Lake Washington/Cedar/Sammamish Watershed (WRIA 8)

WRIA 8 Technical Memorandum 2007-01

WRIA 8 CHINOOK PLAN START-LIST ACTIONS MODELING FISH PERFORMANCE USING Ecosystem Diagnosis and Treatment (EDT)

Prepared for
WRIA 8 Salmon Recovery Council

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WRIA 8 Technical Memorandum 2007-01
Adapting the Start-List to Support WRIA 8 Chinook Objectives

Abstract

The 2005 WRIA 8 Salmon Conservation Plan aims to create habitat conditions that support viable populations of Chinook salmon. Proposed land use, public outreach, and capital projects included in the Plan are hypothesized to change habitat conditions in ways that increase survival of specific Chinook life stages, and ultimately, the productivity, abundance, spatial distribution, and life history diversity of the Cedar River and Sammamish River Chinook populations. Starting from a list of over 1,200 individual actions a Start List was developed of approximately 170 actions were considered to be highly beneficial to Chinook. Of these, a subset of actions was included in the Ecosystem Diagnosis and Treatment (EDT) model to evaluate their relative benefits to VSP parameters for Chinook.

Results are summarized by subbasin/population segment in this memorandum. The actions increased abundance from the current condition by 22% to over 500% and productivity increased by 14% to 56% depending on the population segment. The actions resulted in life history diversity indexes of 60% to 100% of the potential. Chinook originating from Issaquah Creek had the greatest increase over current condition and North Creek had the lowest increase. Issaquah Creek had the greatest number of actions modeled (25 not counting actions in the Sammamish River) and Little Bear Creek had the fewest actions modeled (three not counting actions in the Sammamish River).

Across all subbasins, actions appeared to be targeting the correct habitat features identified in the diagnosis. In only a few cases were key features not addressed by the actions. For example, actions did not address sediment effects in Issaquah Creek. The biggest shortcoming of the Start List scenarios was the lack of actions across all areas identified by the diagnosis or low effectiveness because actions were limited in geographic range or relied too much on passive restoration. At the same time, the likelihood of securing the benefits from the projects evaluated will presumably be high because the 52 projects modeled are very feasible and some are “in-progress.” .

Specific recommendations for the Cedar River are to evaluate additional levee setbacks/removals in some key areas, evaluate the benefits of smaller scale actions (like the Lions Club project – C233) over a broader area, and encouraging habitat enhancement actions within the City of Renton as redevelopment opportunities arise in the lower Cedar or nearby lake shoreline area. Specific recommendations for Bear Creek are to focus on the area upstream and downstream of Cottage Lake Creek and consider active channel restoration. Specific recommendations for Little Bear Creek are to identify actions in the upper watershed and habitat enhancement actions in the City of Woodinville. Specific recommendations for North Creek are to identify actions that can occur over a larger portion of the stream and evaluate additional actions in the Sammamish River. Finally, specific recommendations for Issaquah Creek are to identify active restoration type actions in the upper watershed that will control sediment supply

and delivery. There appears to be excellent opportunities to combine protection actions with some active in-stream restoration to achieve a quicker response.

The additional actions recommended in this Technical Memorandum should be evaluated using the model in combination with an evaluation of possible watershed scale future degradation or improvement (over the same 25 year time lag) resulting from changes in projected growth and development or other protective programs or projects.

Lake Washington and Lake Sammamish were not addressed in this analysis. These are critical rearing and migration corridors that will need to be considered for protection and restoration actions as well as harvest and hatchery effects alongside of river and stream based actions. Previous EDT modeling and reporting indicates that "restoration" of the lakes (both habitat and predation effects) have near-equal recovery benefit as in-river and stream enhancement. For this report, individual habitat actions in the lakes were not "modeled" because the quantification of treatment effectiveness for individual projects is not well established. This is also due in part to uncertainty associated with customization of the EDT model for the lakes

The WRIA 8 Recovery Plan identifies short- and long-term VSP population goals. The effects from these projects are consistent with supporting those goals in the near-term, especially for the core naturally spawning populations in the Cedar River and Bear Creek. These results suggest population diversity as modeled in EDT as life history "trajectories" improves with modeled actions. Results suggest that spatial distribution outside of core areas (Cedar River and Bear Creek) may not expand much due to the low level of modeled effort. An exception to this would be the likely expansion into upper Issaquah Creek with improvement of fish passage. Although no actions were included for the upper Cedar River watershed area as part of this modeling scenario, Cedar River spatial distribution continues to expand due to fish passage above Landsburg dam. Results reported here supporting population goals do not consider the likely future changes in habitat conditions resulting from ongoing growth and development that may result in additional cumulative degradation in parts of the watershed that would offset benefits modeled here to an unknown degree. This would have to be estimated and evaluated as part of a future technical memorandum.

I. Introduction

The 2005 WRIA 8 Salmon Conservation Plan aims to create habitat conditions that support viable populations of Chinook salmon. Proposed land use, public outreach, and capital projects are hypothesized to change habitat conditions in ways that increase survival of specific Chinook life stages, and ultimately, the productivity, abundance, spatial distribution, and life history diversity of the Cedar River and Sammamish River Chinook populations sufficient to support the Chinook population objectives identified in the Plan (Table 1).

Table 1. WRIA 8 Chinook salmon population near-term and long-term goals to achieve viability (less than 5% risk of extinction over 100 years). Reproduced from Chapter 4 of the WRIA 8 Salmon Conservation Plan, page 54.

	Near-Term (10-yr) Objective	Long-Term Goal	Comments
Productivity	• 2X current survival for juveniles and smolts within subareas • ≥2 adult returns/ spawner 2-4 years out of 10	≥1 adult returns / spawner X years out of Y WDFW target: 1-3.1 recruits/spawner in Cedar, 1-3 recruits/spawner in Sammamish	While productivity greater than 1 indicates a growing population, the low current population numbers may require an initially higher productivity to reduce the risk of adverse impacts from Allee effects, environmental perturbations, and natural population fluctuations
Spatial Structure	Convert 1 satellite subarea to core (i.e. Upper Cedar and North Creek); expand spawning area distribution	• Recapture historic distribution; • Consistent use of NLW tribs in addition to Bear for spawning)	Historic Chinook distribution is assumed to be with current hydrologic routing in WRIA 8 (that is, no reconnection of the Cedar River to the Duwamish River and the WRIA 9 Chinook population)
Life History Diversity	Percentage increase in Cedar instream rearing trajectory; improve Sammamish habitat conditions to support eventual smolt rearing	Increase Cedar instream rearing trajectories from 25% to 50% (the presumed historic percentage); Increase % of smolts rearing in the Sammamish River	Changes in juvenile life history trajectories monitored through smolt traps and PIT tags
Abundance	Meet co-manager escapement goals of 1,250 naturally spawning adults on Cedar and 350 in Bear & Cottage Lake Creeks	• WDFW Target: 1,000-8,200 spawners in Cedar; 1,000-4,000 spawners in Sammamish • Use EDT "Margins of Sustainability" to estimate minimum sustainable populations	Escapement is a co-manager objective that reflects management as well as biological needs. However, meeting escapement goals would represent a significant increase for WRIA 8 populations.

Among 1,200 conservation actions identified in WRIA 8, a recommended 10-year 'Start-List' of approximately 170 actions considered to be highly beneficial to Chinook and highly to moderately feasible to implement is proposed. While the Plan hypothesizes a

relationship between conservation actions and Chinook population attributes, it did not include an analysis of the relative impacts of individual actions, nor did it assess whether the suite of actions included in the Start List were sufficient to support the Chinook population objectives.

The WRIA 8 Salmon Conservation Plan is built around an Adaptive Framework, with the intent that the Plan strategies and actions would be modified as necessary in response to new information. A critical step in the adaptive management process is to evaluate whether Start List actions are sufficient to support the Plan objectives, and to identify any adaptations or improvements to the Start List that may be necessary. Since completion of the Plan in 2005, the WRIA 8 Technical Committee (W8TC) has worked with basin experts and a consultant team to estimate the impacts of the Start List actions on habitat conditions and Chinook population attributes using the Ecosystem Diagnosis and Treatment (EDT) habitat model.

II. Purpose

This technical memorandum describes interim EDT modeling results for select restoration actions (Appendix A) in the Start List, and identifies additional recommended projects needed to support the 10-year Chinook population objectives identified in the Plan.

This analysis does not evaluate impacts of future land use scenarios, nor does it evaluate protective actions (such as acquisitions or land use regulations) as the EDT model evaluates protective actions relative to future habitat scenarios. The W8TC, using land use scenarios developed by the Puget Sound Regional Council (PSRC) in partnership with the University of Washington, will evaluate future development conditions. PSRC scenarios will be used to ensure consistency with future development scenarios used by local governments for transportation, economic development, and other purposes, to avoid redundancy, and to leverage the considerable regional investment in the PSRC's modeling effort. There is no timetable for accomplishing this work due to uncertainty in timing of PSRC products (see Next Steps below).

And finally, it is worth repeating that the habitat model used in WRIA 8 provides relative comparisons of actions and relative impacts on Chinook life stages. It is explicitly not intended to generate quantitative predictions of future abundance or productivity. It is most appropriately used to estimate a relative result of proposed strategies compared to current or template conditions.

III.Methods

The EDT model was used to complete the analysis of actions for their benefits to Chinook population viability parameters. We begin with a description of how results are presented from the model and follow with an overview of how actions were constructed and analyzed for Cedar River and Sammamish River Chinook.

Presentation of Model Results

Model output consists of population performance parameters (productivity and capacity) for the Beverton-Holt (B-H) production model for adult and juvenile Chinook. Adult productivity is reported as adult returns per spawner and represents the relative success of the species to complete its life cycle within the habitat it experiences. It determines the resilience to mortality pressures. Habitat quality is a major determinant of a population's productivity. A life cycle productivity of less than 1.0 return per spawner is, by definition, unsustainable. The population is clearly at risk when productivity is between 1.0 and 3.0 returns per spawner, but population recovery targets were identified by Washington Department of Fish and Wildlife based on 1.0 and 3.0 productivity values. Adult capacity is reported as the maximum number of adults that can be produced. It defines how large the population can grow within the environment it experiences, as a result of finite space and food resources. Habitat quantity is a major determinant of the environmental capacity to support population abundance. Finally, we refer to abundance rather than capacity when discussing results. Abundance is the equilibrium run size abundance estimated from the B-H parameters. The equilibrium run size incorporates both productivity and capacity and theoretically would represent the average run size for the population if all sources of mortality were included. However, in our analysis harvest was not included, nor were hatchery effects (genetic and ecological) in our attempt to isolate habitat effects. Only habitat actions as future changes were evaluated. No future harvest, hatchery management actions or influence from growth and development in the watershed were considered.

Juvenile productivity and abundance predicted by the model are at the lower most reach in the subbasin. All juvenile life history types are included in the estimate (fry, presmolts and smolts). Productivity is reported as juveniles per spawner. Juvenile abundance is the predicted number of juveniles that would be produced at the equilibrium adult abundance.

For each population we report an estimate of life history diversity. This is the percent of life history trajectories through space and time that are available to, and used by the population in completing its life cycle. The number of life history trajectories is based on the combination of possible pathways limited by spawn timing, egg incubation requirements, smolt outmigration timing, and other factors. Populations that can utilize a wide variety of life history pathways are likely to be more resilient to the influences of environmental change. Thus, loss of possible trajectories for completing life history pathways could be representative of declining diversity and resiliency of the population.

The spatially and temporally explicit features of the EDT model allow a detailed diagnosis of conditions affecting population performance at multiple scales. The EDT diagnosis includes a "contributing factors" analysis that examines the relative effect on population performance of factors (survival factors, key habitat, and food) specific to the species and life stage and reach. The diagnosis examines the loss due to habitat alterations between the WRIA 8 template and current conditions. The analysis was used to provide guidance to the W8TC when selecting Start List actions.

The detailed reach structure within EDT (Appendix B) was used to analyze geographic priorities for protection and restoration actions. We evaluated protection priorities by splicing in a hypothetical assumption of degraded environmental conditions for a reach or group of reaches and rerunning the model for population performance. The model output is a report of relative loss of performance after running the splice analysis in a systematic fashion for all areas of the watershed. Areas with the highest relative loss are areas that protection is most important. We evaluated restoration priorities by splicing in the template habitat condition (maximum restoration potential) for a reach or group of reaches and rerunning the model for population performance. It is important to note that the analysis only identifies the effect of change within the stream reach of interest. Land use practices and habitat actions may be well upstream of the modeled area.

We also completed a "Scenario Profile" and "Scenario Diagnostic" analysis for each suite of actions. The Scenario Profile is a contributing factor and splice analysis that examined the relative effect on population performance of implementing the actions. The profile examines the increase in survival due to the habitat actions relative to the current condition. The Scenario Diagnostic analysis evaluated the remaining restoration potential and revised protection priorities if the habitat actions were implemented.

It should be noted that differences between geographic areas for the splice analysis priorities are due, in part, to differences in the total length of reaches in the area. For the analysis presented in this technical memorandum we wanted to evaluate the total restoration potential in an area and compare that potential to the potential benefit of implementing the actions. Therefore, the effect of differences in length could be ignored, understanding that an identical project with identical benefits in a short reach will treat a greater proportion of the potential present versus a long reach.

The template condition assumed in the model is referred to as the "Modified Historical" in the figures because we assumed routing of juvenile and adult life history pathways through Lake Washington and the Ship Canal and not via the true historical route through the Black River and Duwamish Estuary.

Development of actions for WRIA 8

Actions were selected in response to the 'Diagnosis' of key habitat attributes for protection and restoration from the Start List. The W8TC developed generic effectiveness assumptions for types of habitat actions (floodplain reconnection, LWD placement, riparian restoration, etc). These assumptions include expected change in attribute condition, time lag necessary to see that change, and any likely dispersal effects of the action on downstream reaches. Assumptions were then provided to basin experts, along with descriptions of Start List actions for their review and input. Workshops held with the basin experts to review and refine action descriptions and refine hypotheses regarding the effectiveness of these actions on habitat attributes from the generic assumptions developed by W8TC. Before running the model, assumptions were documented and sent back to the experts to review and ensure that workshop input was adequately captured in the assumptions. Finally, actions were modeled for the 10 yr and 25 yr time frame. The difference between time frames was the degree of effectiveness of the actions. Actions

such as riparian restoration will have a longer period before achieving maximum effectiveness. Results reported in this document are for the 25 yr time frame.

IV. Results

Model results were generated showing effects of actions on Chinook abundance, productivity, and life history diversity for the Cedar River and North Lake Washington (North, Little Bear, Bear and Issaquah creeks) population components. Juvenile and adult results are shown for each WRIA8 population component. The W8TC and basin experts reviewed the model results to ensure that results for the current condition and future scenarios were reasonable. Adult results for all population components are summarized in Table 2 for results for the current and Start List scenarios.

Model results are described in more detail by population component in the following sections. For each component the baseline results are presented, followed by a review of results for the Start List scenario. We then summarize the major habitat survival factors and geographic areas affecting population performance and compare these to the Start List scenario results. Finally, we summarize geographic priorities for additional actions by population component. Analysis of geographic priorities and scenario effects are reported for the entire area (one or more reaches). Results were not normalized by reach length.

Table 2. Model results by population component. Shown for the Start List scenario results is the percentage hypothesized change from the current condition.

Population Component	Abundance (adults)		Productivity (R/S)		Diversity	
	Current Condition	Start List Scenario	Current Condition	Start List Scenario	Current Condition	Start List Scenario
Cedar River	608	986 (62%)	1.8	2.3 (24%)	72%	85% (18%)
Bear Creek	194	291 (50%)	2.8	3.6 (30%)	74%	100% (34%)
Little Bear Creek	104	137 (31%)	2.6	3.1 (18%)	76%	88% (15%)
North Creek	189	230 (22%)	2.7	3.1 (14%)	77%	88% (14%)
Issaquah Creek	41	249 (509%)	1.2	1.8 (56%)	23%	60% (157%)

Cedar River Results

The modeled output of adult population performance for the baseline scenarios (current and modified historical) for Chinook salmon originating from the Cedar River are summarized in Figure 1. Habitat changes in the freshwater (riverine and lacustrine), and marine environments are hypothesized to have reduced adult abundance by 95%, adult productivity by more than 91%, and life history diversity index by 28%.

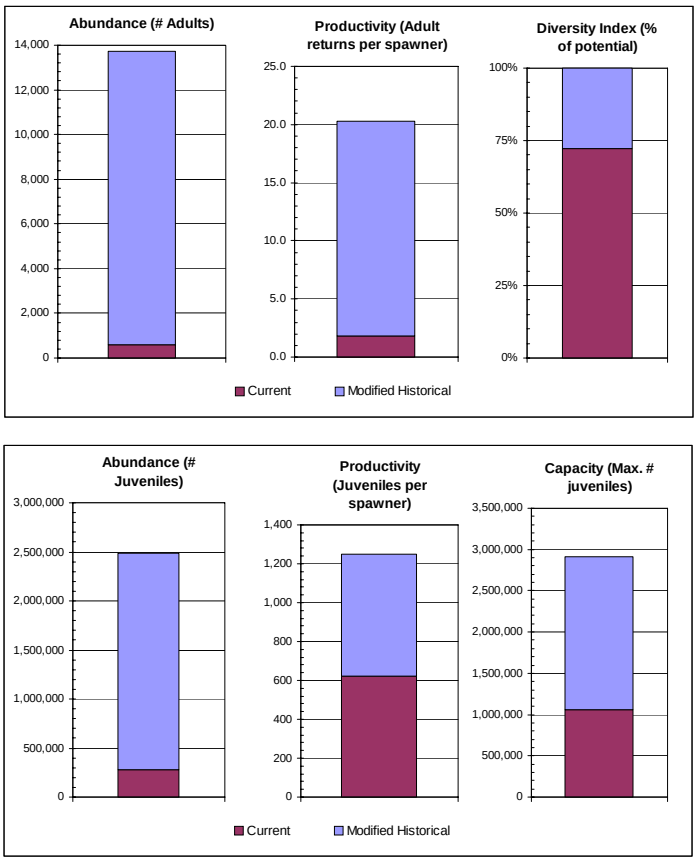


Figure 1. Hypothesized population performance of Cedar River Chinook as estimated from the EDT model for the baseline scenarios (current and modified historical).

Juvenile results at the Cedar River mouth do not show the same degree of loss in performance as the adults, in part because juveniles leaving the Cedar River have yet to experience the increased predation losses in Lake Washington and the Ship Canal. Habitat changes in the Cedar River reduced juvenile productivity by 50% and juvenile capacity by 64%. Estimated juvenile abundance decreased by a larger percent (89%) because abundance is affected by change in juvenile productivity and capacity, and the reduced number of predicted adult spawners in the Cedar River (Figure 1).

Figure 2 presents the potential for the Start List actions – 25 yr lag on Cedar River Chinook. The actions improved abundance by over 62% from the current condition, but abundance remains low relative to the historic condition (7% of historic). Productivity is

predicted to increase by 24%, but remains low (<3.0 returns per spawner). Finally, life history diversity index increased by 18%, up to 85% of the hypothesized modified historical with the Start List scenario.

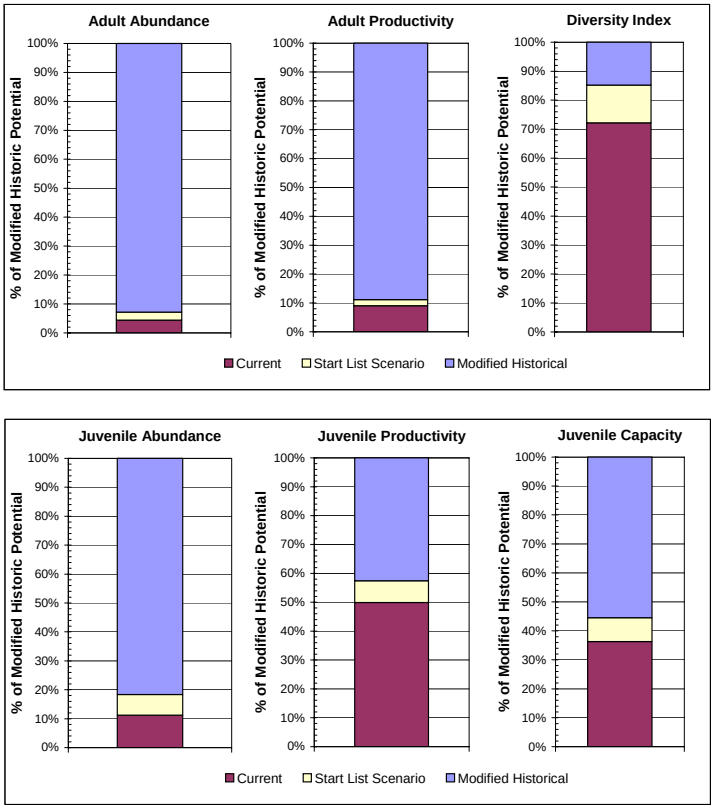


Figure 2. Hypothesized population performance of Cedar River Chinook estimated relative to the modified historic potential. The Start List Scenario includes habitat actions defined for the Cedar River using the 25 yr lag effectiveness assumptions.

The effect of the Start List actions on predicted juvenile performance measures were very similar to adult effects – abundance increased by nearly 64%, and productivity increased by 15%.

Restoration potential for Cedar River Chinook favors actions that address mainstem areas downstream of Landsburg Dam (Figure 3). The areas with highest hypothesized total potential for restoration are Maplewood, Rainbow Bend, Cedar Rapids, and the Cedar River from RM 17 to Landsburg Dam (Cedar River – Below Landsburg). The areas downstream of I-405 had the highest restoration potential per reach length (WRIA 8 2003). The large hypothesized potential restoration benefit for Maplewood and downstream of I-405 is predicated on the assumed potential use for spawning in these areas in addition to the rearing benefit. The model assumes spawning use amounts to 15.5% of the population (within EDT reaches 1-4). Furthermore, spawning use above Landsburg is hypothesized to be approximately 27% of the population based on historical template and possible future use. However, current data (1999-2006) suggest EDT reaches 1-4 contain only approximately 2.2% of the Cedar River population and areas upstream of Landsburg Dam contain approximately 2-3% of Chinook salmon redds. Although reaches 1-4 are critical for rearing and migration (also part of the model computations), the large hypothesized benefit described from the modeling is likely strongly influenced by the spawner use assumption.

In contrast, areas in the Middle Cedar River are likely more important for restoration than the model currently predicts, because current (and likely future) spawner use is proportionately greater. For example, in Rainbow bend (EDT reaches 8-10) the model assumes spawning use is 13.2%. However, currently, spawning use appears to average closer to 20% of the total population (among years 1999-2006). Thus protection and restoration potential is probably underestimated. Actions for improving Chinook abundance and productivity nonetheless should focus on all of these areas because different life history stages are differentially affected among these reaches. These caveats mentioned here suggest equal priority on middle Cedar River reaches is appropriate.

Geographic Area	Protection benefit		Restoration benefit	
	Category	rank	Category	rank
Cedar River - Mouth	C	17	C	16
Cedar River - Renton	C	19	B	9
Cedar River - Maplewood	A	2	A	3
Cedar River - Ron Regis Park	C	7	C	13
Cedar River - Bucks Curve	C	11	C	14
Cedar River - Cedar Rapids	B	5	B	6
Cedar River - Rainbow Bend	B	3	A	4
Cedar River - Lions Club	C	14	C	18
Cedar River - Royal Bend	C	13	D	24
Cedar River - Dorre Don	C	7	C	10
Cedar River - Below Landsburg	B	4	B	7
Cedar River Landsburg Dam	E	23	D	27
Cedar River - Abv Landsburg	A	1	C	11
Taylor-Downs Creek	C	18	D	30
Peterson Creek	D	20	D	30
Rock Creek (lower Basin)	C	11	D	26
Rock Creek (upper basin)	C	16	D	28
Taylor Creek (upper basin)	D	22	D	29
Walsh Ditch	D	21	E	32

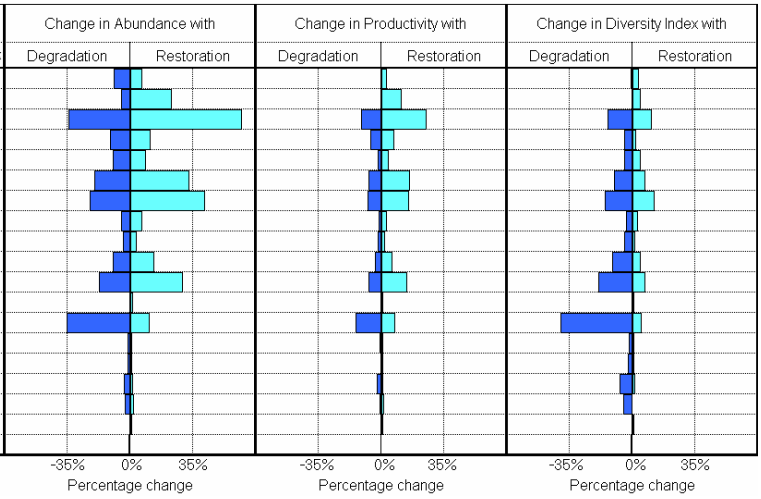


Figure 3. Relative importance of geographic areas within the Cedar River watershed for restoration and protection measures for Cedar River Chinook. Areas are ranked based on their effect on overall population performance. Contributions of performance measures to rankings are graphed.

Survival factors contributing to loss in performance are habitat diversity, channel stability and loss of key habitat (Figure 4). Actions that would improve habitat complexity by increasing in-stream wood, restoring side channel connectivity, removing bank hardening, and reestablishing parts of the historic Cedar River floodplain would address these survival factors.

The Cedar River Start List Scenario actions improved conditions in the Maplewood, Bucks Curve, Rainbow Bend, Cedar Rapids, and Dorre Don areas (Figure 5). The greatest response was the effect of implementing the Maplewood action (C208). Based on current model assumptions for Chinook population trajectories, this action and C206 (riparian and bank restoration just upstream of I-405) would increase Chinook abundance by over 25%. However, based on the project description, full implementation would require the purchase and removal of up to 40 homes. Thus, full implementation may take many, many years and several funding rounds, during which time other important projects may be completed (i.e., Rainbow Bend). Benefits of implementing other actions individually were between 3 - 7%. Actions were on target for the two A category and highest ranked B category geographic areas identified in the diagnosis (Rainbow Bend, Maplewood, and Cedar Rapids). The remaining B category areas (City of Renton, and Below Landsburg) were slightly affected or not affected at all by the Start List actions. Actions correctly addressed the key survival factors identified in the diagnosis – habitat diversity, channel stability, and key habitat (Figure 6).

