2019 WRIA 9 Project
Effectiveness Monitoring

Month Year

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2019 WRIA 9 Project Effectiveness Monitoring

Prepared for:
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EXECUTIVE SUMMARY

This study examines juvenile Chinook salmon use of four projects in the Green River for WRIA (Water Resource Inventory Area) 9 that have either recently been completed or are proposed for funding in the near future. This type of project effectiveness monitoring is essential for understanding how these projects contribute to Chinook recovery goals, how to adaptively manage sites for the greatest benefit, and to provide insight for the design of future projects. The projects monitored and findings from this work include:

- **Duwamish Gardens (RM 7) (post-project):** Seining was conducted at the recently completed Duwamish Gardens using the same sites and methods as a 2016 study by University of Washington, which collected pre-project data for this site. Overall, Chinook were found to use the restoration site throughout the entire sampling period, which was not seen pre-project. Also, the very high densities of Chinook found within the site in February demonstrate the importance of this type of habitat for early fry-migrant Chinook. This work demonstrates the positive impact of restoration in the Duwamish. Future projects in the Duwamish should focus on providing habitat at the full range of tidal elevations and flows and work to create the largest projects possible.

- **Riverton Creek (RM 6.6) and Gilliam Creek (RM 12.5) (pre-project):** Backpack electrofishing was conducted within these two streams, which both feature a flapgate at their confluence with the Green River that is slated to be removed or reconfigured to enhance fish passage. Sampling showed that some juvenile Chinook were able to make it upstream of these flapgates, but not as many as at a Hamm Creek, a nearby control site with no barrier at the mouth. Non-natal Chinook use of these streams (even with poor access) demonstrates the value of these types of projects to contribute to Chinook rearing habitat, and this data will serve as a baseline for evaluating the impact these projects have in the future.

- **Leber Farmstead (RM 23.7) (post-project):** Backpack electrofishing was conducted yearly at the Leber project site and in nearby Mill Creek from 2017 to 2019, with a total of eleven sampling events. During this time, Chinook were found on two occasions inside the project area, both at flows greater than 4,440 cfs in the Green River (USGS Auburn gage), which significantly backwatered the project area and adjacent Mill Creek. Meanwhile, Chinook were found in nearby Mill Creek during six of the nine events. This demonstrates the use of the Leber project site by juvenile Chinook mostly for flood refuge. Based on these results, and the project’s intent to provide rearing habitat during the more typical lower flows occurring throughout the juvenile Chinook rearing period, this site should be considered for adaptive management actions to increase its use over a wider range of flows.
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1.0 INTRODUCTION

Historical Conditions in the Green River Basin
Changes in land use and river hydromodification have severely reduced and limited salmon habitat throughout the Green River basin. These modifications in the Lower Green River, including the diversion of two rivers, a large flood control dam in the upper watershed, and flood containment levees and revetments, have gradually disconnected the floodplain, off-channel habitats, and tributaries from the mainstem. With flow management at the dam, the current 100-year flow in the Green River equals a roughly 2-year historic flow (King County 2010). Only about 18% of the historic Lower Green River floodplain area is now connected to the river during a 100-year flood event, with much of the ‘connected’ floodplain only connected at very high flows (King County 2017a). Fish access has been restricted by levees, culverts, and flap/flood gates and other structures which have reduced the availability of these habitats for rearing, ultimately reducing juvenile salmon productivity and distribution (King County 2005).

Chinook Population Status
Due to these and many other factors, the Chinook salmon population in the Green River has declined from an average of 2,665 adult spawners between 1969 and 2008, to an average of 1,272 from 2009-2018. Due to the risk of extinction, Puget Sound Fall Chinook (including Green River) were listed by the National Marine Fisheries Service (NMFS) as a threatened species under the Endangered Species Act (ESA) in March 1999. In addition, the estimated abundance of natural origin Chinook is likely inflated by the effects of unmarked hatchery Chinook spawning in the river. The percentage of hatchery fish spawning in the river has shown an increasing trend between 2002 and 2018, with a high of 76% in 2017.

Limiting Factors for Chinook Production
Washington Department of Fish and Wildlife (WDFW) has found evidence of a density-dependent relationship between adult spawner abundance and the number of juveniles that leave the river as parr, the ones that live in the river longer before outmigrating to the ocean. This suggests that parr production is limited by the carrying capacity of the current available habitat (Anderson and Topping 2017). This is an important finding because parr contribute to adult returns at rates that are disproportionate to their abundance.

Specifically, about half of the juvenile Chinook salmon that leave the Green River do so as parr; more than nine out of ten returning adults originate as parr. For example, WDFW (WDFW 2018a) found that although Chinook that had outmigrated as fry only made up 1 to 5% of the total adult return from 2015 to 2017, those same fish (outmigrating fry between 2010 and 2014) made up an average of 52% of the total Chinook subyearling outmigration (WDFW 2018b). This research indicates that Chinook parr, which made up an average of 48% of the Chinook subyearling outmigration between 2010 and 2014, produced 93 to 95% of the adult returns between 2015 and 2017. This research suggests that increasing rearing habitat in the Green River basin would increase the abundance of parr, and
therefore adult Chinook returns. In the highly developed Lower Green River, non-natal tributary streams provide a portion of this rearing habitat.

**Effectiveness Monitoring and Habitat Restoration**
In response to the ESA listing of Chinook, the WRIA (Water Resource Inventory Area) 9 Salmon Habitat Plan was created in 2005 to guide and implement local actions in the Green River watershed to improve habitat conditions and support Chinook salmon recovery. To ensure that current science is guiding the implementation of the Salmon Habitat Plan, the WRIA 9 Monitoring and Adaptive Management Plan recommends monitoring activities within the basin each year.

