# COUNTYLINE LEVEE SETBACK PROJECT

# YEAR 3 MONITORING REPORT (2020)


*Submitted* January 2022

Constructed: Summer 2017
Planted: Winter 2017, Fall 2018, Fall 2019
USACE Reference No. NWS-2011-211


King County

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## Acknowledgements
This report was improved by review and feedback from Stephanie Shelton, Jeanne Stypula, Chris Brummer, Brandon Duncan, Kerry Bauman, and John Klochak.


## Suggested Citation
King County. 2022. Countyline Levee Setback Project: Year 3 Monitoring Report (2020). Prepared by Alex Lincoln, Zanna Doak, and Judi Radloff. King County Water and Land Resources Division. Seattle, WA.

# Executive Summary

The Countyline Levee Setback Project aims to reduce flood risk and provide ecological benefits through reconnecting the White River to its floodplain. Constructed in fall of 2017, the project removed portions of an existing levee that had constrained the White River for nearly a century, built a setback levee protected by a biorevetment and eight engineered log structures, and installed tens of thousands of native plants. This document presents results that are part of a comprehensive 10-year effectiveness monitoring effort that will continue through 2027.

This report includes Year 3 (2020) post-construction monitoring results from the Countyline Levee Setback Project. The project continued to meet the majority of its ecological objectives, and met all measured Year 3 performance standards under U.S. Army Corps of Engineers Permit No. NWS-2011-211 (Table ES1). The project area has maintained perennially available side channel habitat, with areas of low velocity edge habitat available for juvenile salmonid rearing and refuge. Native vegetation cover has exceeded performance standards in planted areas, and naturally recruited seedlings are continuing to establish and grow along floodplain gravel and sand bars. Several channels in the floodplain have deepened, and the active channel area has decreased since 2019, indicating that the side channel may be simplifying somewhat compared to the first two years after floodplain reconnection. Future channel dynamics and habitat formation will likely depend on future hydrology and flow regulation, and the resulting movement of sediment and wood.

**Table ES1.** Summary of indicators evaluated, and project performance compared to permit-associated performance standards for Year 3.

| Indicator | Year 3 Performance Standard | Year 3 Status | Details |
|---|---|---|---|
| Channel dynamics | New channel(s) form outside of the pre-project active channel. | ACHIEVED | The new side channel has remained connected year-round, and active channel area remains 115% higher than baseline. Ratio of side channel to main channel length is 177% higher than baseline. |
| Native vegetation cover | Cover by installed trees and shrubs, including cover by volunteers of desirable native woody species, in Year 3 is at least 20% | ACHIEVED | Average percent cover of woody species across all transects within planted areas was 35%, and across all planted and unplanted transects was 37%. |
| Invasive vegetation cover | Less than 10% invasive cover (non-regulated noxious weeds and weeds of concern) in planted areas (5% for King County class A noxious weeds, bindweed, knotweed). Less than 25% reed canary grass on site. | ACHIEVED | Invasive vegetation was present but not prevalent; an average of 2% cover of invasive weeds was found along transects. Knotweed and bindweed were present but not prevalent. Reed canarygrass cover averaged 0.5% cover across transects. |
| Floodplain inundation | On average over years 1, 3, 5, 7, and 10, wetted area in the floodplain between Feb 1 – Mar 31 is 32.5 acres. | ON TARGET[1] | At 6,620 cfs, 57.6 acres of floodplain were inundated. Average inundated area, with Year 1 (56.8 acres at 6,060 cfs), is now 57.2 acres. |
| Low velocity edge habitat | Sum of slow-water (<1.5 ft/sec) bar, bank, backwater, and side channel area increases by >50%, relative to baseline condition. | ACHIEVED | Low velocity edge habitat in the project reach remained high, at 9.6 acres (463% increase compared to baseline). |
| Fish habitat use | Juvenile salmonid frequency of occurrence is highest in backwater and side channels, compared to other edge types. | N/A | Fish sampling was unable to be conducted due to COVID-19 safety considerations. |
| Fish habitat capacity | Habitat capacity at median rearing flows is increased by ≥ 50% compared to baseline. | N/A | Fish sampling was unable to be conducted due to COVID-19 safety considerations. |
| Flood hazard | No significant damage to engineered structures, adjacent flood facilities/infrastructure. Channel migration contained within project area. | ACHIEVED[2] | Engineered structures are intact. Extents of channel migration are contained within project area. Water surface elevations at high flows are reduced compared to pre-project levels. |

[1] Performance standard associated with Natural Resources Damages Assessment (NRDA) consent decree; performance standard under NWS-2011-211 only specifies that inundation will increase as measured between Feb 1 – Mar 31. [2] Performance standard is not associated with NWS-2011-211.

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# I. Project Summary

## Project Setting and Goals

The Countyline Levee Setback Project (Project) area is located on the Lower White River within the City of Sumner, City of Pacific, and unincorporated Pierce County, and is so named because it spans the King-Pierce County boundary (Figure 1). The reach is bounded by the A Street SE and Burlington Northern Santa Fe (BNSF) Railway Bridges at the upstream end (River Mile 6.3) and the 8th Street East Bridge at the downstream end (RM 5.0). Channelization and confinement of the lower White River in the 1900s, combined with the naturally depositional alluvial fan in this reach, have led to reduced channel capacity and substantial loss of aquatic habitat. A more complete history of the White River can be found in the *Countyline Levee Setback Year 1-2 Report* (King County 2020).

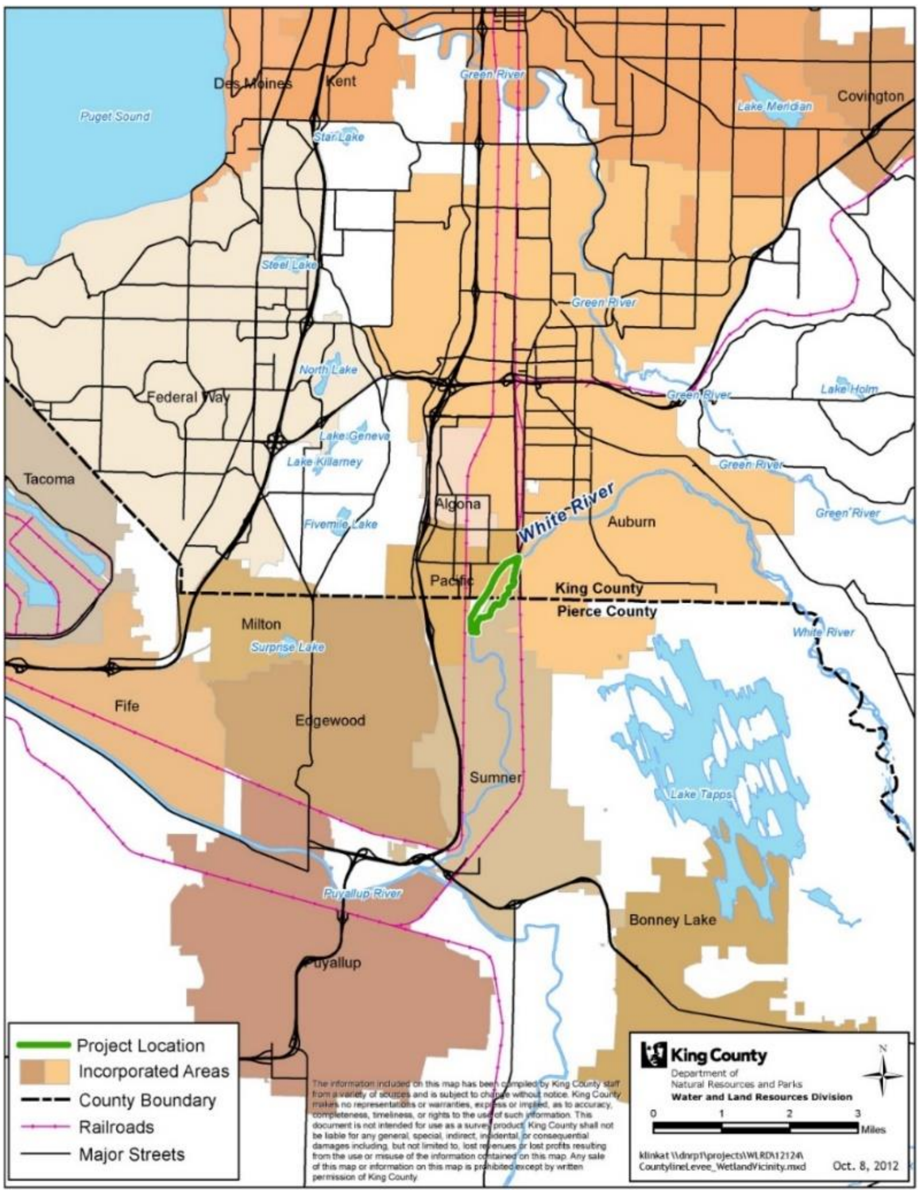


*Figure 1. Countyline reach vicinity map.*

The project reconnected approximately 120 acres of floodplain to the White River channel, with the goals of reducing flood risk, restoring natural river processes, and improving fish habitat through creating off-channel juvenile rearing habitat for salmonids. The habitat restoration goal and related objectives of the Countyline Levee Setback Project are:

> **Goal:** Restore riverine processes and functions to the lower White River and its floodplain within the project area to enhance salmonid rearing habitat, in particular for spring and fall Chinook, coho, and steelhead.
>
> **Objectives:**
> 1. Allow natural channel movement within the project area by removing and setting back the existing levee along the left bank.
> 2. Encourage the formation of off-channel rearing habitat (pool complexes and side-channels), through installation and future natural recruitment of large wood, that will promote the return of the complexity, diversity, and morphology found in an unconstrained floodplain.
> 3. Provide off-channel flood refuge for salmonids by allowing a more natural frequency of inundation of the floodplain complex during flood events within the project boundaries.
> 4. Protect existing mature riparian buffer areas and restore a corridor of mature riparian vegetation within the project boundaries to provide shoreline and stream channel shading, invertebrate prey supply, and large wood recruitment.

## Project Actions

The approach to resolving existing flood risks focused on increasing capacity for flood flows and sediment load. The strategy was two-fold: (1) acquire land rights (fee or easements), and (2) implement capital improvements to modify levees and retrofit revetments so that the river is reconnected to its floodplain. In addition to flood risk benefits, returning the lower White River to a more naturally functioning floodplain was expected to improve aquatic and wildlife habitat. Levees were reconstructed along an alignment set back from the previous active channel and a biorevetment incorporating large wood was constructed to protect the setback facility (Figure 2). Large wood structures were also installed in the floodplain to disperse adversely erosive flows and provide complex habitat. Native vegetation was planted along riparian banks and on top of large wood structures to provide healthy riparian buffer functions in the long term.

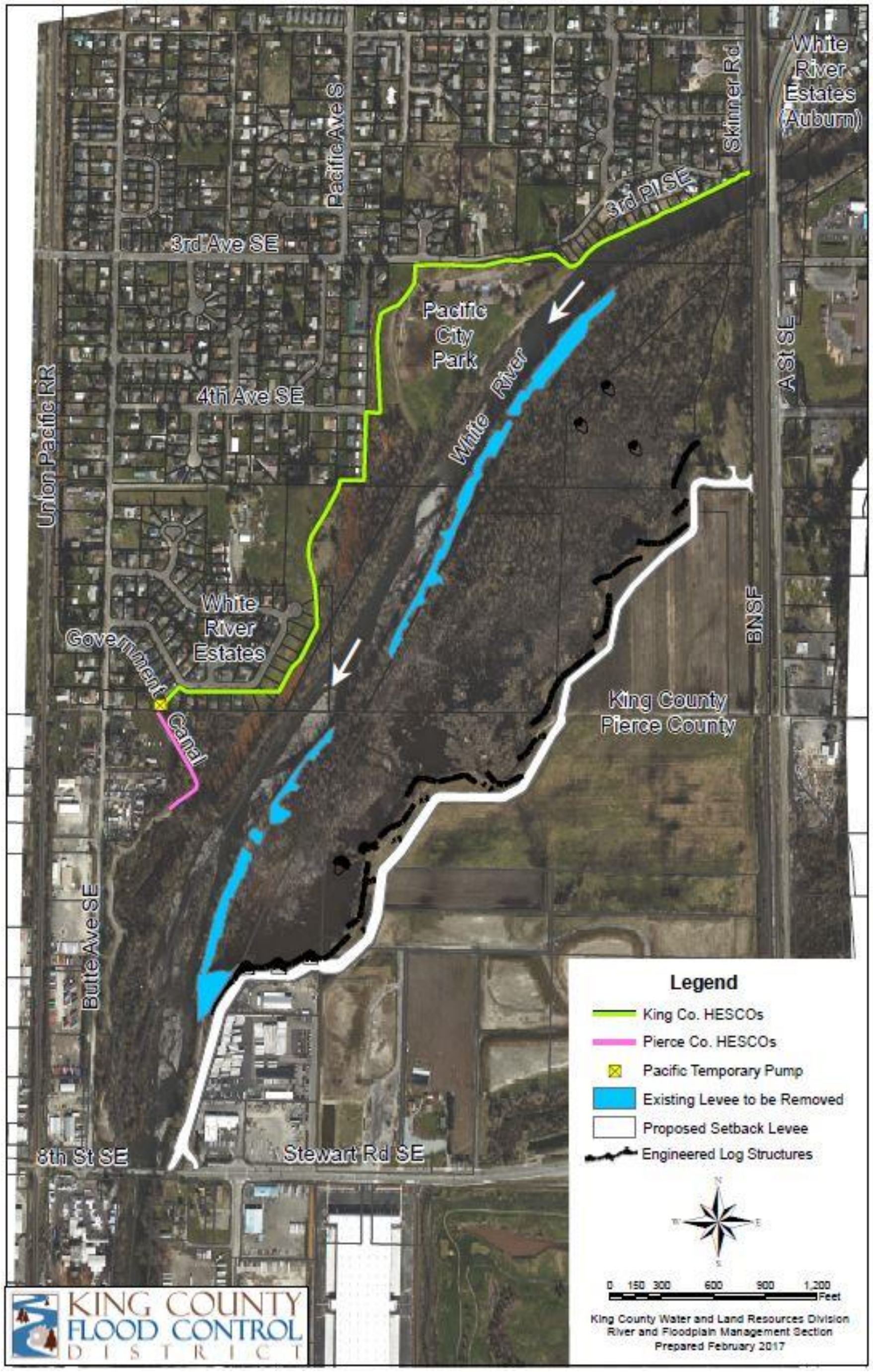


*Figure 2. Countyline Levee Setback project area.*

## Performance Standards

Monitoring objectives and performance standards were designed to determine project effectiveness, and adaptive management recommendations were identified as potential actions or lessons learned in the event that performance standards are not met (Table 1). All indicators except for flood hazard indicators were included as requirements under NWS-2011-211.