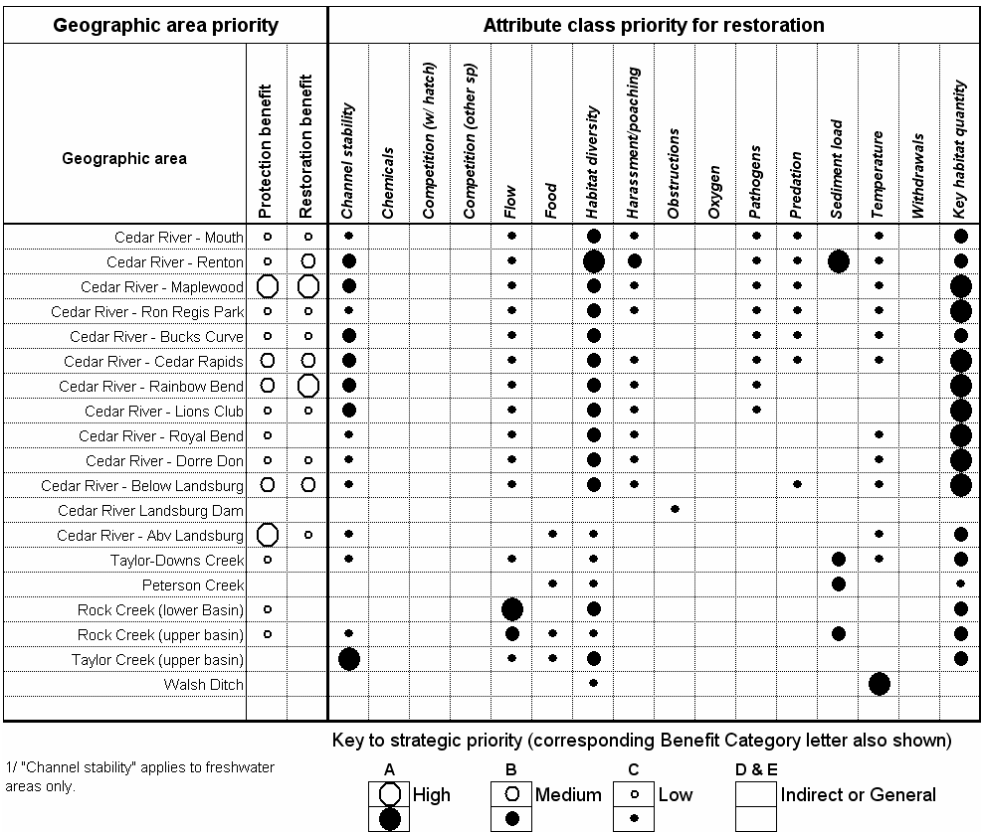


Figure 4. Pattern of habitat constraints on Chinook salmon in the Cedar River for the current condition. The figure shows the relative importance of the 16 survival factors by geographic area – the larger the black dot, the greater the problem. Open circles for protection and restoration benefit are the benefit categories show in Figure 3.

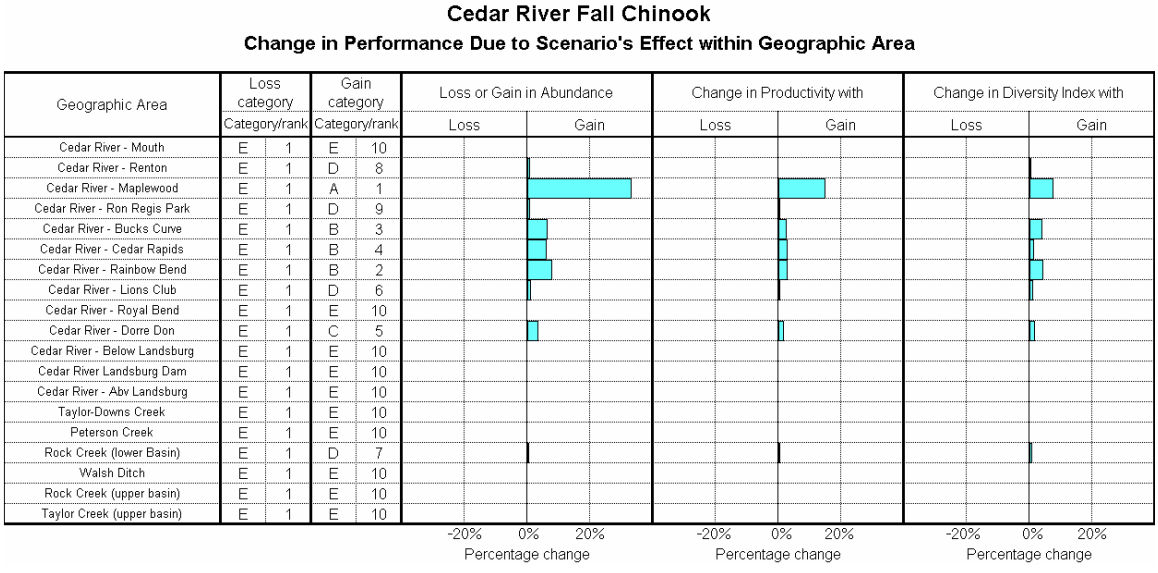


Figure 5. Relative improvement of geographic areas within the Cedar River watershed for scenario benefits for Cedar River Chinook. Areas are ranked based on their effect on overall population performance.

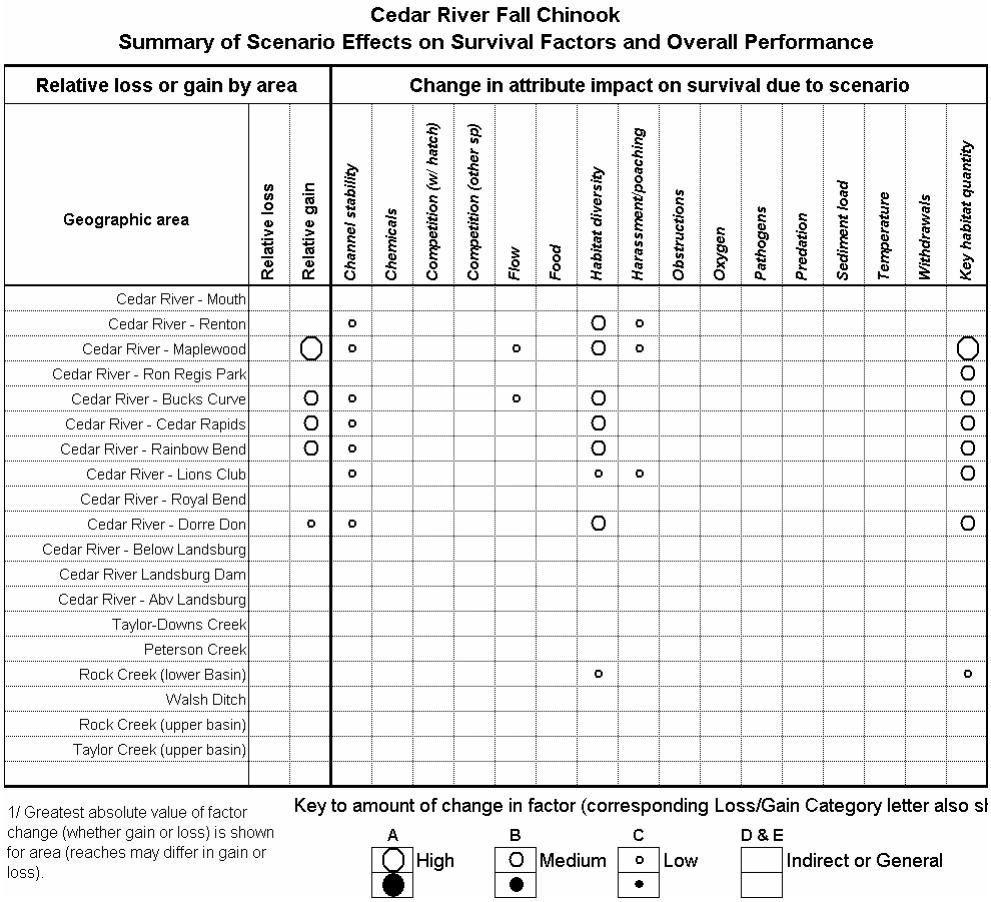


Figure 6. Pattern of habitat improvements on Chinook salmon in the Cedar River for the Cedar River Start List actions – 25 yr lag. The figure shows the relative increase for the 16 survival factors by geographic area – the larger the open dot, the greater contribution to improving survival of the population.

The Start List actions for the Cedar River appear to be targeting the correct areas and habitat features. What is needed is an expanded area and additional effort (Figure 7). Actions that begin to create connectivity between restoration projects and areas that are relatively intact (for example, the combination of Rainbow Bend with the relatively unconfined Belmondo reach downstream) should be prioritized, especially in light of higher than modeled use by Chinook salmon. This could be achieved through levee setbacks or removals in some key areas. In other words, efforts comparable to the group of start-list projects modeled for this effort including those proposed for Maplewood (C208), Bucks Curve (C215), Ricardi (C222), and Rainbow Bend (C235) and Don Dorre (C252). In addition, combining these large scale levee setback type projects with dispersed restoration actions like the Lions Club project (C233) would provide connectivity between the larger floodplain restoration projects.

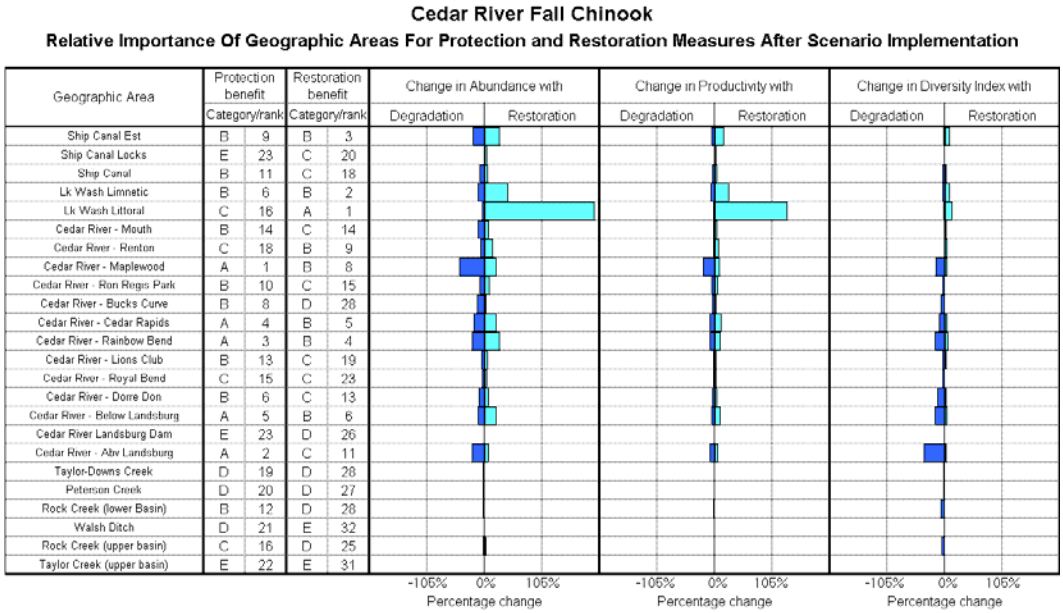


Figure 7. Relative importance of geographic areas within the Cedar River watershed, Lake Washington and the Ship Canal for restoration and protection measures for Cedar River Chinook after implementing the Cedar River Start List actions – 25 yr lag.

For the Cedar River, most (but not all) restoration actions on the start-list were modeled. Specific actions to consider in the Cedar River already on the Start List (but not modeled) are the following:

- C209 Riparian restoration in parkland
- C212/213/C214 Riparian habitat protection and restoration in Reach 4 (Ron Regis)
- C207 Riparian enhancement near multi-family residential uses (Reach 3)
- C229 Protect Riparian buffer behind Scott-Indian Grove levee in Reach 8
- C351 Rock Creek entrance flows
- C333 Taylor Creek floodplain, riparian, and instream restoration (also C332, C331, C336, C330 with high benefit and high feasibility)

Specific actions to consider in the Cedar River on the comprehensive list are the following:

- Herzman Levee in the Cedar Rapids Area (C218),
- River Bend mobile home buyout (partial or full) and restoration (C219/C220)
- C226 Progressive levee removal
- C231 WPA revetment area buyouts and revetment removal
- Setback of the Getchman levee (C243 and C245) to restore floodplain connectivity and

- A dynamic confluence area at the mouth of Taylor Creek, and Jan Road (C241) downstream of the Taylor Creek confluence (C242)-enhance 218th side channel).

These projects listed in the comprehensive list are more likely to have significant effects due to their size and scope of effort and would be consistent with those projects already modeled that show large benefit. Jan Road and Getchman restoration projects build on the proposed Rainbow Bend restoration (C235) as would the WPA levee removal. These projects are downstream of major spawning concentrations and are therefore well located to provide productive rearing habitat.

The lower Cedar River continues to show a high relative restoration potential after implementation of the Start List actions. Potential actions in these reaches are constrained by existing land uses. However, progress would be possible with inclusion of a substantive habitat restoration component for redevelopment opportunities that arise. Examples of habitat enhancement projects associated with redevelopment are found elsewhere in WRIA 8 (e.g., UW Bothell Campus).

Finally, the Start List actions did not address predation losses in Lake Washington. Losses due to predation in the littoral zone of Lake Washington are a significant factor affecting Cedar River Chinook (Figure 7). Predation losses are hypothesized to result from shoreline modifications and high concentrations of predators. However, the individual effectiveness of shoreline projects as they influence capacity or productivity mediated through reduction in predation losses is not well understood and therefore not suited for modeling at this time.

Bear Creek Results

Adult population performance results for the baseline scenarios (current and modified historical) for Chinook salmon originating from Bear Creek are summarized in Figure 8. Habitat changes in the freshwater (riverine and lacustrine), and marine environments have reduced adult abundance by 81%, adult productivity by 86%, and life history diversity index by 26%.

Juvenile results at the mouth of Bear Creek do not show the same degree of loss in performance as the adults, in part because juveniles leaving Bear Creek have yet to experience the degraded Sammamish River and increased predation losses in Lake Washington and the Ship Canal. Habitat changes in Bear Creek reduced juvenile productivity by 67%. Juvenile capacity has not decreased by nearly as much, only 6% relative to the template condition. This is in part because of assumed changes in the lower Bear Creek reaches that increase the quantity of juvenile Chinook rearing habitat by transforming the stream from a pool/riffle composition to a low gradient glide. Estimated juvenile abundance decreased by a much larger percent (50%) because abundance is affected by change in juvenile productivity and capacity, and the reduced number of predicted adult spawners in Bear Creek (Figure 8).

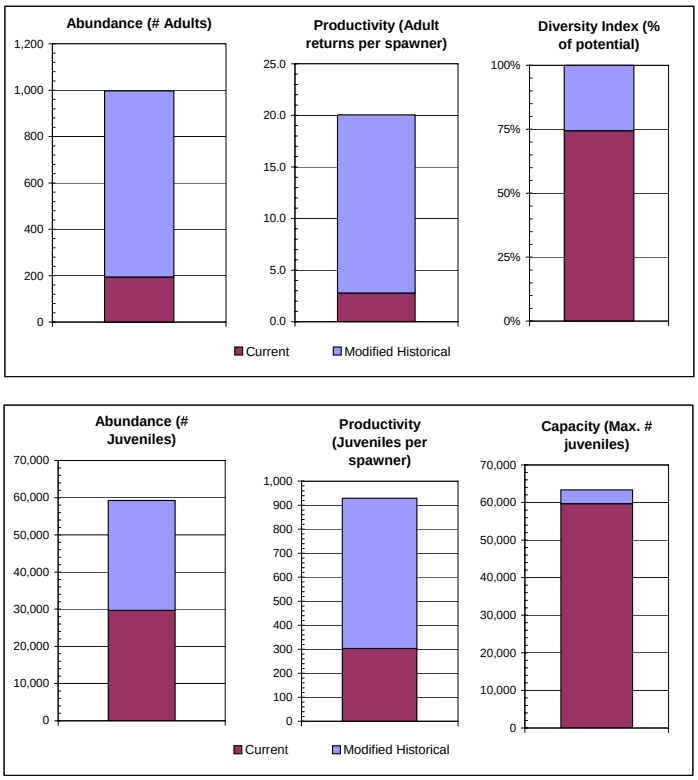


Figure 8. Population performance of Bear Creek Chinook as estimated from the EDT model for the baseline scenarios (current and modified historical).

Figure 9 presents the potential for the Start List actions – 25 yr lag on Bear Creek Chinook. These results include actions in Bear Creek and the Sammamish River and indicate a greater response to the Start List than other WRIA 8 population segments. The actions improved abundance by nearly 50% from the current condition. Predicted abundance relative to the modified historic condition was 29%. Productivity improved by 30%, to a level that begins to suggest long-term sustainability (slightly greater than >3.0 returns per spawner). Finally, life history diversity increased to 100% of the historical potential, all life history pathways were possible. This result does not suggest that Chinook salmon have regained a level of genetic identity or adaptation that might have existed historically.

The effect of the Start List actions on predicted juvenile performance measures were very similar to adult effects – abundance increased by nearly 44%, and productivity increased by 27%.

Restoration potential for Bear Creek Chinook favors actions that address the Sammamish River and Bear Creek below and just above the Cottage Lake Creek confluence (~4.2 miles of stream) (Figure 10). Other areas identified for restoration actions in Bear Creek are Keller Farm, Avondale, and Cottage and Evans creeks. The 4.0 miles of Bear Creek upstream of 133rd St (Bear Creek – Rural) also has a moderate restoration potential. This area has the second highest protection priority. The two geographic areas in the Sammamish River downstream of Bear Creek have a moderate restoration potential. The

diagnosis suggests a broad strategy of restoration addressing tributary habitat (Cottage Lake and Evans creeks), key areas of Bear Creek and the Sammamish River.

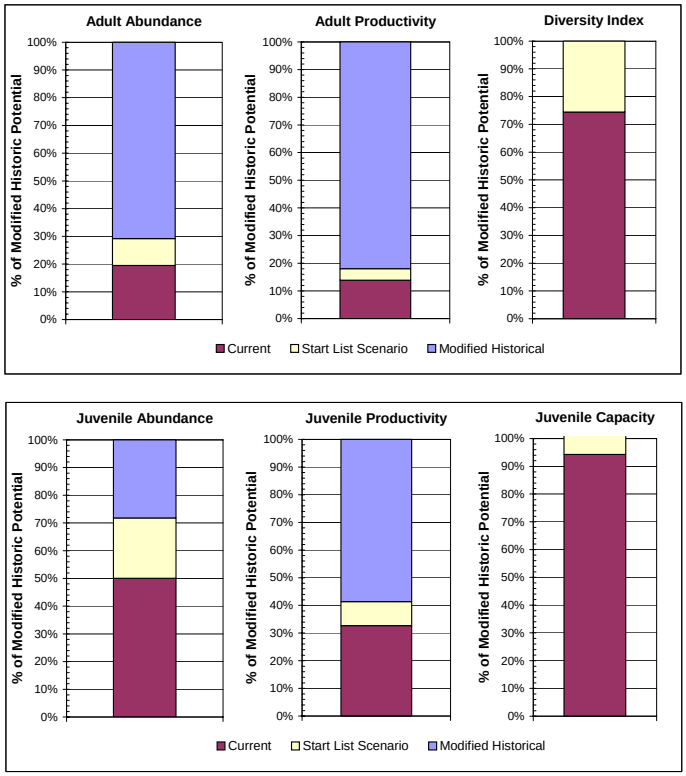


Figure 9. Estimated population performance of Bear Creek Chinook relative to the modified historic potential. The Start List Scenario includes habitat actions defined for Bear Creek and the Sammamish River using the 25 yr lag effectiveness assumptions.

Bear Creek Fall Chinook

Relative Importance Of Geographic Areas For Protection and Restoration Measures

Geographic Area	Protection benefit		Restoration benefit	
	Category	rank	Category	rank
Sammamish R - Lake Washington	E	19	D	27
Sammamish R - Bothel	D	15	B	7
Sammamish R - Woodinville	D	18	C	13
Sammamish R - 116th St to 175th St	D	17	B	3
Sammamish R - Redmond	D	15	B	4
Bear Creek - Redmond	C	11	D	22
Bear Creek - Restoration Project	C	11	E	28
Bear Creek - Avondale	C	13	D	21
Bear Creek - Keller Farm	B	5	B	6
Bear Creek - Cottage Lake Cr area	A	1	A	1
Bear Creek - Rural	A	2	B	7
Evans Creek - Redmond	C	10	C	15
Evans Creek	B	5	B	11
Lower Cottage Lake Cr	B	4	C	12
Upper Cottage Lake Cr	C	9	C	16

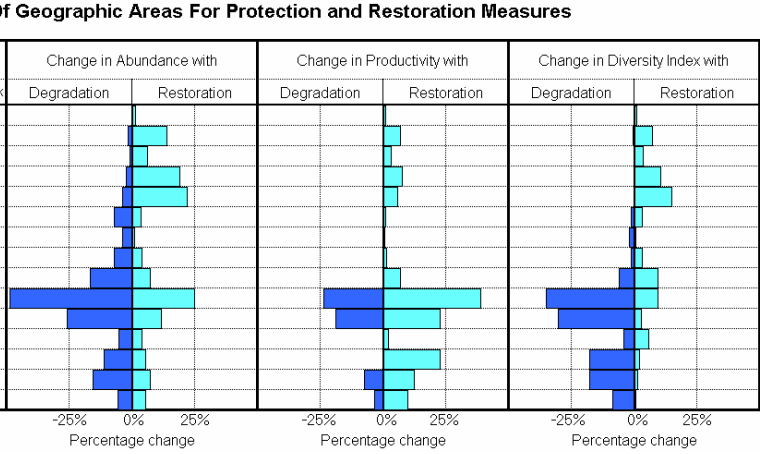


Figure 10. Relative importance of geographic areas within the Bear Creek watershed for restoration and protection measures for Bear Creek Chinook. Areas are ranked based on their effect on overall population performance. Contributions of performance measures to rankings are graphed.

Survival factors contributing to loss in performance of Bear Creek Chinook are habitat diversity (all areas), flow (Sammamish River), sediment (Bear Creek), temperature (Sammamish River), and loss of key habitat (all areas) (Figure 11).

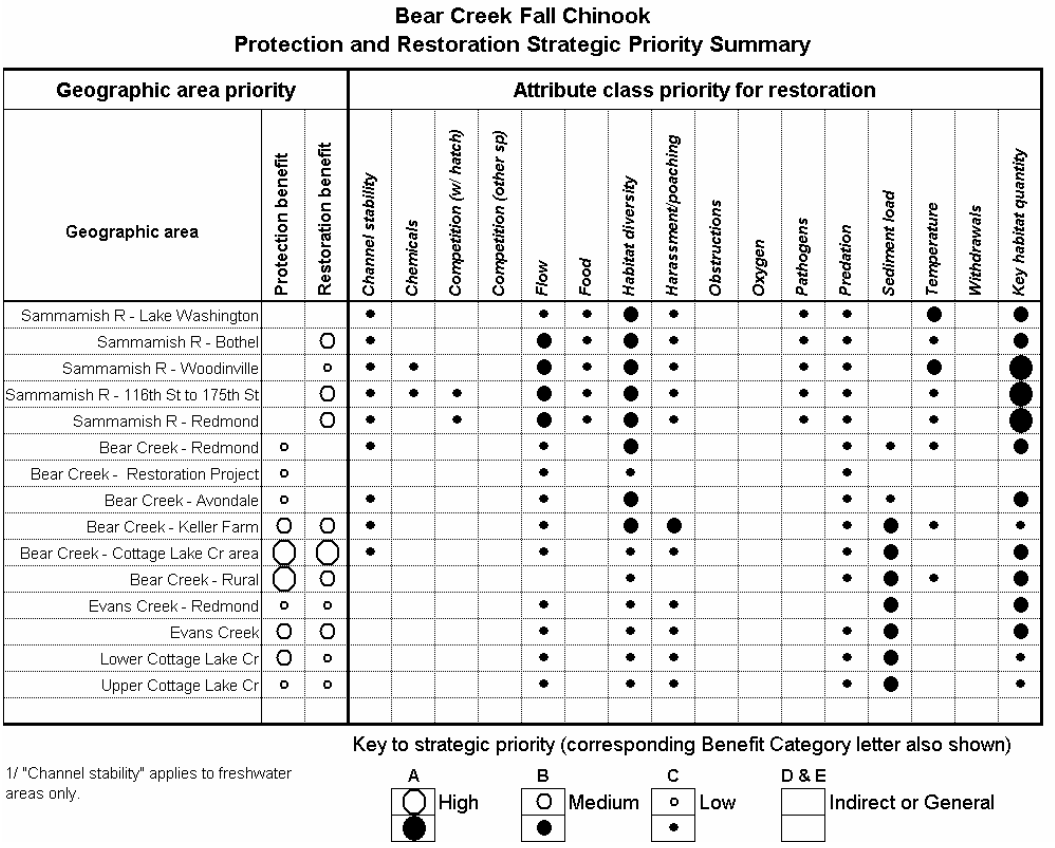


Figure 11. Pattern of habitat constraints on Chinook salmon in Bear Creek for the current condition. The figure shows the relative importance of the 16 survival factors by geographic area – the larger the dot, the greater the problem. Open circles for protection and restoration benefit are the benefit categories shown in Figure 10.

These attributes suggest actions to improve riparian function for shade, trapping sediment, and improving LWD recruitment. Enhancement of in-stream channel complexity by active restructuring of the channel, removal of bank hardening, and placement of wood are viable options as well and may be more realistic in the more developed areas of the watershed.

The Bear Creek and Sammamish River Start List Scenario actions improved conditions in the Sammamish River and lower Bear Creek (Figure 12). The greatest response was the effect of implementing actions in the Sammamish River immediately downstream of Bear Creek and in Bear Creek the Keller Farm (N208) action. Intermediate actions were those in lower Bear Creek (N201 and N206). In contrast to the Cedar River results, the model predicted lower individual project effects, but the effects occurred over a much greater number of geographic areas. It's unclear whether this results from less aggressively scoped "projects" or whether simply the potential benefit relative to current

condition was less. Overall, the benefit appears to be distributed more broadly because numerous projects were envisioned. Actions addressed the key survival factors identified in the diagnosis – habitat diversity, temperature, sediment and key habitat (Figure 13). The predicted effect on flow in the Sammamish River was a secondary effect from improving habitat complexity in the Sammamish River.

Bear Creek Fall Chinook

Change in Performance Due to Scenario's Effect within Geographic Area

Geographic Area	Loss category		Gain category		Loss or Gain in Abundance		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Loss	Gain	Loss	Gain	Loss	Gain
Sammamish R - Lake Washington	E	29	E	13						
Sammamish R - Bothel	E	29	B	9						
Sammamish R - Woodinville	E	29	B	6						
Sammamish R - 116th St to 175th St	E	29	A	2						
Sammamish R - Redmond	E	29	A	3						
Bear Creek - Redmond	E	29	B	7						
Bear Creek - Restoration Project	E	29	E	12						
Bear Creek - Avondale	E	29	B	5						
Bear Creek - Keller Farm	E	29	A	1						
Bear Creek - Cottage Lake Cr area	E	29	B	4						
Bear Creek - Rural	E	29	C	10						
Evans Creek - Redmond	E	29	C	11						
Evans Creek	E	29	E	13						
Lower Cottage Lake Cr	E	29	B	7						
Upper Cottage Lake Cr	E	29	E	13						

-5% 0% 5% Percentage change | -5% 0% 5% Percentage change | -5% 0% 5% Percentage change

Figure 12. Relative improvement of geographic areas within Bear Creek watershed and Sammamish River for scenario benefits for Bear Creek Chinook. Areas are ranked based on their effect on overall population performance.

