreline is armored, disconnecting backshore areas and pocket estuaries from Puget Sound, while also disrupting the natural supply of beach sediment from eroding bluffs. In most cases, shoreline armoring also eliminates vegetated cover and thus exacerbates other pressures on Chinook salmon (e.g., water temperature and predation), and interferes with food web processes.

Altered flows. Altered flows into and within surface waters are caused by changes in land cover, the associated surface hardening (impervious surfaces), and changes in precipitation volume and timing due to climate change, as well as associated impacts such as changes in sediment and debris delivery. Heavy rains and high flows can cause scouring and high water velocities that can push salmon out of the habitat they need for rearing and spawning. Altered low flows, often caused when impervious surfaces prevent infiltration and groundwater recharge, can be exacerbated by climate change and water withdrawals. Peak flows can be challenging to salmon in fall and winter, while low flows are most often problematic in summer and early fall.

Increased water temperatures. A specific water quality issue, high temperatures are linked to and can exacerbate many other pressures in WRIA 8. Increased water temperatures in WRIA 8 are caused by land conversion, altered flows, a lack of riparian cover and groundwater connections, infrastructure (e.g., Ballard Locks) and inadequate estuarine mixing, and climate change. Water temperatures are of greatest concern in the Ship Canal and Sammamish River, but can also be problematic in all streams.

Increased predation by native and non-native species. Increased predation results from the increase or spread of native and non-native fish and other wildlife. Predation on juvenile Chinook salmon is almost certainly a key pressure that affects their recovery in WRIA 8. Predatory fish documented in the Ship Canal include smallmouth bass, largemouth bass, rock bass, yellow perch, and northern pikeminnow (Tabor et al., 2004, 2007, 2010; WDFW/King County unpublished data). More recent studies have investigated the

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[3] Levees are raised embankments built parallel to rivers and are intended to contain or direct flood flows, sometimes allowing water surface elevations in the river or stream to exceed the elevation of the surrounding floodplain. Revetments are not designed to contain floodwaters but rather serve the purpose of preventing bank erosion or lateral channel migration (King County, 2006).

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impact of predation from resident cutthroat and rainbow trout (*O. mykiss*) from 2006 to 2010 in the Cedar River below the Landsburg Diversion Dam (Tabor et al. 2014). Issues such as artificial night-time lighting, shoreline hardening and overwater structures, and increased water temperatures exacerbate the effects of predation on Chinook salmon in WRIA 8.

Impacts to fish passage and survival at the Chittenden (Ballard) Locks. The Ballard Locks is one of the most significant single structures affecting Chinook salmon recovery in WRIA 8. The creation of the Ship Canal and the Ballard Locks in 1916 forever changed the hydrology and function of the watershed by shifting outflow of water from its historic exit in south Lake Washington through the Black River to its present-day configuration through the Montlake Cut, Salmon Bay, and into Shilshole Bay (Chrzastowski, 1981). All WRIA 8 anadromous fish populations must move through the Ballard Locks as they migrate out of and into the watershed. Chinook salmon experience physical trauma, stress and mortality at the Ballard Locks due to elevated water temperatures, decreased dissolved oxygen, and the physical barrier presented by the structure (NMFS, 2008).

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CLIMATE VARIABILITY, CLIMATE CHANGE, AND IMPACTS TO SALMON

In the years since the adoption of the 2005 Plan, our understanding of the effects of a changing climate on Chinook salmon and salmon habitat, and restoration techniques to mitigate those effects, has grown substantially. Research from the Northwest and elsewhere suggests we can and must plan for and adapt to changing watershed conditions and incorporate the concept of resilience into salmon recovery actions.

Intact ecosystems are inherently more resilient systems. Stream corridors with intact riparian zones and floodplains help dissipate destructive flood waters and shade streams from direct sunlight. Stormwater that is allowed to infiltrate into the ground is slowed, cleansed, and cooled before it reaches our streams and lakes. Wood in stream channels can create pools of deeper, cooler water and cover for fish to hide from predators, and can help to lessen the force of floods. Salmon habitat restoration and protection strategies focused on reconnecting floodplains and restoring stream corridors, lake shores, and marine shorelines make our ecosystems and communities more resilient to a changing climate. The present and anticipated effects of climate change emphasize the need to increase the pace of salmon habitat protection and restoration.

NATURAL CLIMATE VARIABILITY AND CLIMATE CHANGE

The Northwest climate naturally varies seasonally, as well as annually, between cool and hot, wet and dry. Year to year variability is generally associated with the El Niño Southern Oscillation (ENSO) which affects ocean currents and temperature as well as global precipitation and air temperature. Longer term decadal patterns are often described by the Pacific Decadal Oscillation, a pattern defined by variations in sea surface temperatures in the North Pacific Ocean.

Notwithstanding the natural variability around climate patterns in the Northwest, the Puget Sound region is already experiencing some of the effects of a changing climate. Records show that all but six of the years from 1980-2014 were above the 20th century average temperature (Mauger et al., 2015). The waters of the North Pacific Ocean and Puget Sound are becoming more acidic as a consequence of increasing carbon dioxide in the atmosphere. Recent years have seen record average summer air temperatures; by mid-century, annual average air temperatures are projected to rise between 4.2 and 5.9 degrees Fahrenheit (F), exacerbating surface water warming. Computer models predict a decline in summer precipitation as well as increases during fall, winter and spring. The region's snowpack is expected to decrease as winters get warmer and wetter. Winter rainstorms are projected to become more intense, which can lead to increased flooding and erosion.

NORTHWEST CLIMATE PROJECTIONS AND EFFECTS ON WRIA 8 CHINOOK SALMON

Salmon in WRIA 8 are projected to face threats related to changes in the timing and intensity of precipitation, increasing air and water temperatures, a reduction in snowpack at low and middle elevations, sea level rise, and ocean acidification. The effects can be grouped into the categories of temperature and precipitation, altered hydrologic patterns, stormwater, sea level rise, and ocean acidification.

Temperature and precipitation

Average annual air temperature for the Puget Sound region has increased by about 1.3 degrees F from 1895 to 2014, while average nighttime air temperatures have increased by 1.8 degrees F. The frost-free season has lengthened by 30 days from 1920 to 2014 (Mauger et al., 2015). Water temperatures will be especially affected by this warming during increasing periods of summer low flows, when they are highly influenced by air temperature. Warmer temperatures will accelerate snow melt during spring and early summer and decrease snow accumulation in winter. While a rising temperature trend is evident in the long-term record, there is no current evidence of a corresponding trend in annual precipitation (Mauger et al., 2015); however, the timing and intensity of precipitation events will likely change. Most scenarios of future climate change project a decline in summer precipitation and increases in winter precipitation extremes (e.g., "atmospheric river" events). While average annual precipitation may be relatively constant, the timing and intensity of events will change.