*Table 1. Performance standards established by the design team and agency permits.*

| Category | Indicator | Objective | Performance Standards[1] | Adaptive Management |
|---|---|---|---|---|
| Project Implementation | As-built condition | Project is constructed according to design specifications and regulatory conditions. | As-built condition satisfies design objectives. | Adjustments to meet design specifications made during construction. |
| Channel Dynamics | Movement | Channel complexity (e.g., sinuosity, formation of multiple channels) will increase. | New channel(s) form outside of the present (pre-project) active channel. | Consider measures to initiate a flow path through appropriate means. |
| Habitat Benefit | Aquatic habitat | The area of slow-water edge habitat will increase. | Sum of slow-water (<1.5 ft/sec) bar, bank, backwater and side channel area increases by >50%, relative to baseline condition. | Project objective not met. |
| | | The area of floodplain inundation will increase. | Floodplain inundation within the project area will increase after project construction, as measured between February 1 and March 31 utilizing aerial photography. | Consider measures to promote floodplain inundation. |
| | Wood | Wood loading will increase over baseline condition. | Wood loading (natural and placed) on site meets or exceeds NMFS recommendation for properly functioning condition (>80 pieces/mile; NMFS 1996). | Project objective not met. |
| | Riparian cover | Installed plants survive. | 80% survival[2] at end of Year 1 growing season for all installed trees and shrubs (excluding stakes)[3]. | Additional planting or maintenance needed. |
| | | Installed plants, as well as volunteers of desirable native woody species, form a dense canopy cover. | Cover by installed trees and shrubs, including cover by volunteers of desirable native woody species: Year 2 at least 15%, Year 3 at least 20%, Year 5 at least 40%, Year 7 at least 60%, and Year 10 at least 75%. | Additional planting or maintenance needed. |
| | | Biorevetment allows a vegetated riparian buffer to establish between river and setback levee. | Average vegetated riparian buffer width of 75 feet. | Reconsider design approach in similar settings. |
| | Invasive cover | Invasive plant cover is minimized due to native revegetation and weed control. | Less than 10% invasive cover (non-regulated noxious weeds and weeds of concern) in planted areas (5% for KC Class A noxious weeds, bindweed, and knotweed). Less than 25% reed canary grass on site as a whole. | Additional maintenance needed. If reed canarygrass performance standard exceeded, plant areas with willow (cultural control). |
| | Wetlands | Wetland area temporarily impacted by construction is restored. | 1.08 acres temporary impacts in Wetlands A and B restored to aquatic habitat condition. | To be determined depending on conditions. |
| Fish use | Habitat preference | Juvenile salmonids preferentially use low velocity edge habitat (specifically backwaters and side channels). | Juvenile salmonid density (or frequency of occurrence) is highest in backwaters and side channels, compared to other edge types. | Revise habitat priorities in future design considerations in Lower White River. |
| | Habitat capacity | Habitat capacity is increased by increasing low velocity edge habitat. | Habitat capacity at project site – estimated as the product of the average density of juvenile salmonids in edge habitats and the area of edge habitat (by type) at median rearing flows increased by >50% compared to baseline. | Project objective not met |
| Flood Hazard | Structural stability | Installed elements (ELJs, setback levee, biorevetment) have remained stable over their design life. | No significant damage to engineered structures that would diminish the intended design function. | Implement repairs and/or prevention measures as needed. |
| | Flood elevations | Flood risks outside of the project area decrease or remain the same, as compared to future conditions without the project. | The project does not directly cause damage to adjacent flood facilities, infrastructure, or private property, as compared to future conditions without the project. | Further flood risk reduction actions may be necessary. Implement repairs or prevention measures as needed. |
| | Channel migration | Allow natural channel movement within the project area. | Channel migration is contained within the project area. | Implement repairs and/or prevention measures as needed. |

[1] Performance assessed over 10-year monitoring period, unless otherwise noted.
[2] Only installed plants count towards achieving the Survival Performance Standard; volunteers do not count.
[3] Plant survival and cover on top of the apex logjams will be assessed when access is feasible.

# II. Monitoring Strategy and Study Design

The focus of this report is habitat monitoring, although effectiveness monitoring includes flood risk reduction parameters as well. Changes in habitat conditions between baseline (2011-2017) and Year 3 (2020) post-construction are evaluated in the current document, to determine whether the project effectively meets the stated habitat goal, objectives, and performance standards, as well as the need for adaptive management actions. Monitoring is focused on whether levee setback project actions are producing the intended effects on habitat conditions, watershed processes, and threatened fishes (Effectiveness Monitoring), in order to improve design, construction, and maintenance practices (Adaptive Management).

## Audience

The primary audiences for implementation and effectiveness monitoring results include:

1. King County staff – Results will be shared to inform future project design, construction, and monitoring protocols, as well as project maintenance and adaptive management needs. The reporting format includes presentations, monitoring reports, and access to real-time data.
2. Regulatory agencies – Monitoring results will allow regulatory agencies to determine whether performance standards are being met, as well as inform review of future projects with similar elements. Monitoring reports will be submitted to the US Army Corps of Engineers in Years 1, 2, 3, 5, 7, and 10.
3. Funding agencies and project stakeholders – Monitoring results will provide funding agencies and project stakeholders with the information necessary to determine whether funding agreements are being followed, as well as to evaluate the effectiveness of the project at meeting funding priorities. The reporting format includes presentations and monitoring reports.
4. Scientific community – This monitoring effort will add to a growing body of research into the effects of large-scale floodplain reconnection projects on channel processes and habitat conditions, as well as the efficacy of levee setbacks for flood risk reduction in depositional rivers.

## Monitoring Objectives and Metrics

Each indicator is associated with a performance standard (objective), method, and metric (output) which will be monitored on a rotating schedule over the 10-year monitoring period (Table 2; King County, 2014).

*Table 2. Monitoring objectives, methods, and outputs.*

| Category | Indicator | Performance Standard | Task | Monitoring Method | Timing (Years) | Output |
|---|---|---|---|---|---|---|
| Project Implementation | As-built condition | As-built condition satisfies design objectives. | 1 | Manage construction to ensure project satisfies design objectives; Produce record drawings. | Immediately post-construction | Record drawings |
| Channel Dynamics | Movement | New channel(s) form outside of the present (pre-project) active channel. | 2 | LiDAR, aerial photography, and field survey | 1, 3, 5, 10 (timing may be adjusted based on high flow events) | Mapped channel forms |
| Habitat Benefit | Aquatic habitat | Sum of slow-water (<1.5 ft/sec) bar, bank, backwater and side channel area increases by >50%, relative to baseline condition. | 3 | Map slow water areas on channel margins at flows representing 50th, 75, and 90th percentile flows during Jan-Jun | 1, 3, 5, 10 | Change in edge habitat area relative to baseline |
| | | Floodplain inundation within the project area will increase after project construction, as measured between February 1 and March 31 utilizing aerial photography. | 4 | Georeferenced aerial photography and field ground-truthing | 1, 3, 5, 7, 10; additional photography may be collected during and following high flow events | Georeferenced photograph of inundated area |
| | Wood | Wood loading (natural and placed) on site meets or exceeds NMFS recommendation for properly functioning condition (>80 pieces/mile; NMFS 1996). | 5 | Object-based image analysis (based on LiDAR and orthophotos) and field survey | 1, 5, 10 | Estimates of wood loading |
| | Riparian cover | 80% survival[2] at end of Year 1 growing season for all installed trees and shrubs (excluding stakes)[3]. | 6 | Fixed plots | 1, 2, 3, 5, 7, 10 | Percent survival of installed plants |
| | | Cover by installed trees and shrubs, including cover by volunteers of desirable native woody species: Year 2 at least 15%, Year 3 at least 20%, Year 5 at least 40%, Year 7 at least 60%, and Year 10 at least 75%. | 7 | Fixed plots | 1, 2, 3, 5, 7, 10 | Percent cover of native installed and volunteer woody vegetation (trees and shrubs) |
| | | Average vegetated riparian buffer width of 75 feet. | | See task 4 | 1, 5, 10 | Minimum, average, and maximum buffer width |
| | Invasive cover | Less than 10% invasive cover (non-regulated noxious weeds and weeds of concern) in planted areas (5% for KC Class A noxious weeds, bindweed, and knotweed). Less than 25% reed canary grass on site as a whole. | | See task 7 | 1, 2, 3, 5, 7, 10 | Percent cover of invasive plants |
| | Wetlands | 1.08 acres temporary impacts in Wetlands A and B restored to aquatic habitat condition. | | See task 4 | 1 | Wetted area |
| Fish use | Habitat preference | Juvenile salmonid density (or frequency of occurrence) is highest in backwaters and side channels, compared to other edge types. | 8 | Sample juvenile salmonids in edge habitat during rearing period | 1, 3, 5, 10 | Relative abundance of juvenile salmonids in discrete habitat types |
| | Habitat capacity | Habitat capacity at project site – estimated as the product of the average density of juvenile salmonids in edge habitats and the area of edge habitat (by type) at median rearing flows increased by >50% compared to baseline. | | See tasks 3 and 10 | 1, 3, 5, 10 | Change in habitat capacity |

# III. Monitoring Methods

## Channel Dynamics and Sediment Conditions

### Channel Dynamics

Channel location and planform were mapped using GIS measurements taken from high-resolution orthoimagery captured before project construction (April 2016, 1800 cfs) and compared to orthoimagery captured post-project at the most comparable flow available (April 2018, 2400 cfs; April 2019, 2860 cfs; August 2020, 1030 cfs). Previously established channel cross section locations were used to evaluate bed elevation changes between 2019 and 2020 LiDAR datasets. Channel complexity was characterized by several metrics that reflect emerging science to improve assessment of channel dynamics and sediment movement:

- Number of side channel nodes and ratio of side channel to main channel length (Stefankiv et al. 2019). Side channel nodes mark the start and end of a side channel that is connected to the mainstem (or another side channel) at one end.
- Number of braid channel nodes (Stefankiv et al. 2019). Braid channel nodes mark the start and end of a smaller channel within the active channel across or between gravel bars. Braid channels are distinguished from side channels by lack of established vegetation.
- Total active channel area (sum of area of water, banks, unvegetated gravel bars, and bars without perennial vegetation) (Collins and Montgomery 2011; Konrad 2015)
- Floodplain connectivity and continuity (Konrad 2015). Area of floodplain inundated at high flow between February 1 and March 31.
- Channel cross section changes reflecting areas of deposition, side channel development, and floodplain connection.

The same pre- and post-project orthoimagery was also used to calculate these complexity metrics. The flow rate at the time of imagery collection is noted as water surface elevation may affect side channel and braid channel engagement, and so imagery at the most comparable flow available was used; we note that imagery available in 2020 was collected at a lower flow than 2016, 2018, and 2019 imagery, which could influence our observations of channel braids in the imagery.

### Sediment Conditions

To evaluate ongoing changes in sediment volume and to estimate quantities of sediment deposited in and eroded from the project area, the change in surface elevation was calculated in GIS from LiDAR data collected at Year 2 in 2019 and Year 3 in 2020. The elevation difference between the two surfaces was calculated to get an elevation change and reveal areas of deposition and erosion and then multiplied by cell area (9 square feet) to estimate a volume. A net volume for entire project area was estimated by summing all volume cells. Calculated values were rounded to reflect the accuracy of the estimates.

## Habitat

### Vegetation Cover

*Transect Sampling*

Forty monitoring transects were established in disturbed areas to evaluate the success of planted vegetation and estimate the rate at which trees colonize bare ground. Ten transects were established within each of four strata: naturally-formed gravel bars, fill on top of engineered log jams, riparian buffers, and levee slopes (Figure 3). Transects did not cross strata and locations were randomly chosen within the appropriate strata. All transects were 30-m long, except for those on engineered log jams which were 15-m long due to the smaller area of fill on top of these structures. One gravel bar transect established in Year 1 was underwater in Year 2 and 3, and so was not sampled.

Within each transect, percent cover of native and invasive tree, shrub, and groundcover species was measured within 1-m radius circular plots. Percent cover was measured by Daubenmire cover class (Daubenmire 1959) within five plots along each 30-m transect (riparian buffer, levee slope, gravel bar transects), evenly spaced at 6-m intervals, and within 3 plots spaced every 5-m along each 15-m transect (engineered log jam transects).  Cover classes were 0-5%, 5-25%, 25-50%, 50-75%, 75-95%, and 95-100%. Mid-points of each cover class were used to calculate averages. Recruitment was also measured within the same 1-m radius plot; all volunteer vegetation was identified to species and counted. Photos were taken from the start and end of each transect, angled along the transect, for a visual record of vegetation establishment over time.

*Site-wide Cover Estimate*

Transect sampling allows for species-specific evaluation of vegetation performance and cover in a subset of the project area. To evaluate site-wide vegetative cover, remote sensing data were used to calculate a Normalized Difference Vegetation Index (NDVI). NDVI is typically used to characterize vegetation growth or vigor, and is defined as the normalized ratio of the red and near infrared spectral bands (Xue and Su 2017). Multispectral imagery collected by drone during peak vegetation growth on August 18, 2020 captured red and near infrared (NIR) spectra, allowing for calculation of NDVI to identify areas with vegetative cover. NDVI ranges between -1 and 1, with values closer to 1 displaying spectral characteristics most similar to vegetation; based on visual comparison with true color imagery collected at the same time, a threshold value to distinguish between vegetation and non-vegetation was determined. The resulting raster was used to calculate a site-wide area with vegetative cover, as well as the area with vegetative cover in planted areas of interest. The calculated NDVI was validated by generating 100 random points and comparing with high resolution true color orthoimagery collected at the same time to determine whether those points were accurately classified as vegetation or non-vegetation; for 2020 data, the analysis was found to correctly classify 95% of points.