Bear Creek Fall Chinook

Summary of Scenario Effects on Survival Factors and Overall Performance

Relative loss or gain by area			Change in attribute impact on survival due to scenario															
Geographic area	Relative loss	Relative gain	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Sammamish R - Lake Washington																		
Sammamish R - Bothel		O							o									o
Sammamish R - Woodinville		O	o				o		O	o						o		O
Sammamish R - 116th St to 175th St		◯	o				o		O	o						o		O
Sammamish R - Redmond		◯	o				o		O	o						o		O
Bear Creek - Redmond		O	o				o		O						o			O
Bear Creek - Restoration Project																		
Bear Creek - Avondale		O	o				o		O						o			O
Bear Creek - Keller Farm		◯	o				o		O	O					O	o		●
Bear Creek - Cottage Lake Cr area		O													o			o
Bear Creek - Rural		o													o			
Evans Creek - Redmond		o							o						o			O
Evans Creek																		
Lower Cottage Lake Cr		O							o	o					o			o
Upper Cottage Lake Cr																		

1/ Greatest absolute value of factor change (whether gain or loss) is shown for area (reaches may differ in gain or loss).

Key to amount of change in factor (corresponding Loss/Gain Category letter also sho

A ◯ High ● | B O Medium ● | C o Low • | D & E Indirect or General

Figure 13. Pattern of habitat improvements on Chinook salmon in Bear Creek and the Sammamish River for the Bear Creek and Sammamish Start List actions – 25 yr lag. The

figure shows the relative increase for the 16 survival factors by geographic area – the larger the dot, the greater contribution to improving survival of the population.

Bear Creek Chinook responded well to the Start List actions. The model predicted abundance to be 30% of historic after implementing all actions in Bear Creek and the Sammamish River or an increase of 50% over the current condition.

The Start List actions addressed nearly all of the restoration potential in lower Bear Creek (Figure 14). What are needed are additional actions in Bear Creek focusing on the areas above and below the Cottage Lake Creek confluence. Start List action N220 included riparian restoration in this area, but did not include any active restoration of the channel. Effectiveness assumptions were low to moderate for the reach upstream of Cottage Lake Creek. However, downstream of Cottage Lake Creek action effectiveness assumptions were low – these were the downstream effects of the action implemented upstream of Cottage Lake Creek. One solution to explore is to expand N220 to a greater portion of the Bear Creek or, in other words, to expand N220 to include the 3.0 miles of stream downstream of Cottage Lake Creek. However, if riparian restoration in the lower reach is not practical because of land use constraints then managers may want to consider active enhancement of the channel using methods found to be successful elsewhere in Lake Washington (e.g., N377 Twin Creeks in North Creek).

Actions proposed for the Sammamish River are important to achieve these predicted benefits. Expansion of riparian restoration and possibly including active channel restoration in the Sammamish River would provide additional benefits (Figure 14).

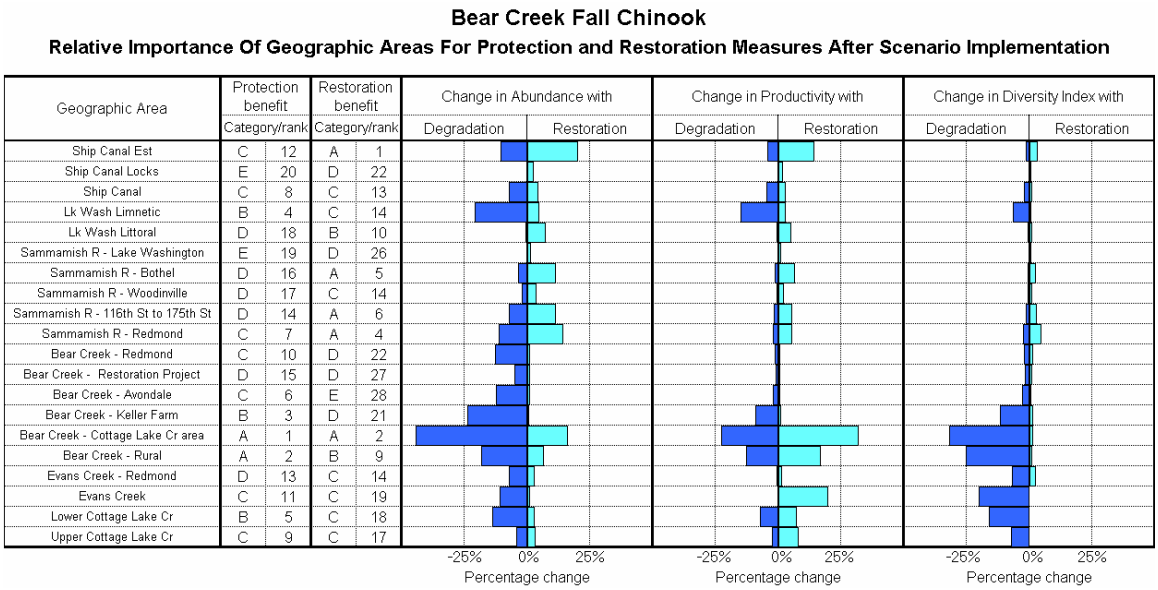


Figure 14. Relative importance of geographic areas within the Bear Creek watershed and Sammamish River for restoration and protection measures for Bear Creek Chinook after implementing the Bear Creek and Sammamish River Start List actions – 25 yr lag.

Little Bear Creek Results

Adult population performance results for the baseline scenarios (current and modified historical) for Chinook salmon originating from Little Bear Creek are summarized in Figure 15. Habitat changes in the freshwater (riverine and lacustrine), and marine environments have reduced adult abundance by 87%, adult productivity by 88%, and life history diversity index by 24%.

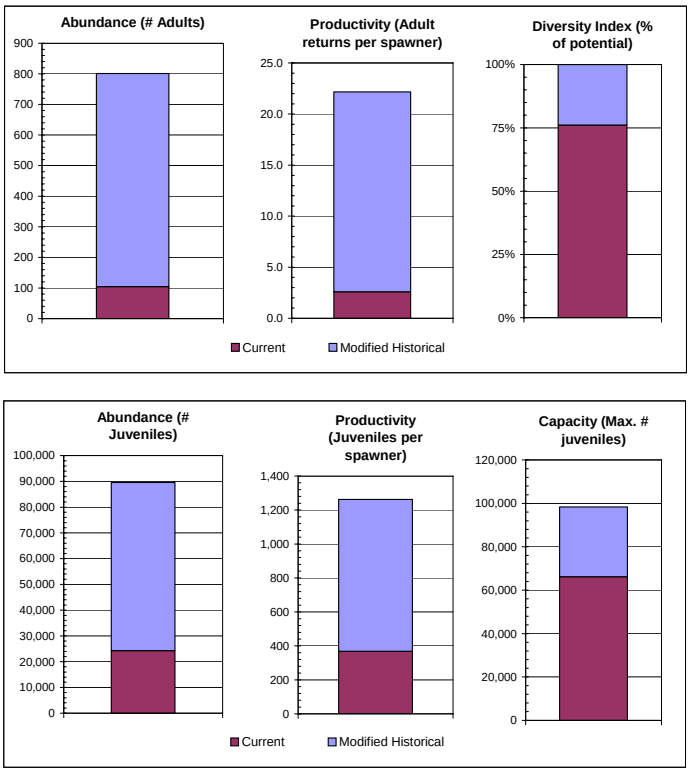


Figure 15. Population performance of Little Bear Creek Chinook as estimated from the EDT model for the baseline scenarios (current and modified historical).

Juvenile results at the mouth of Little Bear Creek do not show the same degree of loss in performance as adults for the same reasons as other subbasins in Sammamish River, juveniles leaving Little Bear Creek have yet to experience the degraded Sammamish River and increased predation losses in Lake Washington and the Ship Canal. Habitat changes in Little Bear Creek reduced juvenile productivity by 71% and juvenile capacity has decreased by 33%. Estimated juvenile abundance decreased by a much larger percent (73%) because abundance is affected by change in juvenile productivity and capacity, and the reduced number of adult spawners predicted in Little Bear Creek (Figure 13).

Figure16 presents the production potential for the Start List actions – 25 yr lag on Little Bear Creek Chinook. The modeled restoration scenario improved abundance by 31% from the current condition, but remains low relative to the historic condition (17% of historic). Productivity is predicted to increase by about 18%, but it too remains at low levels relative to the historic (14%). Finally, life history diversity increased by 15% from the current condition to 88% of the potential with the Start List scenario.

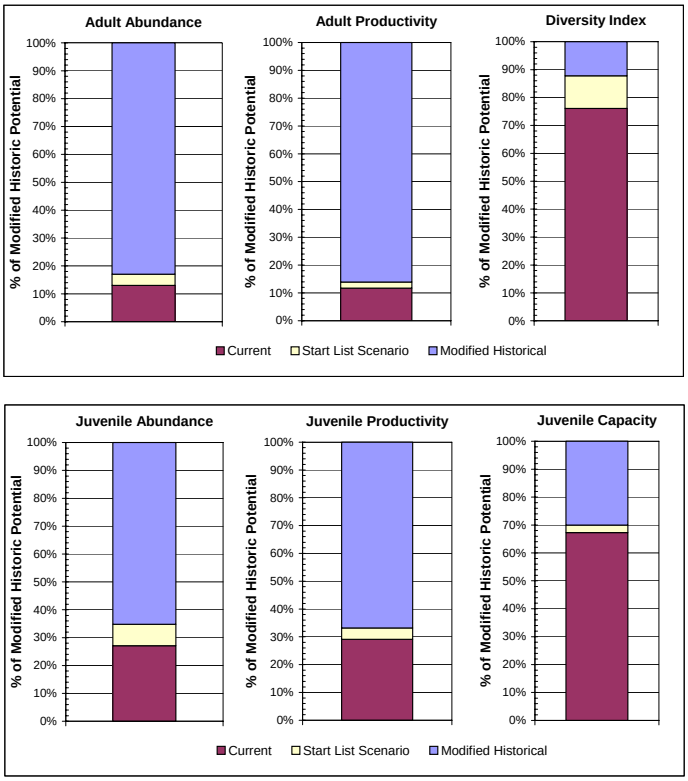


Figure 16. Estimated population performance of Little Bear Creek Chinook relative to the modified historic potential. The Start List Scenario includes habitat actions defined for Little Bear Creek and the Sammamish River using the 25 yr lag effectiveness assumptions.

The effect of the Start List actions on predicted juvenile performance measures were very similar to adult effects – abundance increased by nearly 30%, and productivity increased by 14%.

Restoration potential for Little Bear Creek Chinook favors actions that would address the Sammamish River and Little Bear Creek through the City of Woodinville (Figure 17). Other areas identified for restoration actions are Little Bear Creek – Rural and Little Bear Creek – Upper (~5.5 miles of stream from Canyon Park culvert to upper extent of Chinook utilization).

Survival factors contributing to loss in performance of Little Bear Creek Chinook are habitat diversity (all areas), flow (lower Little Bear Creek and the Sammamish River), sediment (upper Little Bear Creek), channel stability (City of Woodinville and the modified reaches just upstream) and loss of key habitat (all areas) (Figure 18). These attributes suggest actions to actively increase channel complexity in the urban/developed areas of Little Bear Creek and riparian restoration in the upper basin to help alleviate sediment input to the stream and improve channel complexity through the natural recruitment of wood.

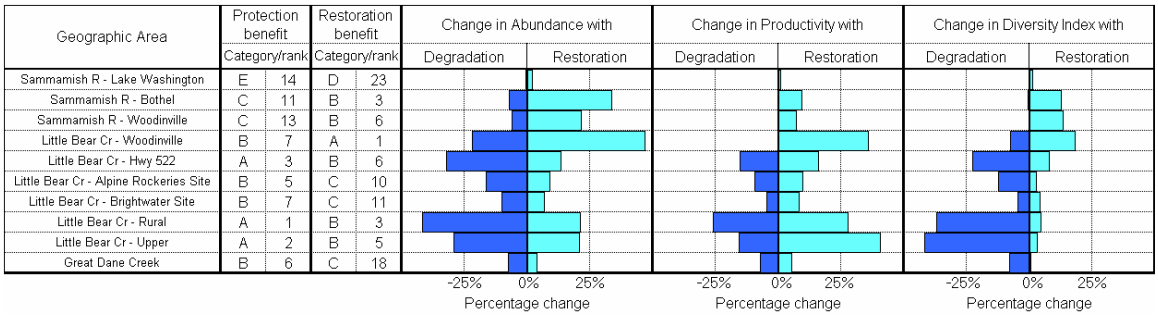


Figure 17. Relative importance of geographic areas within the Little Bear Creek watershed and Sammamish River for restoration and protection measures for Little Bear Creek Chinook. Areas are ranked based on their effect on overall population performance. Contributions of performance measures to rankings are graphed.

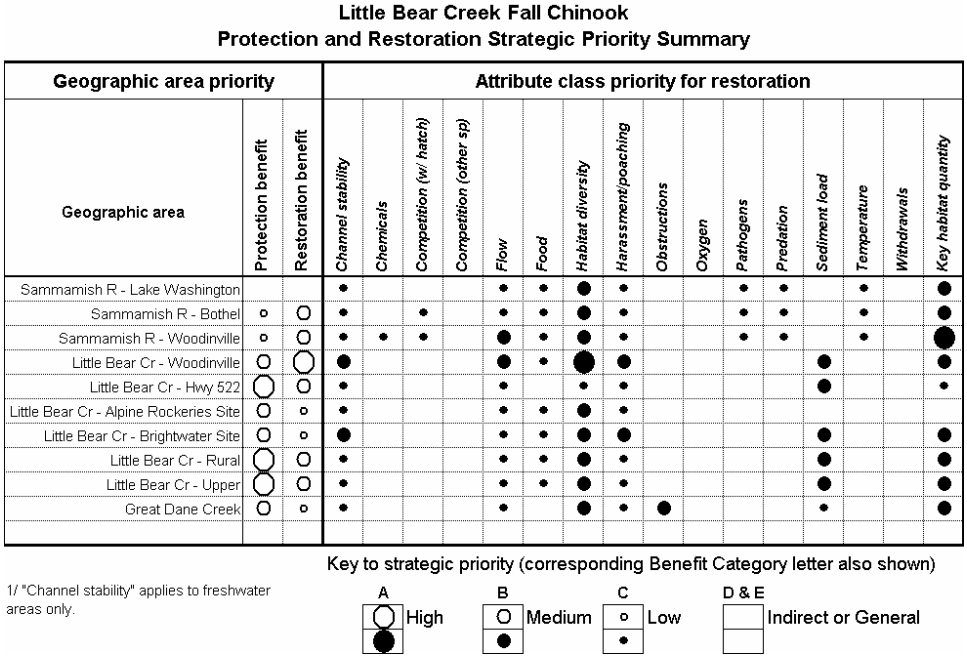


Figure 18. Pattern of habitat constraints on Chinook salmon in Little Bear Creek and the Sammamish River for the current condition. The figure shows the relative importance of the 16 survival factors by geographic area – the larger the dot, the greater the problem. Open circles for protection and restoration benefit are the benefit categories show in Figure 17.

The Little Bear Creek and Sammamish River Start List Scenario actions improved conditions in the Sammamish River and Little Bear Creek within the City of Woodinville and immediately upstream (Figure 19). The greatest response was the effect of implementing actions in the Sammamish River immediately downstream of Little Bear Creek. Within Little Bear Creek only three actions were modeled – N403, N408 and N411. The focus of these actions was riparian revegetation and the placement of wood in the City of Woodinville and the Alpine Rockeries area. The Alpine Rockeries project is likely to be constructed soon (2007). Action effectiveness for N403 and N411 was

assumed to be less than maximum because of infrastructure constraint and because the channel is constrained by development on both banks (Figure 20).

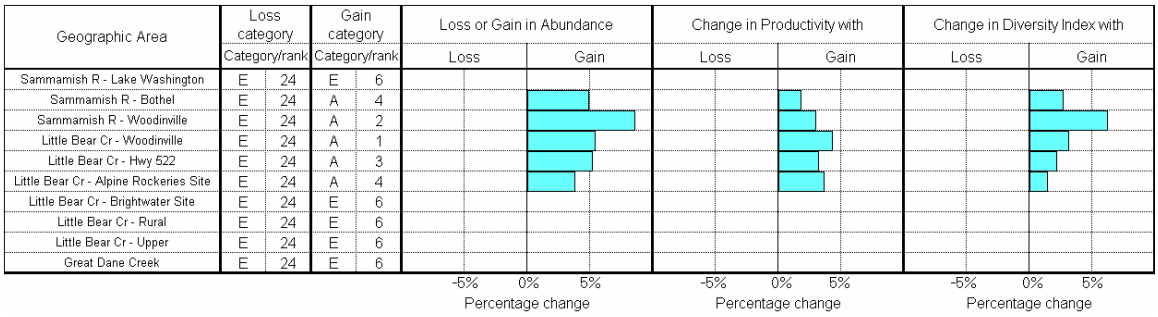


Figure 19. Relative improvement of geographic areas within the Little Bear Creek watershed and Sammamish River for scenario benefits for Little Bear Creek Chinook. Areas are ranked based on their effect on overall population performance.

Little Bear Creek Fall Chinook
Summary of Scenario Effects on Survival Factors and Overall Performance

Relative loss or gain by area			Change in attribute impact on survival due to scenario															
Geographic area	Relative loss	Relative gain	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Sammamish R - Lake Washington																		
Sammamish R - Bothel		◯							o									o
Sammamish R - Woodinville		◯	o				o		○	o						o		○
Little Bear Cr - Woodinville		◯	○						○	o								o
Little Bear Cr - Hwy 522		◯	o				o		o									•
Little Bear Cr - Alpine Rockeries Site		◯	o				o		○	o								o
Little Bear Cr - Brightwater Site																		
Little Bear Cr - Rural																		
Little Bear Cr - Upper																		
Great Dane Creek																		

1/ Greatest absolute value of factor change (whether gain or loss) is shown for area (reaches may differ in gain or loss).

Key to amount of change in factor (corresponding Loss/Gain Category letter also sh

A ◯ ● High
B ○ ● Medium
C o • Low
D & E Indirect or General

Figure 20. Pattern of habitat improvements on Chinook salmon in Little Bear Creek and the Sammamish River for the Little Bear Creek and Sammamish River Start List actions – 25 yr lag. The figure shows the relative increase for the 16 survival factors by geographic area – the larger the dot, the greater contribution to improving survival of the population.

Little Bear Creek Chinook only slightly improved after including the Start List actions. Abundance was predicted to be 17% of historic or an increase of 31% over the current condition.

The Start List actions addressed some of the restoration potential in the Sammamish River and lower Little Bear Creek. No actions from the start-list or comprehensive project list were examined in the upper watershed where there was just as much

restoration potential. Furthermore, the actions that were modeled only partially restored conditions within the geographic areas (~5% improvement vs. a ~25% restoration potential; Figures 17 and 19). Additional actions in Little Bear Creek should focus on the area upstream of 228th St SE (Rural and Upper) and explore options for greater channel enhancement in the lower watershed (Figure 21). However modest, these hypothesized results suggest enhancement in Little Bear Creek and Sammamish River will improve spatial distribution of the Sammamish population of Chinook Salmon.

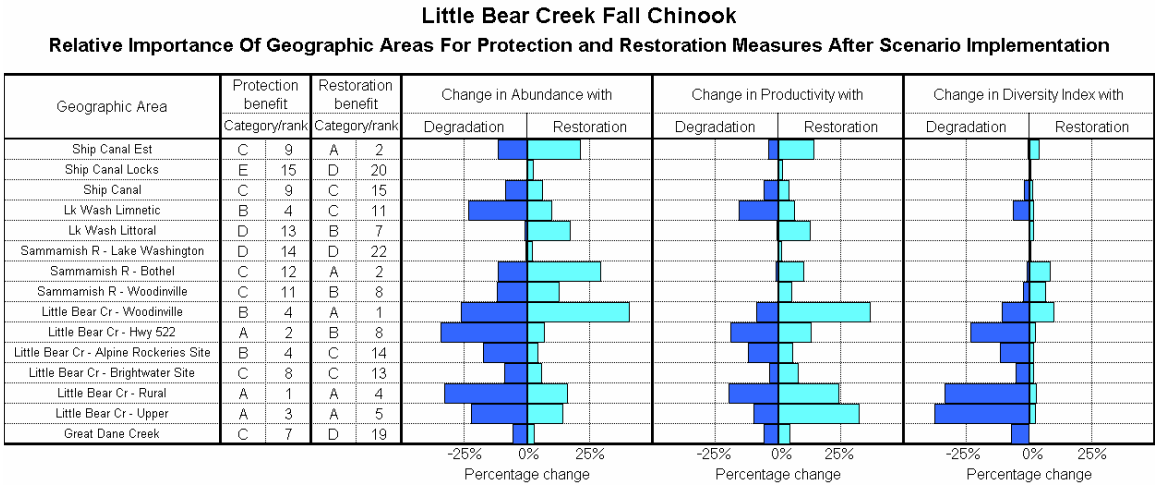


Figure 21. Relative importance of geographic areas within the Little Bear Creek watershed and Sammamish River for restoration and protection measures for Little Bear Creek Chinook after implementing the Little Bear Creek and Sammamish River Start List actions – 25 yr lag.

North Creek Results

Adult population performance results for the baseline scenarios (current and modified historical) for Chinook salmon originating from North Creek are summarized in Figure 19. Habitat changes in the freshwater (riverine, and lacustrine), and marine environments have reduced adult abundance by 83%, adult productivity by 86%, and life history diversity index by 23%.

Juvenile results at the mouth of North Creek do not show the same degree of loss in performance as the adults for the same reasons as other subbasins in Sammamish River, juveniles leaving North Creek have yet to experience the degraded Sammamish River and increased predation losses in Lake Washington and the Ship Canal. Habitat changes in North Creek reduced juvenile productivity by 63% and juvenile capacity has decreased by 15%. Estimated juvenile abundance decreased by a much larger percent (63%) because abundance is affected by change in juvenile productivity and capacity, and the reduced number of adult spawners predicted in North Creek (Figure 22).

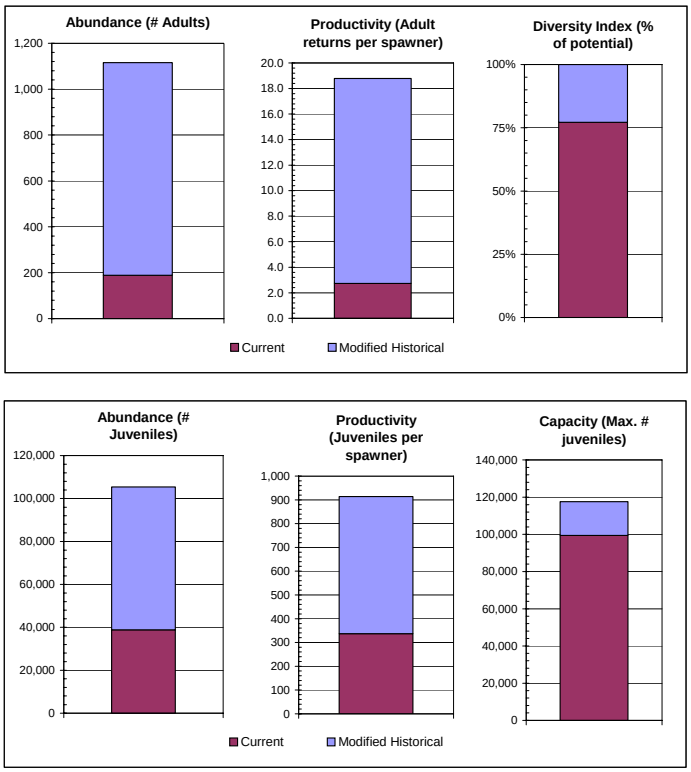


Figure 22. Population performance of North Creek Chinook as estimated from the EDT model for the baseline scenarios (current and modified historical).

Figure 23 presents the production potential for the modeled Start List actions – 25 yr lag for North Creek and the Sammamish River. The Start-List scenario for North Creek included only four actions and predicted scenario effects were less than other subbasins modeled. The modeled restoration scenario improved abundance by 22% from the current condition and remains low relative to the historic condition (21% of historic). Productivity is predicted to increase by about 14% and it too remains at low levels relative to the historic (17%). Finally, life history diversity increased by 14% from the current condition to 88% of the historical potential.

The effect of the Start List actions on predicted juvenile performance measures were very similar to adult effects – abundance increased by nearly 18%, and productivity increased by 8%.

Restoration potential for North Creek Chinook favors actions that would address the Sammamish River and North Creek downstream of Thrashers Corner (Figure 24). The areas with the highest restoration potential are the Sammamish River where North Creek enters, North Creek between the UW Bothell Campus and Thrashers Corner. Actions for improving Chinook abundance and productivity may focus on these areas. However, constraints due to land use in these areas may lead to focusing actions in the upper watershed, where actions will achieve higher restoration effectiveness. Survival factors contributing to loss in performance are habitat diversity, flow, sediment and loss of key habitat (Figure 25). These attributes suggest actions to improve habitat complexity by

increasing in-stream wood, restoring riparian condition, and actively increase channel complexity removal of bank hardening and reestablishing the natural channel configuration.

The North Creek and Sammamish River Start List Scenario actions improved conditions in the Sammamish River and North Creek immediately upstream of the UW Bothell Campus, Thrashers Corner, and Twin Creek area (Figure 26). Actions modeled in North Creek were smaller projects focusing on a particular section of stream. Therefore, at the reach and geographic area scale the effectiveness of the actions was low.

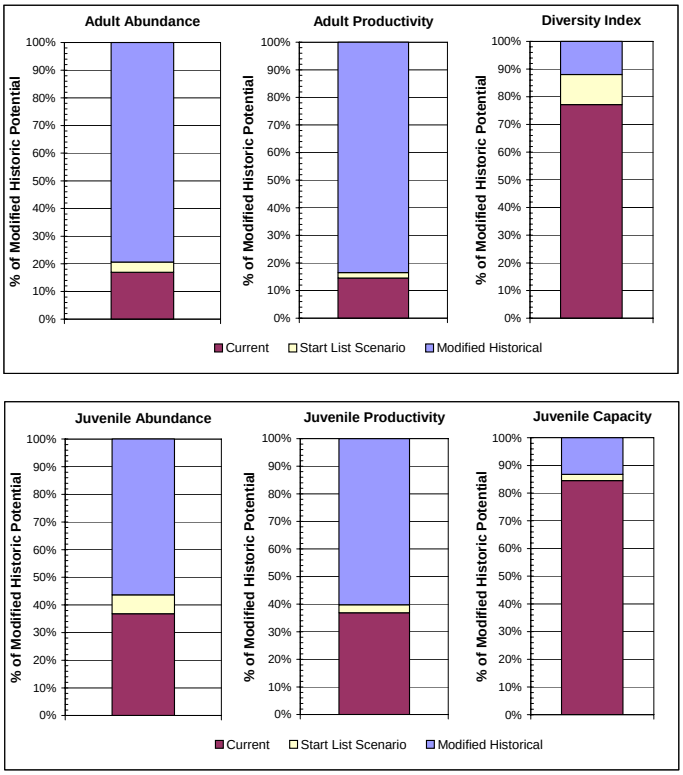


Figure 23. Estimated population performance of North Creek Chinook relative to the modified historic potential. The Start List Scenario includes habitat actions defined for North Creek and the Sammamish River using the 25 yr lag effectiveness assumptions.