Increasing temperatures will affect all life stages of Chinook salmon in WRIA 8, though they are likely to have the most impact on migrating adults and juveniles, especially in the Ship Canal and Sammamish River. Water temperatures above about 77 degrees F can kill Chinook (Richter and Kolmes, 2005), though Chinook salmon appear to be able to withstand higher temperatures for short periods. At about 70 degrees F, adult migration can be blocked. When salmon hold and migrate at temperatures above around 63 degrees F, there is an increase in sublethal effects such as egg abnormalities, or increased susceptibility to parasites or disease (Richter and Kolmes, 2005). Juvenile outmigration behavior also changes when temperatures warm in spring, with juveniles avoiding the warmer surface waters in the Ship Canal as water temperature approaches 68 degrees F (DeVries and Shelly, 2017). Additionally, warm-water predators such as bass become more active as temperatures rise, and are known to consume Chinook salmon in the Ship Canal during spring outmigration (WDFW and King County, unpublished data).

Adult Chinook returning in the late summer and fall tend to congregate in areas of cooler water until environmental cues trigger upstream migration. Temperature mitigation strategies will likely involve efforts to create cooler-water refuges in the Ship Canal and Sammamish River during adult migration periods. Mitigation strategies for juveniles are also yet to be developed. Current concepts being discussed by the TC involve potential management of warm-water predators at key areas (e.g., in the Ship Canal).

The timing of the spring plankton bloom may also be affected by warming lake temperatures. Plankton support the aquatic food web and a shift in timing may alter predator-prey dynamics and food sources for salmon species (Mauger et al., 2015). In the marine environment, changing temperature patterns are likely to affect coastal upwelling and ocean currents, with changes to the composition, abundance, and distribution of marine plankton communities, the basis of the ocean food web. Since salmon spend the majority of their lives in the ocean, these changes will affect overall salmon migration and survival patterns in ways that are as-yet insufficiently studied.

Changing precipitation regimes in WRIA 8 are likely to exacerbate temperature problems during summer and late fall if the timing of fall rains is delayed.

Altered hydrologic patterns

The changing intensity and timing of precipitation events will affect stream flow throughout WRIA 8. More winter precipitation will fall as rain rather than snow, resulting in less winter snow accumulation, higher winter stream flows, increased scour, earlier snowmelt, and lower summer stream flows. "Atmospheric river" storm events may result in more damaging floods that destroy salmon habitat, scour redds, and displace juveniles downstream.

Mitigating the challenges associated with altered hydrologic patterns involves floodplain reconnection and levee setbacks, and other

actions that protect and restore connectivity of the stream system, restoring summer stream flow regimes (e.g., through purchase of water rights or other water conservation measures), reducing erosion and sediment delivery problems (e.g., through restoration of stream channel complexity and other stormwater control measures), restoring riparian functions (e.g., shading, root reinforcement of banks, natural large wood recruitment, trapping sediment etc.), and instream rehabilitation measures (e.g., channel reconstruction, wood installation, gravel additions) (Beechie et al., 2012).

Stormwater

Polluted stormwater runoff is known to be a serious issue for salmon in the Puget Sound region. It is currently considered the top source of pollutants to the Sound. With predicted increases in heavy rainfall events in fall and winter, stormwater runoff will increase pollutant discharge into rivers and streams and, ultimately, Puget Sound. Pesticides, heavy metals, bacteria, motor oils and other pollutants already contribute significantly to stormwater pollution in our region. Stormwater can affect the watershed by washing toxics into streams, and adding nutrients that increase algal blooms and decrease oxygen levels. A key impact of increased stormwater runoff on Chinook salmon is the associated increase in the "flashiness" of the hydrograph, meaning higher, more sudden peak flows during storms. These flows can scour stream beds and banks, flushing out habitat-forming debris and organic matter important to macroinvertebrate communities and small fish. Concentrations of toxic pollutants in stormwater have been shown to cause mutations in salmon embryos and rearing juvenile salmon, though effects on Chinook salmon in WRIA 8 have not been directly observed (Meador et al., 2006). Current research studying the effects of toxic pollutants in stormwater on Chinook salmon survival should help improve the understanding of how great an impact this aspect of stormwater has on juvenile and adult Chinook survival.

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Actions to mitigate the effects of stormwater on salmon include retrofits to areas and facilities developed prior to regulatory requirements; application of low impact development techniques like green stormwater infrastructure; streamside plantings; improved tracking, control and elimination of pollutant sources; and other efforts to restore a natural hydrograph, recharge groundwater, lower stream temperatures, and treat, filter or otherwise eliminate bacteria and other pollutants. Many older developed areas lack adequate stormwater controls. Treating and retaining stormwater at its source before it runs off into streams and rivers may reduce fish exposure to chemicals and stressful hydrologic and water quality conditions.

Sea level rise

The melting of mountain glaciers and ice sheets at both poles, in addition to thermal expansion of the oceans, will continue to result in rising sea levels. Higher sea levels contribute to destructive storm surges and coastal flooding. Low-lying coastal areas will be inundated, and coastal wetlands will become increasingly brackish; coastal communities and shallow nearshore areas, which are rearing areas for young salmon, will expand or contract depending on existing shoreline armoring and future efforts to accommodate or prevent intrusion. In WRIA 8, shoreline armoring is nearly continuous because of the BNSF rail corridor along the coast. This will likely result in a decrease in already limited marine nearshore rearing habitat. Rising sea levels may also affect operation of the Ballard Locks, which could negatively impact fish passage, as well as water quality conditions in the Ship Canal.

Ocean acidification

As oceans absorb excess carbon dioxide from the atmosphere, ocean water will become more acidic. Ocean acidification makes it more difficult for many marine organisms to create shells and skeletons, which could disrupt food resources for salmon and other fish. Studies are limited, but modeling of the Puget Sound food web suggests that alternative sources of food that are not directly affected by acidification may be available for salmon. More research is needed on this issue.

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KEY ACTIONS TO FOSTER CLIMATE RESILIENCE IN WRIA 8

Changing climate conditions affect many aspects of salmon recovery and underscore the importance of improving ecosystem resiliency. Below are several key actions to improve ecosystem resiliency and address current and anticipated effects of a changing climate, which are consistent with WRIA 8 salmon recovery strategies and recommended implementation actions discussed in Sections 4 and 5.

- Work toward resilience by encouraging and restoring natural processes that may moderate expected changes (e.g., floodplain reconnection and restoring natural shorelines).