*Container Plantings*

The planting design for the project included subsets of planting zones where container plantings were installed (mostly 1-gallon), rather than seedlings, bare root, or live stakes. This allows for a paired comparison of the performance of container plantings compared to other stock types; container plantings are generally bigger and may be more robust at time of installation, which may increase

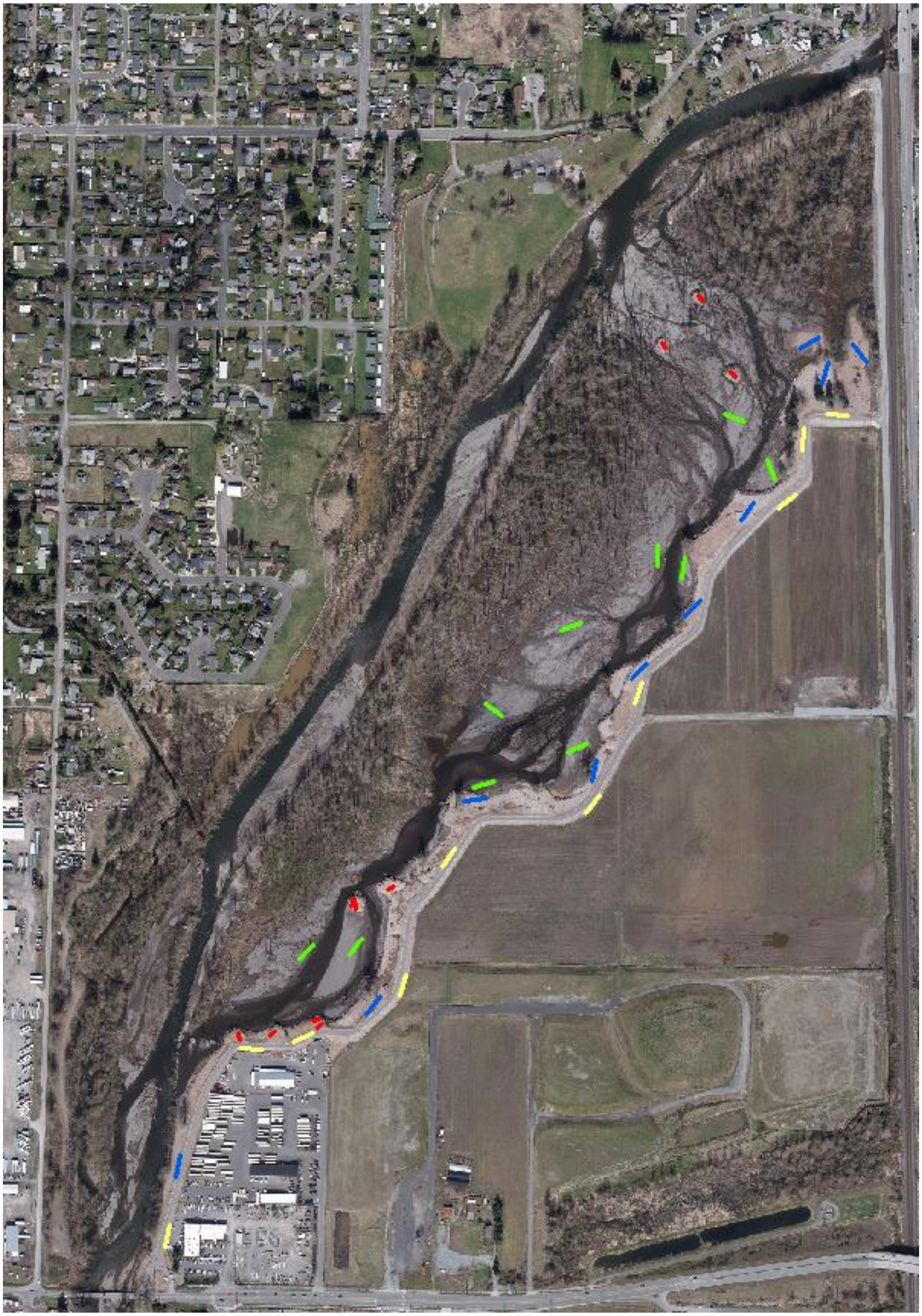

*Figure 3. Vegetation sampling transects. Transects were stratified by planting area, with 10 transects within each area: riparian buffer (blue), levee slope (yellow), engineered log structures (red), and unplanted gravel bars (green).*

survival and/or percent cover in early years, but are typically more expensive. Remotely-sensed percent cover (via NDVI calculation described in the section above) in nine container planting zones was compared to cover calculated in nine paired non-container planting zones to test the hypothesis that container plantings would provide more cover during the early years of site establishment. Data was analyzed using a one-tailed t-test.

## Aquatic Habitat

### *Floodplain Inundation*

Inundated area was estimated using aerial imagery during one pre-project (March 2016, 1800 cfs) period, and six post-project periods over a range of flows. In addition to true color (RBG) imagery, unmanned aerial vehicles (UAVs) also collected imagery that included near infrared (NIR) spectra during two collection events in 2018, one in 2019, and two in 2020. Collection of NIR spectra allows water surfaces to be distinguished from vegetation and bare ground because of the high contrast in the spectral absorption in the NIR band.

In 2018 and 2019, a maximum likelihood classification (MLC) method was used to distinguish inundated area, calibrated against the spectral properties of areas known to be wet or otherwise (i.e., dry or obscured by vegetation). Comparison of these MLC classified areas with a field-verified wetted edge indicated that some wetted areas were obscured by vegetation and so these estimations may have underestimated the actual inundated area. In 2020, the area of inundation was estimated using a Normalized Difference Water Index (NDWI), another remote sensing technique for water body mapping (Ma et al., 2019, Mukherjee et al., 2018) that uses the relationship between NIR and green bands to distinguish between water, vegetation, or soil signatures. This method successfully captured inundated areas with wide ranges of turbidity (e.g., the beaver pond in the northeast area of the project) and small wetted areas interspersed with vegetation in the 2020 dataset.  Pre-project inundated area was calculated by visually delineating wetted areas using the true color orthoimage, given that NIR data was unavailable. Although the methods differ, baseline and year 1, 2, and 3 estimates are presented in this report for a rough comparison.

### *Low Velocity Habitat*

Juvenile salmonids rely heavily on shallow, relatively slow moving waters for rearing (Bjornn and Reiser 1991, Beechie et al. 2005), therefore we surveyed the availability of this habitat in the project reach. The margins of low velocity habitat were located by visually determining the shear line (water velocity was approximately <0.45m/sec), and the slow-water boundary was mapped using a Trimble GeoXH GPS. Low velocity habitat was categorized into backwater, bar, bank and side channel habitat types as outlined in Beechie et al. (2005). Spatial data were transferred to a GIS and the area and distribution of low-velocity areas were evaluated for each habitat type. While low velocity habitat may be present along the entire margin of the river, it was only mapped if the habitat unit area was greater than the stated accuracy of the GPS as reported in real time. Anything smaller than this could not be accurately mapped and likely provided very little habitat value.

Low velocity habitat was surveyed multiple times per year to quantify the relationship between flow and low velocity habitat availability. Prior to project construction, twelve surveys were conducted in three habitat sampling areas along the mainstem (Figure 4). These areas were considered representative of available habitat conditions and channel morphology present pre-project throughout the entire reach. Several pre-project surveys limited habitat collection to along the left bank in 2011 and 2012 due to logistical constraints (Table 3). Post-project surveys conducted in 2018 and 2020 included the entire left bank mainstem as well as the entire reconnected floodplain.

In the current report, before and after low velocity habitat data collected at approximately 1100 cfs (about the median flow from February – March) is compared. Since only a portion of the mainstem was sampled during baseline efforts (0.85 km long reach, versus 2.12 km in Year 1 and 3), data was standardized by length of mainstem river sampled for comparison across sampling periods. The beaver pond in the northeast project area was mapped during the 2018 survey (shown in Figure 19), but was not mapped in 2020 and so was excluded for comparison.

*Table 3. Low flow habitat sampling events.*

| Project Phase | Date | Flow (cfs) | Areas Sampled |
|---|---|---|---|
| Pre-project | 4/13/11 | 1530 | ULB, MLB |
| Pre-project | 10/3/11 | 657 | ULB, MLB |
| Pre-project | 1/31/12 | 2830 | ULB, MLB, URB |
| Pre-project | 5/8/12 | 2920 | ULB, MLB |
| Pre-project | 11/6/12 | 1350 | MLB |
| Pre-project | 2/19/13 | 1100 | ULB, MLB |
| Pre-project | 3/19/15 | 1510 | ULB, MLB, URB |
| **Pre-project** | **5/20/15** | **1080** | **ULB, MLB** |
| Pre-project | 7/22/15 | 806 | ULB, MLB, URB |
| Pre-project | 9/3/15 | 603 | ULB, MLB, URB |
| **Year 1** | **2/26/18** | **1150** | **Entire site, no right bank** |
| Year 1 | 11/5/18 | 1430 | Entire site, no right bank |
| Year 1 | 7/31/18 | 825 | Entire site, no right bank |
| Year 3 | 3/23/20 | 972 | Entire site, no right bank |
| **Year 3** | **7/27/20** | **1110** | **Entire site, no right bank** |

Bolded rows highlight the data compared in this report.
ULB = upper left bank; MLB = middle left bank; URB = upper right bank


*Figure 4. Baseline low velocity habitat and fish sampling areas (overlaid on post-project image).*

## Fish Use

Monitoring fish use of the project reach is intended to evaluate changes in density and distribution of salmonids in low velocity habitats compared to baseline conditions. However, in 2020 COVID-19 safety restrictions prevented sampling and so fish use was not evaluated in Year 3. Similarly, the index of habitat capacity for salmonids was unable to be evaluated given no fish sampling was conducted.

## Flood Hazard

The structural stability of the setback levee was evaluated by inspection by the project design engineers during and following the February 2020 flood event, as well as during the low flow period. Areas of concern were noted and follow-up monitoring was conducted where needed. The ongoing impact of the project on flood elevations was also evaluated by observation during the February 2020 flood event, as well as by evaluating water surface elevations at the USGS 12100498 White River at Pacific gage from October 2016 through 2020 at flow intervals of 1000 cfs from 2,000 to 6,000 cfs as measured by the USGS 12100490 White River at R Street gage. Lateral migration of the mainstem and side channels within the project area was monitored using cross sections derived from both survey and LiDAR, as described in the Channel Dynamics section above, as well as by inspection.

# IV. Monitoring Results and Discussion

## Channel Dynamics and Sediment Conditions

### Channel Dynamics

| Year 3 Performance Standard | Year 3 Status | Details |
|---|---|---|
| New channel(s) form outside of the pre-project active channel. | ACHIEVED | A side channel with multiple braids was maintained outside of the mainstem channel. |

In 2020, the active channel location and planform of the mainstem were similar to 2019 and pre-project conditions (Figure 5). Active channel area in the project area (both mainstem and floodplain) decreased from 2019 to 2020 as the side channel has become more simplified, however across the reach the active channel remained 39.2 acres greater than at baseline (Table 4).

The length of side channel and number of side channels (as measured by node count) continued to increase from 2019 to 2020 and remained three times higher than at baseline (Figure 6). Braided channel length and node count also remained higher in 2020 than at baseline conditions but both decreased from 2019 levels. This observed decrease in braided channel metrics is likely due to a number of factors, such as conversion of braided channels to more stable side channels, as well as data limitations. The 2020 imagery available for this analysis was flown at a lower discharge than the 2018 and 2019 analyses (1030 cfs compared to 2400 cfs and 2860 cfs, respectively), and since braided channel presence is dependent on flow (as gravel bars are exposed or covered by water) the cross-year metrics are not fully comparable.

As of Year 3, the project continues to meet the channel dynamics performance standard of creating a new channel outside of the pre-project active channel. Side and braided channels are expected to continue to evolve, and continued monitoring of these metrics as well as sediment movement is needed to evaluate the possible need for adaptive management in the event that the floodplain channel becomes blocked by sediment aggradation and/or large wood. Additional adjustment, both depositional and erosional, should be anticipated if larger flood flows occur resulting from changes to operations (i.e., flow releases) at Mud Mountain Dam.

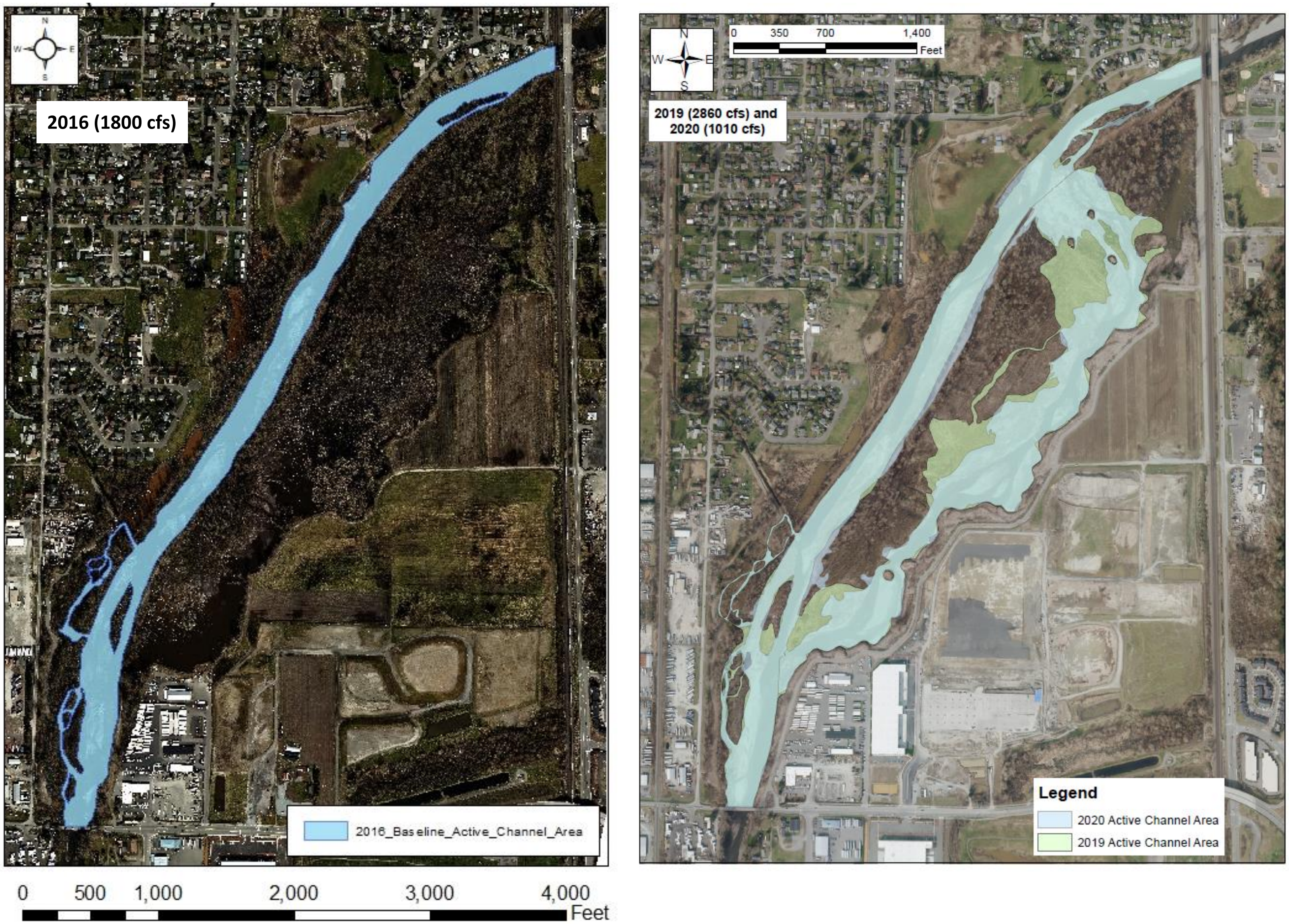


*Figure 5. Change in active channel area between baseline (2016), Year 2 (2019), and Year 3 (2020).*