North Creek Fall Chinook

Relative Importance Of Geographic Areas For Protection and Restoration Measures

Geographic Area	Protection benefit Category	Protection benefit rank	Restoration benefit Category	Restoration benefit rank
Sammamish R - Lake Washington	D	16	D	21
Sammamish R - Bothel	D	14	A	1
North Creek - UW Bothel	C	8	C	11
North Creek - Business Park	C	9	B	4
North Creek - Lower Rural	B	4	B	5
North Creek - Thrasher Corner	B	3	A	2
North Creek - Twin Creek area	B	4	C	13
North Creek - Mill Creek wetlands	A	1	B	6
North Creek - Mill Creek area	B	6	C	19
North Creek - McCollum Park	B	6	C	14
Penny Creek	D	12	D	21
Silver Creek	D	13	C	15

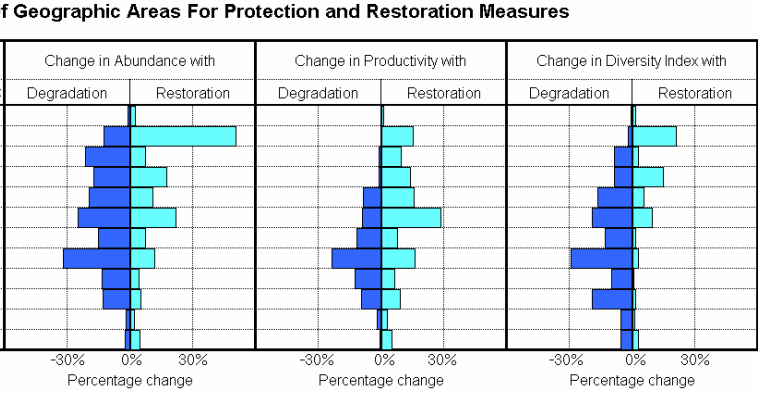


Figure 24. Relative importance of geographic areas within North Creek watershed for restoration and protection measures for North Creek Chinook. Areas are ranked based on their effect on overall population performance. Contributions of performance measures to rankings are graphed.

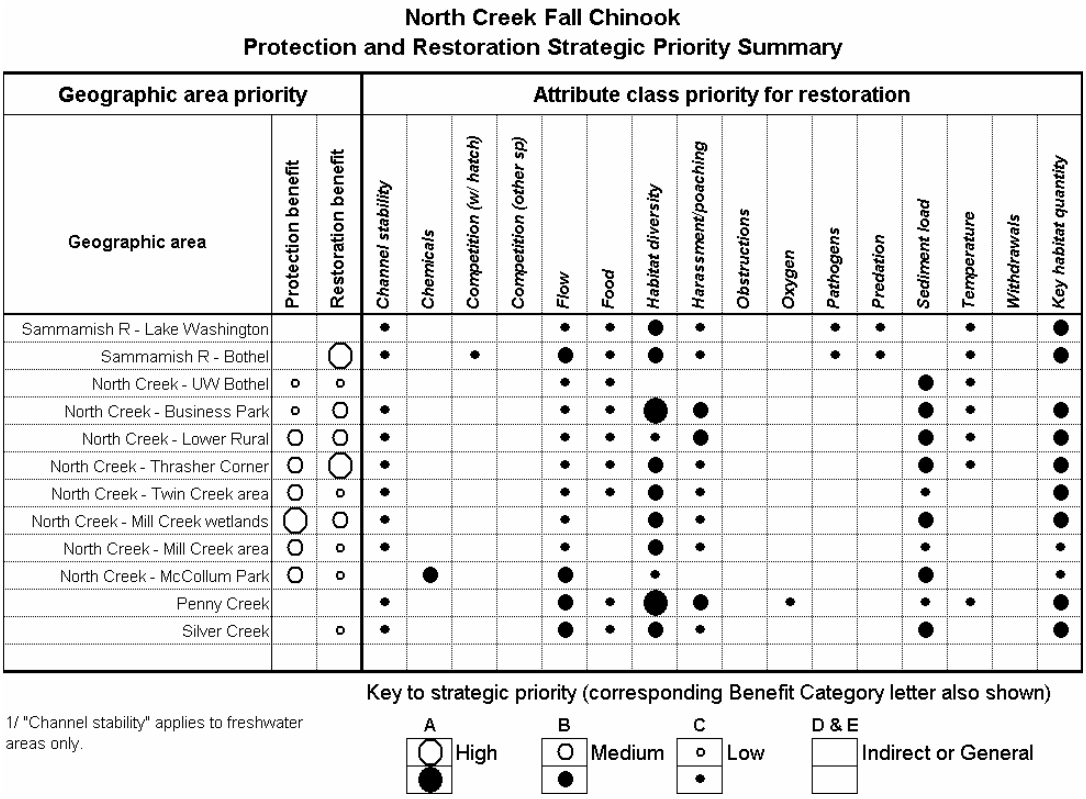


Figure 25. Pattern of habitat constraints on Chinook salmon in the North Creek for the current condition. The figure shows the relative importance of the 16 survival factors by geographic area – the larger the dot, the greater the problem. Open circles for protection and restoration benefit are the benefit categories show in Figure 24.

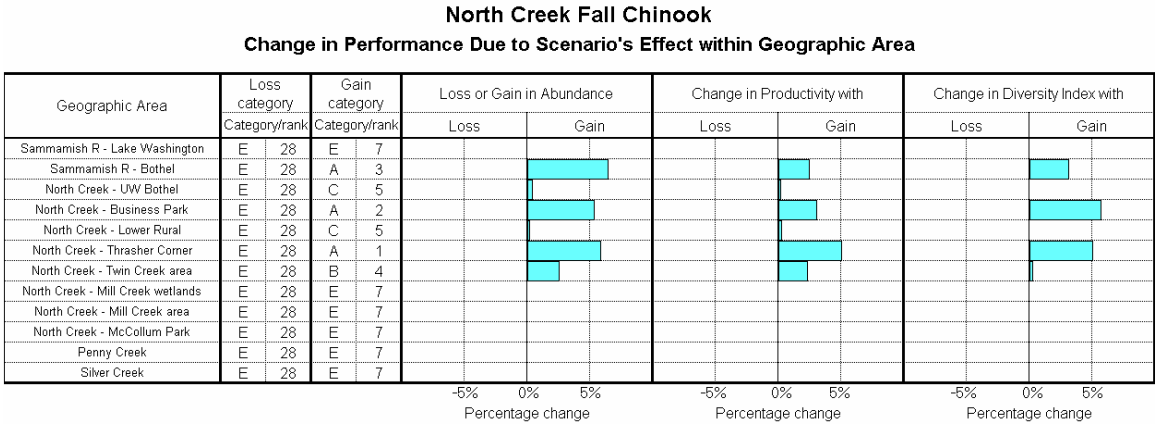


Figure 26. Relative improvement of geographic areas within the North Creek watershed for scenario benefits for North Creek Chinook. Areas are ranked based on their effect on overall population performance.

Four actions were modeled in North Creek – N367, N373, N375, and N377. The focus of these actions was riparian revegetation, the placement of wood, and some reconfiguring the stream channel to improve channel complexity. In general, all of these actions had a fairly high effectiveness at the location of the action (exception was N375, which was mostly a riparian enhancement project because of channel form). Effectiveness of actions at the reach scale was lower because of the limited extent of the actions (Figure 27).

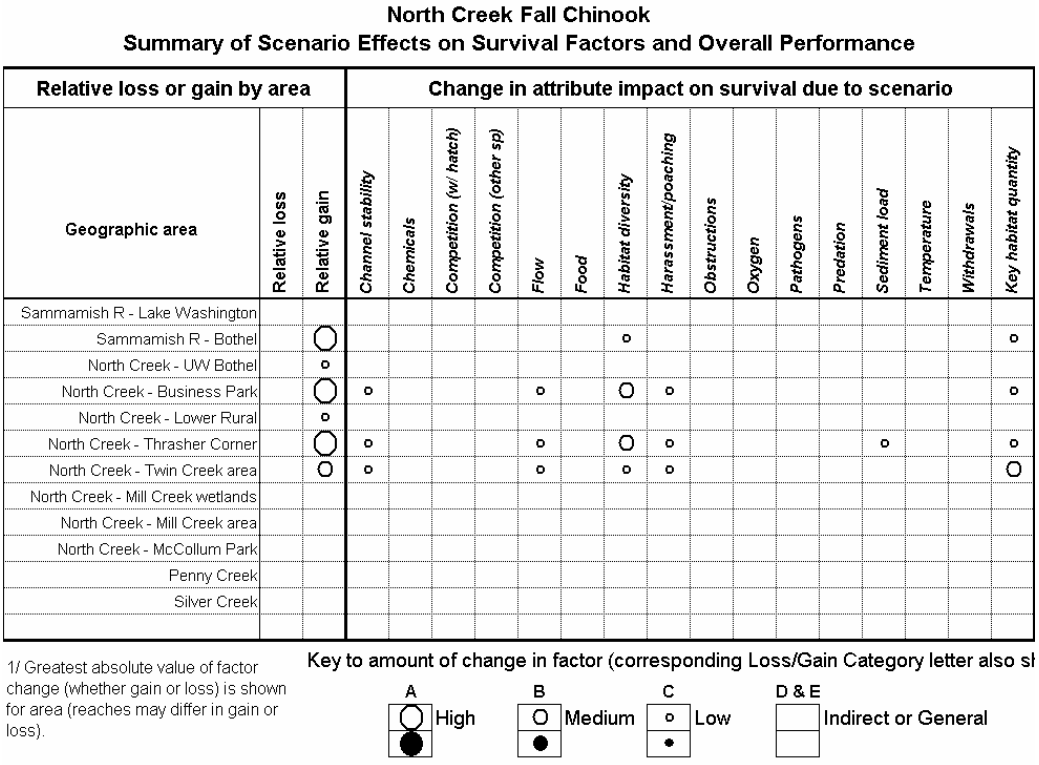


Figure 27. Pattern of habitat improvements on Chinook salmon in the North Creek for the North Creek Start List actions – 25 yr lag. The figure shows the relative increase for the 16 survival factors by geographic area – the larger the dot, the greater contribution to improving survival of the population.

North Creek Chinook only slightly improved after including the Start List actions. Abundance was predicted to be 21% of historic or an increase of 22% over the current condition.

Additional actions in North Creek should focus on the Sammamish River and extend projects identified in the Start List to a greater portion of the stream to capture more of the restoration potential (Figure 28).

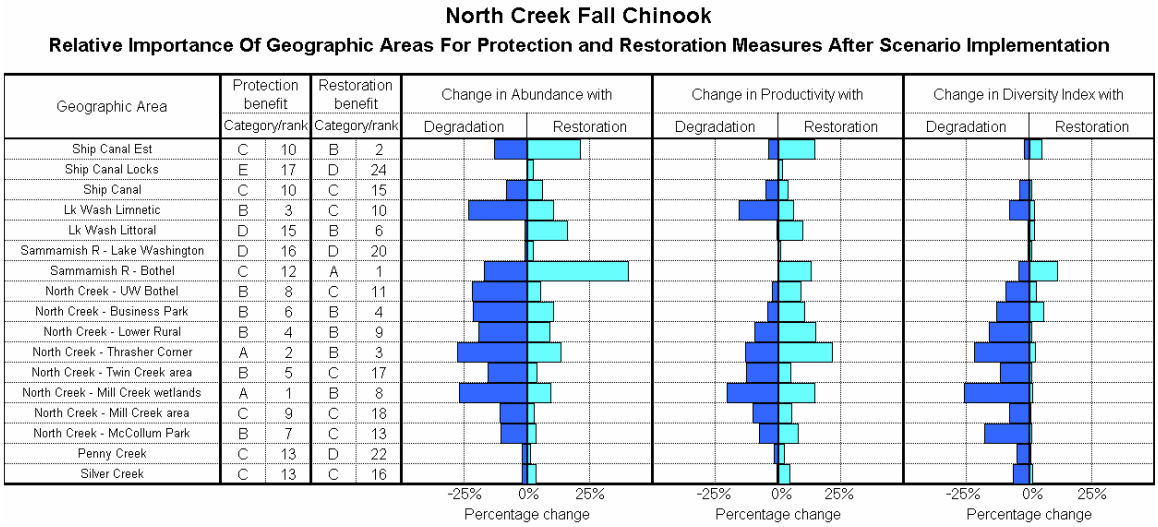


Figure 28. Relative importance of geographic areas within the North Creek watershed for restoration and protection measures for North Creek Chinook after implementing the North Creek Start List actions – 25 yr lag.

Issaquah Creek Results

Adult population performance results for the baseline scenarios (current and modified historical) for Chinook salmon originating from Issaquah Creek are summarized in Figure 29. For Issaquah Creek (and all subbasin areas), these results do not account for any hatchery origin contribution to spawning and represent only the modeled hypothesized Chinook salmon performance based on habitat alone. Issaquah Creek had the greatest loss in population performance of all Chinook population segments. Habitat changes in the freshwater (riverine, and lacustrine), and marine environments have reduced adult abundance by 98%, adult productivity by 92%, and life history diversity index by 76%.

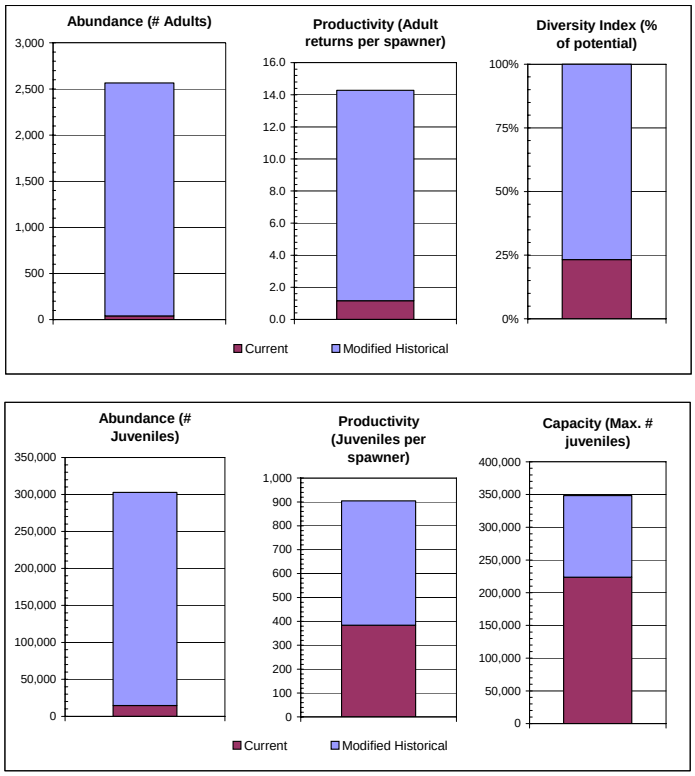


Figure 29. Population performance of Issaquah Creek Chinook as estimated from the EDT model for the baseline scenarios (current and modified historical).

Juvenile results at the mouth of Issaquah Creek tended to show a similar loss in performance as adults – reflecting the greater degradation of habitat in Issaquah Creek and the barrier to adult migration at the Hatchery intake weir. Habitat changes in Issaquah Creek reduced juvenile productivity by nearly 60% and juvenile capacity has decreased by 35%. Estimated juvenile abundance decreased by a much larger percent (95%) because abundance is affected by change in juvenile productivity and capacity, and the reduced number of adult spawners predicted in Issaquah Creek (Figure 29).

Figure 30 presents the production potential for the modeled Start List actions – 25 yr lag for Issaquah Creek and the Sammamish River. The modeled restoration scenario had a large improvement on productivity and abundance of Issaquah Creek Chinook. Issaquah Chinook benefit from actions in Issaquah Creek and actions in the Sammamish River. Productivity and abundance for the current condition were so low that any improvement in survival results in a large percent increase. However results still describe a population at critically low levels. The modeled restoration scenario improved abundance by over 500% from the current condition, but remains low relative to the historic condition (10% of historic). Productivity is predicted to increase by about 60%, but it too remains at low levels relative to the historic (13%) and is well below 3.0 returns per spawner. Finally, life history diversity increased by over 150% from the current condition to 60% of the historical potential.

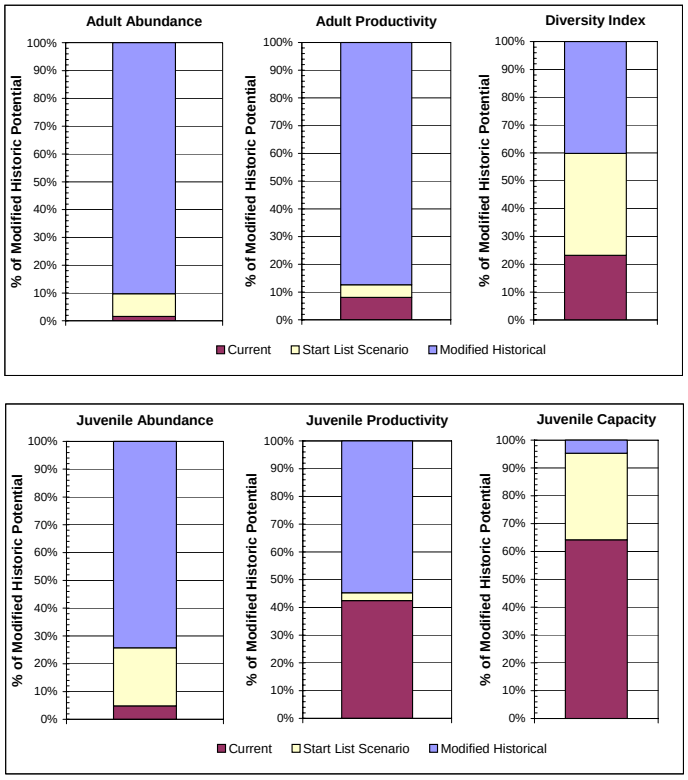


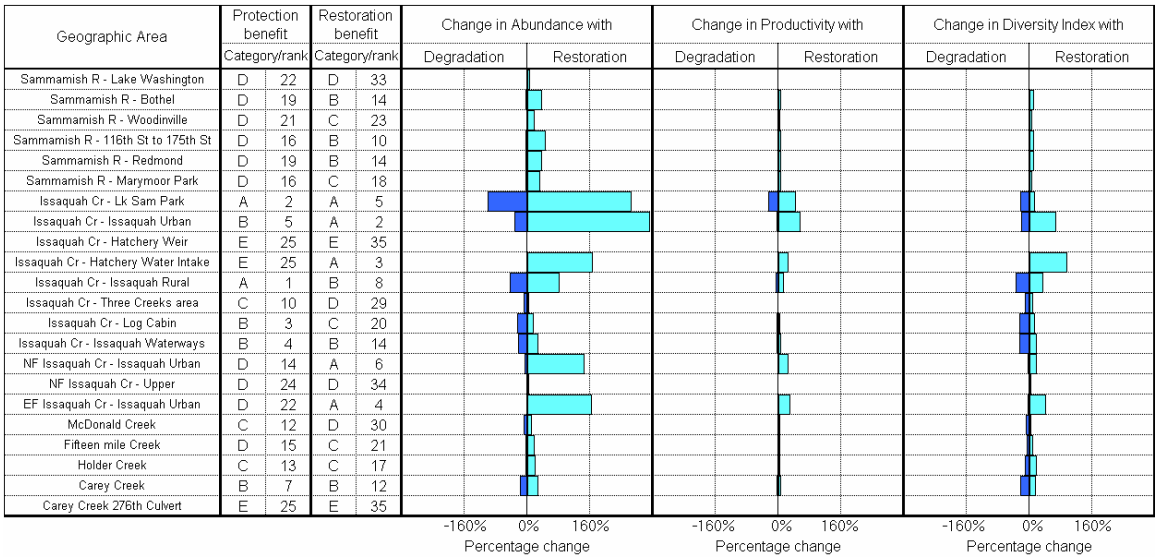
Figure 30. Estimated population performance of Issaquah Creek Chinook relative to the modified historic potential. The Start List Scenario includes habitat actions defined for Issaquah Creek and the Sammamish River using the 25 yr lag effectiveness assumptions.

The effect of the Start List actions on predicted juvenile performance measures were very similar to adult effects on abundance, an increase by of 430%, reflecting the expansion of capacity upstream of the Hatchery intake weir. Productivity increased by a much smaller amount, 7%.

Restoration potential for Issaquah Creek Chinook favors actions that would address the urban areas of Issaquah Creek (and Lake Sammamish State Park) and allowing unimpeded passage at the Hatchery intake weir (Figure 31). Restoration potential of areas upstream of the Hatchery intake weir is low in this analysis (but see the comment below) because the first priority is to provide passage to the upper watershed. The Sammamish River has a lower potential compared to other North Lake Washington Chinook, but still can play a role in improving performance of Issaquah Chinook. Note that the analysis does not show the restoration potential of Lake Sammamish, which among all areas experienced by Issaquah Chinook appeared to have the greatest total restoration benefit based on an earlier EDT analysis.

Survival factors contributing to loss in performance of Issaquah Creek Chinook are sediment (from the upper watershed and tributaries), habitat diversity (particularly the urban areas), obstruction (Hatchery intake weir), temperature (Sammamish River), and loss of key habitat (all areas) (Figure 32). These attributes suggest actions in the upper watershed to reduce the input of sediment affecting reaches downstream, riparian

restoration to trap sediment and increase wood recruitment to the channel, and stream enhancement projects within the City of Issaquah and Lake Sammamish Park.



Geographic Area	Protection benefit		Restoration benefit	
	Category	rank	Category	rank
Sammamish R - Lake Washington	D	22	D	33
Sammamish R - Bothel	D	19	B	14
Sammamish R - Woodinville	D	21	C	23
Sammamish R - 116th St to 175th St	D	16	B	10
Sammamish R - Redmond	D	19	B	14
Sammamish R - Marymoor Park	D	16	C	18
Issaquah Cr - Lk Sam Park	A	2	A	5
Issaquah Cr - Issaquah Urban	B	5	A	2
Issaquah Cr - Hatchery Weir	E	25	E	35
Issaquah Cr - Hatchery Water Intake	E	25	A	3
Issaquah Cr - Issaquah Rural	A	1	B	8
Issaquah Cr - Three Creeks area	C	10	D	29
Issaquah Cr - Log Cabin	B	3	C	20
Issaquah Cr - Issaquah Waterways	B	4	B	14
NF Issaquah Cr - Issaquah Urban	D	14	A	6
NF Issaquah Cr - Upper	D	24	D	34
EF Issaquah Cr - Issaquah Urban	D	22	A	4
McDonald Creek	C	12	D	30
Fifteen mile Creek	D	15	C	21
Holder Creek	C	13	C	17
Carey Creek	B	7	B	12
Carey Creek 276th Culvert	E	25	E	35

Figure 31. Relative importance of geographic areas within the Issaquah Creek watershed for restoration and protection measures for Issaquah Creek Chinook. Areas are ranked based on their effect on overall population performance. Contributions of performance measures to rankings are graphed.

The Issaquah Creek and Sammamish River Start List Scenario actions improved conditions for Issaquah Creek Chinook in the Sammamish River and Issaquah Creek by providing passage at the intake weir, and improving habitat conditions in Lake Sammamish Park and within the City of Issaquah (Figure 33). A total of 25 actions were modeled in Issaquah Creek, more than any other watershed. Six of these actions were protection and included passive restoration of riparian areas in the upper watershed of Issaquah Creek. Several actions were small-scale urban stream enhancement type actions in the City of Issaquah. There were three large-scale actions that addressed a large portion of the lower Issaquah Creek – I202 (Lake Sammamish Park), I207 (Pickering), and I208 (Bush Lane). These actions, combined with restoring passage to the upper, contributed the most to improving abundance of Chinook.

The focus of the actions in the urban areas was to improve habitat diversity by reshaping the channel, the careful placement of wood, and riparian revegetation (Figure 34). Actions in the Sammamish River improved survival of Issaquah Chinook by reducing the effect of high water temperature, improving habitat diversity for migrating juveniles and adults, and reducing harassment on returning adults. Noticeably missing from the Issaquah Start List where actions that would reduce sediment load in the upper watershed that affects all stream reaches downstream. Actions addressing upland land use activities in the upper watershed were thought to be the primary means to reduce sediment load in the watershed and would be addressed in a more comprehensive analysis of land use activities in the watershed. As a result, the restoration improvement mostly affects abundance by increasing Issaquah capacity (improved passage above the hatchery intake weir, but only marginally improves productivity because survival is not improved during

egg incubation through reduction of sediment load. Thus we conclude the primary limiting factor within Issaquah Creek is not sufficiently addressed by these 25 actions. Without selecting actions to treat sediment supply and transport as well as possibly lake treatments, additional improvement in Issaquah Chinook from other urban area treatments will be minor. Benefits from Sammamish River actions may be the next most important as will be all basin wide and site-specific protection actions.

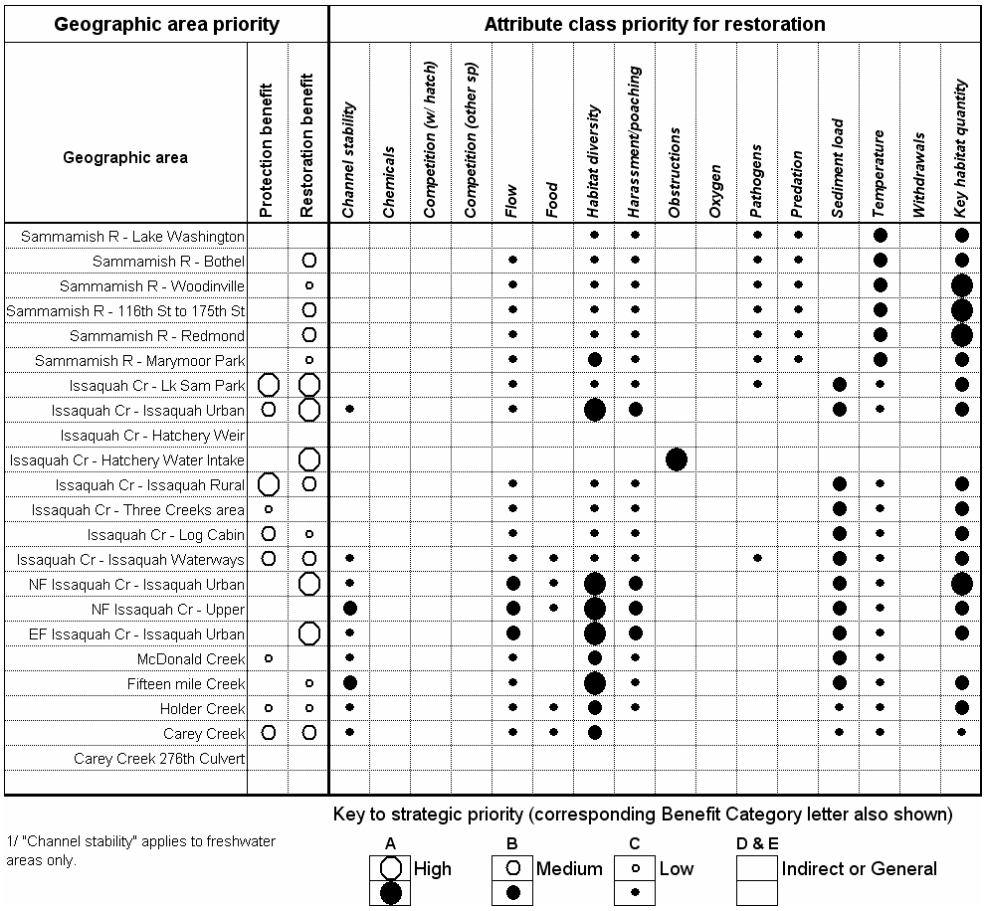


Figure 32. Pattern of habitat constraints on Chinook salmon in Issaquah Creek for the current condition. The figure shows the relative importance of the 16 survival factors by geographic area – the larger the dot, the greater the problem. Open circles for protection and restoration benefit are the benefit categories show in Figure 31.