- Identify how habitat boundaries, such as floodplains, are changing. Limit armoring shorelines where feasible by protecting and restoring shoreline properties. Protect habitat outside current habitat boundaries if evidence exists that habitat boundaries will change. Protect or acquire land that will be inundated by increased flooding and sea level rise.

- Study potential engineered solutions in high-priority, heavily modified areas like the Ship Canal and Sammamish River (e.g., hypolimnetic withdrawal in Lake Washington and/or Lake Sammamish, or chillers to create localized thermal refugia).

- Identify, protect and enhance processes and habitats, such as stream headwaters areas, that provide cool water. Protect and replant forests and riparian buffers, and locate groundwater sources and seeps and protect natural processes that create critical habitats like wetlands, tidal flats, marshes and estuaries; this will help ensure that water can be stored, recharged, and delivered at a moderated pace and temperature. Monitor land cover change and promote actions to minimize impacts to hydrology.

- Protect and restore tributary streams, which are often cooler than mainstem rivers and can provide salmon with cold water refugia.

- Reconnect floodplains (e.g., remove/set back levees and revetments), including oxbows and side channels, to restore areas that provide flood storage and slow water during flood events. Priority should be placed on areas above, below and adjacent to spawning grounds to counter the increased risk of higher flows scouring spawning areas, as well as to provide rearing and refuge habitat during floods.

- Remove and fix fish passage barriers such as culverts to ensure fish access to tributaries.

- Continue to work with Seattle Public Utilities to manage the Chester Morse Reservoir to ameliorate hydrologic impacts, such as low summer flows, in the Cedar River.

- Plant and protect forests in the basin. Work with forestry managers and researchers to investigate longer stand rotations and selective logging to improve basin hydrology. Studies have shown that young tree stands (<100 years) actually decrease summer baseflows due to the water demands of younger trees.

- Study and prioritize areas that need stormwater retrofits, LID, and green stormwater infrastructure projects, and accelerate those actions in areas important to salmon.

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4. STRATEGIES TO ACHIEVE OUR GOALS

A strategy is a group of actions designed to achieve a goal. As a set, the 20 strategies described in this section serve as the primary salmon recovery approach in WRIA 8 and are intended to address the highest priority stresses on Chinook salmon and support the key Chinook salmon life stages. The strategies were developed by examining the initial strategies from the 2005 Plan and additional knowledge gained since 2005, including the key life stages identified by the conceptual model of WRIA 8 Chinook salmon, the current pressures affecting Chinook salmon survival, and new scientific information. WRIA 8 partners were engaged throughout this effort, beginning with a recovery strategies workshop and followed by numerous discussions with the WRIA 8 TC and WRIA 8 Implementation Committee (IC).

A set of clear strategies based on the most recent and applicable science is important for effectively guiding salmon recovery actions in the watershed given limited resources. A full description of each strategy, including a description of its importance, the negative impact (or pressure) it reduces, the benefit or improvement sought, the Chinook salmon lifecycle stage affected, the location in the watershed where implementation is most relevant, and the specific actions needed for implementation, is found in Appendix E. Lists of site-specific projects and land use and education and outreach actions that implement each strategy can be found in Appendix F, Appendix H, and Appendix I, respectively.

To the right are the 20 WRIA 8 Chinook salmon recovery strategies, followed by a brief description of each strategy. The first eight strategies (in bold font) were identified by the WRIA 8 TC as the most important for reducing critical pressures on the highest priority Chinook salmon life stages.

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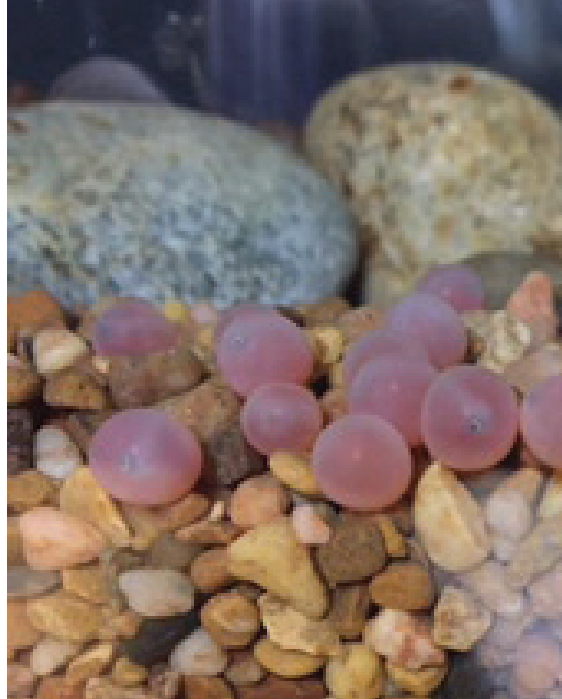
WRIA 8 SALMON RECOVERY STRATEGIES

- **Protect and restore floodplain connectivity**
- **Protect and restore functional riparian vegetation**
- **Protect and restore channel complexity**
- **Restore shallow-water rearing and refuge habitat**
- **Reconnect and enhance creek mouths**
- **Protect and restore cold-water sources and reduce thermal barriers to migration**
- **Improve juvenile and adult survival at the Ballard Locks**
- **Reduce predation on juvenile migrants and lake-rearing fry**
- Remove or reduce impacts of overwater structures
- Remove fish passage barriers
- Protect and restore forest cover and headwater areas
- Provide adequate streamflow
- Restore sediment processes necessary for key life stages
- Restore natural marine shorelines
- Reconnect backshore areas and pocket estuaries
- Protect and restore marine water and sediment quality
- Improve water quality
- Integrate salmon recovery priorities into local and regional planning, regulations, and permitting
- Continue existing and conduct new research, monitoring, and adaptive management on key issues
- Increase awareness of and support for salmon recovery

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PROTECT AND RESTORE FLOODPLAIN CONNECTIVITY

Floodplains provide crucial habitat for juvenile salmon to rear and find refuge from floods and predators. Connected floodplains and associated riparian and instream habitat provide sources of large wood that slow fast-moving water and create channel complexity through braiding and formation of side channels, backwater channels, and off-channel wetlands. In addition, floodplain reconnection improves the connection between surface water and groundwater, and this connectivity provides a source of cooler water and reduces the impacts of increased water temperature from other factors. This strategy will help decrease the negative impacts of nearby land use, levees and revetments, problematic peak and low flows, and increased sediment and pollutant loads. It will also promote resilience to effects of climate change. Monitoring data suggest that—for the Cedar River especially—rearing capacity is a greater limitation than spawning capacity, and restoring floodplain connectivity is the best way to address this limitation. Reconnecting floodplains often provides additional benefits, such as reducing flood risk, improving recreational opportunities, and improving water quality.