This study provides project effectiveness monitoring data for several habitat projects funded by WRIA 9. These projects include both pre- and post-restoration sampling and are intended to provide rearing habitat for Chinook fry to increase parr production, and thereby adult returns. With this in mind, the purpose of this study is to:

1) Provide baseline data for post-project monitoring to assess the effectiveness of habitat restoration to provide rearing habitat for Chinook fry.
2) Provide post-project data to assess the effectiveness of habitat restoration to provide rearing habitat for Chinook fry.
3) Provide pre-project data to assist in the feasibility and design of projects.

The projects that were evaluated include:

1) Duwamish Gardens (post-project)
2) Riverton Creek Flapgate (pre-project)
3) Gilliam Creek Flapgate (pre-project)
4) Leber Homestead (post-project)
2.0 DUWAMISH GARDENS

2.1 Background

Duwamish Gardens was completed in 2016, and was designed to provide off-channel habitat for juvenile salmonids within the Duwamish Estuary at RM (river mile) 7. The 2.16 acre site features an alcove on the right bank of the river that provides nearly 1 acre of off-channel area at high tide (Figure 1), restoring ~500’ of previously armored bank. Historically, the property was a farmstead with numerous residential and agricultural buildings. Prior to construction, riverine habitat at the site consisted of an armored bank with minimal riparian cover throughout the length of the property.

Fish monitoring for this project builds off pre-project sampling data that was collected in 2016 by the University of Washington (Toft & Cordell 2017) on behalf of WRIA 9. Though their sampling effort was aimed at restoration projects throughout the Duwamish, it provides useful pre-project data for the restoration site and other nearby habitats.

Figure 1. Duwamish Gardens site in early 2017 shortly after construction (Mike Perfetti).
2.2 Study Area

Sampling locations included the newly constructed Duwamish Gardens habitat (treatment), as well as three nearby banks (control) (Figure 2). These three controls include two vegetated banks (LB) and one armored bank (RB). All sites sampled were the same locations sampled by Toft and Cordell (2017). Sites were in the same condition as they were during pre-project sampling with the exception of the restored Duwamish Gardens site, which was an armored bank prior to restoration.

![Figure 2. Duwamish Gardens sampling locations. Text indicates the site name (both pre- and post- restoration), and the colored polygons indicate the actual area seined for each sampling date.](image)

2.3 Methods

Pre-project data for this project was collected in 2016 by the University of Washington (Toft and Cordell 2017), which was funded through WRIA 9. In order to allow for pre/post project comparison, the same methods used by Toft and Cordell (2017) were used for the post project evaluation.
Fish sampling was conducted using a PSP (Puget Sound Protocol) beach seine. The “Puget Sound Protocol” (PSP) net was adopted for use in marine nearshore areas and based on studies by Simenstadt (1991). The PSP net has two wings that are each 18 meters long, 2.4 meters high, and made of 3-cm mesh. At the center of the net, the wings connect to a 2-meter-high, 2.4-meter-wide, and 2.3-meter-deep bag of 6-mm mesh. This net was the same net used for pre-project monitoring (Toft and Cordell 2017) as well as previous King County sampling on the Duwamish (Nelson et al. 2004).

Sampling focused on high tide when the project area was inundated. Seining was conducted with one individual on the bank holding one end of the net, while a boat deployed the net out away from the bank in a downstream direction. Once deployed, the boat operator used the boat to push the net upstream and in a large semi-circle around the individual on the bank. Once the semi-circle had been completed, both ends of the net were drawn together on the bank and the net was hauled in. In the event that the seine became snagged or otherwise compromised, the set was abandoned and data discarded. Another set would then be attempted near, but not overlapping, with the previous attempt.

For each control site (DUW-vegetated, CHK-vegetated, CHK-armored), one sampling set was performed for each date. For the treatment, one seine set was performed in February, while two seine sets were performed in March and May. This was done to provide additional sampling in the project area. During the February sampling event only one set was completed successfully. For the March and May events where there are two data points for the treatment, the densities were averaged.

Fish captured in the seine were placed in a bucket of cool aerated water, then identified to species and measured (fork length). Fish that were measured were also anesthetized using MS 222, then allowed to recover before being released. In the event that large numbers of fish were captured (chum fry in this case), a portion of fish were subsampled for length measurements and the rest simply counted and released without being anesthetized.

During each seine set, a GPS was used from the bow of the boat to log the exact outline of each seine set. This enables us to calculate the area sampled for each set. The number of each species captured within the set was then divided by the area to produce a density measurement for the seine set (fish/100m²).

Fish densities (fish/100m²) are limited to graphical presentation, as replication for this study was too low for meaningful statistical analysis. For example, pre-project samples were collected at each site 4 times throughout the season, while post-project samples were collected 3 times throughout the season. Regardless, this is still useful for understanding fish use of the Duwamish Gardens project.

Fork lengths (mm) were recorded for all fish captured. In some cases, only a subset of chum salmon were measured to reduce handling time and ensure survival when catches were very high. Fork lengths are presented graphically for the purpose of comparing size range of fish captured in different habitats (i.e. restored vs. non-restored). A t-test was used to compare chum salmon fork length distribution among sites, as sample sizes for chum...
were large enough for testing. Sample sizes for Chinook were too small for statistical testing.

## 2.4 Results

### How did Chinook use Duwamish Gardens before restoration?
Prior to construction, Chinook were captured at the Duwamish Gardens treatment site (DUW-Treatment) once out of the four sampling events (Figure 3). This sampling event found only 1.1 Chinook per 100m². Densities were generally low for all sites in this area throughout the sampling season, with the exception of April, in which higher densities of Chinook were found at the CHK-Armored and DUW-Vegetated sites. Compared to the other sites sampled, the Duwamish Gardens Treatment site generally featured similar or lower densities of juvenile Chinook than the other three control sites.