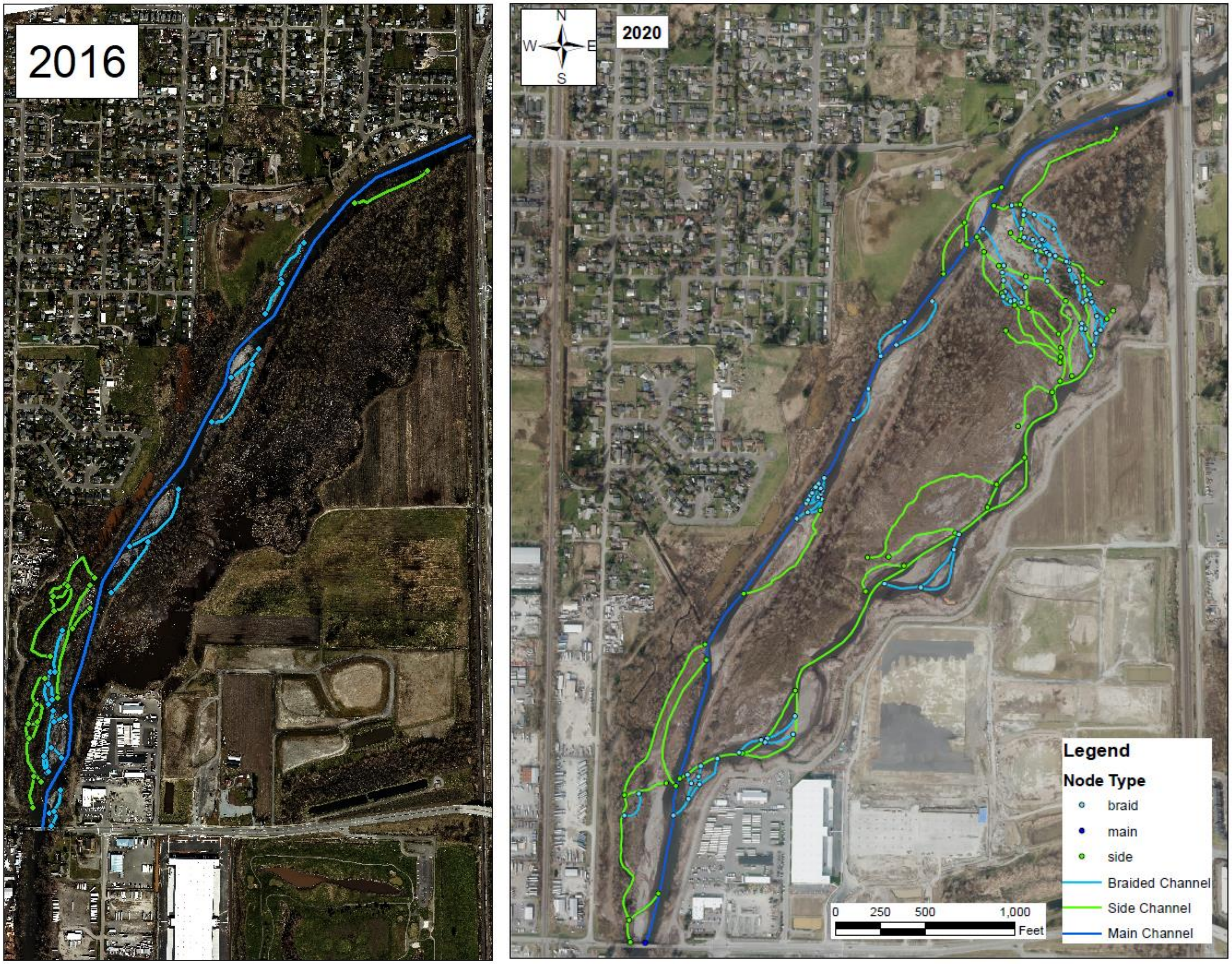


*Figure 6. Change in braided and side channel length and nodes between baseline (2016), Year 3 (2020).*

*Table 4. Geomorphic change between baseline and Years 1, 2, and 3.*

| | Baseline (2016) | Year 1 (2018) / % Change from Baseline | Year 2 (2019) / % Change from Baseline | Year 3 (2020) / % Change from Baseline |
|---|---|---|---|---|
| Active Channel area (acres) | 33.9 | 82.6 / 143% | 87.0 / 157% | 73.1 / 115% |
| Side Channel total length (ft) | 5,745 | 14,644 / 155% | 17,170 / 199% | 20,364 / 254% |
| Number of side channel nodes | 20 | 24 / 20% | 46/ 130% | 49 / 145% |
| Side channel:Mainstem channel ratio | 1.056 | 1.65 / 56% | 2.25 / 114% | 2.92 / 177% |
| Number of braided channel nodes | 30 | 74 / 147% | 44 / 47% | 98 / 227% |
| Braided Channel total length (ft) | 7,437 | 11,733 / 58% | 15,790 / 112% | 9,072 / 22% |
| Braided channel:Mainstem channel ratio | 0.816 | 2.06 / 152% | 2.45 / 200% | 1.30 / 59% |

Cross sections were selected throughout the reach to compare bed elevation in 2019 and 2020 (Table 5, Figure 7). Examination of cross section plots showed that at RM 6.145, just upstream of the floodplain side channel inlet, a mainstem left bank side channel deepened. A cross section extending across the floodplain side channel inlet (XS 6.071) showed an increase in bed surface at many points, potentially reflecting deposition of wood and sediment after the February 2020 high flow event. Cross sections throughout the floodplain showed side channel deepening in various areas, and the variability in elevation is evidence of channel complexity and roughness. Just upstream of the Stewart Road bridge and below the point where the side channel reconnects with the mainstem, the White River thalweg moved towards the opposite bank, eroding the left bank gravel bar and forming a new right bank gravel bar.

*Table 5. Channel bed elevations (feet) averaged across selected cross sections. Cross sections are labeled by river mile. Horizontal datum: NAD 1983 HARN Washington State Plane Coordinate System North Zone.*

| Cross-section | *2019* | *2020* | *Difference (ft)* |
|---|---|---|---|
| XS 6.145 | 81.89 | 82.41 | +0.52 |
| XS 6.077 | 81.29 | 81.43 | +0.14 |
| XS 6.071 | 81.31 | 81.88 | +0.57 |
| XS 5.93 | 76.97 | 77.09 | +0.12 |
| XS 5.920 | 77.12 | 77.31 | +0.19 |
| XS 5.7449 | 74.36 | 74.29 | -0.07 |
| XS 5.3929 | 70.83 | 70.92 | +0.09 |
| XS 5.041 | 63.85 | 63.82 | -0.03 |

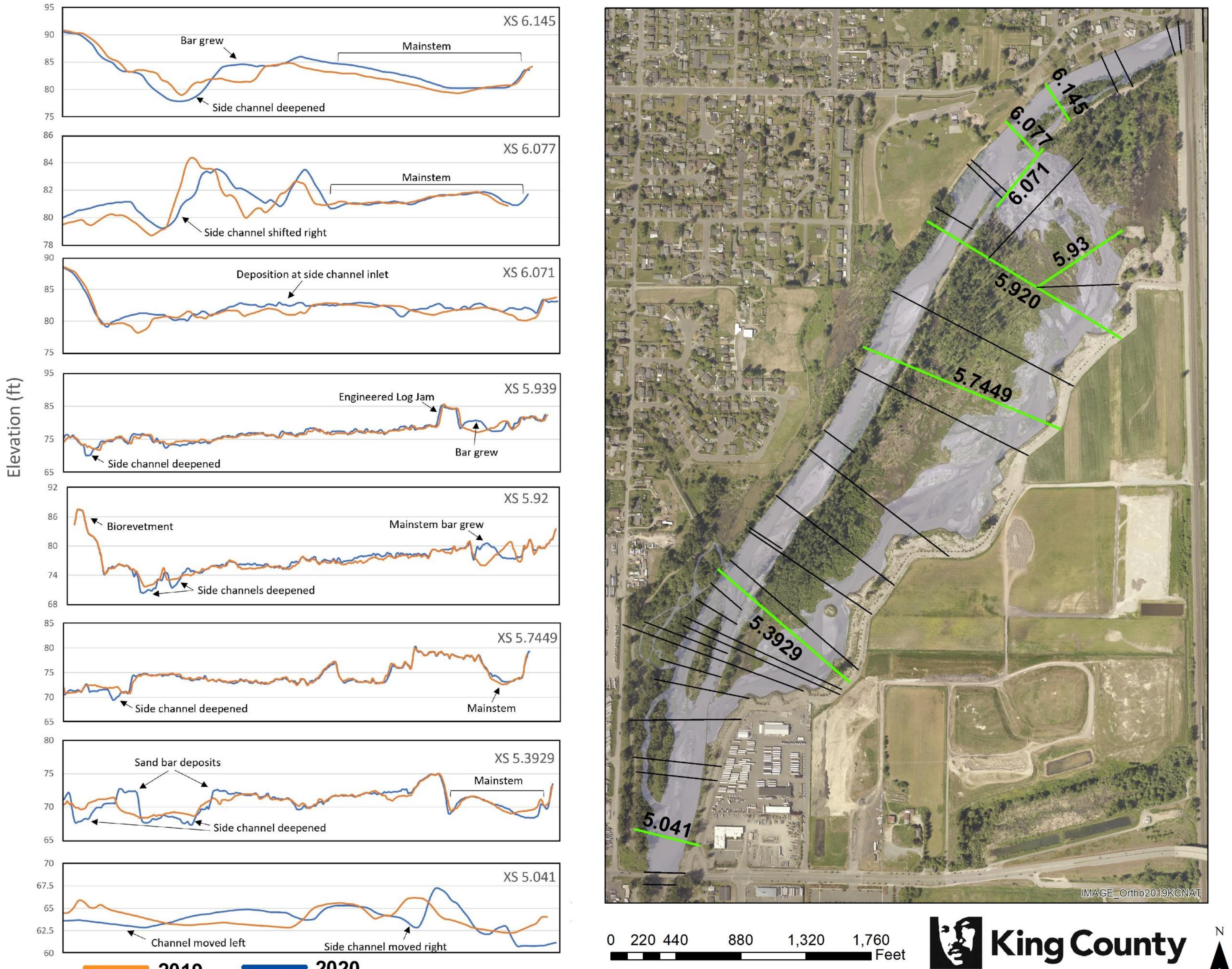


*Figure 7. Cross sections comparing 2019 and 2020 channel bed elevations. Selected cross sections highlighted in green, and active channel shown in pale purple in the map on right. Lateral extent of each cross section was determined by channel extents, so levees and revetments are not shown.*

## Sediment Conditions

| Indicator | Year 3 Performance Standard | Details |
|---|---|---|
| Sediment conditions | None specified | Net sediment export of about 2,100 cubic yards was estimated between 2019 and 2020 across the reach; net deposition was estimated in upstream mainstem and floodplain areas with net erosion in downstream areas. |

Between 2019 and 2020, a net loss of 2,137 cubic yards of sediment was estimated in the reach between the A Street and Stewart Street bridges. Most of the net erosion was observed in the downstream sections of mainstem and floodplain (Figures 8 and 9, Table 6); as calculated from LiDAR, a net 3,806 cubic yards of sediment moved out of the floodplain while 1,669 cubic yards of sediment was deposited throughout the mainstem. This is a different pattern than was observed in the first year post-construction, when large amounts of sediment were deposited throughout the floodplain, but especially in the downstream sections of floodplain where large volumes of sand-sized material were deposited. In Year 3, some floodplain sandbars enlarged (downstream from mid-project vegetated islands and downstream of the southern engineered log jam), while adjacent channels eroded sediment and deepened. Continued monitoring of sediment changes will increase our understanding of these channel responses; one explanation for sediment mobilization in downstream project areas is that deposition where the channel widens at the side channel inlet could have increased channel slope and resulted in increased water velocity and sediment export downstream.