PROTECT AND RESTORE FUNCTIONAL RIPARIAN VEGETATION

Protecting and restoring riparian trees is important throughout the watershed and offers direct and indirect benefits to Chinook salmon via food web inputs, water quality protection (including reducing thermal, pollutant, and fine sediment inputs), and as a source of large wood for recruitment. This strategy mitigates some of the impacts of land conversion and urbanization, shoreline armoring, invasive plant infestations, polluted stormwater runoff and increased water temperature from climate change. In Tier 2 areas, this strategy is particularly important to prevent loss of spawning or rearing habitat, ultimately protecting the spatial

diversity of Chinook salmon in the watershed. By trapping sediment and filtering pollutants, functional riparian buffers also reduce the impacts of nonpoint-source pollution.

PROTECT AND RESTORE CHANNEL COMPLEXITY

Complex stream channels provide a range of habitats necessary for Chinook salmon spawning, rearing, and survival. They provide pools and eddies where salmon can rest, feed, and find refuge from predators and floods. Adding large wood can improve natural processes for maintaining or creating pools and riffles and sorting sediment and gravels, all of which create the complex habitat that salmon require. Increased wood loading will improve habitat complexity in nearly all areas of stream habitat within WRIA 8. Restoring channel complexity lessens the impacts of shoreline hardening, altered peak flows due to impervious surfaces, and increased water temperature.

RESTORE SHALLOW-WATER REARING AND REFUGE HABITAT

Gently sloping sandy beaches maximize shallow-water habitat for lake-rearing juveniles outmigrating to Puget Sound, and can help provide refuge from native and non-native predators. Bulkheads or other shoreline hardening and nighttime lighting affect juvenile behavior in ways that may increase their susceptibility to predation. The effects of these changes can be mitigated in key areas through soft shoreline techniques and lighting modifications. Shallow-water rearing and refuge habitats are particularly critical in Lake Washington south of I 90 as lake-rearing juveniles enter from the Cedar River to rear in and migrate through the lake, as well as the south end of Lake Sammamish where juveniles enter from Issaquah Creek. Improved shorelines throughout the migration corridor would improve refuge from predation and provide terrestrial insects for food.

RECONNECT AND ENHANCE CREEK MOUTHS

The area where a creek enters a river or lake provides habitat for juvenile rearing and refuge from predators as juveniles migrate to marine waters. Daylighting or restoring creeks, reducing their gradient to make them available to juvenile salmon, and removing armoring near creek mouths should restore their ecological function and reduce the impact of land cover conversion for residential, commercial, or industrial use, as well as the effects of predation. All creek mouths are important, but efforts should prioritize those in the south end of Lake Washington for rearing and migration to increase survival of Cedar River juveniles. This includes enhancing the associated creek delta habitat.

PROTECT AND RESTORE COLD-WATER SOURCES AND REDUCE THERMAL BARRIERS TO MIGRATION

Areas of water warmer than about 65 degrees F can delay migration, diminish spawning success, and contribute to pre-spawn mortality. While other strategies help protect and restore cold water sources (e.g., floodplain reconnection, riparian cover and forest retention throughout the watershed), this strategy focuses specifically on key areas known to be migratory bottlenecks (e.g., Ship Canal and Sammamish River), or where problems could develop for other life stages through climate change impacts. However, high water temperatures may indirectly exacerbate other stresses to Chinook salmon (e.g., disease) as they migrate or rear, ultimately affecting their survival and/or ability to reproduce. This emerging issue will be tracked and adaptively managed, particularly as it affects key life stages. Cold-water sources will become more important throughout the watershed for all life stages, not just migration, as water temperatures increase.

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IMPROVE JUVENILE AND ADULT SURVIVAL AT THE BALLARD LOCKS

The primary fish passage barrier in the watershed is the Ballard Locks, which affects salmon survival and the timing of adult and juvenile passage into and out of the watershed. As a legacy land use impact that forever changed the hydrology of the watershed, the pressure exerted by the Ballard Locks can be mitigated but not removed. Measures to improve fish passage conditions and survival through the Ballard Locks are of paramount importance. This strategy focuses on USACE funding and implementing critical facility upgrades to ensure effective fish passage and continued safe facility operation.

REDUCE PREDATION OF JUVENILE MIGRANTS AND LAKE-REARING FRY

Predation of juvenile Chinook salmon by native and non-native species is a long-suspected issue affecting juvenile survival in the freshwater system, especially in Lake Washington, Lake Sammamish, and the Ship Canal. The magnitude of the problem is not well quantified, and ongoing research is attempting to clarify the relative impact of predation on freshwater juvenile survival in WRIA 8. Additionally, emerging research suggests that artificial nighttime lighting may alter juvenile fish behavior in a way that makes them more susceptible to predators and increases the length of time predators actively feed. With improved juvenile survival, greater numbers of adults are likely to return, boosting the odds for recovering a self-sustaining Chinook salmon population.

REMOVE OR REDUCE IMPACT OF OVERWATER STRUCTURES

Removing or reducing the impact of overwater structures works to alleviate the pressure of residential and commercial land use along the lakeshores and migration corridors. This strategy reduces the effects of docks, piers, pilings, and other overwater structures that make juveniles more susceptible to predation, since docks can provide cover for predators and/or juveniles will avoid overwater structures and move to deeper water where they are more susceptible to predators. The primary purpose of this strategy is to improve juvenile survival during lake rearing and outmigration.

REMOVE FISH PASSAGE BARRIERS

Ensuring that Chinook salmon can access a range of habitat types is important for all life stages, but fish passage is not a primary limiting factor in WRIA 8 for many life stages of Chinook, especially since the two largest passage barriers that existed at the time of the ESA listing—the Landsburg Diversion Dam and the Issaquah Hatchery Intake Dam—have been addressed. Providing juvenile Chinook salmon with access to more area for rearing, especially in small channels where many fish passage barriers still exist, is important. Also, ensuring juveniles have access to available cooler water habitat can mitigate the effects of increased water temperatures. Removing barriers to fish passage in Tier 2 areas is important to maintain the potential for spatial diversity. As development continues and new roads are built, creek crossings should be minimized to prevent future barriers, and new crossings should use bridges or culverts designed to accommodate fish passage.