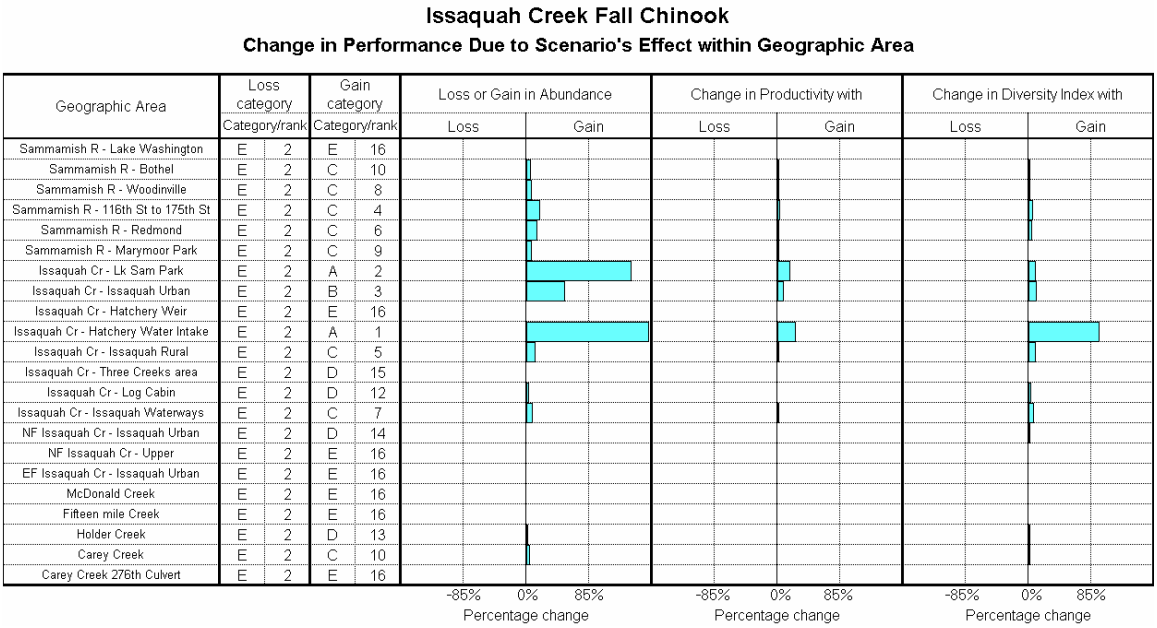


Figure 33. Relative improvement of geographic areas within the Issaquah Creek watershed and Sammamish River for scenario benefits for Issaquah Creek Chinook. Areas are ranked based on their effect on overall population performance.

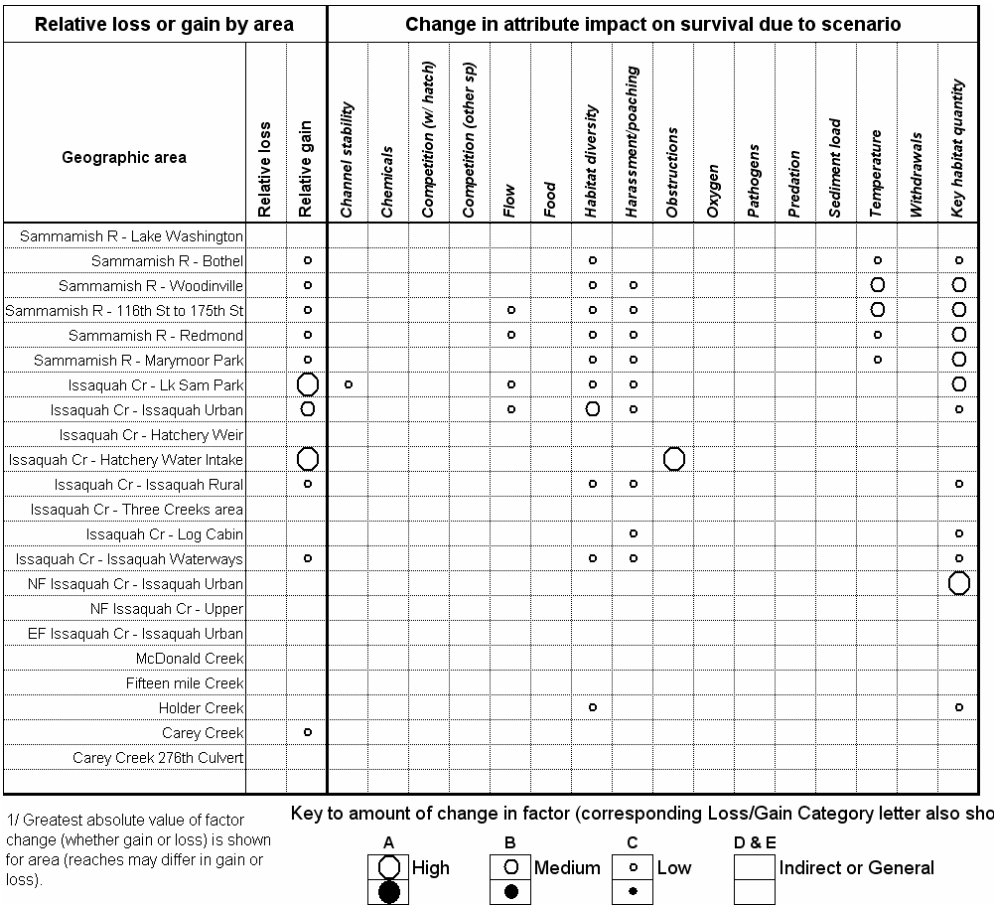


Figure 34. Pattern of habitat improvements on Chinook salmon in Issaquah Creek for the Issaquah Creek and Sammamish River Start List actions – 25 yr lag. The figure shows the relative increase for the 16 survival factors by geographic area – the larger the dot, the greater contribution to improving survival of the population.

Issaquah Creek Chinook improved significantly after including the Start List actions. Abundance increased by more than 500% over the current condition, primarily because more habitat is available upstream from the hatchery intake weir. Productivity of adults and juveniles remained little unchanged. Issaquah Creek Chinook remain low relative the historic condition (10% of historic).

Additional actions in lower Issaquah Creek may want to focus on the urban areas to the extent possible (Figure 35). However, greater gains will likely be possible from additional actions in the upper watershed to control sediment supply over a broad geographic area where there are fewer constraints due to land use. Active riparian restoration will be a critical part of this approach in order to stabilize streambanks that are highly sensitive (erodibility) to slight buffer impairment . Including channel restoration into some of the large protection actions that are underway in Issaquah Creek upstream of the Hatchery intake weir and in Holder and Carey creeks is another possibility.

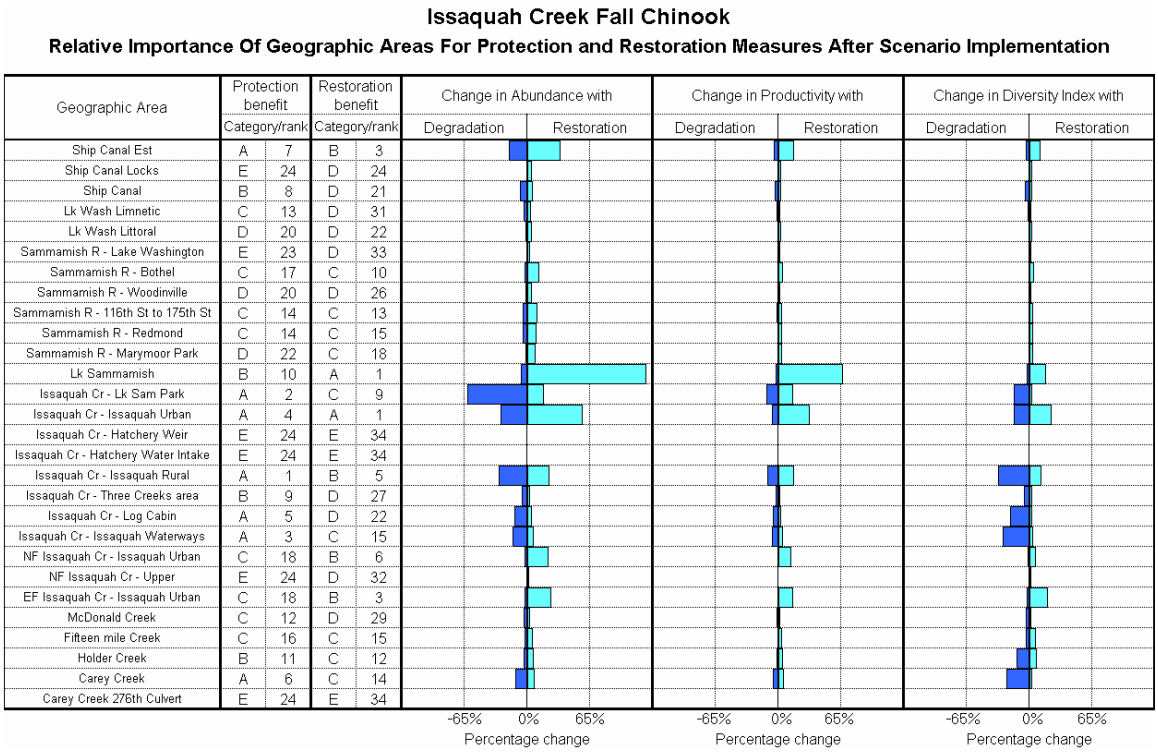


Figure 35. Relative importance of geographic areas within the Issaquah Creek watershed and Sammamish River for restoration and protection measures for Issaquah Creek Chinook after implementing the Issaquah Creek and Sammamish River Start List actions – 25 yr lag.

V. Discussion

Across all subbasins evaluated here, the modeled Start List actions were inline with the diagnosis. There were only a few cases where actions did not address the primary reaches or survival factors identified in the diagnosis, notably, Issaquah Creek. Unfortunately, the modeled Start List actions were not sufficient to improve habitat productivity and capacity to levels that meet long-term goals. Long-terms goals (Table 1) were used for comparison because lag time for project effects were based on 25 years, much longer than the 10-year short-term goals. Nevertheless, project effects improve all population parameters considered. Important caveats are that modeled effects do not account for potential degradation to the current baseline over the same 25 year lag time, so modeled benefits here would be higher than expected. Additional modeling to test future degradation from growth and development could be implemented in order to compare projected 25 year lag time benefits with the results modeled here., At the same time, this project list (52 projects) likely under-represents the full level of protection and restoration effort expended watershed wide. For example this analysis does not include protection programs and numerous other projects being implemented, but not modeled. Without comprehensively accounting for all habitat efforts and future growth and development, the cumulative benefits will not be estimated. However, this exercise has been extremely useful to evaluate the relative benenfits from individual projects. It is recommended that interpretation regarding relative benefits based on project type, scope and scale be used to assist with future project prioritization.

Although model outputs for abundance and productivity are suitable for comparing to Plan goals, other EDT outputs are not well suited for evaluating fish performance against Plan goals. For example, diversity, as an EDT output represents those possible life history trajectories which are viable for life history completion. If diversity is 100%, all possible life history pathways are viable based on the assumed or known specific life history requirements for each population. However, this result does not inform as to which life history trajectories are most favored or proportionately used. This result also does not suggest that Chinook salmon have regained a level of genetic identity, fitness or adaptation that might have existed historically. Specific goals for Cedar River population diversity are based on augmenting the proportion of in-river rearing, which is not directly informed by the model output. This goal will need to be monitored directly as part of Cedar River fry and smolt outmigration trapping and PIT-tag studies.

Plan goals for spatial structure also are not directly informed by model outputs except at the subbasin scale for the Sammamish population. Because the Sammamish population is comprised of several breeding groups among independently modeled subbasins, the relative change in abundance or productivity offers insight to the Plan goals. For the Sammamish, the short- and long-term goals in summary are to create one new core area, expand spawning area distribution, recapture historic distribution, and maintain consistent use of other north Lake Washington tributaries in addition to Bear Creek (Table 1). The most likely candidate area for core area conversion is Issaquah Creek, where a naturally spawning breeding group is established, but allied closely with the Issaquah Creek hatchery and severely limited from use of upper Issaquah Creek. The

most likely area for expansion of spawning area distribution is in Issaquah Creek above the hatchery intake weir. The only area evaluated as part of this modeling exercise with hypothesized historic distribution, also, is upper Issaquah Creek. Because no actions were modeled in Kelsey, Thornton, May, Swamp, McAleer, Lyon, Coal or any other creeks, we cannot assess the potential that improvement in abundance and hence spatial distribution would be enhanced through implementation of Plan actions. Furthermore, the limited hypothesized benefit from the few actions evaluated in North and Little Bear creeks is worrisome because future risk to baseline conditions in these urbanizing areas could counter these modest benefits. Should that occur, reduction in spatial structure is likely and long term goals would not be met.

Table 3A and B. Comparison between modeled Start-list scenario outputs and long term objectives. For productivity (R/S), the start-list scenario results depicts the density-independent growth rate. The long term objective from WDFW represents lifecycle productivity and would include density-dependent effects. The percentage increase shown in parentheses represents the improvement over current conditions for all parameters.

A.

	Abundance (adults)		Productivity (R/S)		Diversity	
Population Component	**Start List Scenario**	**Long-term objective**	**Start List Scenario**	**Long-term objective**	**Start List Scenario**	**Long-term objective**
Cedar River	986 (62%)	1000-8200	2.3 (24%)	1-3.1 **	85% (18%)	NA
Sammamish	907 (71%)	1000-4000	2.9 (12%) *	1-3.0 **		
Bear Creek	291 (50%)		3.6 (30%)	1-3.0 **	100% (34%)	NA
Little Bear Creek	137 (31%)		3.1 (18%)	1-3.0 **	88% (15%)	NA
North Creek	230 (22%)		3.1 (14%)	1-3.0 **	88% (14%)	NA
Issaquah Creek	249 (509%)		1.8 (56%)	1-3.0 **	60% (157%)	NA

B.

	Abundance (juveniles)		Spatial Structure	
Population Component	**Start List Scenario**	**Near-term objective*** **	**Start List Scenario, % increase in abundance, productivity**	**Long-term objective**
Cedar River	457,711	558,017 (64%)	(62%) (24%)	Yes
Sammamish				
Bear Creek	42,568	59,258 (44%)	(50%) (30%)	Yes
Little Bear Creek	31,218	48,556 (29%)	(31%) (18%)	No
North Creek	45,993	77,629 (18%)	(22%) (14%)	No
Issaquah Creek	63,311	NA	(509%) (56%)	Yes

* Sammamish weighted productivity estimate is based on subbasin productivity weighted by abundance.
** The long term objective from WDFW represents lifecycle productivity and would include density-dependent effects.
*** Near-term objective based on 2x current abundance.

The short answer is more actions are needed to improve Chinook salmon performance to levels approaching recovery objectives. Within the urban areas, stream conditions are poor and whereas restoration potential may be high, opportunities are limited and feasibility may be low. The cities of Renton, Redmond, Woodinville, Bothell, Kenmore and Issaquah are all located in the lower portion of subbasins and represent a gauntlet of degraded conditions that rearing/migrating Chinook must pass through to access higher quality upstream habitat. These areas will require a more actively managed enhancement

strategy to improve habitat conditions. Actions such as N201 and N208 in lower Bear Creek and I207 and I208 in lower Issaquah Creek, although expensive to implement because of the high cost of acquiring land, were considered by the W8TC to have high effectiveness towards improving habitat conditions. Similar results have been obtained at the mouth of North Creek where the formerly channelized creek was restored within a newly active floodplain. These restored conditions are highly protective of Chinook salmon using North Creek. Hallmarks of these projects, are large scale and scope that Chinook salmon respond to. Benefits from some enhancement of the lower Cedar River would be hypothesized to be similar.

Within the semi-rural and rural areas of the subbasins much of the emphasis of the Start List actions was on restoring riparian conditions and removing river flood hazards in order to allow natural watershed process to restore channel features and habitats (such as LWD). In many cases, riparian conditions were only partially restored because of land use constraints and the lag time needed for riparian restoration. There were examples of riparian revegetation combined with in-stream restoration (N282 in lower Cottage Creek is one example). This type of action should be considered in other areas of the subbasins.

Finally, this analysis did not evaluate or hypothesize recovery benefit from a reduction in predation loss in the lakes or hypothesize restoration potential from individual project actions to improve habitat in the lakes, locks or nearshore. Addressing predation losses may be important to achieving recovery criteria and could be considered as part of H-integration.

VI. Project Recommendations

As the results show, the hypothesized benefits (at 25 years) from implementing the modeled projects are on the right track, but fall short of Plan goals, even without considering future cumulative impacts that might also accrue with new growth and development. This effort to model 52 selected restoration actions did not include the complete Start List. Specific Start List (and comprehensive list) actions to consider for additional modeling and/or prioritized implementation (through revision of future 3-year lists) include the following projects by area. Prioritization for implementation based on benefit will be influenced by not only the location but also by the scale and scope of the project. Larger projects, in scale and scope, naturally will likely produce greater population response than smaller projects with fewer project objectives. For example, a Cedar River levee setback project that includes, land acquisition, levee removal, floodplain connectivity, large woody debris enhancement, and riparian planting over a large area naturally will be expected to have more benefit than projects proposing single objectives, or otherwise smaller scale projects

<u>Cedar River</u>

- C209 Riparian restoration in City of Renton parkland
- C212/213/C214 Riparian habitat protection and restoration in Reach 4 (Ron Regis). These projects reflect reach-wide objectives but not feasible projects.
- C207 Riparian enhancement near multi-family residential uses (Reach 3)

- C229 Protect Riparian buffer behind Scott-Indian Grove levee in Reach 8
- C351 Rock Creek entrance flows
- C333 Taylor Creek floodplain, riparian, and instream restoration (also C332, C331, C336, C330 with high benefit and high feasibility)

Specific actions to consider for additional modeling and/or prioritized implementation in the Cedar River on the comprehensive list are the following:

- C218 Herzman Levee in the Cedar Rapids Area,
- C219/220 River bend mobile home buyout (partial or full) and restoration
- C226 Progressive levee removal
- C231 WPA revetment area buyouts and revetment removal
- C243 and C245 Setback of the Getchman levee to restore floodplain connectivity
- C241 and C242 A dynamic confluence area at the mouth of Taylor Creek, and Jan Road downstream of the Taylor Creek confluence - enhance 218th side channel.

Other Cedar River restoration actions include those which have lower benefit or feasibility rating. Benefit may be related to scope and feasibility may be related to land ownership both of which could change in the future at numerous locations, as it did, for example, at Rainbow Bend. In the Cedar River, the Comprehensive King County Flood Hazard Management Plan identifies the following projects as priorities for implementation in addition to some of the projects above:

- C254 and C257 Orchard Grove
- C216 Elliott Bridge Levee Setback and Acquisition
- C243 Rhode Levee Setback and Home Buyouts

<u>North Creek</u>

- N378 Restoration in Reaches 4 & 5, particularly at Clearwater School (formerly known as North Creek School).
- N386 North Creek Regional Park stream channel enhancement, Reach 7
- N381 Buyout frequently flooded home and restore floodplain/riparian near Waxon Rd.
- N382 Add LWD in Reach 6, between North Creek Regional park and 196th
- N379/N384/N388/N391/N394 Work with landowners in Reaches 5/6/7/9/10 to restore riparian vegetation and to do stream enhancements
- N395 Install grade control structures (very large logs) from Northwest Stream Center to 128th in McCollum Park.

<u>Bear Creek</u>

- N219 Feasibility and design for placement of LWD in Reach 7, Bear Creek
- N220 To include the 3.0 miles of stream downstream of Cottage Lake Creek.
- N226 Feasibility and design for placement of LWD in Reach 8, Bear Creek

- N242 Feasibility and design for placement of LWD in Reach 10, Bear Creek
- N267 Riparian planting in wetland south of Woodinville-Duvall Rd., Bear Creek
- N314 Feasibility and design for placement of LWD in Reach 5/6, Cottage Creek

Other moderate benefit or feasibility projects could be considered for prioritization should scope (benefit) or feasibility improve.

Little Bear Creek

- N401/N402 – 132nd Ave NE fish passage/134th Ave NE fish passage
- N404 – Add water quality and retention /detention facilities for SR522/195th NE (this action would be difficult to model as a habitat effectiveness action)
- N407 – Fish passage improvements at 195th St NE
- N412 – Improve water quality in reach 5
- N415 – Floodplain restoration adjacent to Route 9
- N425 – Increase channel complexity and floodplain connectivity in reach 11 between 180th St SE and Maltby Road.

Although individually modest, these hypothesized benefits suggest enhancement in Little Bear Creek and Sammamish River will improve spatial distribution of the Sammamish population of Chinook Salmon.

Sammamish River

- N333 – Lake Pointe property riparian and aquatic restoration
- N332 – Sammamish River mouth wetland restoration
- N355 Lower Bear Creek restoration and pool creation/ overlaps with N201
- N351 Riparian restoration between Willows Golf Course and NE 116th

Issaquah Creek

Additional actions in lower Issaquah Creek may want to focus on the urban areas to the extent possible (Figure 35). At the same time, there are only 6 projects that were not included in the group of modeled projects in lower Issaquah Creek and North Fork Issaquah Creek. The projects and the following group in upper Issaquah Creek could be modeled for their benefit.

- I209 – Streamside property downstream of Juniper St (requires acquisition)
- I272/I278/I280 – Increase buffers and restore riparian areas (North Fork 1, 2 ,3)
- I273 – Protect/Restore instream flow (North Fork)
- I279 – reduce sedimentation problems (North Fork)

- I232/I233 – Work with private landowners to protect buffers and restore habitat (Reach 9)
- I239 – Log Cabin site restoration (Reach 11)

- I245/I246 – Agricultural water quality management/buffers and riparian restoration (Reach 12)
- I248 – Carey/Holder/Issaquah Creek confluence restoration (Reach 12)
- I266 – Fifteenmile Creek riparian restoration

VII. Next Steps

The WRIA 8 Technical Committee recommended next steps for use of these EDT modeling results and using the EDT model for additional applications, including:

1. Use results from this EDT treatment report to guide selection and prioritization of projects with large hypothesized benefits for Chinook salmon. Specifically, apply results learned here for prioritization of the 3 –Year List. Then, for future updates, incorporate Start-list and comprehensive list projects with potentially high benefit similar to those identified in these modeling results. Originally Plan projects were ranked according potential benefit and feasibility of action but not evaluated in terms of project scope or scale. For example, EDT treatment results for the Cedar River show the greatest benefit from larger scale projects that restore multiple functions over larger areas (e.g. levee setbacks) in critical reaches. In the Cedar River, three levee setback projects are included on the 3-year list, but not prioritized. Among these, the Ricardi levee is currently funded (through SRFBoard, in part), designed, and being monitored, the Rainbow Bend is largest in area and partially funded and acquired, and Buck's Curve is most constrained by roads, though potentially large in scope and scale. Therefore, prioritization for implementation among these projects is - Ricardi, Rainbow Bend, then Buck's Curve. Prioritization may help inform use of lead entity capacity funding. Hypothesized benefits for Comprehensive List projects included in the Project Recommendation Section of this report could be evaluated similarly.

2. Apply 2 or 3 WRIA 8 future change scenarios in order to assess the risk that modeled project benefits would be limited by growth and development affecting aquatic habitats for fish. For this effort we would make assumptions about the "effectiveness" of various WRIA-wide protection programs (critical areas regulations, land use restrictions, shoreline master program updates, plus individual protection actions) as part of a range of build-out scenarios that would potentially affect most EDT reaches in the watershed. This effort would not be dependent upon using the PSRC predictive model of future land use/land cover changes (although the effort could accommodate the PSRC model as one alternative if the PSRC product is ever finalized). Instead the approach would rely on selecting scenarios representing hypothetical future low, moderate and high watershed conditions (similar to the Watershed Evaluation, Appendix 3-C, Volume III, of the Plan) that would be embodied in selected habitat attributes. As a pilot effort, one or two subbasins could be selected for this exercise instead of the entire WRIA.

Acknowledgements

This project was funded by King Conservation District and King County Department of Natural Resources. This report is a product of the WRIA 8 Technical Committee and Mobrand Biometrics.

Appendix A – Actions applied for Start List scenarios. For each project, the consultant developed assumptions about the scale, scope and likely effectiveness of the project, including influence on surrounding stream reaches.

Cedar River:

Action	Description	Reaches affected by Action
C204 - Riparian Restore	Project Logan St to I-405. Industrial/Urban reach. Discussed including LWD (smaller pieces). It was suggested LWD would create some higher diversity pools in this reach. Possibility that predators will also occupy this habitat but decided that LWD and habitat structure will provide refuge from predators. Mostly a slight improvement to riparian function and adding wood a small improvement in LWD.	Cedar-1 & 2
C206 - Riparian Restore	Project RB industrial site just upstream of I-405. Assumed 1,150 ft of RB replanted, LWD placement, and some removal of bank hardening.	Cedar-2 & 3
C208 - Maplewood	This project also includes benefits to flood hazard reduction. A significant portion of the homes are inside the Cedar River flood zone. Left bank is a high bank with potential for slides. Project would buy out homes and set back the inside bend of river at least to the existing road (151st) if not further. We also considered if a landslide on LB were to block river and amount of flooding and risk to property, etc. Tie in with flood hazard needs to include both phases of action: 1) Set back levees (south end of Erickson levee) to restore active channel (LWD, riparian restoration, etc) and 2) Restore floodplain capacity by removing all homes in floodway & removing Erickson levee.	Cedar-3
C215 - Bucks Curve	Two project scopes - 1) Floodplain hazard reduction – remove homes with a levee setback and 2) Floodplain hazard reduction and active restoration – remove homes, with levee setback and reconfigure channel using LWD. LWD placed to promote channel configuration (reconnecting side channels). ACTION ASSUMPTIONS ASSUME FULL SCOPE INCLUDING JONES RD SETBACK.	Cedar-4 & 5
C233 - Renton Lions Club	LWD placement to reconnect side channels. No levee removal or major channel reconfiguration. Included restoration of off-channel pond egress channel.	Cedar-11
C235 - Rainbow Bend	The protection portion of this project (C232 Belmondo) is on the start-list, and is part of the 2006 SRFB application list. C235 Cedar Grove Rd Levee Removal is the restoration component of this project, but is not specifically listed on the start-list. However, the two are projects are linked, as it is necessary to do the acquisition for the restoration to occur, and both actions will be included in the 'start-list' scenario for EDT modeling purposes. We discussed several stages to this project: 1. Purchase homes (currently proposed as C232 SRFB application), 2. Remove mobile home park downstream of homes, 3. If can remove mobile home park then remove levees, 4. If cannot remove mobile home park then set back levees – need to protect mobile home park. Assumptions based on removal of mobile home park.	Cedar-8, 9 and 10
C252 - Don Dorre	Protect 71 acres, 14 parcels in reaches 14 and 15. Remove Lower Dorre Don levee and homes in both reaches. Also includes portion of the Young levee upstream of Lower Dorre Don. The railroad levee (Elkington) and bridge limit restoration potential. Upstream of railroad trail, there is a chance to remove homes and Lower Dorre Don Rd to recreate a side channel that would go against trail fill. Need to place LWD to promote channel migration without endangering trail. Discussed including an off-channel pond below trail on left bank. No chance river migrating because of trail crossing and fill. In Cedar-14 – most likely action is to improve channel connectivity to flood plain during moderate to high flows (possibility excavating channels to reconnect river to floodplain).	Cedar-13, 14 and 15
C341 - Lower Rock Creek	Stream rehabilitation lower 300 ft of Rock Creek - Armoring would be removed, but do not widen or move the channel. Placement LWD in lower most reach. Wetland may be connect to stream creating off-channel habitat in reach. No hydrologic effects, as this is not intended to provide flood storage or otherwise	Rock-1

	impact flow attributes.	