### How did juvenile Chinook use Duwamish Gardens after restoration?
Results from post-project sampling showed substantial changes in Chinook densities relative to nearby control sites (Figure 4) during one month of sampling. During the first sampling in February, Chinook density at the treatment site was 22 Chinook per 100m², while no Chinook were captured at the three control sites. During the March and May...
sampling events, Chinook densities were generally low throughout all the sites but were highest at the treatment site.

Aside from variation in densities, the treatment site was the only site where Chinook were captured during all sampling events. No Chinook were captured at the Chinook Wind (armored) control, and only once at both the Chinook Wind (vegetated) and Duwamish Gardens (vegetated) control sites.

![Figure 4. Post-restoration Chinook densities at the four project sites sampled in 2019 by King County.](image)

No patterns were observed for chum salmon densities, though the highest density was observed at the treatment site in May (316.6 fish/100m²). Similar to Chinook, however, the treatment site was the only location where chum were captured during all sampling events.

**Did Chinook lengths vary among sites post-restoration?**

Chinook fork lengths were compared among sites and sampling dates (Figure 5). Overall, Chinook lengths were generally similar or smaller at the treatment site than control sites (those where fish were captured) and size increased over time, though low sample sizes for the March and May events limit our ability to draw statistical conclusions from the data.
Figure 5. Chinook fork length distribution for all sites across dates. Box plot boundaries indicate 25th and 75th percentile, whiskers indicate 10th and 90th percentile, center line is median, red line is mean, and points are outliers.

**Did Chum lengths vary among sites post-restoration?**

Chum fork lengths were compared among sites and sampling dates (Figure 6). Overall, chum captured at the treatment site were smaller than those captured at control sites. During March and May, chum were significantly smaller at the treatment site than those captured at control sites (when present) \( p<0.001 \).
2.4.1 Caveats

While sampling pre-and post-restoration was done at the same locations, sampling did not occur at precisely the same time of year or with the same frequency. This reduces our ability to make reliable comparisons of patterns throughout the rearing period, but is still useful for addressing variability throughout the rearing period.

Prior to construction, the currently restored area featured a straight armored bank. Post restoration, the restored area featured gently sloping banks with fine sediment. Seining efficiency likely differs between these two types of habitats. In shallower habitats, the seine is likely more effective as it maintains bottom contact throughout the set, reducing the ability for fish to escape.

Comparing juvenile salmonid abundances from year to year poses additional limitations. Regardless of habitat use, juvenile salmon populations can vary drastically from year to year due to outside factors (e.g., adult returns or egg-to-fry survival) which directly impacts the ability to compare densities. While comparing densities between years is difficult, sites can still be compared relative to each other. For this, it can be assumed that habitat selection remains the same.
2.5 Discussion

Though sampling for this project was limited and split between two different sampling efforts, the results demonstrate several important findings:

- Chinook are using the newly created Duwamish Gardens restoration project
- Chinook are using the project throughout the rearing period, as they were captured during every sampling event- unlike all other control sites sampled. However, the site only provides habitat at higher tides, meaning fish using the site are forced back into the Duwamish River during low tides.
- Chinook densities were exceptionally high earlier in the year, potentially showing the importance of this project and habitat types created by this project for the fry life history.
- Fork lengths for chum (and possibly Chinook) were generally smaller in the treatment. This could indicate that this type of habitat is providing preferential habitat for smaller fish than the control sites.

Chum generally have a shorter freshwater rearing period than Chinook as they typically outmigrate as fry, therefore comparing habitat use by Chum is likely not contributing to the assessment of the project’s overall success. With that said, assessing length distributions of Chum is likely helpful for understanding habitat use and the ability of certain sized fish to persist or rear in these habitat types.

2.6 Recommendations

Based on the findings from this report as well as previous research, the following recommendations are made:

- Results suggest that the Duwamish Gardens site is providing meaningful habitat for juvenile Chinook. Constructing additional projects in the Duwamish will likely contribute to Chinook recovery.
- Construct habitats that provide shallow, low velocity nursery habitats for young fry throughout all flows and/or tides.
- In addition to high tide sampling, future sampling should perform monitoring at low tide to address habitat availability/use when most of the existing restoration projects are not inundated.
3.0 RIVERTON AND GILLIAM CREEK

3.1 Background

Riverton (RM 6.6) and Gilliam (RM 12.5) Creeks are tributary streams to the Duwamish and Lower Green and both feature partial barriers at their confluence. These streams feature important off-channel rearing and flood refuge habitat for non-natal juvenile Chinook salmon. Non-natal indicates that these fish were born outside of the tributary stream they are rearing in.

Non-natal tributaries have been found to be important habitat for juvenile Chinook rearing in the habitat-limited Lower Green River (King County 2019). Both of these streams feature non-natal habitat that is partially inaccessible by a barrier. The removal of these barriers has the potential to open up significant areas for rearing and high flow refuge for juvenile Chinook. While these smaller streams are not known to support spawning adult Chinook, these projects would also benefit other species of salmon, like coho, that must navigate these barriers to spawn.

3.2 Study Area

Riverton Creek is located along the left bank at RM 6.6, and features twin flapgates at its confluence which severely limit fish passage at most water elevations (Figure 7). Above this barrier, most of the stream channel is confined with degraded habitat conditions. The proposed restoration project for this site will remove the flapgate/culvert barrier at the confluence, as well as add habitat features including large wood and riparian planting. Sampling in Riverton Creek included four 10m transects upstream of the culverts within the proposed project area. Two of these transects were within the lower 100m of the stream, which feature a straight channel with little complexity. The other two transects are within the remnant pocket marsh located from 120 to 230m upstream from the confluence.
Gilliam Creek is located along the left bank at RM 12.5 in the Lower Green, and features a large single flapgate at its confluence (Figure 8). This structure is a passage barrier for juvenile salmonids at most flows, though some juvenile Chinook have been found above the flapgate. The lower reaches of the stream channel are highly constrained, due to being confined between Hwy 405 and Tukwila Parkway. The Gilliam Creek flapgate, confluence, and stream channel upstream have been undergoing feasibility analyses to look at different restoration alternatives. Sampling in Gilliam Creek included two 10m transects upstream of the flapgate, up to 180m upstream. Both transects were stream habitat within the daylighted portion of the stream along Tukwila Parkway.
In addition to Riverton and Gilliam Creeks, sampling for this portion of the study also included Hamm Creek as a control site. Hamm Creek is a tributary to the Duwamish (RM 4.9) and features a restored and relatively unconfined channel with no juvenile passage barriers observed within the reach sampled (Figure 9). This portion of Hamm Creek features a previous restoration project, in which King County and the U.S. Army Corps completed 2300' of stream restoration including channel reconfiguration, large wood installation, and planting. This was completed in 2000. Sampling for this reach included three 10m transects from the confluence with the Green upstream ~260 meters.
3.3 Methods