*Table 6. Net change in sediment volume (cubic yards) from 2019 to 2020. Zones correspond to those shown in Figure 9.*

| Zone | Net volume change (cubic yards) | Zone | Net volume change (cubic yards) |
|---|---|---|---|
| 1 | 5,913 | 11 | -170 |
| 2 | 3,968 | 12 | -2,215 |
| 3 | 4,184 | 13 | -1,991 |
| 4 | -636 | 14 | -900 |
| 5 | -1,494 | 15 | -1,676 |
| 6 | -7,040 | 16 | -1,334 |
| 7 | -3,226 | 17 | -1,772 |
| 8 | 5,990 | 18 | -1,350 |
| 9 | 1,834 | 19 | -744 |
| 10 | 521 | | |

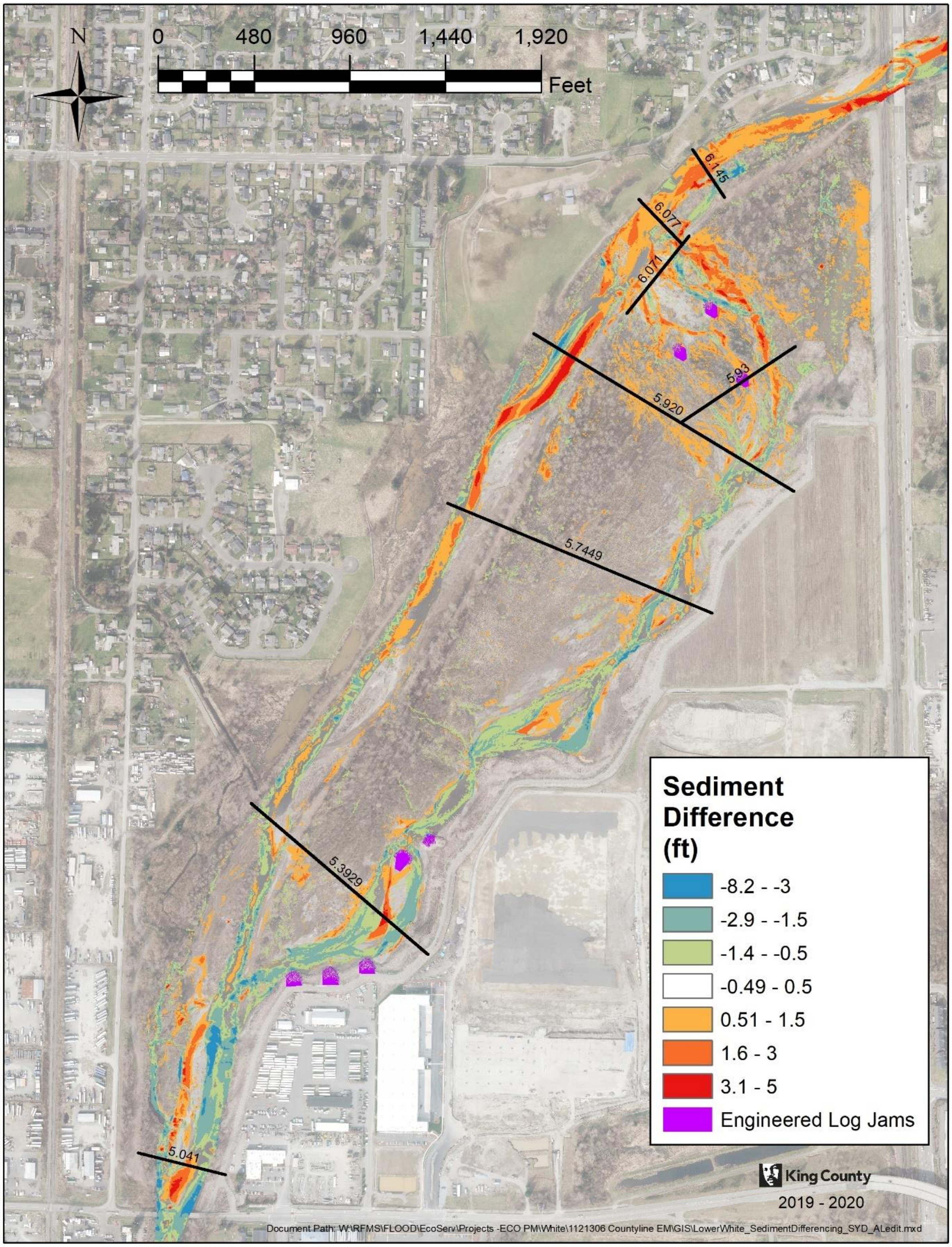


*Figure 8. Elevation change in the project area between 2019 and 2020.*

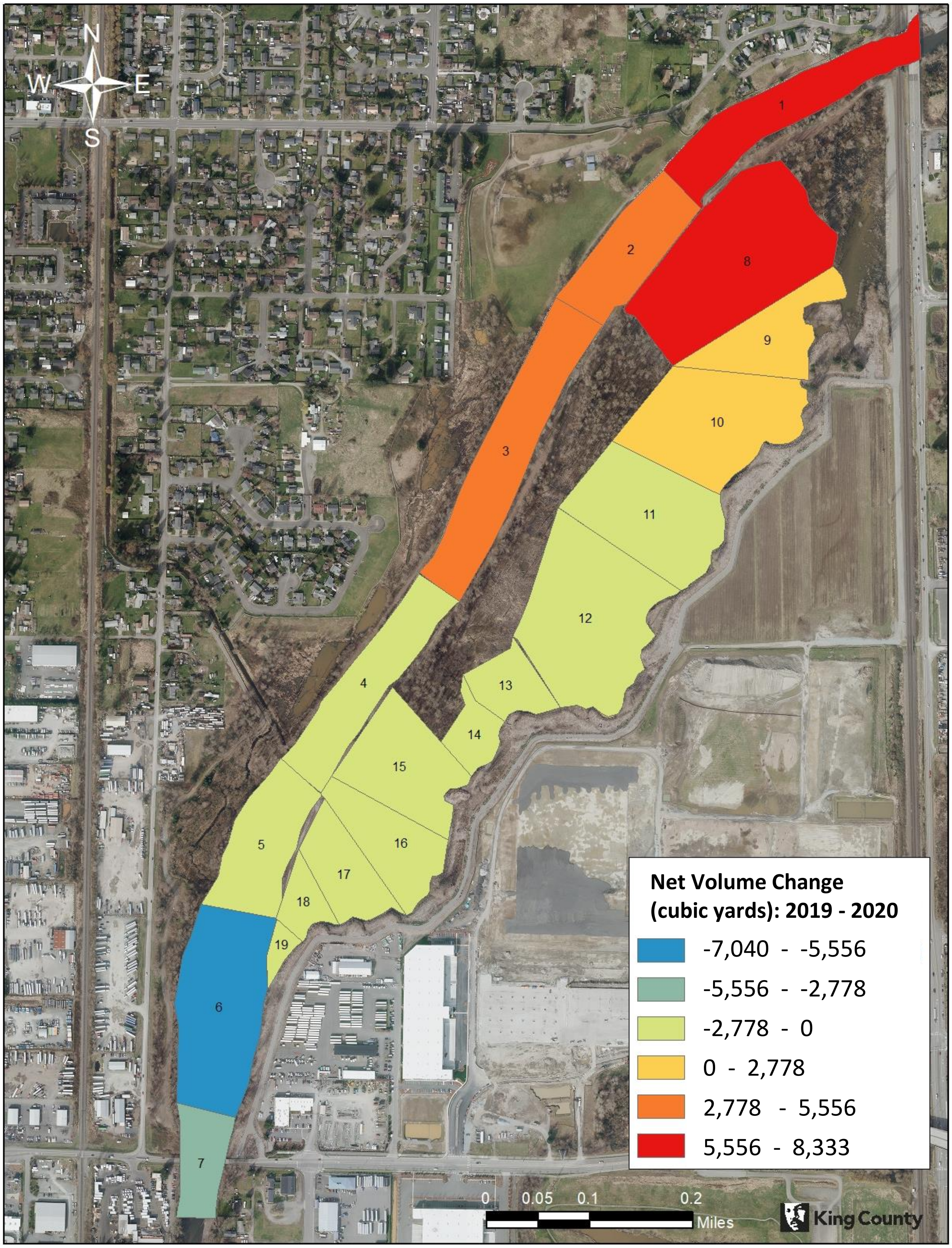


*Figure 9. Zones within mainstem and floodplain areas for which change in sediment volume was calculated in Table 6.*

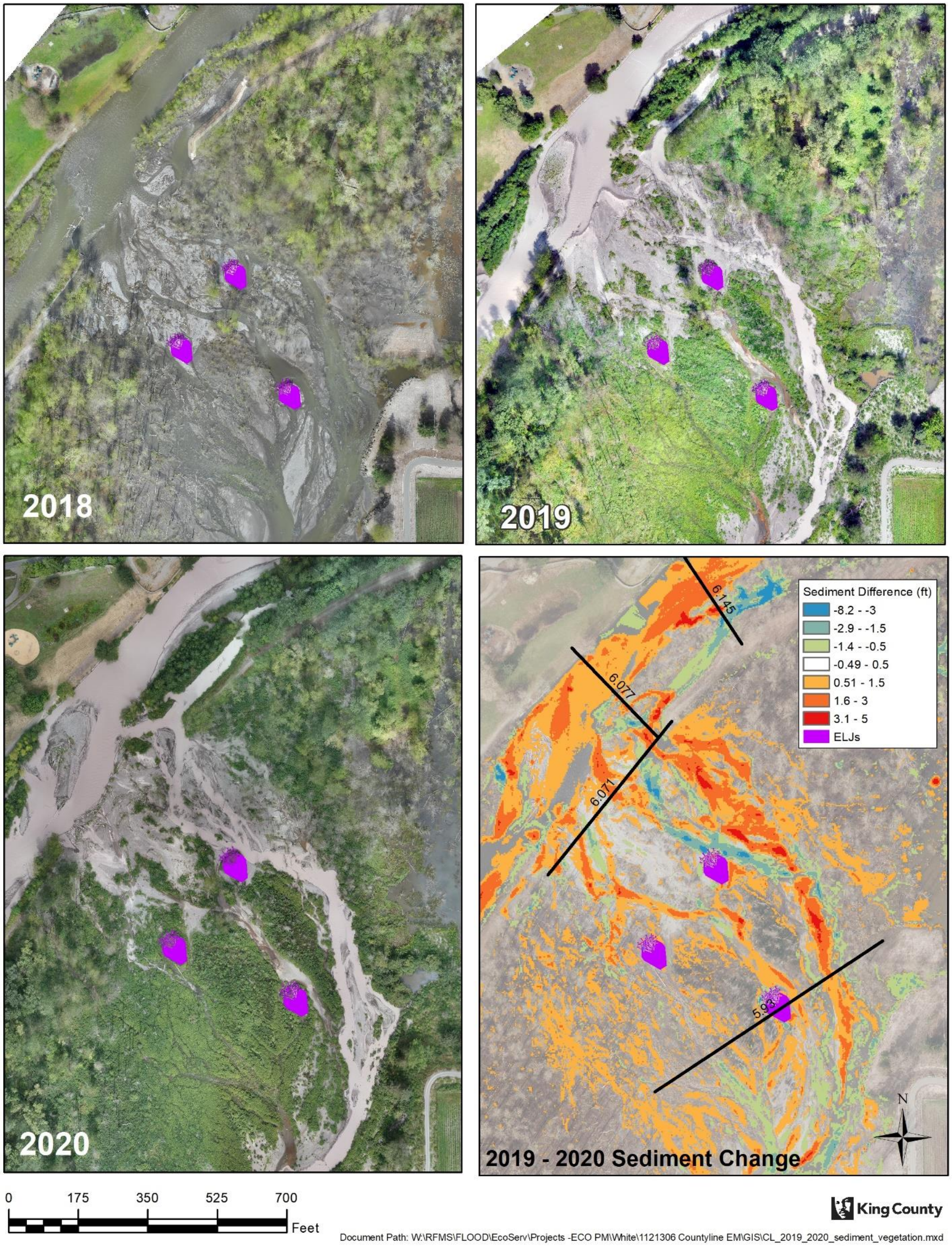


*Figure 10. Aerial imagery and sediment differencing in the side channel inlet area between 2018 - 2020.*

Vegetation growth may be contributing to patterns of channel development and aggradation at the inlet area. Portions of areas that were previously braided channel in 2018 have increased in vegetative cover over time (Figure 10), which may have slow flows and induced sediment deposition in these areas, resulting in concentrated flow in fewer braided channels. Concentrated flow may have contributed to the channel deepening observed along cross section 5.939 (Figure 7).

## Habitat

In addition to aquatic habitat, the project site continues to provide habitat for a variety of terrestrial and amphibious species, including bald eagles (nest remained active in 2020), great blue herons, red wing blackbirds, Canada Geese, red-tailed hawks, a number of duck species, deer, American bullfrogs, mink, and opossum. A beaver dam complex in the northeast area of the project has expanded and remained active as of the date of this report (Figure 11). Beaver browse was also regularly observed on site (Figure 12).

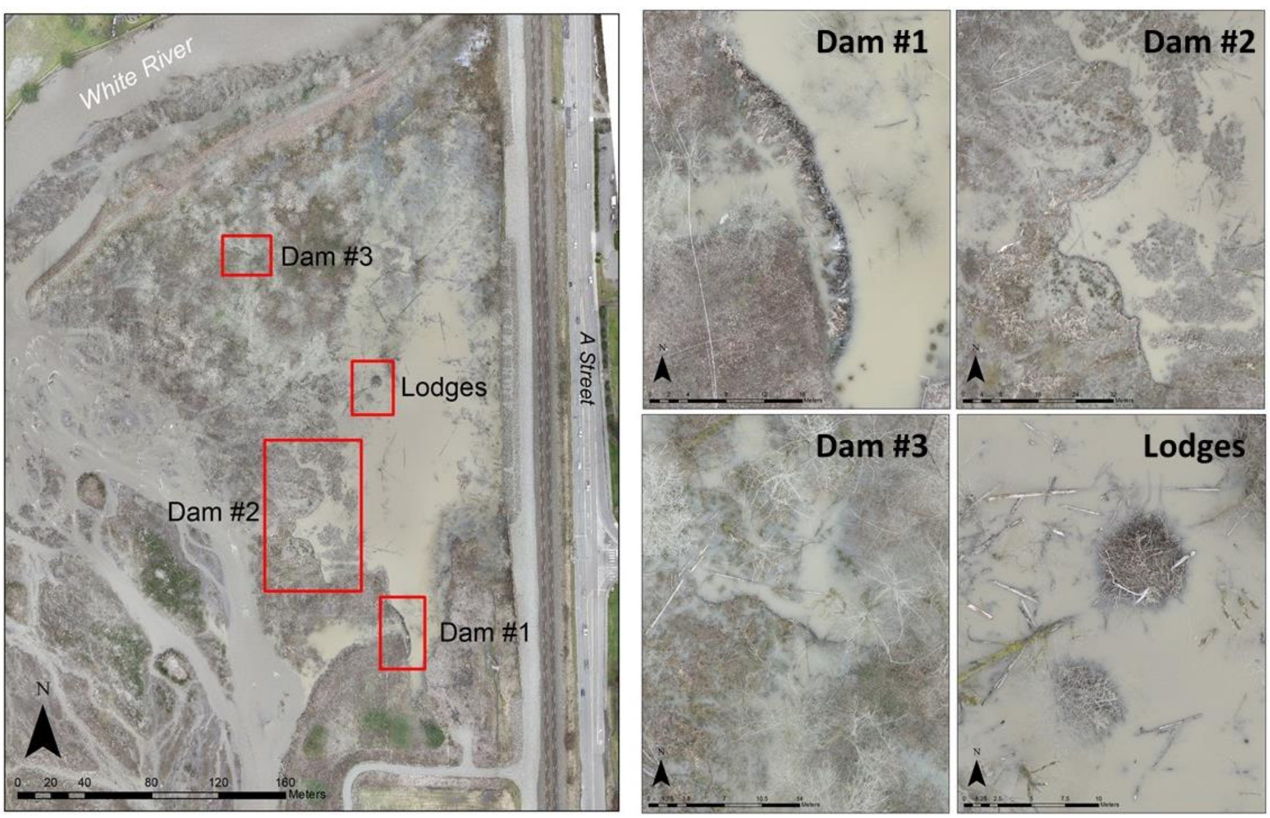


*Figure 11. A complex of three beaver dams and 2 lodges visible in high resolution aerial imagery collected on February 23, 2021 (4,920 cfs at R Street gage).*