Sammamish River:

Action	Description	Reaches affected by Action
N201 - Bear Creek Mouth Restoration	Effectiveness assumptions for the 10 and 25 yr in Sam-5 are the same and reflect creek mouth restoration of Bear Creek - action includes placement of wood at the creek mouth, construction of a distributary channel with a back water pool and construction of a primary pool at mouth of creek. Action will include reshaping levees at mouth of Bear Creek to create more shallow water habitat. The effect on temperature of this project and others in Bear Creek was modeled as a separate action.	Sammamish-5
N201, N206, N208-Bear Cr Riparian Restoration	Effectiveness assumptions assume a 2C drop in water temperature leaving Bear Creek and results from temperature modeling in the Sammamish River. Temperature modeling shows that riparian shading can have an effect -- Appendix B of the Sammamish Corridor Action Plan. Based on modeling, riparian restoration of Bear Creek such that temperature of Bear Creek was 2 degrees C cooler would reduce maximum temperatures in the Sammamish River. Major effect is in Sammmish-5 between the Bear Creek confluence and the RR bridge (effectiveness of 0.2) and lesser effect (0.05) downstream to Blyth Park.	Sammamish-2, 3A, 3B, 4A, 4B & 5
N334 - Wildcliff Shores	Plant native species, reshape bank to improve edge habitat and create backwater pools with LWD	Sammamish-1B
N335 - Swamp Creek Mouth	Large parcel to the south of Swamp Creek mouth (Swamp Creek Regional Park) – opportunity to create emergent habitat on Swamp Creek with a dendritic channel and multiple outlets to the Sammamish River. Action includes placement of LWD accumulations in Swamp Creek. Widen the area of Swamp Creek for gravel deposition near 522, good groundwater upwelling in this area. Reshape Sammamish River bank and canopy, some backwater pools in Sammamish River reach. Assume that off-channel and ponds are seasonally flooded in summer due to reverse hydrology of Sammamish River and Lake Washington.	Sammamish-1B
N337 - Bothell Side Channel on RB	Wetland restoration on right bank of Sammamish River (Reach 2), restore historic wetlands on RB downstream of 102 Ave bridge to include seasonally inundated wetlands with small channels connecting to river. Assumed excavation of an off-channel pond in perched wetland and riparian restoration along Sammamish River bank.	Sammamish-2
N338 - Bothell Side Channel on LB	Ideally, project would begin on east side of 102nd, go through a culvert under 102nd into wetlands/depressional areas on west side of 102 and connect with the existing side-channel on the LB of the Sammamish River. Wetlands are adjacent to 102 avenue. Effectiveness assumptions are based on this premise. Restoration of remnant side channel effecting channel width and a seasonally inundated off-channel habitat pond, riparian restoration scaled to reach length, LWD placement, and good water quality benefits due to peaty soils – Misc. Toxic and nutrient enrichment leave at 0.4. Estimate about 1/4 of LB of reach affected by this project. Assuming that side channel is connected at top and bottom at most flows. Additional wetland area inundated during high flows and/or water to off-channel ponds from upland or groundwater sources.	Sammamish-2
N339, N357, N342, & N346-tributary mouth thermal refugia	Project benefits are based on effects on temperature of tributary streams. Geoff Clayton summarized temperatures for various streams and the Sammamish River. Some tributaries are ~10°F cooler, while others are nearly as warm as the Sammamish River. An additional component to this project is riparian restoration of tributary stream in floodplain. Tributaries warming as they cross the valley floor – providing shade will reduce the warming. Two Phases: 1) 10 yr lag restore tributary mouth with pool habitat; 2) 25 yr lag include restoration of tributary riparian. Difference in temperature effectiveness of actions between lags is due to tributary riparian restoration: 1) temperature maximum after 10 yrs - 0.01, 25 yrs 0.05; 2) temperature spatial variation after 10 yrs 0.20, after 25 yrs 0.40	Sammamish-2, 3A, 3B, 4A, 4B, 5 & 6A

Action	Description	Reaches affected by Action
N343 & N356- Sammamish River regrade & riparian revegetation	This is a fairly extensive project - effectiveness assumptions assume project extends from Marymoor to near City of Woodinville. King County owns 100' buffer on each side of stream. Within this area possibility to setback/reslope levee to create shallow water habitat, create pool/riffle habitat with structure, and riparian vegetation. Impacts may be lower in urban parts of Redmond than by the golf course, but 100 foot right-of-way exists throughout this area. Discussed creating a bench with seasonally flooded wetlands or a connect side channel. No resolution on actual design. Effectiveness revisions: Habitat types – 0.2; 2. Max width – 0.2; 3. Riparian Function – 0.65 (width 100' on both banks); Removed harassment effect; 6. No change channel length as channel will not be relocated. Temperature effect based on modeling. Included TempSptVar associated with tributaries.	Sammamish-2, 3A, 3B, 4A, 4B, & 5
N358 - Sammamish Transition Zone	Reconstruct channel for 1,400' downstream of weir. Restore channel sinuosity (2 outside bends) of mainstem; relocate stream entering upstream of weir to flow into a wetland and river downstream of weir. This stream would be designed to be an interflow channel rather than a surface flow channel to maintain cool stream temperatures. The size of the project is limited by cultural artifacts found just north/downstream of the parking lot on the right bank. We discussed including an overflow channel upstream of weir. Will connect to a seasonally flood wetland. We would include an off-channel effect with the overflow channel. Added a HbOffChan factor of 0.4 due to the off-channel area increase. At outside of channel meanders include LWD and pools. Restore riparian with native plant revegetation. We decided to remove Max Temp effect from action – temperature affected by Lake Sammamish. We concluded a moderate Temp Spt Var effect from ground water entering pools (0.2), since hydraulic head exists in this reach to drive flow thru gravels and meanders.	Sammamish-6A
N362 - Upper Sam Riparian Restore	Action includes riparian revegetation between Lake Sammamish and Weir. Continue and expand projects such as Sammamish Re-Leaf and Redmond Riverwalk to plant early successional riparian vegetation to provide shade. Property is all under public ownership, and future plans for a second trail near this reach of river would provide good opportunities for riparian restoration.	Sammamish-6B

Bear Creek:

Action	Description	Reaches affected by Action
N201 - Lower Bear Creek Restoration	N201 includes creek mouth restoration in the Sammamish along with restoration of reach 1 of Bear Creek. This section deals with the Bear Creek portion only – the project will be divided into the Sammamish River and Bear Creek portions for modeling purposes. This project is a reconstruction of the channel in lower Bear Creek. Opportunity for restoration is constrained by freeway and other structures. Use previously completed restoration in reach 2 as template, and extend habitat conditions downstream to reach 1.	Bear-1
N206 - Riparian Restoration Bear Creek Avondale	Riparian restoration Reach 3 of Bear Creek – City of Redmond property. Project include in-channel restoration – LWD and removal bank hardening. Riparian area for reveg about 100 m on each side.	Bear-1, 2 & 3
N208 - Restore Keller Farm Bear & Evans Cr	This project was described as full restoration of channel structure (width, habitat types, LWD). Includes riparian revegetation but of limited width in Evans Creek. Bear Creek (Keller Farm) assume high riparian restoration. We included off-channel habitat in the action. Also included beaver ponds. Water quality improved by this action but also strongly affected by upstream conditions. Evans Creek very short section of stream affected. Effectiveness on water quality attributes negligible.	Bear-3, 4, & 5, Evans-1
N220 - Riparian Restoration Bear Creek Cottage Lake Area	Restore forest cover on cleared, undeveloped properties in Lower Bear Reach 7. Upper portion of reach has good riparian condition.	Bear-6 & 7
N228 - Riparian Restoration Swansons	Restore forest cover on cleared, undeveloped properties in Upper Bear Reaches 8, Swanson Horse Farm. Concluded active riparian restoration with no channel reconstruction. Objective is to reduce fine sediments, restore riparian areas, and pursue farm plan.	Bear-7 & 8
N236 & N289 - Nickels Farm Riparian Restoration	Restore forest cover on cleared, farm land, Nickels Farm. Concluded active riparian restoration with no channel reconstruction. Objective is to reduce fine sediment, nutrient inputs and restore riparian vegetation. Appears that ~2/3 of reach will be affected by this action.	Bear-6
N282 - Restoration Lower Cottage Creek	Explore opportunities to improve floodplain connection in Reach 1 of Cottage Creek by removing riprap or artificial constrictions. ASSUME THIS PROJECT WILL INCLUDE RIPARIAN RESTORATION AND WOOD. Includes removing bank hardening to protect water main. Assumed that water main would be relocated to allow removal bank hardening. Assume armoring removed over 500 m distance.	Bear-6 & Cottage-1
N298 - Cottage Creek Riparian Restoration	Active riparian restoration combined with passive restoration (educate home owners along stream). Action will affect 3/4 of Cottage-3 reach.	Bear-6 & Cottage-1, 2 & 3

Little Bear Creek:

Action	Description	Reaches affected by Action
N403 - Riparian revegetation & instream LWD	General riparian restoration and some LWD placement in Little Bear-2. Improve habitat diversity for juvenile rearing and migrating adults. Reach is constrained by City of Woodinville on one side and highway 520 on the other. Riparian restoration at best 50' on each side of stream. LWD will be mostly smaller pieces with moderate effect on channel structure. Any more ambitious placement of wood may affect infra-structure.	Little Bear-2
N408 - Riparian revegetation & instream LWD	General riparian restoration and some LWD placement in Little Bear-2. Improve habitat diversity for juvenile rearing and migrating adults. Reach is moderately constrained by highway 520. Assumed sufficient room to allow placement LWD to a greater extent than lower reach. Action is affecting most of the reach. Riparian condition appears to be fair in current condition based on aerial photos. Downstream recruitment of wood limited by 520 crossing.	Little Bear-2 & 3
N411 - Alpine Rockeries Riparian revegetation and instream LWD	Restore 800' of channel adjacent to Alpine Rockery. Channel in current condition is constrained by commercial development and Highway 520. Channel is constrained upstream and downstream of this restoration project. Project will restore about 20% of Little Bear-5	Little Bear-4 & 5

North Creek:

Action	Description	Reaches affected by Action
N___-Bothell Campus	Maturation of the UW Bothell Campus restoration project. Restoration project was just completed during baseline characterization. This action accounts for maturation of this project for analysis future conditions.	North-1
N367-Floodplain Restore	Project location is unused baseball diamond and privately-owned property in the NE corner of the 195th / I-405 interchange. Includes levee setback and creation off high-flow channel in baseball field, with LWD used as hydraulic control. Main flows would remain in existing channel. LWD would be added throughout channel, including parcel south of 195th. Creates pool habitats throughout the project N and S of 195th, with off-channel habitat in the baseball field. See monitoring report for Twin Creeks restoration for LWD levels.	North-1 & 2
N373-Floodplain Restore	Project is in the lower section of North-4 in a field directly north of 228th. Berm on the west side of property re-directs flows around the north and east side of field. City has a stormwater pond on the south side of property adjacent to 228th. Project would create side-channel habitat in bypass channel, add LWD from berm to 228th, and restore riparian condition.	North-3 & 4
N375 - Thrasher Corner Wetland Enhance	Project is to enhance riparian vegetation and add structure using placement of LWD. Not likely to form a single channel due to high sediment loads, likely to stay a dendritic channel. LWD may fill with sediment, action effectiveness assumptions based on assumption that project will not attempt to re-engineer plan-form of channel. Instead project will focus on increasing riparian function.	North-3 & 4
N377-Twin Creeks Restoration	Expand existing restoration project upstream and downstream in North Creek. Restore riparian vegetation, add LWD, and enhance side channel habitat. Approximately 600' of enhancement. Existing restoration site is at confluence of Tambark/Silver Cr and North Creek by the mobile home park. According to monitoring report provided by Frank Leonetti, completed restoration project is 317 m long. This section has highest levels of LWD in North Creek. Existing work shows high effectiveness at restoring pool habitats.	North-4 & 5

Issaquah Creek:

Action	Description	Reaches affected by Action
I225 - Issaquah Greenway Acquisitions I224 - restoration	Purchase of surrounding wetlands upstream of hatchery dam (Issaquah-7) and downstream of Sycamore. This project assumed to include channel restoration – reestablish channel meander, removal bank hardening where present, and possibly creating some off-channel habitat by excavating a backwater pool with an upstream pond/channel.	Issaquah-6 & 7
I223&I222 - Johnson & Wildwood Acquisition and I219/I220 - Riparian Revegetation	Johnson Property - 8 acre forested area on RB of Issaquah Creek downstream of hatchery dam – Issaquah-6. Possible high density development with 100' setback. This property combined with I222 would help protect riparian inside the Issaquah City limits. Wildwood - acquisition of private property on LB of Issaquah-6 downstream of Johnson. No real restoration actions planned with these projects other than some passive riparian restoration. Wildwood action would buy out opposite bank and allow passive riparian restoration. This would prohibit landscaping and clearing in place by landowners on these small parcels. No changes to channel structure - assume a slight increase in LWD in channel but hazard trees will be removed by the City of Issaquah. Assumed no changes to channel structure.	Issaquah-6
I208 - Bush Lane Acquisition and I206 - Riparian revegetation and channel restoration	This is inside the Issaquah urban growth area. Potential for high density development in this area. Expensive to acquire, but combined with protection/restoration currently underway on LB (Pickering Place), could create a large protected/restored section of Issaquah Creek on both banks and some of lower NF Issaquah. This will acquire property on RB of stream in Issaquah-2 and LB of NF Issaquah-1. Property is just upstream of NF confluence and downstream of I-5. We discussed restoration associated with the property (riparian, in-channel LWD, removal of bank hardening where appropriate, and reestablish channel meander). A smaller fraction of NF Issaquah affected by this action.	Issaquah-1 & 2 and NF Issaquah-1
I207 - Pickering Riparian revegetation and channel restoration	Issaquah-2 - Pickering reach; located between SE 56th Street and I-90. Stream restoration along 1,800 ft of west bank Issaquah Creek within 200 ft shoreline setback. Restoration assumed to include removal of hardened banks, floodplain restoration, side channels, riparian enhancements. Extension of work conducted by City of Issaquah in 1998.	Issaquah-1 & 2
I-214 - Juniper Acquisition and I-212, Riparian revegetation and channel restoration	A small 2 acre property that could be developed. This might include a small restoration component if purchased. Scale is limited because of infra-structure. This will affect the lower portion of Issaquah-4. Mostly a narrow area of moderately high quality riparian forest. The acquisition is not connected to any other properties. Downstream of Anderson but separated by a road crossing.	Issaquah-4
I211 - Issaquah Cr Park Riparian revegetation and channel restoration	Just downstream of Anderson parcel (I215) – Issaquah-4. Propose to restore instream habitat features on city owned park land. This is an urban restoration project with moderate effectiveness because of constraints from surrounding development. LWD placement will be moderate (not to levels of historical density). Action will also include some riparian replanting and removal of bank hardening.	Issaquah-4
I215/I213/I285 & I216/I282/ I283 - Anderson & Parks Fac Riparian revegetation and channel restoration	This includes the restoration side of I215. This action also includes restoration activities at City of Issaquah maintenance facility at confluence of EF Issaquah Creek. Action described as placement of wood to stabilize banks and create fish habitat, removal of bank hardening where feasible and riparian replanting. This is not thought to be a large source of sediment of other pollutants to channel. Action will mostly improve a degraded section of Issaquah Creek in the city. Riparian restoration in the city is limited because of risk of hazard trees and possibility of LWD affecting channel flow in unwanted ways. The action might include some off-channel habitat on the Anderson property or at confluence but will be very limited.	Issaquah-4 & EF Issaquah-1

Action	Description	Reaches affected by Action
I226&I227 - Squak Valley Riparian revegetation and channel restoration Add I228?	City of Issaquah and ACOE are proposing to enhance portions of creek to improve habitat complexity and riparian forest. City is not willing to simply let natural processes take over. Any restoration will be engineered solutions. We considered such actions as creating off-channel areas connected to stream, some careful removal of an old levee keeping stream in current channel, some placement of LWD and active riparian restoration. In all, restoration will be tightly managed to avoid unintended effects. Projects are South Squak (City of Issaquah) and North Squak (ACOE). Description no longer fits.	Issaquah-7 & 8
I202 Sammamish Park Riparian revegetation and channel restoration	Some discussion as to exactly what is the desired future condition for this reach. We thought the stream had been relocated at the mouth, straightened (LIDAR shows some remnant channels), and ditched. We considered reconnecting the historic channels and allowing creek to reestablish its historic meander. We assumed LWD can be restored to historic counts. Riparian restoration to help with natural recruitment of LWD, shade, and channel complexity. Lower portion of reach is backwater from lake and may not have much channel restoration potential (we considered placement of LWD to provide refuge from predators).	Issaquah-1
I230 15 Mile Confluence Riparian revegetation and channel restoration	This action requires working with private landowners to change behavior along the stream. Issues are bank hardening, landscaping to edge of stream, removal of wood from channel, and use of yard chemicals. Restoration effectiveness will be dependent on willing landowners. Action restoration assumptions assumed to be fairly low (5 – 10% effectiveness).	Issaquah-9
I231 Gleason Cr Riparian revegetation and channel restoration	Remove a section of bank hardening that is maintained by King County - lower portion of Issaquah-9. Area affected is downstream of 113th Street crossing. Need to maintain stable bank due to flooding concerns, but intent is to use more natural, fish friendly bank stabilization.	Issaquah-9
I240&I243 Four Creek Riparian revegetation and channel restoration	This action requires working with private landowners to change behavior along the stream. Issues are bank hardening, landscaping to edge of stream, removal of wood from channel, and use of yard chemicals. Restoration effectiveness will be dependent on willing landowners. We thought this might be difficult unless some success stories (e.g., successful use of natural techniques to protect banks) were available to help educate people. Action restoration assumptions will be fairly low (5 – 10% effectiveness).	Issaquah-11
I234&I236 McDonald Cr Confluence Riparian revegetation and channel restoration	This action requires working with private landowners to change behavior along the stream. Issues are bank hardening, landscaping to edge of stream, removal of wood from channel, and use of yard chemicals. Restoration effectiveness will be dependent on willing landowners. We thought this might be difficult unless some success stories (e.g., successful use of natural techniques to protect banks) were available to help educate people. Action restoration assumptions will be fairly low (5 – 10% effectiveness).	Issaquah-10 & 11
I244 Log Cabin Riparian revegetation and channel protection	This is a large acquisition that has been in the works for several years. Currently 118 acres protected and a few remaining areas have offers – total 155 acres. This action protects a large portion of Issaquah-11. The reach is in moderately good condition. Any development would be 5 acre lots with 25' riparian buffer. Most restoration will be passive with some removal of non-native species and replanting. No in-channel restoration planned	Issaquah-10 & 11
I249 Issaquah Waterways Riparian revegetation and channel protection	This is a conservation easement affecting lower Issaquah-12. Same development possibility as the Log Cabin reach – 5 acre with 25' riparian buffer. Easement will set aside 21 development units and allow 3 to be developed as part of a 120 acre tract (total 24 units). Includes expansion of riparian buffer along stream. Restoration will be active riparian (with removal of invasive vegetation and replanting desired species) restoration. Property is a combination of forest and cleared fields.	Issaquah-11 & 12

Action	Description	Reaches affected by Action
I250 Carey/Holder Confluence Riparian revegetation and channel protection	Action includes upper portion of Issaquah-12 and lower portions of Holder and Carey creeks. This acquisition will be purchase of property and may include active riparian restoration. Includes expansion of riparian buffer. Restoration will be active riparian (with removal of invasive vegetation and replanting desired species) restoration. Property is a combination of forest and cleared fields. Development pressure is same as I244 and I249.	Issaquah-12, Holder-1 & Carey-1
I253, I254, & I255 Issaquah Waterways Carey Riparian revegetation and channel protection	Carey Creek reaches 1 and 2. Proposed to work with landowners to purchase easements where possible. Includes passive restoration. No large tracts were identified, simply pick up easements were possible.	Carey-1 & 2
I__ - Provide for adult passage Issaquah Hatchery Intake Weir	Removes upstream passage barrier at hatchery intake weir during all periods (currently a barrier at low flows during portion of Chinook migration)	Hatcher Intake Fish Ladder

Appendix B – Reach geographic areas used in analysis of restoration and protection priorities and scenario benefits for WRIA 8 Chinook.

Cedar River:

Stream	Geographic Areas	EDT Reaches	Description
Cedar River	Cedar River - Mouth	Cedar-1	Cedar River from mouth to Logan St Bridge (RM 1.0)
	Cedar River - Renton	Cedar-2	Cedar River from Logan St Bridge (RM 1.0) to I-405 (RM 1.6)
	Cedar River – Maplewood	Cedar-3	Cedar River from I-405 (RM 1.6) to SR 169 Bridge (RM 4.2)
	Cedar River - Ron Regis Park	Cedar-4	Cedar River from SR 169 Bridge (RM 4.2) to upstream of Landslide (RM 4.7)
	Cedar River - Bucks Curve	Cedar-5	Cedar River from SR 169 Bridge (RM 4.2) to upstream of Landslide (RM 4.7)
	Cedar River - Cedar Rapids	Cedar-6 & 7	Cedar River from RM 5.8 to RM 8.2
	Cedar River - Rainbow Bend	Cedar-8, 9 & 10	Cedar River from RM 8.2 to just downstream of Taylor Cr (RM 12.7)
	Cedar River - Lions Club	Cedar-11	Cedar River from just downstream of Taylor Cr (RM 12.7) to RM 13.8
	Cedar River - Royal Bend	Cedar-12	Cedar River from RM 13.8 to RM 14.3
	Cedar River - Dorre Don	Cedar-13, 14 & 15	Cedar River from RM 14.3 to RR Trail Crossing at RM 17.0
	Cedar River - Below Landsburg	Cedar-16, 17 & 18	Cedar River from RR Trail Crossing at RM 17 to Landsburg Dam (RM 21.7)
	Cedar River Landsburg Dam	Cedar R Landsburg Dam	Landsburg Dam on the Cedar River (RM 21.7)
	Cedar River - Above Landsburg	Cedar-19, 20, 21, 22, 23, 24, 25, 26, 27 & 28	Cedar River from Landsburg Dam (RM 21.7) to Lower Cedar Falls (RM 34.3)
Taylor Creek	Taylor/Downs Creek	Taylor/Downs-1	Taylor/Downs Creek from mouth to Maxwell Rd Crossing (RM 0.4)
Peterson Creek	Peterson Creek	Peterson-1	Peterson Creek from mouth to RM 0.5; stream begins to increase in gradient and enters ravine.
Rock Creek	Rock Creek (lower basin)	Rock-1, 2, Rock Creek Culvert, Rock-3, 4A, 4B, & 5	Rock Creek from mouth to RM 0.65
Rock Creek (upper basin)	Rock Creek (upper basin)	Rock (upper basin)-1	'Rock Creek from mouth to 40/18 Rd junction (RM 1.6 Walsh Ditch diversion)
Taylor Creek (upper)	Taylor Creek (upper basin)	Taylor (upper basin)-1	Taylor Creek (upper basin tributary) from mouth to RR grade/bridge (RM 0.03)
Walsh Ditch	Walsh Ditch	Walsh Ditch-1	Walsh Ditch from mouth to RM 0.2 (bottom of ravine)

Sammamish River:

Stream	Geographic Areas	EDT Reaches	Description
Sammamish River	Sammamish R – Lake Washington	Sammamish-1A	Mouth to upper extent template delta (68th St Bridge)
	Sammamish R – Bothell	Sammamish-1B & 2	Upper extent template delta (68th St Bridge) to North Creek Confluence
	Sammamish R – Woodinville	Sammamish-3A	North Creek Confluence to 175th St (downstream end of agriculture area)
	Sammamish R – 116th St to 175th St.	Sammamish-3B & 4A	175th St (downstream end of agriculture area) to 116th St (Redmond City Boundary)
	Sammamish R – Redmond	Sammamish-4B & 5	116th St (Redmond City Boundary) to confluence Bear Creek

Bear Creek:

Stream	Geographic Area	EDT Reaches	Description
Bear Creek	Bear Creek – Redmond	Bear-1	Bear Creek from mouth to bottom of restoration reach
	Bear Creek – Restoration Project	Bear-2	Bear Creek from bottom of restoration reach to RR tracks (WDFW trap)
	Bear Creek – Avondale	Bear-3	Bear Creek from RR tracks (WDFW trap) to Avondale Rd Crossing (potential restoration reach)
	Bear Creek – Keller Farm	Bear-4 & 5	Bear Creek from Avondale Rd Crossing (potential restoration reach) to Trailer Park (Keller Farm reach)
	Bear Creek – Cottage Lake Cr area	Bear-6 & 7	Bear Creek from Trailer Park (top Keller Farm reach) to 133rd St (King County gage site)
	Bear Creek – Rural	Bear-8, 9, 10, 11, 12, 13 & 14	Bear Creek from 133rd St (King County gage site) to upper extent Chinook in Bear Creek (0.5 miles upstream of Woodinville-Duvall Rd)
Evans Creek	Evans Creek – Redmond	Evans-1 & 2	Mouth to Union Hill Rd Crossing
	Evans Creek	Evans-3, 4, 5, 6 & 7	Union Hill Rd Crossing to 224th St Rd Crossing
Cottage Lake Creek	Cottage Lake Creek	Cottage-1, 2, 3, 4 & 5	Cottage Creek from mouth to confluence with Cold Creek

Little Bear Creek:

Stream	Geographic Areas	EDT Reaches	Description
Little Bear Creek	Little Bear Cr – Woodinville	Little Bear-1 & 2	Little Bear from mouth to Hwy 522 Crossing
	Little Bear Cr - Hwy 522	Little Bear-3 & 4	Little Bear from Hwy 522 Crossing to begin industrial reach (Alpine Rocky Industrial)
	Little Bear Cr – Alpine Rockeries Site	Little Bear-5	Little Bear from begin industrial reach (Alpine Rocky Industrial) to confluence Howell Creek (top of industrial area)
	Little Bear Cr – Brightwater Site	Little Bear-6	Little Bear from confluence Howell Creek (top of industrial area) to Canyon Park Culvert (Brightwater site)
	Little Bear Cr - Rural	Little Bear-7, 8 & 9	Little Bear from Canyon Park Culvert (upstream end of Brightwater site) to Little Bear Rd culvert
	Little Bear Cr – Upper	Little Bear-10, 11 & 12	Little Bear from Little Bear Rd culvert to upper extent Chinook potential (nr Silver Firs Subdivision)
Great Dane Creek	Great Dane Creek	Great Dane-1 & 2	Great Dane Creek from mouth to upper extent Chinook potential (0.25 miles)