Fish sampling was conducted via backpack electrofishing once per month in February, March, and May of 2019 to target the freshwater rearing period for juvenile Chinook in the Green River. Within each stream, fish sampling was performed within the proposed project area (Riverton and Gilliam), or near the confluence within the 100-year floodplain (Hamm Creek control). The intent of sampling near the confluence was to target areas most likely to support non-natal rearing, based on recent non-natal tributary work in the Lower Green (King County 2019), as well as observations from nearby basins (Tabor et al. 2011b, Tabor & Moore 2018). All sites were sampled during low tide and periods where tributary flow conditions would be similar between sampling events (i.e., not immediately after a large rain event).

This sampling effort focused only on sampling stream-type habitats (see King County 2019), therefore were grouped for analysis. At Riverton Creek, the stream habitats were further broken down into two distinct areas: the lower channelized portion, and the upper meandering portion that flows through the small pocket marsh. While both of these segments were flowing streams, the lower channelized portion featured high velocities, deeper water, and less complexity. The channel flowing through the small pocket marsh was wider, shallower, and contained lower velocities.

Electrofishing was the method chosen to estimate relative abundance of juvenile salmon, as it can be effective with varying turbidity, in-stream debris, and water depth. Electrofishing was conducted using a Smith-Root LR-20B® backpack electrofisher following protocols outlined by NMFS (2000), and WDFW (2005). Electrofishing was conducted within relatively short 10 meter (m) long reaches in the same manner as King County (2019). A single-pass method working from downstream to upstream was used. Single-pass electrofishing requires less time and fewer personnel to complete than multi-pass
electrofishing. This allows for more sites to be sampled in less time with a smaller crew. Captured fish were placed in a bucket of aerated stream water, anesthetized using MS 222 (if necessary), identified to species or genus, and measured to the nearest millimeter (fork length). After recovering completely fish were released.

3.4 Results

Were juvenile Chinook found in these tributaries?
Juvenile Chinook were found in all streams sampled, though densities were variable from stream to stream. Overall, the highest relative abundance of Chinook was found in Hamm Creek, followed by Riverton Creek and Mill Creek (Figure 10). Mill Creek and Leber (Section 4) are included for reference.

![Figure 10. Catch Per Unit Effort (CPUE) for Juvenile Chinook for each site and date.](image)

When were juvenile Chinook found in these tributaries?
Similar to results from King County (2019), juvenile Chinook relative abundance (CPUE) generally declined throughout the sampling period (Figure 10). Mean CPUE was highest during the February sampling event for 3 of 4 streams. No Chinook were captured during the final sampling event in May.

What habitats were juvenile Chinook found in at Riverton Creek?
Overall, mean Chinook densities were greater within the marsh section than the lower channelized portion (Figure 11). Of the 6 transects sampled in the lower channel throughout the sampling period, Chinook were only captured 1 time. In addition, no other
Chinook were observed within this section. In the Marsh section, Chinook were captured in 3 of the 6 transects. In addition, Chinook were regularly observed throughout this reach when walking between sampling transects.

![Graph showing Juvenile Chinook CPUE within two habitat areas of Riverton Creek for all sampling events in 2019.](image)

**Figure 11.** Juvenile Chinook CPUE within the two habitat areas of Riverton Creek for all sampling events in 2019.

**What other fish were captured in these streams?**
A total of 10 species were captured during sampling, all of which were native (Table 1).
### Table 1. Fish species and counts for all streams sampled in 2019.

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name - life stage</th>
<th>Gilliam (6)</th>
<th>Hamm (9)</th>
<th>Leber (BW) (6)</th>
<th>Leber (CF) (3)</th>
<th>Mill (5)</th>
<th>Riverton (12)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Oncorhynchus tshawytscha</em></td>
<td>Chinook - subyearling natural</td>
<td>2</td>
<td>19</td>
<td>7</td>
<td>8</td>
<td></td>
<td></td>
<td>36</td>
</tr>
<tr>
<td><em>Oncorhynchus kisutch</em></td>
<td>Coho (total)</td>
<td>2</td>
<td>17</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td>30</td>
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<td></td>
<td>subyearling natural</td>
<td></td>
<td></td>
<td>1</td>
<td>11</td>
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<td></td>
<td>12</td>
</tr>
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<td></td>
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<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>yearling hatchery</td>
<td></td>
<td></td>
<td>2</td>
<td>15</td>
<td></td>
<td></td>
<td>17</td>
</tr>
<tr>
<td><em>Oncorhynchus mykiss</em></td>
<td>rainbow trout - parr</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>15</td>
<td>1</td>
<td></td>
<td>11</td>
</tr>
<tr>
<td><em>Oncorhynchus mykiss</em></td>
<td>steelhead - hatchery</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
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<td><em>Oncorhynchus keta</em></td>
<td>chum - subyearling</td>
<td>67</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>72</td>
</tr>
<tr>
<td><em>Oncorhynchus clarkii clarkii</em></td>
<td>cutthroat trout</td>
<td>16</td>
<td></td>
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<td>16</td>
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<tr>
<td><em>Cottus sp.</em></td>
<td>sculpin sp.</td>
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<td>2</td>
<td>2</td>
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<td></td>
<td></td>
<td>12</td>
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<tr>
<td><em>Catostomus macrocheilus</em></td>
<td>largescale sucker</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td><em>Rhinichthys sp.</em></td>
<td>dace sp.</td>
<td>1</td>
<td></td>
<td>1</td>
<td>7</td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td><em>Gasterosteus aculeatus</em></td>
<td>three-spined stickleback</td>
<td>2</td>
<td>17</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>12</td>
<td>34</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>35</td>
<td>113</td>
<td>1</td>
<td>6</td>
<td>34</td>
<td>39</td>
<td>228</td>
</tr>
</tbody>
</table>