PROTECT AND RESTORE FOREST COVER AND HEADWATER AREAS

Retaining forest cover and functional upland habitat in areas throughout the watershed is important for water quantity and quality, particularly to address changes in winter peak flows, summer low flows, and water temperatures as climate change progresses. This strategy reduces the impacts of land conversion, pollutant- and sediment-filled runoff, and changes in water flow and temperature. Since implementation of the 2005 Plan, many of the opportunities to purchase or protect headwater areas have been acted on or otherwise addressed. Remaining opportunities are limited but exist along the middle and upper reaches of Bear/Cottage Lake, Issaquah, Little Bear, and North creeks. Incentivizing and regulating retention of forest cover and reforestation on private lands, as well as reducing impervious cover through low impact development (LID) practices, are likely to be effective in indirectly benefiting all life stages of WRIA 8 Chinook salmon populations.

PROVIDE ADEQUATE STREAMFLOW

Adequate streamflow is important to provide habitat during critical rearing and migration stages. This strategy, intended to address the impacts of both high and low flows, would reduce the impacts of land conversion, water withdrawals, increasing water temperatures, scouring events, and fish passage barriers. Reducing illegal withdrawals and protecting or enhancing flows are important actions throughout WRIA 8, especially in the Sammamish River basin and its tributaries, and may become more important in the future, as climate changes.

RESTORE SEDIMENT PROCESSES NECESSARY FOR KEY LIFE STAGES

This strategy addresses two issues – excessive fine-grained sediments and insufficient spawning gravel. An excess of fine sediment is a concern during incubation, when redds/eggs can be smothered by fine particles. This issue is most prevalent along Bear Creek/Cottage Lake Creek, Issaquah Creek, and in all Tier 2 streams. Beneficial gravels for spawning can be lacking where natural sediment recruitment processes are interrupted, such as where levees disconnect the river from the floodplain on the Cedar River or confluence areas on other streams are modified. This strategy reduces the impacts of land conversion, shoreline hardening, and impervious surface runoff.

RESTORE NATURAL MARINE SHORELINES

Preventing and removing bulkheads and armoring along the marine shoreline will allow for a more natural shoreline with increased overhanging vegetation, connected drift cells and pocket estuaries, and increased extent of eelgrass beds and forage fish spawning habitat. These features will improve the marine food web function and increase success of juvenile Chinook salmon rearing and migrating. The BNSF railway runs along most of the WRIA 8 marine shoreline, severely limiting restoration opportunities. However, any shoreline enhancement or restoration will offer regional salmon recovery benefits, as Chinook salmon from other watersheds also rear in or migrate through the WRIA 8 nearshore. Opportunities exist to enhance the habitat in front of the BNSF railway through beach nourishment, as well as behind or above BNSF through riparian restoration. Identifying and restoring shoreline sediment processes are also important to support habitat for primary Chinook prey species, such as sand lance and smelt.

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RECONNECT BACKSHORE AREAS AND POCKET ESTUARIES

Many backshore areas and pocket estuaries have been disconnected from Puget Sound, resulting in a lack of tidal inundation and reducing or preventing access by migrating adult and juvenile salmon. Along the nearshore, creek mouths provide important rearing habitat, and recent research suggests these areas are important to the overall life history of Puget Sound salmon. Much of the WRIA 8 shoreline is disconnected from the Sound by armoring from the railroad prism, but juvenile salmon need viable rearing and refuge locations along the shoreline wherever possible. This strategy will mitigate the effects of the railroad, perched culverts, and shoreline hardening in commercial and residential areas.

PROTECT AND RESTORE MARINE WATER AND SEDIMENT QUALITY

Improving marine water and sediment quality where possible and capping contaminated sediment in the nearshore, especially near commercial and industrial areas, may improve early marine survival directly or indirectly. Additional research is needed to better understand how impaired marine water and sediment affect Chinook salmon early marine survival and the food web. WRIA 8 will track and adaptively manage this emerging issue. The strategy will mitigate the legacy and current impacts of land conversion and of point and nonpoint source pollution.

IMPROVE WATER QUALITY

"Water quality" is multi-faceted and intersects with salmon recovery in many ways. The purpose of this strategy is to support water quality improvements beyond water quality permit requirements through encouraging individuals and jurisdictions to participate in voluntary and incentive-based programs. Improvements should target reductions in polluted runoff from impervious surfaces, nonpoint source pollution, fine sediment inputs, and altered flows. This strategy is primarily implemented through education and outreach programs. Several water quality elements are also addressed by other strategies in this section (local and regional planning, regulations, and permitting; protect and restore cold water sources and reduce thermal barriers to migration; protect and restore functional riparian vegetation; and, protect and restore forest cover and headwater areas). New regional research is underway to identify possible impacts of polluted stormwater runoff on Chinook salmon, and any findings will be adaptively managed at the local level and in implementation of the 2017 Plan.

INTEGRATE SALMON RECOVERY PRIORITIES INTO LOCAL AND REGIONAL PLANNING, REGULATIONS, AND PERMITTING

Local jurisdictions, state agencies, and federal agencies should consult the WRIA 8 Plan for the best available science on incorporating Chinook salmon requirements into required planning for shorelines, land use, water quality, and project permitting. The 2005 Plan and this update are built on the assumption that regulations are protective and supportive of sustaining salmon in the watershed; the other strategies articulated in the plan provide additional ecological efforts necessary for recovery. While WRIA 8 staff will not track these actions specifically, or likely fund capital projects through the process, this strategy is foundational to the success of others.

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CONTINUE EXISTING AND CONDUCT NEW RESEARCH, MONITORING, AND ADAPTIVE MANAGEMENT ON KEY ISSUES

Specific research and monitoring are necessary to ensure that the latest science informs implementation of recovery strategies and actions. The MAP (Appendix A) details the indicators that should be tracked to support a complete adaptive management cycle. This strategy highlights research and monitoring needed to further develop or refine strategies or address data gaps on specific issues critical for recovery. These include emerging issues such as impacts on salmon survival from predation, artificial light, and climate change. WRIA 8 relies on regional research for issues related to stormwater impacts and early marine survival, such as the Salish Sea Marine Survival Project.

INCREASE AWARENESS OF AND SUPPORT FOR SALMON RECOVERY

While most strategies include specific outreach/education actions to support their implementation, this strategy is entirely focused on the importance of raising awareness of and broadening support for salmon recovery in general. The intent of this strategy is to ensure watershed-wide awareness of salmon, agreement on the ecological, cultural, recreational and economic importance of salmon in the watershed, and an understanding of the individual actions that can support salmon recovery. With a growing human population in the watershed and many new residents who may be unfamiliar with Chinook salmon, this strategy is critical to meeting specific habitat and Chinook salmon population goals articulated in this plan.