*Figure 12. Beaver browsed willow (left) and western red cedar (right) observed April 2021.*

## Vegetation Cover

| Year 3 Performance Standard | Year 3 Status | Details |
|---|---|---|
| Cover by installed trees and shrubs, including cover by volunteers of desirable native woody species, in Year 3 is at least 20% | ACHIEVED | Percent cover of trees and shrubs averaged 35% across transects in planted areas. |
| Less than 10% invasive cover (non-regulated noxious weeds and weeds of concern) in planted areas (5% for King County class A noxious weeds, bindweed, and knotweed). Less than 25% reed canary grass on site as a whole. | ACHIEVED | An average of 2% cover of invasive weeds was found across monitored transects. Knotweed and bindweed were present but infrequent. Reed canarygrass cover averaged 0.5% across transects. |

*Transect Sampling*

Average tree and shrub cover across all sampled transects (including unplanted gravel bars) was 21% and 16% respectively (37% combined) in Year 3. In planted areas, combined average shrub (17%) and tree (17%) cover was 35%, exceeding the Year 3 performance standard of 20% cover of native woody species in planted areas. Cover of native woody species continued to vary across planted areas and across transects within planted area types; average cover was 29% (SD = 12%) in levee slope (LS) areas, 35% (SD = 23%) in riparian buffer (RB) areas, 43% (SD = 23%) in unplanted gravel bars, and 43% (SD = 15%) in engineered log jam (ELJ) areas. When evaluating performance of each planted area compared to the Year 3 performance standard, all planted areas significantly exceeded the standard of 20% ($p<0.05$). Conservative estimates of percent cover of woody species by planting area (i.e., calculated using the lowest value of each cover class range, rather than mid-point), indicate that at minimum, 24% cover was observed in ELJ areas, 14% in LS areas, and 18% in RB areas.

Average cover of native woody species has increased each year for all vegetation area types except riparian buffer, where similar cover was observed in Year 2 and 3 (Figures 13 and 14). Cover of native woody species in LS transects has steadily increased over time, though remains the lowest perhaps due to lower soil moisture on levee slopes. Average percent cover of native ground cover species was observed to be 11% across all sampled transects. Vegetation establishment has exceeded expectations so far, possibly resulting from soil preparation, plant selection, natural recruitment, and regular watering delivered by the extensive irrigation system used on site for the first 3 years. This irrigation system was disassembled in early 2021.

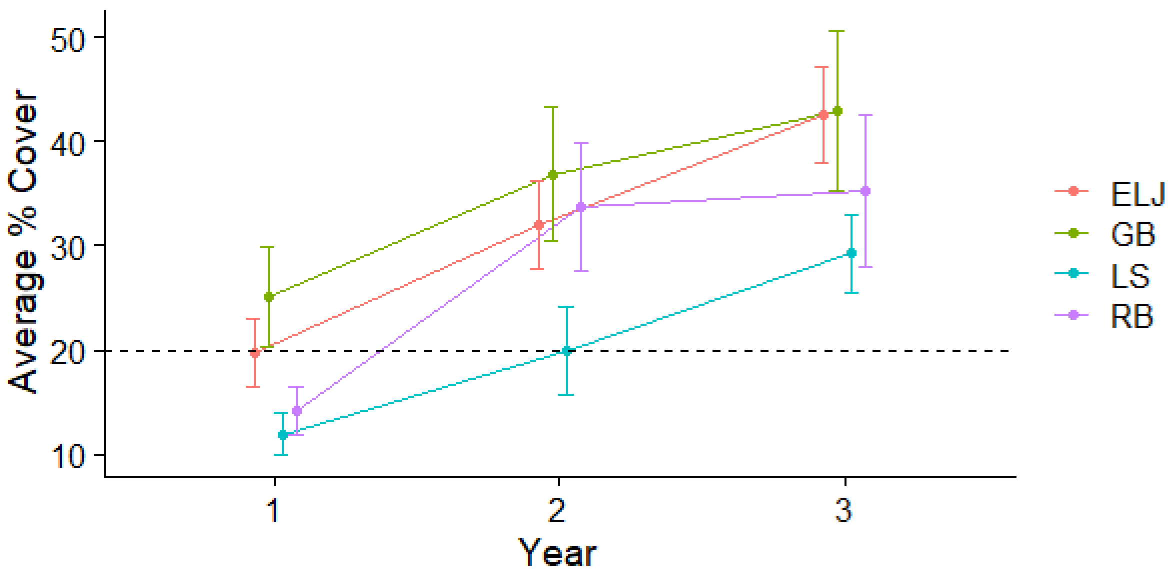


*Figure 13. Percent cover of woody species in years 1, 2, and 3, averaged across sampling transects, by planting area. Engineered Log Jam (ELJ), unplanted gravel bar (GB), levee slope (LS), and riparian buffer (RB). Error bars denote standard errors, and dashed line shows the Year 3 performance standard of 20% cover.*

No King County Class A noxious weeds, field bindweed (*Convolvulus arvensis*), or Japanese knotweed (*Polygonum cuspidatum*) were observed in planted vegetation transects throughout the project area. However, small amounts of knotweed and bindweed were noted in the project area. An average of 2% cover of non-regulated noxious weeds (evergreen blackberry *Ruvus laciniatus*, thistle species *Cirsium* spp., and common teasel *Dipsacus fullonum*) and King County Weeds of Concern (Scotch broom *Cytisus scoparius*, creeping buttercup *Ranunculus repens*, and Himalayan blackberry *Rubus armeniacus*) was found across transects. As in Year 2, non-regulated weed cover was higher in ELJ planting areas (4%) than LS (2%) or RB (1%) planting areas, likely due to challenges in accessing these areas for vegetation maintenance. Reed canarygrass (*Phalaris arundinacea*) cover averaged 0.5% across all transects sampled, and was most frequently found in GB transects. The site is meeting invasive cover performance standards of less than 10% cover of non-regulated invasive species, less than 25% reed canary grass, and less than 5% Class A noxious weeds, bindweed, and knotweed. Vegetation maintenance in planted and floodplain areas is ongoing to manage for undesirable species.

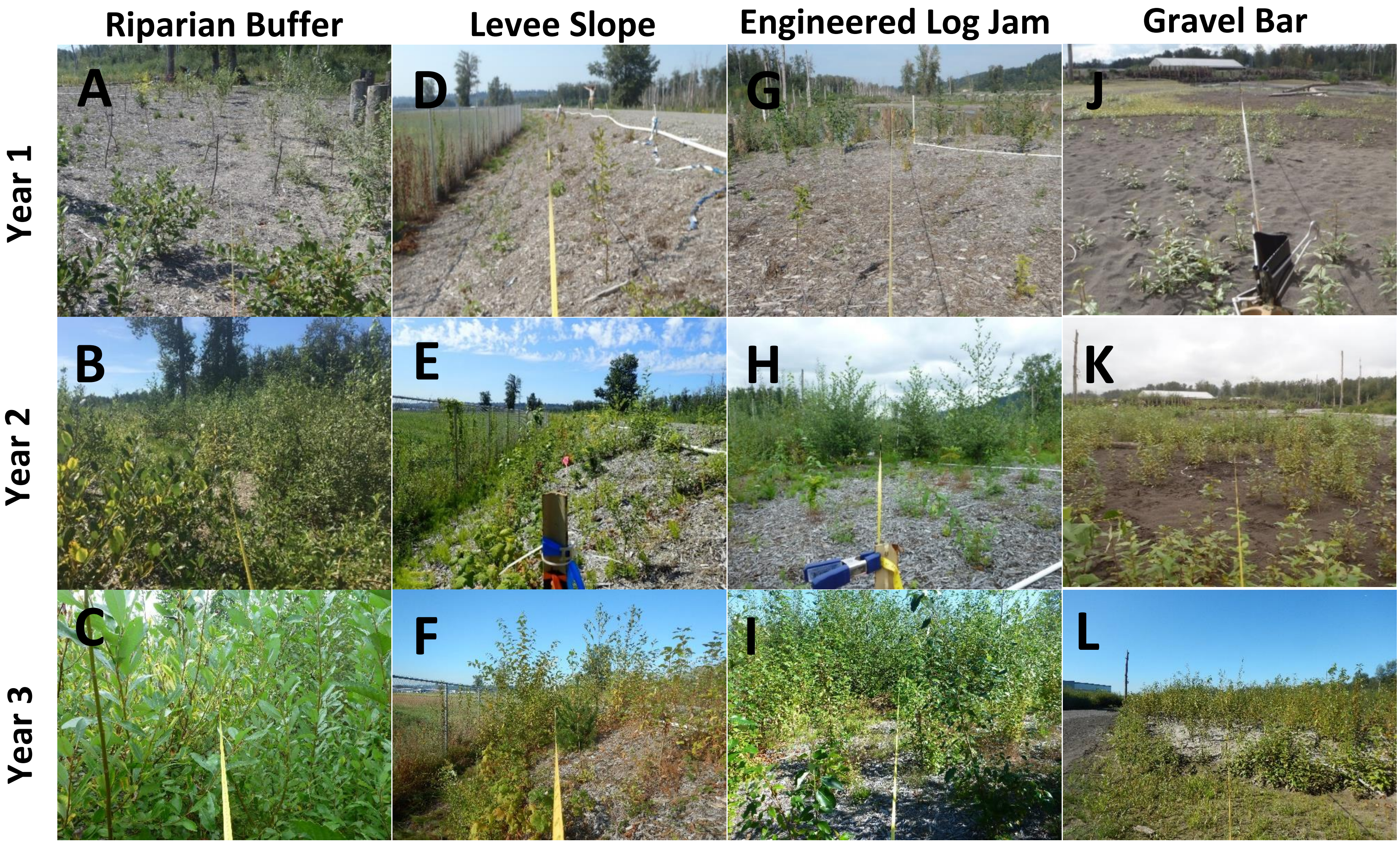


*Figure 14. Photos of vegetation transects in riparian buffer, levee slope, engineered log jam, and unplanted gravel bar areas at Year 1, 2, and 3. Panels A,B,C show transect RB-3 (at 0-m), D,E,F show transect LS-1 (at 0-m), G,H,I show transect ELJ-2 (at 15-m), and J,K,L show transect GB-2 (at 0-m).*

*Site-wide Cover Estimate*

Remote sensing analysis (NDVI) found that sitewide, across planted areas, percent cover was 63% (Figure 16). We did not expect that the NDVI method and transect sampling would produce identical or directly comparable estimates of percent cover, since the NDVI estimate includes all vegetation, (including non-native species, whereas data reported above from transects separate out native and non-native cover and include woody species only), and methodology limitations differ (e.g., cover class bins for field collected data, soil color influences on spectral reflectance) which may under or overestimate cover in some areas.

To explore differences in methodology, we compared field-measured and remotely-sensed percent cover at 20 randomly selected 1-m radius circular plots throughout planted areas in 2021. Remotely-sensed percent cover was generated in GIS using NDVI calculated from August 2021 imagery, and as described in the Vegetation Cover methods above. Field-measured percent cover was collected within 2 days of the aerial imagery collection, such that vegetation conditions were the same, and binned percent cover by 10% cover classes (e.g., 0-10%, 10-20%). Results indicate that remotely sensed cover using NDVI overestimates vegetative cover compared to field data, particularly in plots with intermediate cover values (Figure 15). This non-linear relationship between vegetative cover and NDVI, and saturation of NDVI in areas with denser vegetation, has also been found by others (Jiang et al. 2006). Other methods of calculating the percent cover from NDVI, as described in Jiang et al. (2006), minimally or did not improve the relationship between field measured and remotely sensed data. Despite this observed non-linear relationship, tracking NDVI over time can be useful in quantifying site-wide change in vegetation cover (recognizing is it an over-estimate), and/or in measuring other vegetation metrics such as health and density.