#### 3.4.1 Caveats

Single-pass electrofishing allows spatial and temporal trends in abundance to be measured, but may not be representative of absolute population density (Bertrand et al. 2006). In addition, variation in depth and water clarity may influence overall sampling efficiency, though conditions at the five sites were relatively similar during the sampling period.
3.5 Discussion

Compared to the unconfined Hamm Creek control site, Riverton and Gilliam Creeks had much lower Chinook CPUE. Of the two flapgated streams (Riverton and Gilliam), Riverton had consistently higher Chinook CPUE than Gilliam. Project managers speculate that the regular tidal inundation of the Riverton Creek flapgate allowed for more opportunities for juveniles to access this habitat than at Gilliam Creek, which is much less affected by the tide.

Despite the presence of a flapgate and a straightened, urban stream, Chinook were found in Gilliam Creek in February. Access to this stream is likely very restricted, and the presence of Chinook suggests that allowing unrestricted access will increase Chinook use.

Based on these results, allowing unrestricted access to Riverton Creek will likely improve Chinook use. Riverton Creek, and other streams in the Duwamish, provide both habitat at high tides, as well as stream habitat away from the river at low tide. Fish within Riverton Creek were found almost exclusively in the marsh habitat, which demonstrates the value of this habitat not only for this project but for juvenile Chinook in the Duwamish.

Similar to the results from King County (2019), Chinook use of these non-natal tributaries was high early in the season and declined as the season progressed. Sampling for this project occurred nearly a month earlier than King County (2019), which shows the importance of these tributaries very early in the season for newly emerged fry which migrate out of the middle Green River in high numbers early in the season. Due to the current poor survival rate of Duwamish rearing fry outmigrants to adulthood, this monitoring once again demonstrates the importance of non-natal tributaries for Chinook fry as both flood refuge and rearing habitat to allow them to grow to the parr stage.

3.6 Recommendations

Based on these results, the following actions should be addressed:

- Continue to fund and construct projects that restore access to and the quality of non-natal tributaries
- Chinook were found almost entirely in the stream marsh habitat at Riverton Creek. Restoration should focus on providing similar habitat- which featured slow moving, meandering flows with vegetation and LWD cover.
- Chinook use of non-natal tributaries was highest early in the year. If unrestricted access cannot be provided through barrier removal, flood facilities such as flapgates should be designed to allow Chinook fry access during high flows that occur during the early rearing months.
4.0 LEBER HOMESTEAD

4.1 Background

The Leber Homestead is the site of a salmon habitat project located within the City of Kent, near the confluence of Mill Creek with the Lower Green River (RM 23.7). The Leber project is the first of several similar proposed projects creating backwater habitat to be built over the next ten years in the Lower Green River. Given the significant investment in creating these types of habitats, it is important to understand how well these habitats are functioning for juvenile Chinook and if different design approaches are better than others. Leber is also unique in that it is not directly connected to the Green River as originally proposed; rather, it was connected to Mill Creek upstream from its confluence with the Green River in order to avoid removing semi-mature trees that shade the Green River. Monitoring for this project was initially conducted in 2017 and continued in 2018 and 2019, building upon the initial fish monitoring conducted in 2017 (King County 2017b, Appendix B).

Project construction for Leber was completed in late 2016, with planting completed in early 2017. The project involved excavating a large backwater that is connected to Mill Creek approximately 500 feet upstream from its confluence with the Green River. Forty-three large wood structures were placed in the project area and 31,907 riparian and upland plants were installed. The Leber project was designed to backwater at approximately 1,330 cfs (based on the Green River flows at Auburn USGS gage station), with the objective of providing 125 days of inundation during the January to June juvenile rearing period (Rowena Valencia-Gica, personal communication). In addition, the project objectives included creating 1.6 acres of off-channel habitat below ordinary high-water mark and 5 acres below the 100-year flood height, over 40 large wood structures, >50,000 native plantings, and over 50-acre feet of flood storage.

Based on the very low numbers and poor Chinook spawning habitat in Mill Creek, it is presumed that any Chinook encountered during sampling of the Leber project site are of non-natal origin and accessed the site by moving up Mill Creek from the Green River (King County 2019).

4.2 Study Area

A total of three different habitat types were sampled within or adjacent to the project area (Figure 12). These included the Leber backwater habitat (when inundated), the Leber confluence with Mill Creek, and adjacent Mill Creek upstream of the confluence. The intent of sampling at these three habitat types was to document the presence of juvenile Chinook both within and adjacent to the project area.

Each of the three habitat types sampled were distinctly different. The Mill Creek habitat featured a 10-meter-long transect along the left bank of the stream, sampled from downstream to upstream. The Leber confluence habitat featured a small eddy and shear
line between the backwatered portion of the Leber project and the flowing Mill Creek. Sampling targeted this shear line and eddy. The Leber backwater habitat focused on sampling the shoreline of the Leber project itself. Sampling in the backwater habitat was done whenever possible based on when it was inundated. Backwater transects ranged from 10 to 100 meters with the intent of sampling as much area as possible to detect Chinook if present.