5. IMPLEMENTATION FRAMEWORK

The 2017 Plan will be implemented through numerous comprehensive actions, developed through a collaborative process involving local stakeholders, jurisdiction staff, environmental and business representatives, and project experts. The 2017 Plan's actions are grouped into three categories:

- Site-specific habitat protection and restoration projects, which seek to protect a specific area through acquisition or easements, or restore habitat with projects such as levee setbacks, revegetation, addition of large wood, and removal of barriers to fish passage.
- Land use actions, which focus on accommodating future growth while minimizing impacts to salmon habitat. Recommended actions address planning, regulations, best management practices (BMPs), and incentive programs.
- Public education and outreach actions, which support land use and site-specific actions and/or encourage behavior that helps salmon – through, for example, workshops for shoreline landowners, general awareness campaigns, community stewardship, and promoting BMPs and incentive programs.

SITE-SPECIFIC PROJECTS

The 2005 Plan offered a comprehensive approach for salmon habitat protection and restoration in the watershed through an extensive list of protection and restoration projects. The original project list contains actions focused on protecting intact habitat and natural processes that support salmon, restoring degraded habitat to create conditions more suitable for salmon, and acquiring land to facilitate future restoration projects. This suite of habitat projects represents the actions thought to be needed to effect change in WRIA 8 salmon populations.

As part of the 2017 Plan, WRIA 8 partners and staff revisited the 2005 project list to ensure the list is up to date and addresses the current thinking about recovery needs in the watershed. This involved convening groups of partners by geographic area to evaluate the 2005 project list. Partners provided input to update and refine existing projects and project descriptions and offered new project concepts that align with the suite of updated WRIA 8 recovery strategies.

In many cases, the 2005 project list lacked specificity, and an emphasis of the 2017 Plan is to focus the project list on specific

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actions in specific areas. This resulted in removing many vague project references from the 2005 project list, yet where these concepts remain important priorities for implementation, they are carried forward in the 2017 Plan update as recovery strategies.

The 2005 Plan identified a "Start List" of projects envisioned as the focus of the first 10 years of plan implementation. In the absence of quantified habitat goals, the Start List was developed in part to measure and track implementation progress. Now that habitat goals exist – which are a more effective mechanism for measuring progress than the number of projects implemented – the Start List concept has not been carried forward in the 2017 Plan.

In the 2005 Plan and again in the 2017 Plan, implementation of habitat protection and restoration projects is a voluntary activity. This is an important consideration, especially for local jurisdictions that have other capital priorities for their limited public resources. Looking forward, WRIA 8 encourages jurisdictions to explore multi-benefit approaches to capital project implementation, whereby habitat restoration is incorporated into stormwater, drainage, parks, and other related capital projects and programs. Grant funders are increasingly recognizing the value of multi-benefit approaches to project implementation, which in turn offers an opportunity to leverage local investments. Additionally, given that grant resources continue to be insufficient to achieve recovery objectives, WRIA 8 Salmon Recovery Council members from partner jurisdictions are encouraged to prioritize habitat protection and restoration in local budgets to the extent practical to accelerate the pace of implementation and move toward the recovery goals outlined in this plan.

Please see Appendix F for the full list of WRIA 8 projects.

Role of mitigation in salmon recovery

The premise of the WRIA 8 Plan's identified habitat protection and restoration projects and programmatic actions is to prevent further decline of Chinook habitat and restore degraded habitat in order to make significant net improvements in habitat to address limiting factors and support recovery. It is clear that simply maintaining status quo habitat conditions will not restore sustainable, harvestable levels of Chinook. Land use changes and associated impacts will continue as the region's population grows, especially within urban growth areas designated under the Growth Management Act, further reducing and degrading habitat throughout the watershed. It is important to understand how efforts to address the negative impacts of development affect WRIA 8 Chinook salmon habitat protection and restoration.

What is mitigation?

Development projects require permits at local, state, and/or federal levels, which identify potential impacts to protected environmental features—such as wetlands—and species—such as Chinook salmon. In large measure, the regulatory and permit process requires avoiding and minimizing potential impacts as much as possible. When development activities will create unavoidable environmental impacts but are allowable under the existing regulatory framework, project sponsors are required by regulators to take a defined action or set of actions to offset or mitigate the impact.

How mitigation works

Mitigation projects can occur on-site (at or near the development project) or off-site. On-site mitigation is generally preferable when it is ecologically feasible and likely to succeed long-term. However, if mitigation on or adjacent to the development site is impractical or will not result in meaningful and sustainable ecological benefits, off-site mitigation becomes an option under state and federal rules. One increasingly common option for off-site mitigation includes purchasing mitigation credits from a certified mitigation bank or in-lieu fee mitigation program (e.g., King County's

Mitigation Reserves Program). Mitigation banks are constructed and certified before impact, and project proponents purchase credits in the bank to mitigate for unavoidable impacts. In-lieu fee mitigation programs first collect impact fees from development projects and then use those fees to identify and implement mitigation projects within an associated service area.

Both mitigation banks and in-lieu fee programs undergo significant state and federal scrutiny during their initial establishment and through ongoing oversight. Mitigation projects only earn credit when success is proven, and mitigation sites are monitored and maintained in perpetuity with funding set aside to ensure projects are completed successfully. As a result, these off-site, and in some cases out-of-kind, mitigation options are proving increasingly effective in improving ecological functions in areas of a watershed that have been prioritized for restoration.

Mitigation and salmon recovery

With the establishment of mitigation banks and programs such as King County's Mitigation Reserves Program, mitigation funds have become part of the fabric of funding sources that can support implementation of habitat restoration projects. This is especially true in highly urbanized watersheds, where large development or transportation projects can create significant mitigation needs. In some cases, mitigation funding may be capable of implementing all or portions of a project identified on the WRIA 8 project list.

The use of mitigation funds to implement habitat enhancement projects can improve ecological functions in some areas sooner than may otherwise be possible by simply relying on grant-funded restoration or limited local funds.

At the same time, it is important to recognize that mitigation projects do not represent net improvements in overall habitat conditions since each mitigation action is linked to new habitat impacts resulting from a development action. No comprehensive and consistent method currently exists to account for the impacts accrued through actions that incrementally degrade habitat, water quality, and hydrologic functions within our watersheds, not to mention across the broader region. This conundrum exists even as mitigation funded projects are helping to implement key priorities and strategies identified in the WRIA 8 plan.

Accounting for mitigation in salmon recovery tracking and reporting

The habitat protection and restoration actions identified in the 2017 Plan, and the associated quantitative habitat goals, are meant to represent net gains in habitat and ecological functions. Since mitigation is intended to offset impacts to habitat from various development projects, habitat enhancements funded through mitigation do not represent net habitat gains. For purposes of tracking habitat restoration progress in WRIA 8, we will work with project managers, mitigation program managers, and other partners to ensure appropriate accounting for habitat improvements as well as their associated environmental impacts. To produce a transparent accounting and reporting of net progress towards achieving WRIA 8 habitat goals, WRIA 8 will document which projects, or portions of projects, were implemented with mitigation funding.