North Creek:

Stream	Geographic Areas	EDT Reaches	Description
North Creek	North Creek – UW Bothell	North-1	North Creek from mouth to top of Cascadia Restoration project
	North Creek – Business Park	North-2	North Creek from top of Cascadia Restoration project to upstream end of business park
	North Creek – Lower Rural	North-3	North Creek from upstream end of business park to 228th SE Canyon Park Rd Crossing
	North Creek – Thrasher Corner	North-4	North Creek from 228th SE Canyon Park Rd Crossing to 208th St Culvert
	North Creek 208th Culvert	North 208th Culvert	North Creek 208th St Culvert
	North Creek – Twin Creek area	North-5	North Creek from 208th St Culvert to 196th St culvert
	North Creek 196th Culvert	North 196th Culvert	North Creek 196th St culvert
	North Creek – Mill Creek wetlands	North-6 & 7	North Creek from 196th St culvert to confluence Penny Creek (begin Mill Creek development around 164th)
	North Creek – Mill Creek area	North-8	North Creek from confluence Penny Creek (begin Mill Creek development area ~164th) to top end of Mill Creek development area (approx 156th)
	North Creek – McCollum Park	North-9 & 10	North Creek from upper end of Mill Creek development area (approx 156th) to 128th Crossing
Penny Creek	Penny Creek	Penny-1	Penny Creek from mouth to retention pond
Silver Creek	Silver Creek	Silver-1	Silver Creek from mouth to 196th Culvert

Issaquah Creek:

Stream	Geographic Areas	EDT Reaches	Description
Issaquah Creek	Issaquah Cr – Lk Sam Park	Issaquah-1	Issaquah Creek from mouth to confluence with NF Issaquah Creek
	Issaquah Cr – Issaquah Urban	Issaquah-2, 3,4 5 & 6	Issaquah Creek from confluence with NF Issaquah Creek to Hatchery Water Intake Fish Ladder
	Issaquah Cr – Hatchery Weir	Issaquah Fish Hatch Weir	Issaquah Creek Fish Hatchery Weir
	Issaquah Cr – Hatchery Water Intake	Hatcher Intake Fish Ladder	Issaquah Creek Fish Hatchery Water Intake Fish Ladder
	Issaquah Cr – Issaquah Rural	Issaquah-7, 8 & 9	Issaquah Creek from Hatchery Water Intake Fish Ladder to confluence with 15 Mile Creek
	Issaquah Cr – Three Creeks area	Issaquah-10	Issaquah Creek from confluence with 15 Mile Creek to confluence with McDonald Creek
	Issaquah Cr – Log Cabin	Issaquah-11	Issaquah Creek from confluence with McDonald Creek to Cedar Grove Rd
	Issaquah Cr – Issaquah Waterways	Issaquah-12	Issaquah Creek from Cedar Grove Rd to confluence with Holder and Carey creeks
NF Issaquah Creek	NF Issaquah Cr – Issaquah Urban	NF Issaquah-1 & 2	NF Issaquah from mouth to 66th St (beginning ravine)
	NF Issaquah Cr – Upper	NF Issaquah-3	NF Issaquah from 66th St (beginning ravine) to upper extent Chinook potential.
EF Issaquah Creek	EF Issaquah Cr – Issaquah Urban	EF Issaquah-1, 2 & 3	EF Issaquah Creek from mouth to High Point
McDonald Creek	McDonald Creek	McDonald-1	McDonald Creek from mouth to confluence with tributary 0212A
Fifteen mile Creek	Fifteen mile Creek	15Mile-1 & 2	Fifteen mile Creek from mouth to 240th St.
Holder Creek	Holder Creek	Holder-1, 2, 3	Holder Creek from mouth to SR 18 crossing.
Carey Creek	Carey Creek	Carey-1, 2, 3, & 4	Carey Creek from mouth to falls
	Carey creek 276th Culvert	Carey 276th Culvert	Carey Creek 276th St Crossing

Appendix C

Summary EDT Assessment Start-List Actions for Issaquah Creek

April 14, 2006

Introduction

This summary is a brief overview of action assumptions and EDT model results for the Issaquah Creek Start List actions. This analysis addresses the restoration benefits of these actions. Protection benefits will be evaluated at a later date along with effects of alternative land use scenarios in the watershed.

Issaquah Creek actions were described at a workshop in mid-September with King County, the City of Issaquah and WDFW. The City of Issaquah and King County help describe the location and the broad objectives of each action in the Start List. Note from this discussion were translated by Greg Blair (Mobrand Jones & Stokes) into specific effectiveness assumptions for the EDT model. Effectiveness assumptions were developed to be consistent with for other WRIA subbasins with similar actions. Concerns of damage to infrastructure within the City of Issaquah constrained expectations of actions that increased in-stream wood and channel migration more than in other WRIA 8 subbasins.

This summary includes revisions identified at the March WRIA 8 Technical Committee meeting. These revisions include input errors for actions I202, I207 and I208 and a revision to trajectory juvenile timing patterns. Specifically, habitat type effectiveness assumptions were incorrectly entered (glides were not included in the effectiveness table) such that juvenile capacity results exceeded template conditions. Juvenile outmigration timing was revised such that 70 percent of the trajectories remained in Issaquah Creek for 4 to 8 weeks before migrating and 30 percent migrate as newly emerged fry. Previously this composition was closer to 50:50.

Overview Analytical Process

The analysis of actions in EDT includes assessment of three baseline reference conditions (Figure 1). These conditions represent an assessment of the current condition, the template condition, and a hypothetical degraded condition. With these reference conditions, the EDT model is used to analyze a wide range of actions that can directly or indirectly modify salmon habitat. The actions are categorized into three types, depending upon their effect on the existing environment:

- restoration
- protection
- degradation

A restoration action is one that improves conditions for salmon; it partially or fully restores one, or more, condition to its pristine state. A protection action is one that partially or fully prevents any further deterioration of the stream from its current state.

A degradation action, or event or activity, is one that worsens a condition for salmon survival compared to its current state.

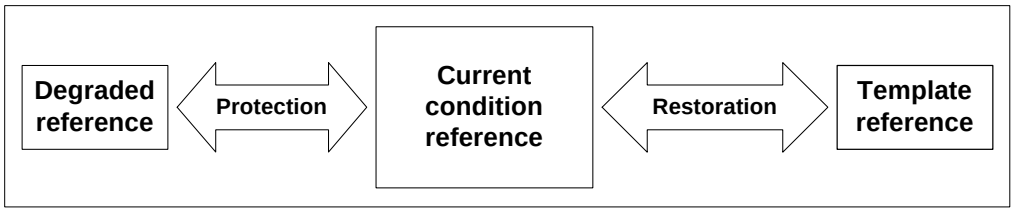


Figure 1. The EDT Framework for defining actions. Three reference points for modeling action effectiveness assumptions.

The effectiveness of any action, if actually implemented, is dependent upon how well the action addresses the cause of the problem, at the appropriate reach and/or watershed scale (Roper et al., 1997; Dewberry and Doppelt, 1996). A challenging aspect of evaluating action effectiveness prior to implementation in a watershed is making assumptions about how that action will operate within the context of the physical, chemical, and ecological processes at work in that watershed. This requires including people familiar with the watershed in the development of assumptions.

In EDT, restorations actions are positive attribute effectiveness assumptions with values between 0.0 and 1.0. These positive assumptions move the attribute ratings toward those in the template condition (the template condition represents full restoration potential). Therefore, an effectiveness rating of 1.0 represents full restoration of an attribute, a rating between 0.0 and 1.0 represents partial restoration, and a rating of 0.0 represents no restoration (Figure 2).

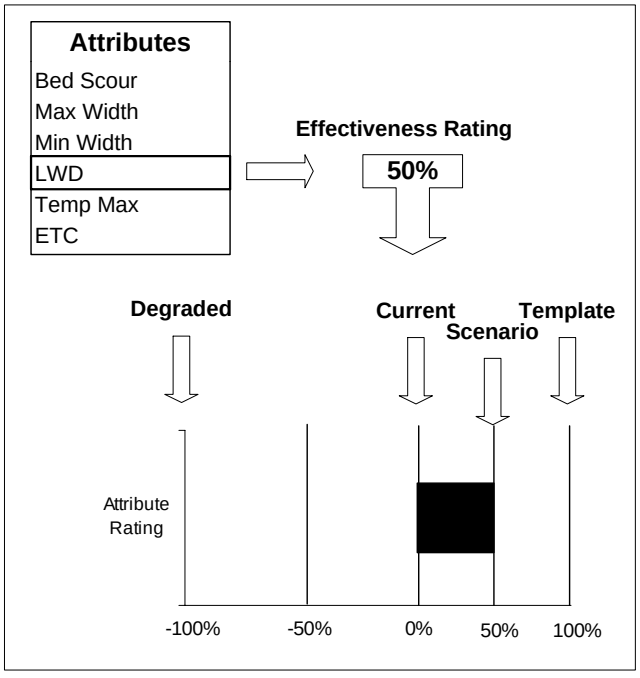


Figure 2. The effect of a restoration action that implements a 50% effectiveness assumption for LWD. The dark bar represents the increase in rating potential for the scenario.

Actions are typically combined in the EDT model using a formula that assumes that actions operate on the remaining potential. Restoration actions are combined as follows:

$$E_R = 1 - \prod_{i=1}^{N} 1 - e_i \qquad \text{Equation 1}$$

Where e is the action effectiveness rating for a particular attribute/reach and E_R is the combined restoration effectiveness.

The new rating for scenario S is calculated by:

$$R_S = \left[(R_T - R_C) \times E_R \right] + R_C \qquad \text{Equation 2}$$

Where in equation 2, R is the attribute rating for scenario C for the current condition and scenario T for the template condition.

For example, take two actions each with 50% restoration effectiveness. The first action will restore 50% of the difference between the current and template reference conditions. Implementing the second action will restore 50% of the remaining difference (in this example the total restoration is 75%). Results are independent of the order of the actions.

Some actions are of a nature that suggest that Equation 1 should be additive instead of multiplicative. For example, an additive approach is more appropriate when two actions affect the same attribute and reach, but at different locations within the reach. A good example is two actions that remove bank hardening in different locations in the same reach. The overall effectiveness of bank hardening removal would be the sum of the two actions. Several actions were combined using the additive model for analysis of the overall Start List scenarios. These are presented in the results as a combined action.

Issaquah Creek Start List Actions

Table 1 list the Start List actions entered for Issaquah Creek. Actions that were combined for scenario the analysis are identified in Table 2. These combined actions were used only for the combined Start List scenario.

The Start List actions included several that were primarily protection type actions. However, these actions also included a restoration component (passive and active) and were included in the analysis.

Actions were described for a 10 yr future and a 25 yr future. These are termed “Lag Time” in EDT. They represent our effectiveness expectations for 10 and 25 yrs after implementation. Specific effectiveness assumptions for each action and combined actions are described in the Excel file “Issaquah Creek ActionEffectTable_2-13-06_For Distribution.xls”

Table 1. Issaquah Creek Start List actions.

Action Name	Objective	Description	Comments
I202 - Sammamish Park Restoration	Improve habitat complexity to reduce predation, provide rearing habitat and if possible reduce summer temperatures.	Action will affect Issaquah-1. Some discussion as to exactly what is the desired future condition for this reach. We thought the stream had been relocated at the mouth, straightened (LIDAR shows some remnant channels), and ditched. We discussed reconnecting the historic channels and allowing creek to reestablish its historic meander. We will assume LWD can be restored to historic counts. Riparian restoration to help with natural recruitment of LWD, shade, and channel complexity. Lower portion of reach is backwater from lake and may not have much channel restoration potential (we discussed placement of LWD to provide refuge from predators).	Assuming a very extensive channel reconfiguration - high restoration effectiveness. Affecting entire length of Issaquah-1
I207 - Pickering Place Riparian	Channel and riparian restoration associated with Pickering Place	Issaquah-2 - Pickering reach; located between SE 56th Street and I-90. Stream restoration along 1,800 ft of west bank Issaquah Creek within 200 ft shoreline setback. Restoration could included removal of hardened banks, floodplain restoration, side channels, riparian enhancments. Extension of work conducted by City in 1998.	This action was described in meeting handouts but not discussed in detail at workshop. Reduced effectiveness because of limitations with Pickering Place development. Can only work within 200 ft setback. Effectiveness assumptions are less than I208 because basic assumption that unrestricted access to floodplain (I208) will be more effective than restricted access as part of a shoreline setback like I207.
I208 - Bush Lane Acq and Restoration	Channel and riparian restoration associated with Bush Lane Acquisition; does not include Pickering action	This is inside the Issaquah urban growth area. Potential for high density development in this area. Expensive to acquire, but combined with protection/restoration currently underway on LB (Pickering Place), could create a large protected/restored section of Issaquah Creek on both banks and some of lower NF Issaquah. This will acquire property on RB of stream in Issaquah-2 and LB of NF Issaquah-1. Property is just upstream of NF confluence and downstream of I-5. We discussed restoration associated with the property (riparian, in-channel LWD, removal of bank hardening where appropriate, and reestablish channel meander). A smaller fraction of NF Issaquah affected by this action.	Bush Lane action would cover ~75% of RB of Issaquah-2. Also need to consider how this action combines with Pickering Place action I207 (LB Issaquah-2)

Action Name	Objective	Description	Comments
I211 - Issaquah Park Restoration	Channel and riparian restoration associated on city owned land; urban restoration project	Just downstream of Anderson parcel (I214) – Issaquah-4. Propose to restore instream habitat features on city owned park land. This is an urban restoration project with moderate effectiveness because of constraints from surrounding development. LWD placement will be moderate (no where near historical loading). Action will also include some riparian replanting and possibly some removal of bank hardening.	Urban stream restoration project on city owned land. Wood imported and anchored to remain in project area. Low likelihood of new wood recruited to reach from upstream or riparian. Project is adjacent to Anderson Acq and upstream of Juniper Acres. This action is just the city park restoration. Combined actions are assumed to be additive and should be modeled together as a single action.
I215 - Juniper Acres Acq and Restoration	Channel and riparian restoration associated with purchase Juniper Acres property	A small 2 acre property that could be developed. This might include a small restoration component if purchased. Scale is limited because of infra-structure.This will affect the lower portion of Issaquah-4. Mostly a narrow area of moderately high quality riparian forest. The acquisition is not connected to any other properties. Downsteam of Anderson but separated by a road crossing.	Restoration action associated with Juniper property. Small amount of active restoration assumed for this acquistion based on workshop notes. Very small property low effect on reach (~25% of Issaquah-4 affected)
I216 & I282 - Anderson and Parks Fac Restore	Channel and riparian restoration associated with purchase Anderson property and relocating City Maintenance Facility	This includes the restoration side of I214. This also includes restoration activities at City of Issaquah maintenance facility at confluence of EF Issaquah Creek. Action will affect Issaquah 4 and EF Issaquah-1. Action described as placement of wood to stabilize banks and create fish habitat, removal of bank hardening where feasible and riparian replanting. This is not thought to be a large source of sediment of other pollutants to channel. Action will mostly improve a degraded section of Issaquah Creek in the city. Riparian restoration in the city is limited because of risk of hazard trees and possibility of LWD affecting channel flow in unwanted ways. The action might include some off-channel habitat on the Anderson property or at confluence but will be very limited.	Restoration action associated with Anderson property and city Parks Maintenance factility (LB EF). Active restoration assumed for this acquistion based on workshop notes. Very small property low effect on reach (~25% of Issaquah-4 affected - 50% of EF Issaquah-1). I-214 Anderson Acq was modeled as a protection action. This action describes restoration benefits of the acquistion in conjunction with restoration actions with the City Maintenance Facility. The comined action is only relevant if I214 is implemented.
I222 & I223 - Johnson and Wildwood Restoration	Protect riparian inside the Issaquah City limits. Including passive riparian restoration	Johnson Property - 8 acre forested area on RB of Issaquah Creek downstream of hatchery dam – Issaquah-6. Possible high density development with 100' setback. This property combined with I222 would help protect riparian inside the Issaquah City limits. Wildwood - acquisition of private property on LB of Issaquah-6 downstream of Johnson. No real restoration actions planned with these projects other than some passive riparian restoration. Wildwood action would buy out opposite bank and allow passive riparian restoration. This would prohibit landscaping and clearing in place by landowners on these small parcels. No changes to channel structure - assume a slight increase in LWD in channel but hazard trees will be removed by the City of Issaquah. Assumed no changes to channel structure.	Both actions combined because affecting same reach and identical effects

Action Name	Objective	Description	Comments
I225 - Issaquah Greenway Restoration	Acquisition and restoration wetland Issaquah Creek - Issaquah-7	Purchase of surrounding wetlands upstream of hatchery dam (Issaquah-7) and downstream of Sycamore. This project assumed to include channel restoration – reestablish channel meander, removal bank hardening where present, and possibly creating some off-channel habitat by excavating a backwater pool with an upstream pond/channel.	Discussion suggested that there was a low likelihood that this area will be developed as most is classified a wetland and is unbuildable with today's zoning.
I226 & I227 - Squak Valley Restoration	Acquisition and restoration floodplain habitat along RB Issaquah-8	Estimate that about ½ of Issaquah-8 will be affected by these actions. Appears that creek was straightened and ditched in the section. City of Issaquah and ACOE are proposing to enhance portions of creek to improve habitat complexity and riparian forest. City is not willing to simply let natural processes take over. Any restoration will be engineered solutions. We discussed such actions as creating off-channel areas connected to stream, some careful removal of an old levee keeping stream in current channel, some placement of LWD and active riparian restoration. We did not discuss specific effectiveness assumptions, but general tenor of discussion suggested moderate effectiveness values. In all, restoration will be tightly managed to avoid unintended effects. Projects are South Squak (City of Issaquah) and North Squak (ACOE).	RB Issaquah Creek - fairly aggressive restoration with engineered solutions. LB of creek has homes
I230 15 Mile Cr Confl Restoration	Working with private landowners to change riparian land use practices; bank hardening, landscaping, LWD removal.	Same as I234 and I236 – this action requires working with private landowners to change behavior along the stream. Issues are bank hardening, landscaping to edge of stream, removal of wood from channel, and use of yard chemicals. Restoration effectiveness will be dependent on willing landowners.. Action will affect upper Issaquah-9. Action restoration assumptions will be fairly low (5 – 10% effectiveness).	Project includes education and demonstration of fish friendly riiparian management. Low effectiveness when considering entire reach.
I231 Gleason Restoration	Instream channel enhancement by removing bank hardening or install "fish friendly" bank structures.	Remove a section of bank hardening that is maintained by King County - lower portion of Issaquah-9. Area affected is downstream of 113th Street crossing. Need to maintain stable bank due to flooding concerns, but intent is to use more natural, fish friendly bank stabilization. Compared to I230, assume a slightly higher effectiveness for this action as it does not require cooperation with landowners.	Remove bank hardening in Issaquah Creek
I234 & I236 McDonald Confl Restoration	Working with private landowners to change riparian land use practices; bank hardening, landscaping, LWD removal.	This action requires working with private landowners to change behavior along the stream. Issues are bank hardening, landscaping to edge of stream, removal of wood from channel, and use of yard chemicals. Restoration effectiveness will be dependent on willing landowners. We thought this might be difficult unless some success stories (e.g., successful use of natural techniques to protect banks) were available to help educate people. Action will affect upper Issaquah-10 and lower Issaquah-11. Action restoration assumptions will be fairly low (5 – 10% effectiveness).	Project includes education and demonstration of fish friendly riiparian management. Low effectiveness when considering entire reach.

Action Name	Objective	Description	Comments
I240 & I243 Four Creek Restoration	Working with private landowners to change riparian land use practices; bank hardening, landscaping, LWD removal.	This action requires working with private landowners to change behavior along the stream. Issues are bank hardening, landscaping to edge of stream, removal of wood from channel, and use of yard chemicals. Restoration effectiveness will be dependent on willing landowners. We thought this might be difficult unless some success stories (e.g., successful use of natural techniques to protect banks) were available to help educate people. Action will affect mid Issaquah-11. Action restoration assumptions will be fairly low (5 – 10% effectiveness). Action similar to I234, but farther upstream in another subdivision.	Consider this action with I234 & I 236. All affecting same reach of Issaquah
I244 Log Cabin Acq and Restoration	Passive and active riparian restoration with acquisition	This is a large acquisition that has been in the works for several years. Currently 118 acres protected and a few remaining areas have offers – total 155 acres. This action protects a large portion of Issaquah-11. The reach is in moderately good condition. Any development would be 5 acre lots with 25' riparian buffer. Most restoration will be passive with some removal of non-native species and replanting. No in-channel restoration planned	Active riparian restoration with removal invasive species and replanting; passive in-stream restoration with wood recruited from riparian, stream shade, and restoration natural channel process. Riparian is in moderately good shape, long term improving in-stream conditions. Action is affecting 75% of Issaquah-11
I249 Issaquah Waterways Acq and Restoration	Passive and active riparian restoration with acquisition	This is a conservation easement affecting lower Issaquah-12. Same development possibility as the Log Cabin reach – 5 acre with 25' riparian buffer. Easement will set aside 21 development units and allow 3 to be developed as part of a 120 acre tract (total 24 units). Acquiring easement is in process – offer has been made. Includes expansion of riparian buffer. Restoration will be active riparian (with removal of invasive vegetation and replanting desired species) restoration. Property is a combination of forest and cleared fields. Talking with Mary this action may also include some misc parcels within Issaquah-12 (middle reach); total approximately 150 acres.	Active riparian restoration with removal invasive species and replanting; passive in-stream restoration with wood recruited from riparian, stream shade, and restoration natural channel process. Riparian is in moderately good shape, long term improving in-stream conditions. Action is affecting 75% of Issaquah-12; used same assumptions as I244 for Log Cabin action
I250 Carey/Holder Confluence Acq and Restoration	Passive and active riparian restoration with acquisition	Similar to I249 only upstream at confluence affecting upper portion of Issaquah-12 (~15%) and lower Holder and Carey creeks (~25%). This acquisition will be purchase of property and may include active riparian restoration. Includes expansion of riparian buffer. Restoration will be active riparian (with removal of invasive vegetation and replanting desired species) restoration. Property is a combination of forest and cleared fields. Development pressure is same as I244 and I249.	Active riparian restoration with removal invasive species and replanting; passive in-stream restoration with wood recruited from riparian, stream shade, and restoration natural channel process. Riparian is in moderately good shape, long term improving in-stream conditions. Action is affecting top 15% of Issaquah-12 and bottom 25% of Holder-1 and Carey-1; used similar assumptions as I244 and I249. Adjusted to account for reach length affected by project.

Action Name	Objective	Description	Comments
I253 & I254 & I255 Issaquah Waterways Carey Acq	Passive and active riparian restoration with acquisition	Carey Creek reaches 1 and 2. Proposed to work with landowners to purchase easements where possible. Includes passive restoration. No large tracts were identified, simply pick up easements were possible.	Active riparian restoration with removal invasive species and replanting; passive in-stream restoration with wood recruited from riparian, stream shade, and restoration natural channel process. No particular parcels identified. Mary thought this action was more conservation easements than fee-simple acquisitions. Reduced effectiveness assumptions because of this. HOWEVER, action covers all of Carey-1 and Carey-2, effectiveness assumptions keep high (same as I249 for example) because entire reach affected.
Issaquah Hatchery Dam Passage	Allow unhindered adult passage chinook and coho	Removes upstream passage barrier at hatchery dam during all periods (currently a barrier at low flows)	

Table 2. Issaquah Actions combined for scenario analysis.

Action Name	Description
I208&I207 - Bush & Pickering Restore	Combined Action - These are inside the Issaquah urban growth area. Potential for high density development in this area. Expensive to acquire, but combined with protection/restoration currently underway on LB (Pickering Place), could create a large protected/restored section of Issaquah Creek on both banks and some of lower NF Issaquah. This will acquire property on RB of stream in Issaquah-2 and LB of NF Issaquah-1. Property is just upstream of NF confluence and downstream of I-5. We discussed restoration associated with the property (riparian, in-channel LWD, removal of bank hardening where appropriate, and reestablish channel meander). A smaller fraction of NF Issaquah affected by this action.
I215_I211_I216_I282 Restore	Combined Action - Action includes acquistion and restoration of 4 areas: Juniper Acres, Issaquah Creek Park, Anderson and Parks Maintenance facility. Together these actions would cover a majority of Issaquah 4 and create ~50 - 100 ft riparian buffer on both sides of stream. Juniper Acres is seperated from rest of project by road. This action should be used when evaluating combined benefit of these actions. Action is largely a urban enhancement project with limits because of infrastructure.
I230&I231 15 Mile & Gleason Cr Restore	Combined Action - I231 - remove a section of bank hardening that is maintained by King County - lower portion of Issaquah-9. Area affected is downstream of 113th Street crossing. Need to maintain stable bank due to flooding concerns, but intent is to use more natural, fish friendly bank stabilization. Compared to I230, assume a slightly higher effectiveness for this action as it does not require cooperation with landowners. This action is combined with I230 - working with private landowners to change behavior along the stream. Issues are bank hardening, landscaping to edge of stream, removal of wood from channel, and use of yard chemicals. Restoration effectiveness will be dependent on willing landowners.. Action will affect upper Issaquah-9. Action restoration assumptions will be fairly low (5 – 10% effectiveness).
I240_I243_I234_I236_I244 Iss-11 Restore	Combined Action - Combination of Log Cabin reach acquistion in upper Issaquah-11 and working with private land owners in lower Issaquah-11. Together these actions address all of Issaquah-11.

Analysis Baseline Model Results

Model timing of juveniles leaving Issaquah Creek is presented in Figure 3. The late February to early April migration represents juvenile life histories moving downstream into Lake Sammamish immediately after emergence. The later migration from mid April to early July represents larger juveniles that spent 4 to 8 weeks rearing in Issaquah Creek before migrating to sea.

Baseline population performance results for Issaquah Creek Chinook are summarized in Figure 4 and Table 3. As a result of habitat changes in all areas used by Issaquah Chinook:

Adult abundance is reduced by 99%,

Productivity is reduced by more than 90%,

Diversity index is reduced by 78%

Together these results show a population that is cannot sustain itself on natural production alone. These results suggest that naturally spawning Chinook in Issaquah Creek are sustained by strays from the Issaquah Creek Hatchery.