![Figure 12. Leber project area showing the three sampled habitats.](image)

### 4.3 Methods

Fish sampling was conducted via backpack electrofishing between February and May from 2017 to 2019 to target the freshwater rearing period for juvenile Chinook in the Green River. Sampling events were opportunistic, with the intent of targeting both a range of flows and dates (Table 2).
Table 2. Sampling dates for Leber Homestead including flow and habitat type sampled. “x” indicates habitats sampled, while bold “C” indicates habitats where Chinook were captured.

<table>
<thead>
<tr>
<th>Date</th>
<th>Flow (cfs)</th>
<th>Locations Sampled</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mill Creek</td>
</tr>
<tr>
<td>3/2/2017</td>
<td>1540</td>
<td>C</td>
</tr>
<tr>
<td>3/16/2017</td>
<td>7480</td>
<td></td>
</tr>
<tr>
<td>3/30/2017</td>
<td>4440</td>
<td></td>
</tr>
<tr>
<td>3/19/2018</td>
<td>1100</td>
<td>C</td>
</tr>
<tr>
<td>4/9/2018</td>
<td>3490</td>
<td>x</td>
</tr>
<tr>
<td>4/12/2018</td>
<td>2850</td>
<td>x</td>
</tr>
<tr>
<td>5/14/2018</td>
<td>1660</td>
<td>C</td>
</tr>
<tr>
<td>2/21/2019</td>
<td>1020</td>
<td>C</td>
</tr>
<tr>
<td>3/26/2019</td>
<td>1050</td>
<td>C</td>
</tr>
<tr>
<td>4/16/2019</td>
<td>2610</td>
<td>C</td>
</tr>
<tr>
<td>5/15/2019</td>
<td>948</td>
<td>x</td>
</tr>
</tbody>
</table>

Electrofishing was the method chosen to estimate relative abundance of juvenile salmon, as it can be effective with varying turbidity, in-stream debris, and water depth. Electrofishing was performed by a team of two trained biologists using a Smith-Root LR-20B® backpack electrofisher following protocols outlined by NMFS (2000) and WDFW (2005). Electrofishing was performed by wading or walking along the bank carefully and electrofishing an approximately 2-meter-wide swath along the shore, with one biologist electrofishing and one netting. Single-pass electrofishing was used, which requires less time and fewer personnel to complete than multi-pass electrofishing. This allows for more sites to be sampled in less time with a smaller crew. Single-pass electrofishing allows spatial and temporal trends in abundance to be measured, but may not be representative of absolute population density (Bertrand et al. 2006). Captured fish were placed in a bucket of aerated stream water, anesthetized using MS 222, identified to species or genus, and measured to the nearest millimeter (fork length). After recovering completely, fish were released.

Electrofishing data were reported as catch per unit effort (CPUE), which is the number of individuals of a particular species captured divided by the seconds spent electrofishing. CPUE was used to compare relative abundance among different habitat units during the sample period. It is important to note that water conditions (primarily depth and turbidity) changed quite drastically between sampling events, which likely influenced capture efficiency.

Water quality data were collected by both King County and Tetra Tech on behalf of the City of Kent in 2017. Data collected by Tetra Tech (Tetra Tech 2017) included temperature, dissolved oxygen, pH, and specific conductivity. Samples were also analyzed for
nitrate+nitrite, ammonia, total nitrates, arsenic, lead, copper, zinc, diesel, motor oil, and turbidity.

Surface water data were collected at the project site on March 3, 2017 by Kollin Higgins. The sites sampled (labeled A-G) are from upstream to downstream within the Leber project area, with “A” starting near S 262nd Street. No sampling was done in the northeastern arm of the project. The water within the site appeared to come from groundwater within the project area, which then flows out and into Mill Creek.

4.3.1 Caveats

Due to the differences in depth, flow, and cover between each of the three habitat types sampled at Leber, electrofishing efficiency likely varied. The variation may lead to fish in the deeper areas (the Leber backwater) having CPUE calculations that are biased low. In addition, the two electrofishing biologists could not effectively sample the wood structures in the center of the project area when the site was inundated. Access was attempted using an inflatable raft; however, water levels were too deep with too much debris present to permit the collection of meaningful data.

4.4 Results

Were Chinook found at the Leber project site?

Between 2017 and 2019, there were 11 total sampling events at the Leber site with various habitats being sampled each time:

- At the Leber backwatered habitat Chinook were only found at 2 of 10 sampling events, both in 2017.
- At Mill Creek upstream of the project, Chinook were found at 6 of 9 sampling events.
- At the confluence of Leber and Mill Creek, Chinook were only found at 1 of 7 sampling events; however, at higher flows this confluence disappears as both the project and creek backwater, and the location is unsafe to sample.

At which flows were Chinook found in the Leber project site?

Within the project area itself, Chinook were observed when flows were above 4,440 cfs in the Green River (Figure 13). From the designed inundation level of 1,330 cfs to approximately 2,000 cfs, the source of water in the backwatered area of Leber was primarily groundwater, which may be responsible for the lack of fish observed due to potentially unfavorable water quality conditions.
Were there any water quality issues with groundwater at Leber?

Results from the Tetra Tech report show high specific conductivity in the interior of the project, indicating groundwater origin (Table 3). Dissolved oxygen concentrations within the project area were highly variable, ranging from 2.0 to 8.1mg/L, often below the salmon rearing standard of 6.5mg/L. pH was also variable and often fell near or below the salmon rearing minimum of 6.5. Water temperatures were higher in the project area and exceeded the salmon rearing standard of 17.5 deg C in May and June, though no data were collected earlier in the rearing period to demonstrate that this is a problem earlier in the year. This may be due to the young riparian vegetation at the time of sampling and lack of flow that is typical for backwater habitats.

No concentrations of concern were observed for nitrate+nitrite, ammonia, total nitrates, arsenic, lead, copper, zinc, diesel, motor oil, and turbidity; total arsenic concentrations were higher in the project area than in Mill Creek but were well below state water quality standards (Tetra Tech 2017).