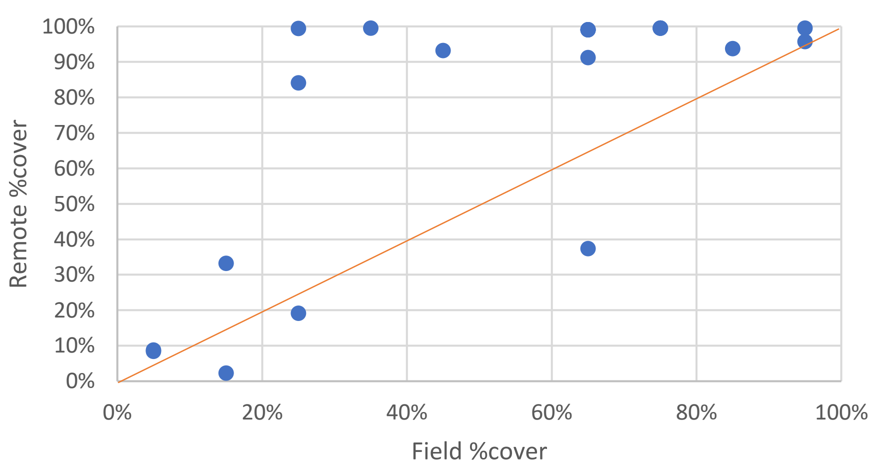


*Figure 15. Percent cover as measured in the field versus remotely by NDVI. Orange line represents 1:1; points above the line are plots where NDVI overestimated cover compared to field data, points below the line are plots where NDVI underestimated compared to field data.*

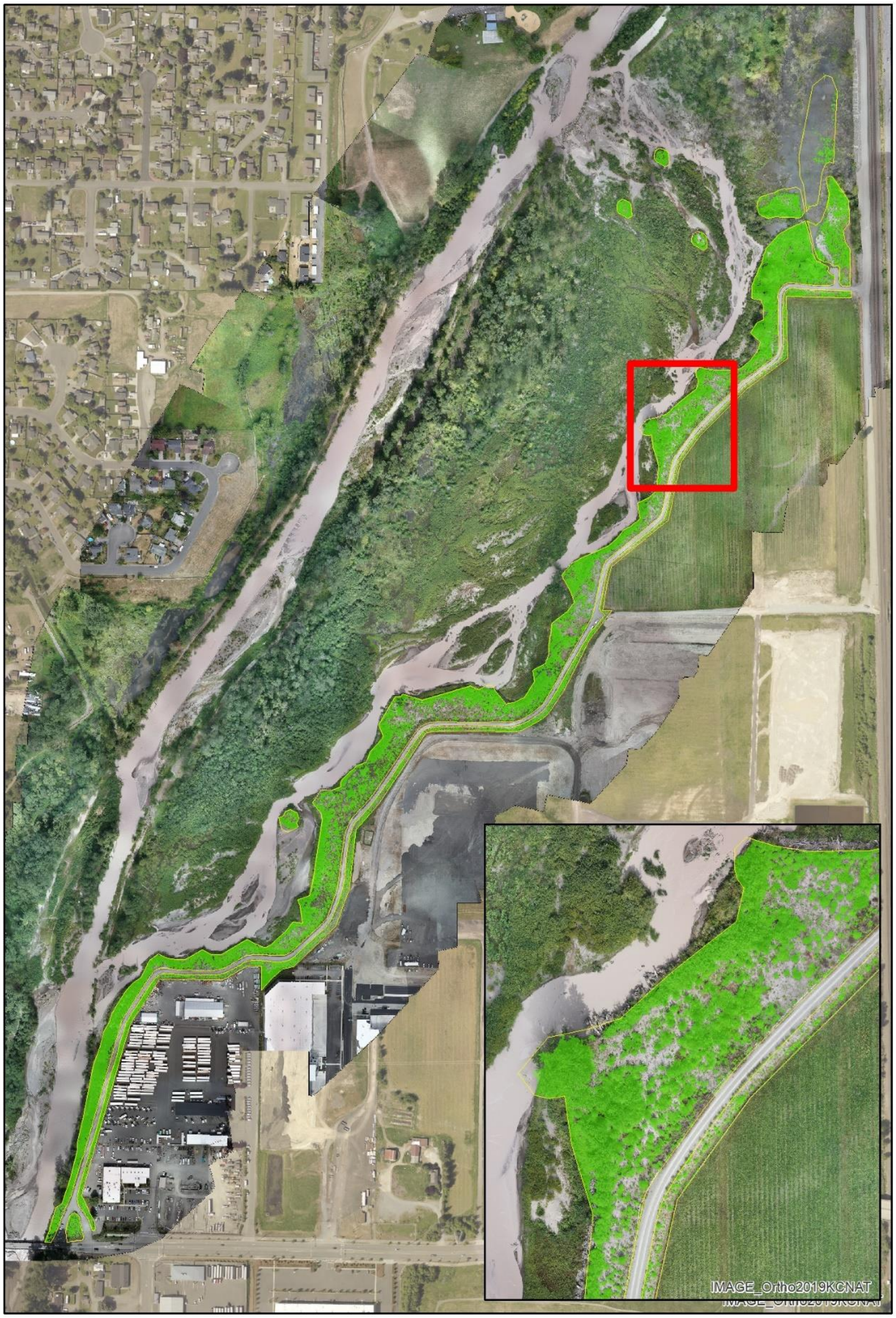


*Figure 16. Remotely sensed vegetation in planted areas (bright green) as calculated by NDVI.*

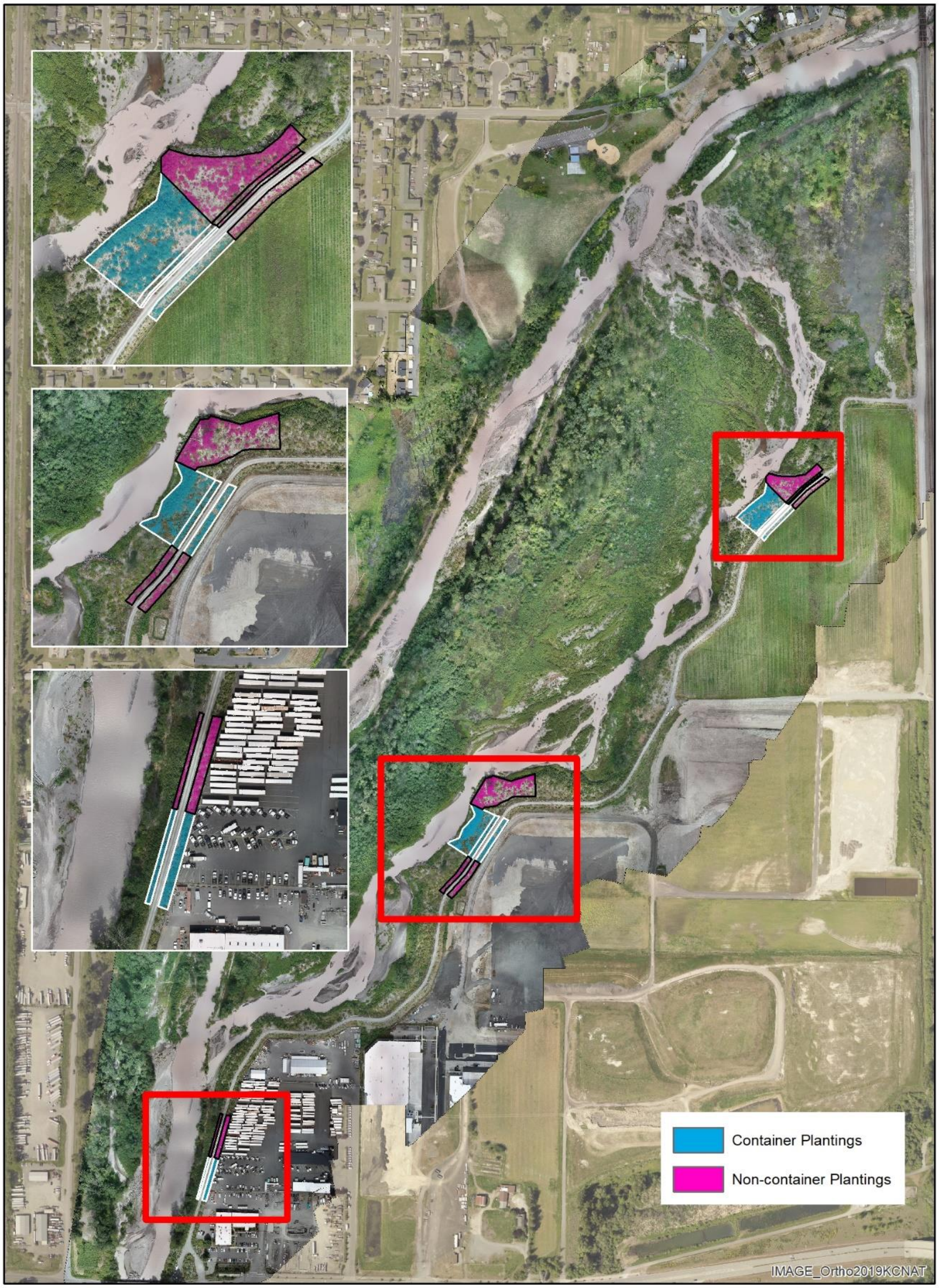


*Figure 17. Percent cover, as calculated by NDVI, in a subset of planted areas where container plantings (blue) and non-container plantings (pink) were installed.*

*Container Plantings*

On average, zones where container plantings were installed had a remotely sensed, (i.e., by NDVI), percent cover 7% higher than paired zones without container plantings (range: 9% lower to 20% higher; one-tailed p-test: $p=0.03$). While statistically significant, the areas appear visually similar in vegetative cover (Figure 17), and the relatively small average difference in percent cover after three years of establishment may not warrant the additional cost of container plantings. However, we also note that this analysis is imperfect, since cover provided by naturally recruited cottonwood and alder saplings are included in these calculations, rather than cover just from container and non-container plantings. Further investigations on this subject could collect paired field data to evaluate cover, growth, and/or rigor of plants installed as container plantings versus bare root or seedlings.

*Vegetation and Site Maintenance*

Growth and survival of planted and naturally recruited vegetation has likely benefitted from ongoing site maintenance actions. These actions include manual and chemical control of undesirable vegetation in planted areas and unplanted floodplain areas, regular watering of planted areas in summer months from 2018 to 2020 with an irrigation system and municipal water supply, and installation of additional plantings in Years 1 and 2. Descriptions of maintenance actions are found in Table 7. Undesirable controlled vegetation species included yellow flag iris, Himalayan blackberry, bindweed, thistles, bittersweet nightshade, reed canary grass, tansy ragwort, common tansy, poison hemlock, purple loosestrife, bird's food trefoil, Scotch broom, and Japanese knotweed. Irrigation frequency was determined based on soil moisture readings, targeting soil moisture between 8-12%.

*Table 7. Site maintenance activities between 2018 and 2020.*

| Year | Maintenance Activities |
|---|---|
| 2018 | • Undesirable species removal (manual and chemical control)<br>• Irrigation of planted areas 1-3x per week by irrigation system<br>• Replant 800 live stakes, 2800 trees, and 4,250 shrubs |
| 2019 | • Undesirable species removal (manual and chemical control)<br>• Irrigation of planted areas 1x per week by irrigation system<br>• Replant landward levee slopes with 20 Western red cedar and 30 Douglas fir. |
| 2020 | • Undesirable species removal (manual and chemical control)<br>• Irrigation of planted areas 1x per week by water truck |

## Aquatic Habitat

### *Floodplain Inundation*

| **Year 3 Performance Standard** | **Year 3 Status** | **Details** |
|---|---|---|
| On average over years 1, 3, 5, 7, and 10, wetted area in the floodplain between Feb 1 – Mar 31 is 32.5 acres. | ON TARGET | The average of Year 1 and Year 3 inundation estimates was 57.2 acres, indicating the project is on target to meet the inundation performance standard. |

The area of inundated floodplain during the monitoring window (Feb 1 – Mar 31) remained high during Year 3; 57.6 acres of floodplain were inundated at 6,620 cfs (Figure 19). The relationship between discharge and inundated area appears fairly linear between 2400 cfs and 6000 cfs (Table 8; Figure 18). The flow at which the relationship plateaus is untested; the area landward of the biorevetment structures was designed to be inundated at the 2-year flood flow (~9,600 cfs), however these flows have not occurred since project construction. In the future, high flow conditions that could result in substantial channel change in the floodplain may alter the relationship observed here.

*Table 8. Acres of floodplain inundated at baseline and after construction.*

| Measurement period | Date | Flow at Auburn (cfs) | Visual Delineation Method (acres) | MLC or NDWI method (acres) |
|---|---|---|---|---|
| Baseline | 3/18/2016 | 1800 | 7.8 | -- |
| Year 1 | 2/6/2018 | 6060 | 63.3 | 56.8 |
| Year 1 | 4/9/2018 | 2400 | 21 | 24 |
| Year 2 | 4/9/2019 | 2860 | 28 | 22.2 |
| Year 2 | 4/12/2019 | 4050 | 56 | -- |
| Year 3 | 2/8/2020 | 6620 | -- | 57.6* |

*Imagery from 2/8/2020 was analyzed using the normalized difference water index (NDWI) instead of maximum likelihood classification (MLC), as it was found to provide a better visual match to known inundated areas for the 2020 imagery.

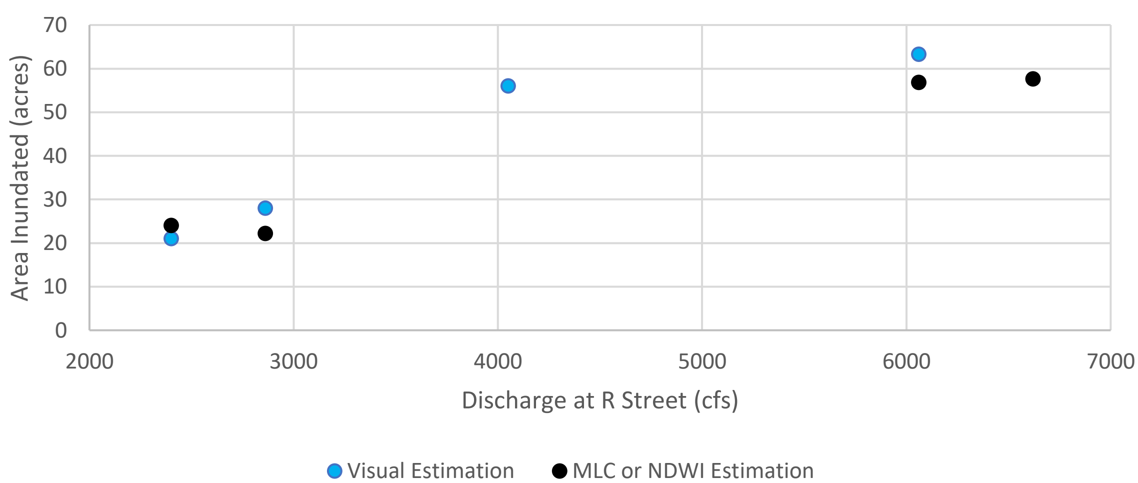


*Figure 18. Inundated acreage within the project area versus discharge between Feb 1 – Mar 31 in all years after construction.*