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LAND USE ACTION RECOMMENDATIONS

In addition to habitat protection and restoration projects, land use actions are critical to protecting and restoring habitat conditions for Chinook salmon and to the success of salmon recovery in WRIA 8. Land use actions are defined as policies, rules, or other non-capital actions that programmatically address habitat protection.

Local governments are responsible for land use actions, which include planning, regulations, incentive programs and BMPs that address landscape features or ecological processes such as forest cover, road crossings, riparian buffer conditions, natural flow regimes, and sediment dynamics. Land use actions determine where and how urban growth takes place in the watershed, how stormwater is managed, and the degree to which environmentally critical and sensitive areas and functioning habitat processes are protected. These actions are particularly important to accommodate a rapidly growing population and mitigate the effects of a changing climate. Together with land protection and restoration actions, land use policies will determine whether salmon continue to return to our watershed each year.

In many cases, land use actions complement or support implementation of site-specific project actions. The 2005 Plan grouped the actions by geographic subarea (i.e., Cedar River, north Lake Washington tributaries, Issaquah Creek, and migratory and rearing areas). For the 2017 Plan, the list of recommended land use actions was revisited and updated to serve as a resource for partners and decision-makers in land use planning and decisions, and to better focus and guide future investment of resources to support implementation of salmon recovery strategies.

See Appendix H for a list of recommended land use actions organized by land use category.

Growth Management Act

Under the Growth Management Act (GMA), local jurisdictions must protect critical areas and designate natural resource lands (e.g., forest, agricultural, and mineral areas) and urban growth areas, which identify where urban growth and development may occur. The 2017 Plan calls for managing growth in a way that minimizes negative impacts to salmon. This includes maintaining existing UGA boundaries, unless altering the boundary would be beneficial to salmon.

Plan recommendations within UGAs:

- Manage growth to minimize impacts to water quality, riparian forest cover, and flows
- Promote LID and green stormwater infrastructure
- Use incentive programs to protect watershed functions and values (examples include transfer of development rights, public benefit ratings system, etc.)
- Promote restoring native vegetation cover

Plan recommendation outside UGAs:

- Promote livestock BMPs to protect ecological functions
- Use incentive programs to protect forest cover and protect and restore riparian buffers (examples include transfer of development rights, public benefit ratings system, etc.)
- Ensure maintenance of properties protected through fee acquisitions or easements

Critical Areas Ordinance

Local governments have critical area ordinances to protect the natural environment and public health/safety, including measures to preserve and enhance "unique, fragile, and valuable elements of the environment," with special consideration for actions that preserve or enhance anadromous fisheries. These regulations have great potential for achieving salmon conservation objectives, including:

- Protecting aquatic areas
- Protecting riparian buffers and nearshore vegetation
- Protecting forest cover
- Protecting wetlands
- Protecting water quality

Shoreline Management Act and Shoreline Master Programs

A goal of the Shoreline Management Act (SMA) is to "prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines" and to facilitate public access to shorelines of the state. Local governments are required to develop shoreline master programs (SMPs), which are the primary means for administering the SMA. These SMPs include a characterization of a jurisdiction's shorelines, including rivers, large lakes, and marine shorelines, and their associated ecological functions. The primary overlap between the 2017 Plan and SMPs is the protection of shoreline forest/vegetation cover and the protection of vegetated riparian buffers.

Water Quality and Stormwater Management, including NPDES Permit

Improving water quality and managing stormwater are critical for creating and maintaining stream and water conditions that support salmon survival. In particular, local jurisdictions are required, under their NPDES permits, to develop and implement

stormwater management programs to protect water quality and reduce pollutant discharge. There are at least three areas of strong overlap between stormwater management actions and salmon recovery:

1. Regulatory activities – Local government partners should implement and enforce NPDES permit conditions to improve water quality by restoring natural flow regimes. State and local partners need to work together to address water quality-impaired Tier 1 and Tier 2 streams with total maximum daily load designations for excessive pollution, temperatures or dissolved oxygen. These actions help address impacts to salmon in WRIA 8 streams.

2. Incentive-based and voluntary programs – Local government partners and community organizations concerned about water quality can go beyond NPDES requirements by increasing and promoting stormwater management structure retrofits, LID, and GSI, as well as pollutant source control efforts.

stormwater discharge permit requires local governments to develop public education and outreach programs. Many of the actions required by these programs also support salmon recovery.

Groundwater

Groundwater contributes to streamflow and functions as a coldwater input for many streams, which is especially needed in streams affected by high water temperatures. Ensuring that groundwater is protected and hydrologic connections are maintained and improved throughout the watershed is important for improving habitat conditions for salmon. The following actions are key:

- Encourage LID, GSI and natural drainage systems to promote groundwater recharge

- Protect streamflow and hydrologic integrity through regulations, incentives, and acquisitions
- Educate the public about the importance of groundwater for human health, fish and wildlife, and ecosystem processes

Floodplain Management

The King County Flood Control District (FCD) is responsible for managing flood risk along the County's major river systems, and local jurisdictions participating in the National Flood Insurance Program also share flood risk reduction obligations. In WRIA 8, FCD activities most commonly overlap with salmon recovery priorities along the Cedar River and Sammamish River. In many cases, potential projects to reduce flood risk are close to or in the same location as habitat restoration projects, creating opportunities to collaborate and identify solutions that meet both flood risk reduction and salmon habitat restoration goals. In addition to floodplain management on the Cedar River and Sammamish River, some local governments also manage floodplains on streams to reduce flooding and restore habitat.

EDUCATION AND OUTREACH ACTION RECOMMENDATIONS

Since WRIA 8 is the most populous watershed in the state, raising public awareness of salmon recovery, and building and sustaining public and political will to take action, are imperative if conditions for salmon are to be improved in the watershed. Without public and political support over the long-term, Chinook salmon recovery efforts cannot succeed, especially as our region continues to grow.

Outreach and education actions support land use management and capital projects, or promote behavior change to improve habitat conditions. They can apply to a specific location, a particular target audience, or throughout the basin. The 2005 Plan ranked outreach and education actions as high, medium, and low priority. To better prioritize and guide outreach and education efforts, the 2017 Plan uses the results of WRIA 8 programmatic action implementation surveys conducted in 2009 and 2015, a 2009 outreach and education gap analysis, and feedback from the WRIA 8 Salmon Summit in 2016. This information provided the basis for a suite of draft outreach and education actions that were reviewed and revised at a workshop of education and outreach partners in 2016.