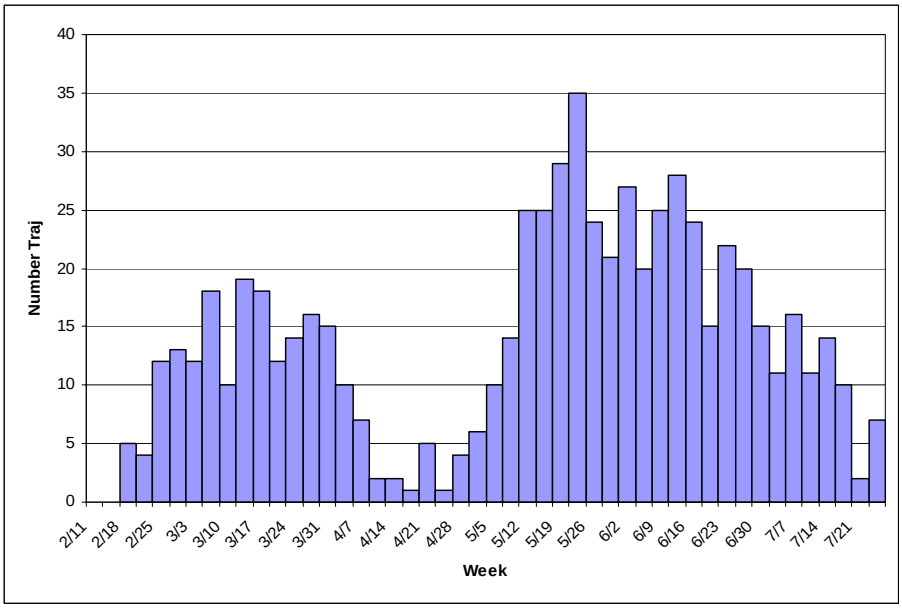


Figure 3. Life history timing of juvenile Chinook leaving Issaquah Creek used in the EDT model.

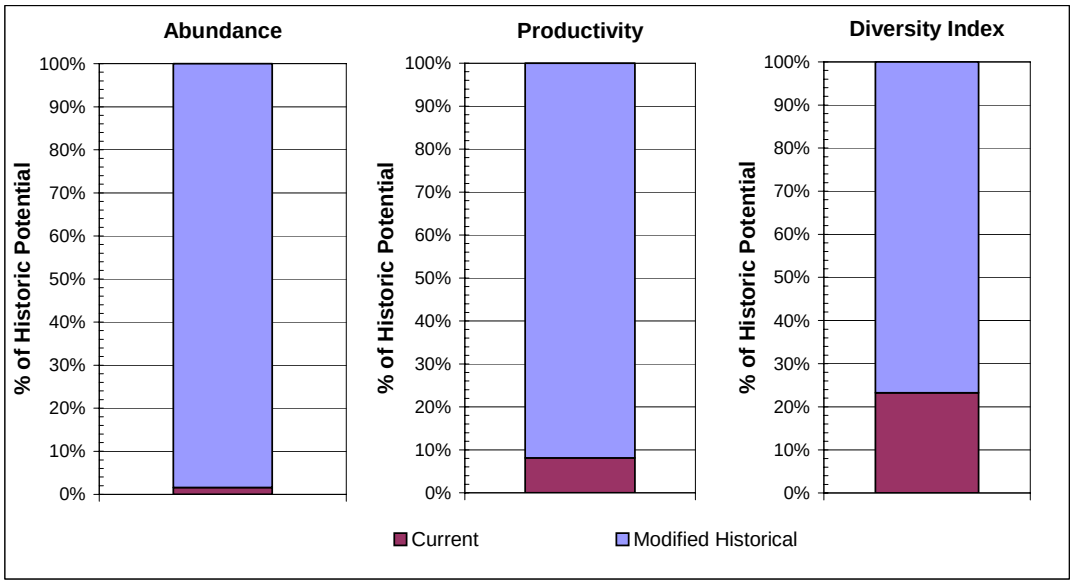


Figure 4. Population performance of Issaquah Creek Chinook as estimated from the EDT model.

Geographic area priorities for Issaquah Creek Chinook are summarized in Figure 5.

Protection values are generally low in all areas, indicating that the existing habitat is highly degraded and has low potential to support Chinook salmon; the Lake Sammamish State Park and the upper rural area of Issaquah Creek ranked highest for protection,

Restoration values are high in nearly all areas. The analysis includes areas outside of Issaquah Creek. Restoration value is highest for Lake Sammamish,

Within Issaquah Creek the upper watershed ranked highest for restoration.

Table 3. Issaquah Creek Chinook baseline results for adults back to spawning and juveniles leaving Issaquah Creek.

Scenario	Diversity Index	Prod	Capacity	Abundance
Adult Performance				
Current Condition	23%	1.16	294	41
Template (all areas)	100%	14.28	2,758	2,565
Juvenile Performance				
Current Condition	NA	384	223,702	14,675
Template (all areas)	NA	904	348,300	302,834

Adult passage obstruction is a key limiting factor for Issaquah Creek Chinook (Figure 6). Chinook distribution in Issaquah Creek is partially restricted to the lower 4.7 miles of the creek and to the E.F. and N.F. tributaries because of a hatchery water intake dam. Other limiting factors are habitat diversity in the urban portions of the watershed (includes the lower reaches of E.F. and N.F. Issaquah), and key habitat and sediment load in most areas.

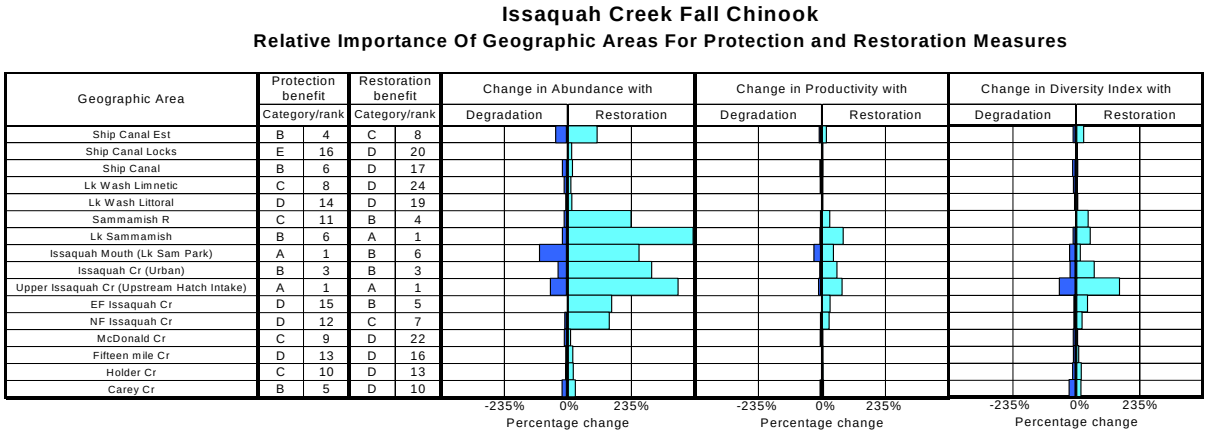
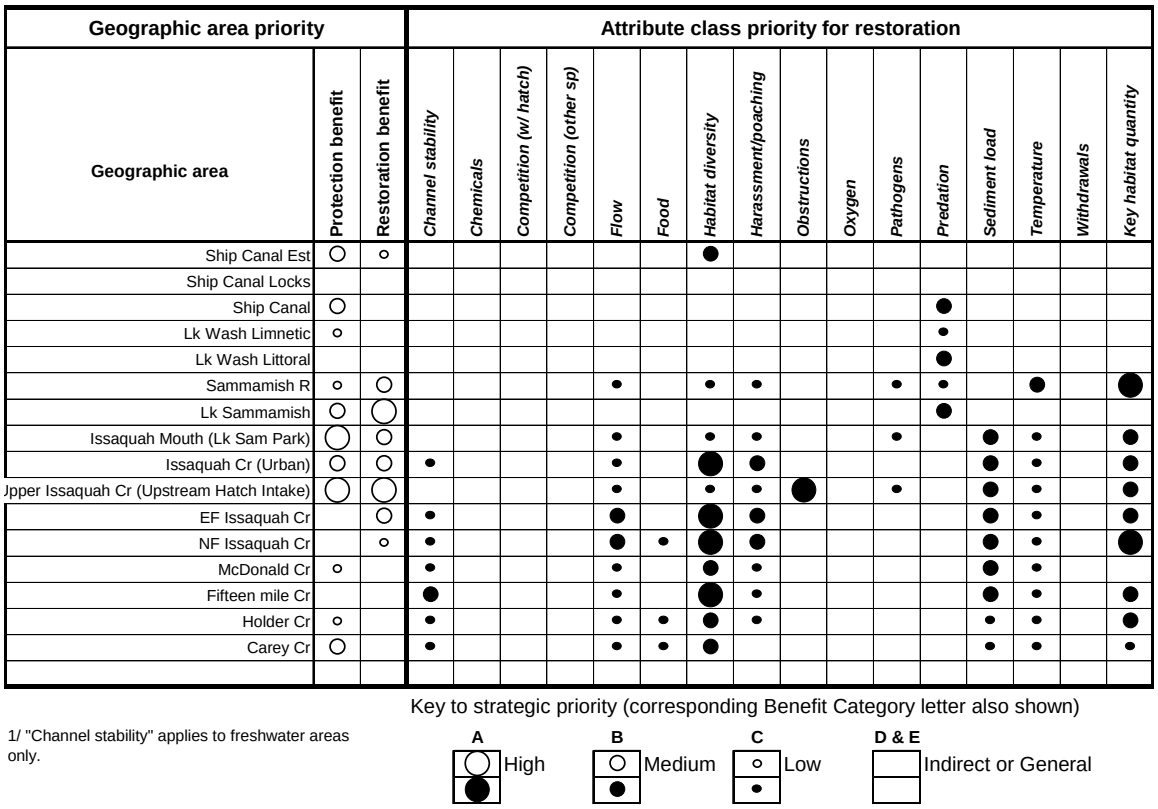


Figure 5. Relative importance of geographic areas with the WRIA 8 watershed for restoration and protection measures for Issaquah Creek Chinook.

Issaquah Creek Fall Chinook
Protection and Restoration Strategic Priority Summary



1/ "Channel stability" applies to freshwater areas only.

Figure 6. Pattern of habitat constraints on Chinook salmon in Issaquah Creek. The figure shows the relative importance of the 16 survival factors by geographic area – the larger dot, the greater the problem. Open circles for protection and restoration benefit are simply the benefit categories show in Figure 5.

Analysis of Recovery Actions

Results are presented for the 25 yr lag as a percent of the historical condition (i.e., 100% is fully restored population performance). Results for Issaquah Creek Chinook include the 25 yr Start List scenario for the Sammamish River (Figure 7 and Table 4).

As a result of the proposed restoration actions in Issaquah Creek (25 yr lag) and the Sammamish River:

Potential abundance increased by over 500 percent from the current condition, but remains low relative to the historic condition (91%),

Productivity increased by about 50%, but remains at critically low levels (<2.0 returns per spawner),

Diversity index increased by 150% to 60% of potential.

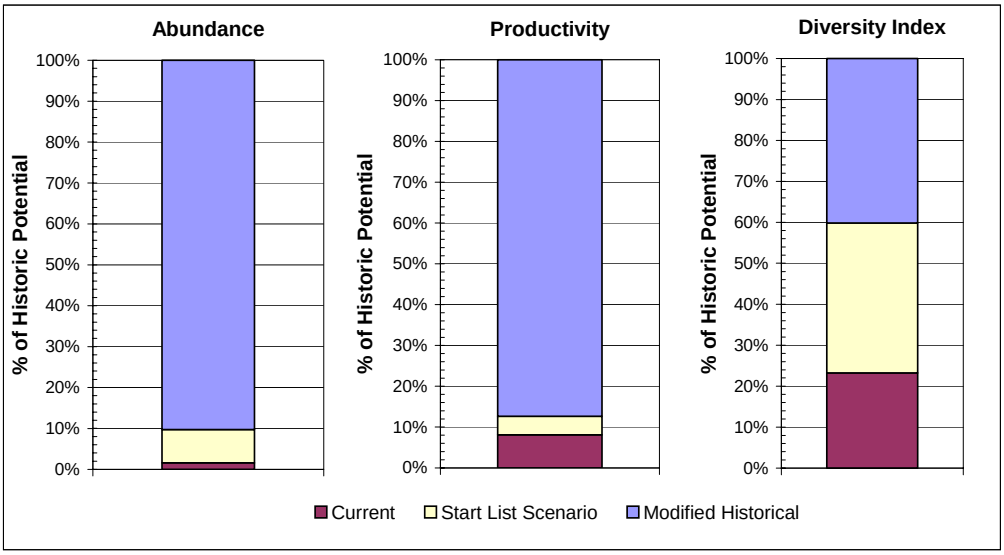


Figure 7. Estimated population performance of Issaquah Creek Chinook relative to the historic potential for habitat actions defined for Issaquah Creek and Sammamish River for the 25 yr lag.

Table 4. Issaquah Creek Chinook baseline and scenario (25 yr lag) results for adults back to spawning and juveniles leaving Issaquah Creek. Scenario results include the Sammamish River Start List actions for the 25 yr lag.

Scenario	Diversity Index	Prod	Capacity	Abundance
Adult Performance				
Current Condition	23%	1.16	294	41
Issaquah Creek Start List Scenario 25 yr Lag & Sammamish River 25 yr Start List Scenario	60%	1.81	558	249
Template (all areas)	100%	14.28	2,758	2,565
Juvenile Performance				
Current Condition	NA	384	223,702	14,675
Issaquah Creek Start List Scenario 25 yr Lag & Sammamish River 25 yr Start List Scenario	NA	409	331,772	77,987
Template (all areas)	NA	904	348,300	302,834

The model is used to evaluate change in survival factors with the 25 yr lag scenario (Issaquah and Sammamish River Start List actions) (Figure 8).

The most effective single action is restoring upstream passage at the hatchery water intake dam.

Restoring upstream passage to upper Issaquah Creek combined with some large-scale passive restoration actions in upper Issaquah Creek contributed the most to improving performance of Issaquah Creek Chinook.

Riparian and channel restoration in the Lake Sammamish State Park is intermediate. Most park structures are set back from the stream and the action had high restoration objectives for improving channel structure and riparian forest.

Actions in the Sammamish River benefited Issaquah Creek Chinook as well as Chinook originating from tributaries of the Sammamish River (not shown here but will be considered in the WRIA 8 planning process). Issaquah Creek Chinook use the Sammamish River for juvenile rearing/migration and adult migration.

Actions in the City of Issaquah benefited population performance and should not be ignored. However constraints within the urban landscape limited the restoration potential of these actions.

Issaquah Creek Fall Chinook
Summary of Scenario Effects on Survival Factors and Overall Performance

Relative loss or gain by area			Change in attribute impact on survival due to scenario															
Geographic area	Relative loss	Relative gain	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Sammamish R		o							o	o						o		◯
Lk Sammamish																		
Issaquah Mouth (Lk Sam Park)		◯	o				o		o	o								◯
Issaquah Cr (Urban)		o					o		◯	o								o
Upper Issaquah Cr (Upstream Hatch Intake)		◯							o	o	◯							o
EF Issaquah Cr																		
NF Issaquah Cr																		◯
McDonald Cr																		
Fifteen mile Cr																		
Holder Cr		o							o									o
Carey Cr																		

Key to amount of change in factor (corresponding Loss/Gain Category letter also shown)

1/ Greatest absolute value of factor change (whether gain or loss) is shown for area (reaches may differ in gain or loss).

A ◯ High
B ◯ Medium
C o Low
D & E Indirect or General

Figure 8. Pattern of habitat improvements on Chinook salmon in Issaquah Creek – 25 yr lag Start List scenario. The figure shows the relative increase for the 16 survival factors by geographic area – the larger dot, the greater contribution to improving survival of the population.

Analysis Individual Actions

Actions for the 25 yr lag were modeled individually and combined actions. Actions were ranked for predicted effect on each performance measure (diversity, productivity, and abundance) and the combined rank across all population performance measures (Table 5).

Conclusions are as follows:

- I202 – restoration of Issaquah Creek in Lake Sammamish Park ranked number 1 for productivity and abundance and second for diversity. This action had high restoration effectiveness in Issaquah Creek 1.

- Restoration of passage at the Issaquah Hatchery intake weir ranked first for diversity index and second for other measures. This action restored full migration potential to upper Issaquah Creek (~11 miles of stream). The current condition assumed a complete barrier to adults during the low flow months (July and August) and a partial barrier in September (50%) and October (75%).

- The combined Pickering (I207) and Bush Lane (I208) actions ranked third. Together these actions had high restoration effectiveness in Issaquah-2.

- Actions upstream of the hatchery intake weir do not include full passage at the weir. Benefits of these actions will be higher once passage was restored at the weir.

- Several actions ranked low for restoration benefit (for example, I253, I254 and I255), but are primarily protection actions and need to be evaluated for protection benefit.

Table 5. Summary of predicted individual action benefits (25 yr lag) to population performance of Issaquah Creek Chinook. Results are presented as a percent change from current condition. All actions include the Sammamish River Start List actions for the 25 yr lag.

Action	Lag	Life History Diversity	Productivity (adult returns per spawner)	Capacity (adults)	Abundance Adults	Diversity Rank	Productivity Rank	Abundance Rank	Overall Rank
Current condition	***-----***	***23%***	***1.16***	***294***	***41***				
I202 – Lk Sammamish Park Restoration	25yr	20%	26%	44%	226%	2	1	1	1
I207 - Pickering Place Riparian	25yr	12%	10%	13%	77%	5	4	5	5
I208 - Bush Lane Acq and Restoration	25yr	13%	9%	17%	80%	3	5	4	4
I207 and I208 Combined Issaquah-2	25yr	13%	10%	18%	87%	3	3	3	3
I211 - Issaquah Park Restoration	25yr	2%	1%	2%	7%	10	8	7	8
I215 - Juniper Acres Acq and Restoration	25yr	1%	0%	0%	1%	15	18	18	16
I216 & I282 - Anderson and Parks Fac Restore	25yr	1%	0%	1%	0%	15	21	21	21
I211, I215, I216 and I282 Combined Issaquah-4	25yr	6%	3%	3%	19%	7	6	6	6
I222 & I223 - Johnson and Wildwood Restoration	25yr	0%	0%	0%	2%	20	16	16	17
I225 - Issaquah Greenway Restoration	25yr	1%	0%	0%	3%	15	14	14	15
I226 & I227 - Squak Valley Restoration	25yr	3%	1%	1%	4%	9	11	10	10
I230 15 Mile Cr Confl Restoration	25yr	0%	0%	0%	1%	20	17	17	19
I231 Gleason Restoration	25yr	2%	0%	0%	3%	10	12	13	12
I230 and I231 Combined Issaquah-9	25yr	2%	1%	0%	4%	10	10	11	11
I234 & I236 McDonald Confl Restoration	25yr	1%	0%	0%	0%	15	19	19	18
I240 & I243 Four Creek Restoration	25yr	1%	0%	0%	0%	15	20	20	20
I244 Log Cabin Acq and Restoration	25yr	2%	0%	0%	2%	10	15	15	14
I234, I236, I240, I243 and I244 Combined Issaquah-11	25yr	2%	0%	1%	3%	10	13	12	12
I249 Issaquah Waterways Acq and Restoration	25yr	6%	1%	1%	6%	6	7	8	7
I250 Carey/Holder Confluence Acq and Restoration	25yr	3%	1%	0%	5%	8	9	9	9
I253 & I254 & I255 Issaquah Waterways Carey Acq	25yr	0%	0%	6%	0%	20	21	22	22
Issaquah Hatchery Dam Passage	25yr	103%	22%	33%	184%	1	2	2	2
Issaquah Creek Start List	**25yr**	157%	56%	89%	509%				

Analysis Segment Survival Issaquah Creek, Lake Sammamish, and Sammamish River

Segment survival represents average trajectory survival as computed by the EDT model (based on environmental characterization and life stage specific habitat-species rules). Current and template segment survival was calculated for two segments for juveniles (through Lk Sammamish, and through the Sammamish River) and three segments for adults (through Sammamish River, through Lake Sammamish, and in Issaquah Creek back to spawning). Results are presented in Table 6.

Table 6. Calculated segment survival from EDT model for Issaquah Creek Chinook.

Life Stage	Segment	Survival Current	Survival Template	Change Survival
Juvenile migrants	Lake Sammamish	20%	31%	11%
Juvenile migrants	Sammamish River	64%	78%	16%
Adult migrants	Sammamish River	83%	96%	13%
Adult migrants	Lake Sammamish	99%	99%	0%
Adult migrants and prespawn holding	Issaquah Creek	63%	94%	30%

Of the segments examined, the time from adults entering Issaquah Creek to the beginning of spawning showed the greatest change in survival (30%) between scenarios. Juveniles in Lake Sammamish and Sammamish River were intermediate (11% and 14%, respectively). Adult survival in Lake Sammamish is high in part because of the assumption that migrating adults are above to avoid warm temperatures in the lake.

These result show that Issaquah Creek is the most significant effect on population performance, affecting juveniles and adults. Productivity of Chinook from spawning to juvenile outmigration from Issaquah Creek is less than half of the template, or 384 juveniles per spawner for the current condition vs. 900 juveniles per spawner for the template condition.

After implementation of the Issaquah Creek Start List scenario (25 yr lag) survival of adults in Issaquah Creek improved to 83% and productivity from spawning to juvenile outmigration from Issaquah Creek increased to 409 juveniles per spawner (still less than half of the template). Survival of juvenile outmigrant in the Sammamish River increased to 67% and adults in Sammamish River increased to 87% (Sammamish River Start List Scenario).

Most of the restoration potential remains in Issaquah Creek areas (Figure 9). Lake Sammamish ranks highest as a single geographic area. Remaining survival factors affecting Issaquah Creek Chinook after implementing the Start List scenarios are shown in Figure 10.

Issaquah Creek Fall Chinook

Relative Importance Of Geographic Areas For Protection & Restoration Measures After Scenario Implementat

Geographic Area	Protection benefit		Restoration benefit	
	Category	rank	Category	rank
Ship Canal Est	B	5	B	6
Ship Canal Locks	E	16	D	19
Ship Canal	C	6	D	17
Lk Wash Limnetic	D	11	E	23
Lk Wash Littoral	E	15	D	18
Sammamish R	C	9	B	4
Lk Sammamish	C	7	A	1
Issaquah Mouth (Lk Sam Park)	A	2	C	9
Issaquah Cr (Urban)	B	3	A	1
Upper Issaquah Cr (Upstream Hatch Intake)	A	1	B	3
EF Issaquah Cr	D	13	B	5
NF Issaquah Cr	D	13	B	7
McDonald Cr	C	9	E	22
Fifteen mile Cr	D	12	D	14
Holder Cr	C	7	D	12
Carey Cr	B	4	D	13

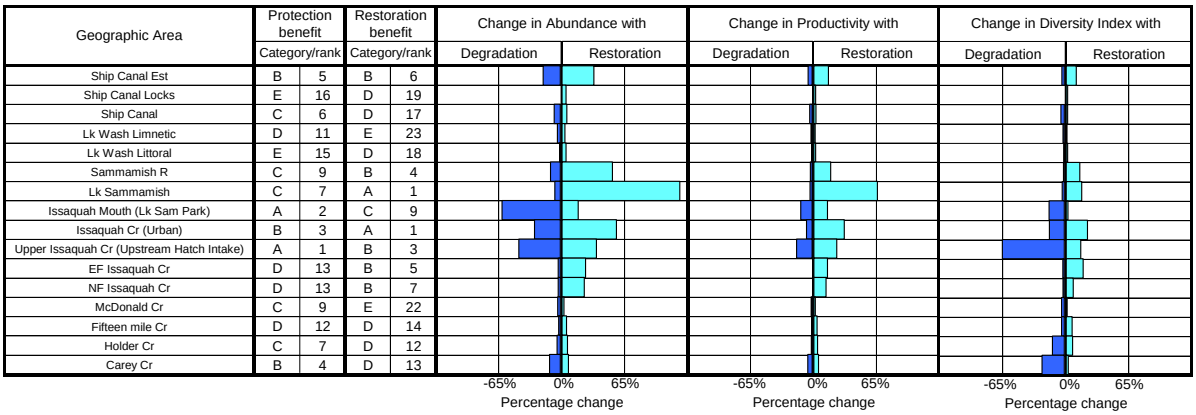


Figure 9. Relative importance of geographic areas with the WRIA 8 watershed for restoration and protection measures for Issaquah Creek Chinook after implementation of the Issaquah and Sammamish River Start List scenarios (25 yr lag).

Issaquah Creek Fall Chinook

Protection and Restoration Strategic Priority Summary After Scenario Implementation

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Ship Canal Est	○	○							●									
Ship Canal Locks																		
Ship Canal	○													●				
Lk Wash Limnetic														●				
Lk Wash Littoral														●				
Sammamish R	○	○					●		●	●			●	●		●		●
Lk Sammamish	○	◯												●				
Issaquah Mouth (Lk Sam Park)	◯	○					●						●		●	●		●
Issaquah Cr (Urban)	○	◯	●				●		●	●					●	●		●
Upper Issaquah Cr (Upstream Hatch Intake)	◯	○					●		●						●	●		●
EF Issaquah Cr		○	●				●		●	●					●	●		●
NF Issaquah Cr		○	●				●	●	●	●					●	●		●
McDonald Cr	○		●				●		●	●					●	●		
Fifteen mile Cr			●				●		●	●					●	●		●
Holder Cr	○		●				●	●	●	●					●	●		●
Carey Cr	○						●	●	●						●	●		●

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

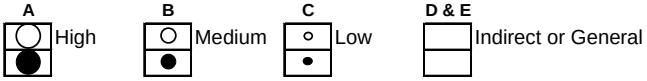


Figure 10. Pattern of habitat constraints on Chinook salmon in Issaquah Creek after implementing the Issaquah and Sammamish River Start List scenarios. The figure shows the relative importance of the 16 survival factors by geographic area – the larger dot, the greater the problem. Open circles for protection and restoration benefit are simply the benefit categories show in Figure 9.

Analysis Baseline and Start List Scenario with High Survival Lake Sammamish

A high survival scenario was created for Lake Sammamish by reducing the effect of cutthroat predation on juvenile Chinook. Population performance results with the high survival assumption are presented in Table 7.

Table 7. Issaquah Creek Chinook baseline and scenario (25 yr lag) results for adults back to spawning with high survival in Lake Sammamish. Scenario results include the Sammamish River Start List actions for the 25 yr lag.

Scenario	Diversity Index	Prod	Capacity	Abundance
Adult Performance				
Current Condition	28%	1.48	358	117
Issaquah Creek Start List Scenario 25 yr Lag & Sammamish River 25 yr Start List Scenario	60%	2.20	672	370
Template (all areas)	100%	14.60	2,808	2,616

Segment survival in Lake Sammamish with reduced cutthroat predation effect was:

- 24% for the current and Start List conditions
- 32% for the historical condition

Conclusions

Action Assumptions:

- No actions were assumed to address inter-gravel fine sediment at this time. At the March WRIA 8 review we decided to consider effects of land use patterns on fine sediment in Issaquah Creek.

- No actions were assumed to address instream high or low flow at this time. At the March WRIA 8 review we decided to consider effects of land use patterns on flow in Issaquah Creek.

General Conclusions:

- The primary focus for this population should be on improving productivity. Productivity for the current condition scenario was barely above 1.0. The 25 yr scenario predicted a productivity approaching 2.0.

- Planning needs to include conditions outside the Issaquah watershed that affect Issaquah Creek Chinook (Lake Sammamish and Sammamish River).

- However, after review it is clear that most of the restoration potential is in Issaquah Creek – mostly improving incubation and juvenile rearing.

- Our assumption of poor survival conditions in Lake Sammamish is significant. The analysis suggests strategies are needed to improve survival of juveniles by reducing predation.

- Protection actions in Issaquah Creek are important to ensure that the benefits of the expensive restoration actions are not lost due to degradation of the stream environment resulting from urbanization of the mid and watershed. Several actions are mostly acquisition and protection of high quality areas. These benefits were not modeled in this analysis