Table 3. Field data collected at the Leber site as published in Figure 8 by Tetra Tech (2017).
Surface water data was collected at the project site on March 3rd, 2017 by Kollin Higgins using a YSI multi-parameter sonde. No sampling was done in the north eastern arm of the project. While the site consisted almost entirely of groundwater, the optical dissolved oxygen (ODO), temperature (C), pH, specific conductivity (\( \mu s/cm \)), and conductivity (\( \mu s/cm \)) were tolerable for salmonids at the time of sampling (Table 4). The primary difference between the project area and nearby Mill Creek was higher temperature (~3.8 degrees C warmer in the project area) and higher conductivity (2.3 to 2.8 times higher in the project area than in Mill Creek).

Table 4. Surface water parameters and measurements collected at Leber and nearby Mill Creek on 3/3/2017. The sites sampled (labeled A-G) are from upstream to downstream within the Leber project area, with “A” starting near S 262nd Street.

<table>
<thead>
<tr>
<th>Location</th>
<th>Site #</th>
<th>Temp (C)</th>
<th>pH</th>
<th>ODO (mg/L)</th>
<th>ODO (% sat)</th>
<th>Specific Conductivity (( \mu s/cm ))</th>
<th>Cond (( \mu s/cm ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leber</td>
<td>a</td>
<td>11.69</td>
<td>6.58</td>
<td>6.88</td>
<td>63.5</td>
<td>415</td>
<td>308.8</td>
</tr>
<tr>
<td>Leber</td>
<td>b</td>
<td>11.54</td>
<td>6.67</td>
<td>9.18</td>
<td>84.2</td>
<td>447.8</td>
<td>332.9</td>
</tr>
<tr>
<td>Leber</td>
<td>c</td>
<td>11.58</td>
<td>6.69</td>
<td>8.42</td>
<td>77.4</td>
<td>505.6</td>
<td>376</td>
</tr>
</tbody>
</table>
4.5 Discussion

During the sampling performed at Leber from 2017-2019, juvenile Chinook were only found within the project area above 4,440 cfs (Auburn gage). These results suggest that the project is currently functioning to provide flood refuge habitat. While off-channel habitat is a critical habitat type and necessary for the survival of juvenile Chinook, sampling results suggest that this project is not performing as originally designed, which was to provide rearing habitat at approximately 1,330 cfs and above. Modifications to the existing design should be considered as adaptive management for Leber, and future projects should consider Leber performance so that they are more likely to provide rearing and flood refuge habitat at a greater range of flows.

When Chinook were not occupying Leber, they were found in nearby Mill Creek at lower flows. This observation fits with previous work indicating that non-natal tributaries (such as Mill Creek) are functioning to provide both flood refuge and rearing habitat for Chinook throughout the rearing period (King County 2019). Modifying the existing project to incorporate flowing aquatic habitat for rearing in addition to the backwater habitat (as currently exists) for flood refuge could provide the full benefits of both types of habitat using the same project footprint.

While not originally anticipated in the design, year-round groundwater flow was encountered in the southwestern portion of the excavated area that appears to be impacting the designed function and performance standards of the site. Unmixed groundwater generally has low levels of dissolved oxygen compared to surface water and may dissuade fish from using the project under these conditions. While this groundwater has kept the backwater area wet during much of the juvenile rearing period, it also appears to provide enough “flow” to prevent Mill Creek water from entering the site at flows less than approximately 2,000 cfs.

Increasing the connectivity and inundation range of the project, addressing groundwater input, or incorporating through-flow from Mill Creek could allow fish to utilize the site much more frequently. If 4,440 cfs is the minimum flow at which Chinook use the Leber site, Chinook could only use the project during the January to June rearing period for 5.5% of the time in 2017, 3.9% of the time in 2018, and 0% of the time in 2019 (Table 4). To explore other possible outcomes, potential inundation under several lower flows was investigated. Assuming Chinook would use the site at 4,000 cfs, this would equate to the project being usable 7.2% of the time in 2017, 8.3% in 2018, and 0% in 2019. For comparison, if the project was modified to allow Chinook to use the project at 3,000 cfs,
this would equate to the project being usable 18.8% of the time in 2017, 21% of the time in 2018, and 6.6% of the time in 2019.

It is important to note that fish may not have been observed in the project area below 4,440 cfs simply because they do not depend on this backwater habitat type in the Lower Green at lower flows. Water from Mill Creek was observed backwatering into the project at flows greater than approximately 2,000 cfs, which should have reduced or eliminated concerns of groundwater influence on fish use.

### Table 4. Percent of total days during the Chinook rearing period with a maximum flow meeting or exceeding 4,440 cfs, 4,000 cfs, and 3,000 cfs.

<table>
<thead>
<tr>
<th>Month</th>
<th>4,440 cfs</th>
<th>4,000 cfs</th>
<th>3,000 cfs</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>February</td>
<td>0.0%</td>
<td>25.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>March</td>
<td>29.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>April</td>
<td>3.3%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>May</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>June</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5.5%</strong></td>
<td><strong>3.9%</strong></td>
<td><strong>0.0%</strong></td>
</tr>
</tbody>
</table>

While the site may have a low percentage of days during the rearing period when it is being used by juvenile Chinook, flood refuge habitat is a very critical and greatly limited type of habitat in the Lower Green. Its presence within this project during infrequent high flow events may contribute greatly to fry survival by allowing them to stay in the Lower Green during the highest flows. While the project appeared to be used for only 5.5% of the rearing period in 2017, it may be that this 5.5% of flows that would otherwise flush rearing Chinook out of the Lower Green without flood refuge habitat. Given the limited area for meaningful habitat restoration in the Lower Green, however, it is imperative to make restoration projects as useful as possible to provide the greatest range of benefits to Chinook.