See Appendix I for recommended outreach and education priorities.

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6. ADAPTIVE MANAGEMENT PROCESS

Effective implementation of the WRIA 8 Plan requires adaptive management. The major steps of an adaptive management cycle are to:

1. Set a vision and identify goals
2. Plan actions and identify monitoring needs
3. Implement and monitor
4. Analyze data and use results to adapt assumptions and approach
5. Capture lessons learned and share results

The 2005 Plan set a vision for recovery and identified the actions for implementation. WRIA 8 has adaptively managed the 2005 Plan using monitoring results, studies and research, and lessons learned from implementing projects to inform recommendations to the WRIA 8 Salmon Recovery Council for ways to adjust implementation. Progress reports completed in 2010 and 2015 shared implementation status, analyzed data, identified challenges, and assessed recovery assumptions.

The 2017 Plan includes quantitative habitat goals and revised recovery strategies developed using new information and lessons learned from the past decade of implementation. The goals and strategies will improve our ability to adaptively manage implementation moving forward, help partners work together toward the same goals, implement the most important actions, and improve our ability to track and report on our progress. Implementation of the 2017 Plan will be adaptively managed by linking monitoring and new and emerging information to decision-making through reports and presentations to the Salmon Recovery Council, and through specific recommendations from the TC and IC. This approach enables the Salmon Recovery Council to have a common understanding and adjust the direction of implementation based on monitoring results and lessons learned.

In 2017, WRIA 8 developed the MAP (Appendix A) to guide monitoring and reporting on progress towards implementing recovery strategies and meeting habitat recovery goals throughout the watershed, to prioritize restoration actions, and to identify gaps. The adaptive management approach evaluates success in meeting 2017 Plan habitat goals, and uses triggers to guide future actions or changes (Table 5). A trigger refers to a threshold of the habitat indicator that prompts a recommended action. In the case of WRIA 8 habitat

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goals, five-year triggers are established to assess whether implementation in on track (i.e., 50% of the way toward implementation of the 2025 goal).

Adaptive management involves assessing both indicators associated with project implementation and the success of land use actions and education and outreach programs in supporting implementation of recovery strategies. The expectation moving forward is that the WRIA 8 TC will regularly review and report data from monitoring efforts (annually for fish population data and every five years for habitat condition data) to assess the effectiveness of restoration and recovery actions and report to the IC and Salmon Recovery Council. The WRIA 8 IC will work with local government and non-governmental partners to review and assess land use actions and education and outreach programs at least every five years to help highlight any changes

that should be considered. The WRIA 8 TC will track new technology and information on Chinook salmon, and the monitoring plan will be updated as needed, pending coordination with the Puget Sound Partnership to assure consistency with the Puget Sound Chinook salmon recovery framework.

Assuming the appropriate information is collected to a sufficient degree to inform decision-making, the process in WRIA 8 typically involves discussing monitoring results within the TC and IC and developing and submitting joint TC/IC recommendations to the Salmon Recovery Council for their consideration and action. The adaptive management process will also affect how WRIA 8 staff develop their work plans and assist project sponsors with implementation. This process will continue to be followed in the future with continued oversight by the WRIA 8 Salmon Recovery Council.

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WRIA 8 Habitat Goal Adaptive Management Triggers

Habitat Component	2025 Goals	2020 Trigger (50%)
Cedar River	Total connected floodplain acres between Lake Washington and Landsburg Diversion Dam will be 1,170 acres by 2025. Average wood volume will quadruple over current basin conditions (RM 4 to Landsburg Diversion Dam) by 2025.	Total connected floodplain acres <1,105 acres Average wood volume <21 m^3/100 m
Sammamish River	Areas of river will be cool enough to support Chinook salmon migration and survival (increase riparian cover and add thermal refugia) by 2025.	<1 thermal refuge added Net riparian cover added <20 acres
Streams (Bear/Cottage Lake, Issaquah, Evans, Kelsey, Little Bear, North creeks)	Area of riparian cover in each Tier 1 and Tier 2 stream will increase by 10% over 2015 conditions by 2025. Average wood volume will double over current basin conditions by 2025.	Varies by stream: cover in each stream increases by <5% over 2015 conditions Varies by stream: wood volume in each stream increases by <50%
Lakes	Natural lake shoreline[1] south of I-90 (Lake Washington) and throughout Lake Sammamish will double over 2015 conditions by 2025. Natural riparian vegetation within 25 feet of shoreline south of I-90 (Lake Washington) and throughout Lake Sammamish will double over 2015 conditions by 2025.	Natural lake shoreline < X acres (baseline assessment required) Natural riparian vegetation restored < 30 acres
Nearshore (Pocket Estuaries)	Pocket estuaries along WRIA 8 shoreline will support juvenile Chinook salmon for rearing and migration.	<1 stream mouth/pocket estuary added

[1] "Natural lake shoreline" is defined by the WRIA 8 Technical Committee as without bulkhead, with slope and substrate matching historic lakeshore contours for the area under consideration.

Table 5. WRIA 8 Habitat Goal Adaptive Management Triggers

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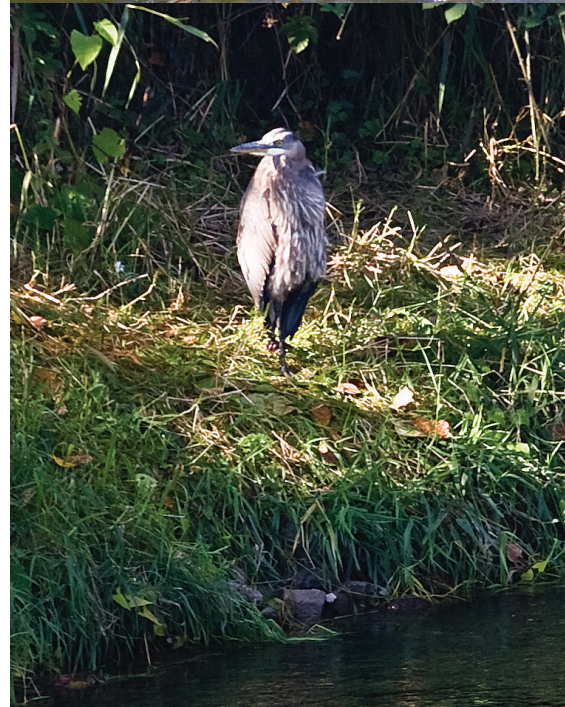
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10-YEAR UPDATE

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2017

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