### 4.6 Recommendations

While Chinook have been observed using the Leber project area for flood refuge, the project site could be improved to provide lower flow rearing habitat as well as for existing flood refuge habitat to function at a greater range of flows than what has been observed. The project area could be enhanced in several ways. One option would be to go back to the original design concept and create a connection with both the river and Mill Creek. This could be accomplished by notchting the high ground between the Green River and the Leber project to allow more fish access to the project area from the river at a wide range of flows. This was looked at extensively during the design phase but was ultimately abandoned largely due to riparian tree removal concerns. In order to accomplish this, dozens of
mature trees that shade the Green River from southern exposure would need to be removed, which was a major concern for the design team (M. Knox, personal communication). This issue would need to be addressed in order to move forward with a direct connection to the river.

Additionally, the project site could be reconfigured to allow part or all of Mill Creek to be channeled through the site and out to the Lower Green through a notch in the north portion of the project. The current stream channel is incised, and this would provide a large increase in low velocity rearing habitat within Mill Creek, as well as continued flood refuge habitat as it currently exists in the project area. Given that the vegetation at the project site has grown, adding this additional phase to the project could help retain some mature riparian vegetation to shade the stream within the project area. Again, this option would require a large cut through the river bank and require dozens of trees that shade the Green River to be removed.

While the project appears to be functioning to hold water at the designed elevations, the unexpected impacts of groundwater flow may have implications for fish use. While the water quality parameters of the groundwater present within the site appear to be sufficient for salmonids, none were found within the groundwater portion of the site. Further evaluation of the groundwater source, water quality, and water quantity would be helpful for assessing groundwater’s impact on fish use of the site. Options may also be explored to control, route, or store groundwater in the site. Additionally, enhancing hyporheic flow from the river may improve water quality and rearing conditions within the project area. This could be accomplished by installing a ditch or culvert and backfilling with drain rock.
5.0 CONCLUSIONS

This study provides project effectiveness monitoring data for several habitat projects funded by WRIA 9. Overall, this sampling effort was successful in collecting valuable pre-project monitoring data for Riverton Creek and Gilliam Creek. It also provides insight regarding how and when juveniles are using these streams in the presence of a barrier. In addition, post-project monitoring data were collected at the Duwamish Gardens site as well as Leber Homestead. This post-project monitoring has provided useful data regarding how the completed sites are functioning, as well as insight as to how project managers can adaptively manage these sites and design other projects in the future.

New Insights

Duwamish Gardens

Sampling at the project site showed a notable increase in Chinook use compared to nearby controls for fry-type juvenile Chinook. Also, the project site was the only site (out of four) sampled where Chinook were present throughout the entire sampling period (February-May). While these results demonstrate the usefulness of this project (and type of habitat) in the Duwamish, it was noted that the project site is often dry at low tides- which forces fish to go elsewhere to find rearing habitat. Future projects should aim to provide as much rearing habitat as possible at the full range of flows/tides juvenile Chinook experience during the rearing period.

Riverton and Gilliam Creeks

Similar to findings by King County (2019), this project demonstrated consistent use of nonnatal tributaries by juvenile Chinook during pre-project monitoring for Riverton and Gilliam Creek projects. The finding of juveniles in all tributaries shows that Chinook will utilize accessible streams, however, observing the highest densities in the Hamm Creek control site shows that the use of these streams could be much higher.

Leber Homestead

Based on fish sampling conducted from 2017-2019, Leber was successful at creating flood refuge habitat. While this is an important type of habitat, the objective of the design was to have juvenile Chinook use the site more frequently. Adaptive management alternatives should be evaluated and implemented at this site to increase its use over a wider range of flows.

Future Monitoring

Project effectiveness monitoring is essential for understanding how these projects contribute to Chinook recovery goals, learning how to adaptively manage sites for the
greatest benefit, and providing insight towards the design of future projects. In order to utilize limited salmon recovery in the most meaningful and impactful way possible, it is critical to consistently monitor the impacts of work that has been done. This not only helps project managers understand the success of projects but also helps inform the design and prioritization of future projects.

Post-project monitoring should be conducted at Riverton and Gilliam Creeks following construction. Juvenile fish passage/non-natal tributary enhancement projects have not been completed in the Green River to date, therefore assessing the success of these projects will be critical for these types of projects in the future.

Monitoring at the Leber site should be expanded beyond daytime fish presence. A more in-depth evaluation of how much of the site is inundated at various flows should be undertaken, as well as an evaluation of the source of water responsible for the inundation (i.e. groundwater or surface water). More comprehensive water quality monitoring should be undertaken to verify that the dominant source of water within the site (groundwater at lower flows, stream water at higher flows) provides acceptable water quality for juvenile Chinook rearing needs. Modifying groundwater inflow or incorporating hyporheic flow should also be evaluated. Monitoring should be focused on answering questions of how the site could be adapted to provide rearing habitat under lower flow conditions.
6.0 REFERENCES


King County. 2017a. A synthesis of changes in our knowledge of Chinook salmon productivity and habitat uses in WRIA 9 (2004–2016). Prepared by Kollin Higgins for the WRIA 9 Watershed Ecological Forum. King County Department of Natural Resources and Parks, Seattle, WA.

King County. 2017b. 2014 Juvenile salmonid use of aquatic habitats in the Lower Green River. Prepared by Chris Gregersen, King County Water and Land Resources Division, Seattle, WA.

King County. 2010. Green River external advisory review panel report. Prepared by Tetra Tech, Seattle, WA.

King County. 2005. WRIA 9 strategic assessment report -Scientific foundation for salmonid habitat conservation. Prepared by King County Water and Land Resources Division, Seattle, WA.


Toft, J.D., and J.R. Cordell. 2017. Densities of juvenile salmon at restored sites in the Duwamish estuary transition zone, 2016. School of Aquatic and Fishery Sciences, University of Washington. Seattle, WA.