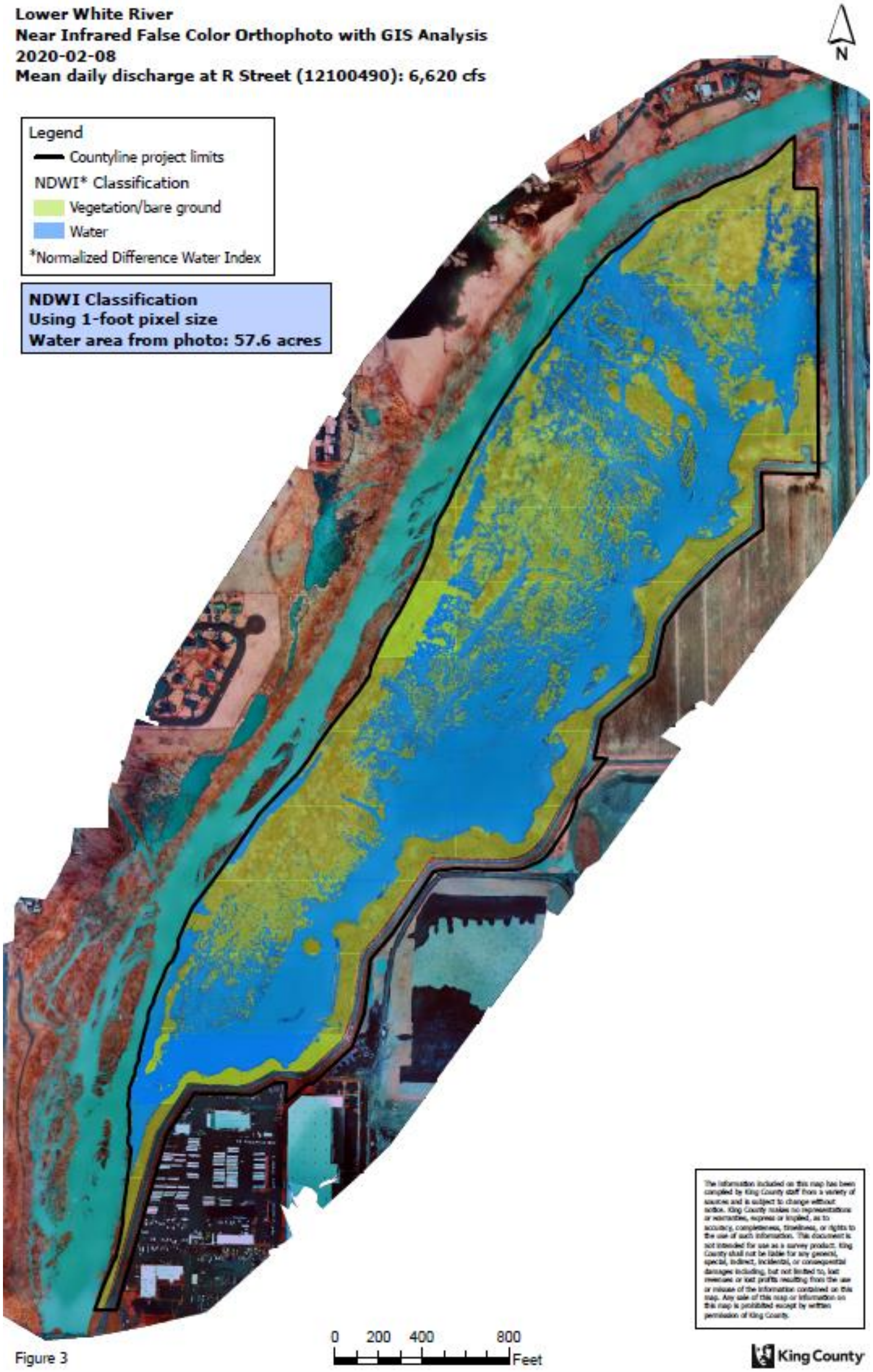


*Figure 19. Inundated areas at Year 3.*

*Low Velocity Habitat*

| Year 3 Performance Standard | Year 3 Status | Details |
|---|---|---|
| Sum of slow-water (<1.5 ft/sec) bar, bank, backwater, and side channel area increases by >50%, relative to baseline condition. | ACHIEVED | Slow-water habitat availability remained far greater than at baseline; the 9.6 acres of low velocity habitat in Year 3 represented a 463% increase from pre-project conditions. |

By Year 3, low velocity habitat area per km increased by 463% compared to baseline conditions. In Year 3 at 1110 cfs, a total of 39,900 square meters (9.6 acres) of slow-water habitat was mapped in the floodplain and along the left bank mainstem White River in between the A Street and Stewart Road bridges within the 2.12 km reach (18,820 $m^2$/km). In comparison, 63,273 $m^2$ was mapped in the same reach in Year 1 (29,845 $m^2$/km), and 2,839 $m^2$ in the subset areas along 0.85 km at baseline (3,340 $m^2$/km). Most of the slow-water habitat in both the mainstem and floodplain was side channel habitat, though bar, bank, and backwater habitats were also found (Table 9).

Figures 20 and 21 compare low velocity habitat per km over time across three sampling events with comparable flows. At approximately 1100 cfs at the R Street gage, slow-water habitat was greater during Year 1 compared to Year 3. This may be due to decreased inundation of the floodplain area at low flows in Year 3 resulting from sediment deposition, particularly following a high flow event in February 2020 that resulted in aggradation at the side channel inlet and likely changed flow splitting between the mainstem and side channel (see Flood Hazard subsection below for more discussion). The reduction in low velocity habitat from Year 1 to 3 could also be due to channel simplification and deepening that may concentrate flow into fewer channels. These changes may reflect either site stabilization or channel dynamism; continued monitoring will help distinguish between these possibilities.

Low velocity side channel habitat in the mainstem increased substantially in Year 3 compared to baseline and Year 1. While Year 1 low velocity habitat was primarily found in the floodplain, low velocity habitat distribution was more evenly split between mainstem (43%) and floodplain (57%) areas in Year 3; comparing the mainstem only, low velocity habitat increased from baseline by 141% in Year 3.

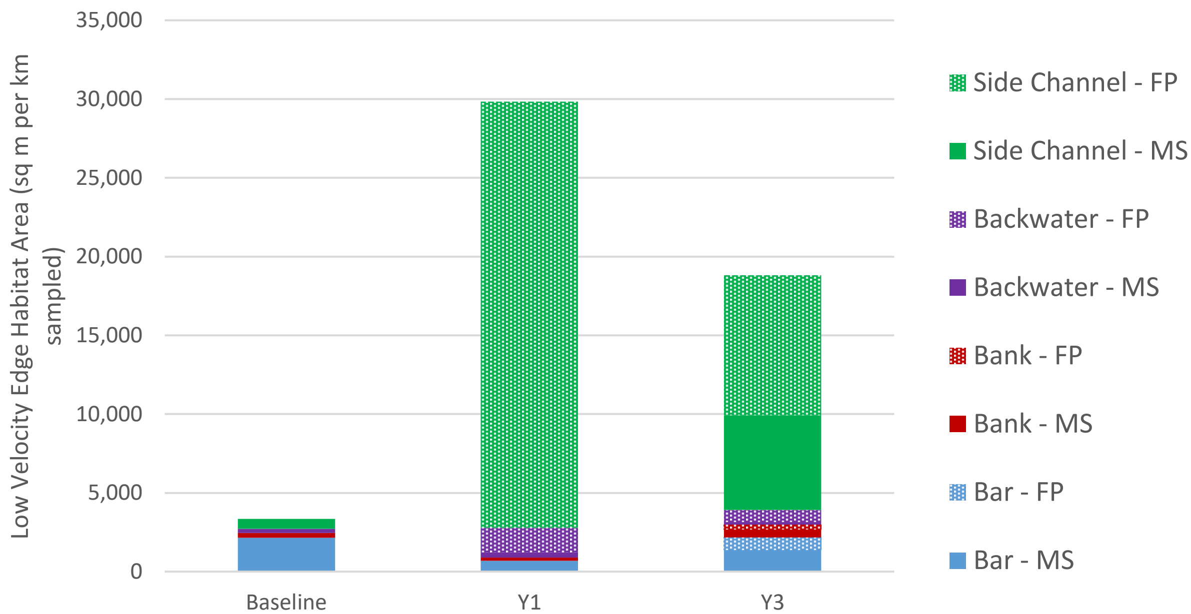


*Figure 20. Slow-water habitat by type at baseline (5/20/2015), Year 1 (2/26/2018), and Year 3 (7/27/2020) at approximately 1100 cfs. Bars are separated into habitat mapped in the mainstem (MS; solid) and habitat mapped in the floodplain (FP; dotted). Side channel habitat in Year 1 includes bar and bank habitat within the floodplain side channel.*

*Table 9. Low velocity habitat area ($m^2$ per km surveyed) by type at baseline, Year 1, and Year 3.*

| | | Bar | Bank | Backwater | Side Channel | Total |
|---|---|---|---|---|---|---|
| Mainstem | Baseline (5/20/2015)[a] | 2,144 | 312 | 259 | 626 | 3,340 |
| | Year 1 (2/26/2018) | 685 | 208 | 320 | 0 | 1,213 |
| | Year 3 (7/27/2020) | 1,407 | 493 | 146 | 5,998 | 8,044 |
| Floodplain | Baseline (5/20/2015) | 0 | 0 | 0 | 0 | 0 |
| | Year 1 (2/26/2018) | 0[b] | 0[b] | 1,562 | 27,070 | 28,632 |
| | Year 3 (7/27/2020) | 767 | 323 | 779 | 8,906 | 10,775 |

[a] Values reported in area per km surveyed, but only 0.85 km surveyed at baseline so values are greater than what was observed.

[b] In Year 1, bar and bank habitat is included as side channel habitat

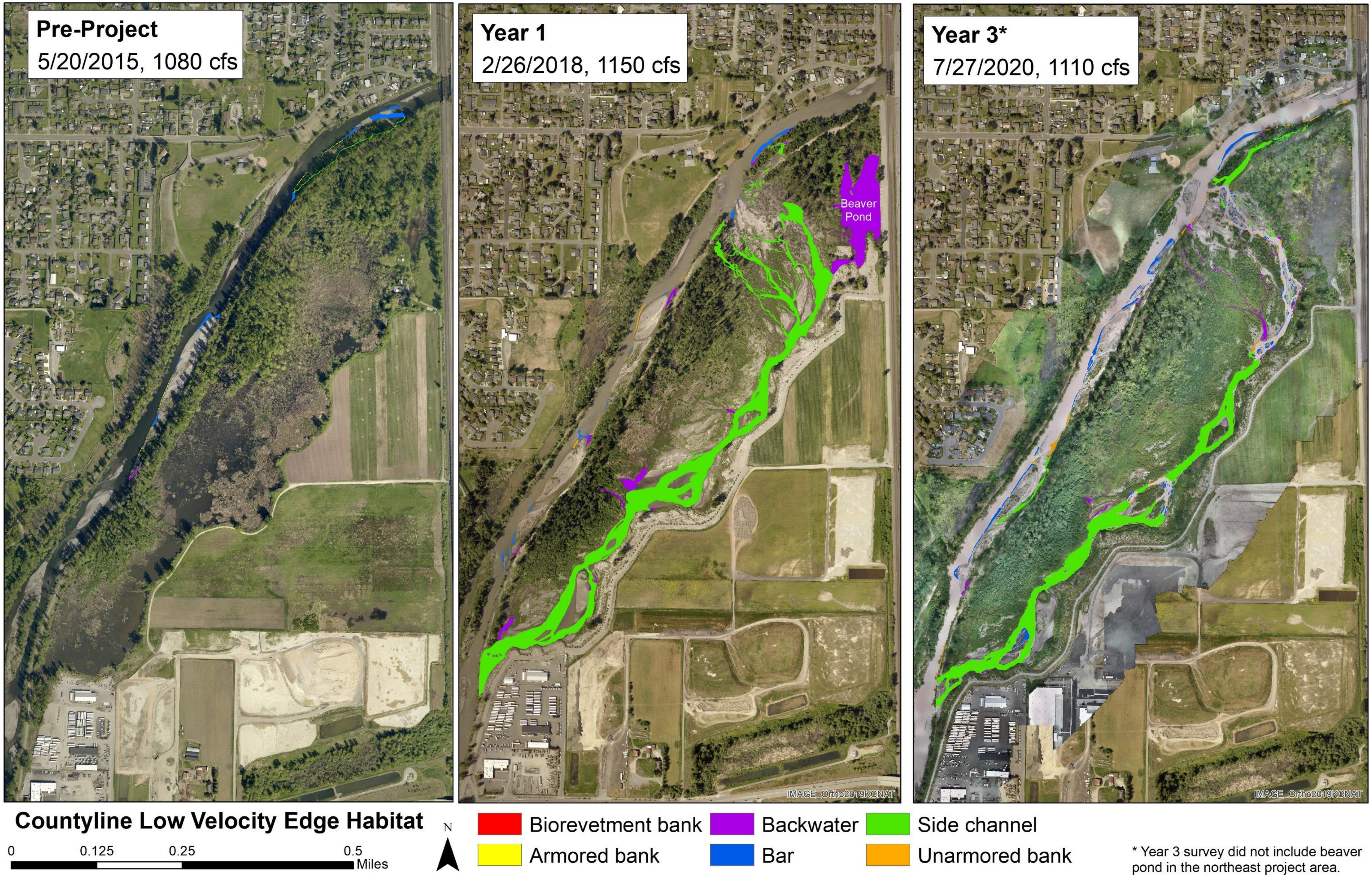


*Figure 21. Comparison of baseline, Year 1, and Year 3 low velocity habitat areas. Backwatered beaver pond area was mapped in 2018, but not in 2020, so is excluded from analyses but shown here in middle panel*

## Flood Hazard

| Year 3 Performance Standard | Year 3 Status | Details |
|---|---|---|
| No significant damage to engineered structures, adjacent flood facilities/infrastructure. Channel migration contained within project area. | ACHIEVED | Engineered structures are intact. Extents of channel migration are contained within project area. Water surface elevations at high flows are reduced compared to pre-project levels. |

No substantial damages to engineered structures throughout the project reach were observed during the first three years post-construction. Several areas continue to be monitored, including approximately 120 feet of biorevetment that has experienced some scour, erosion along the coir lifts near the floodplain side channel inlet, and a downed cottonwood that fell onto the biorevetment in 2018 (no damages were sustained). Inspections and channel cross sections confirmed that lateral migration into the left bank has been effectively resisted by the biorevetment and levee and with channel movement limited to within project area. The project has not created damages to adjacent facilities or infrastructure.

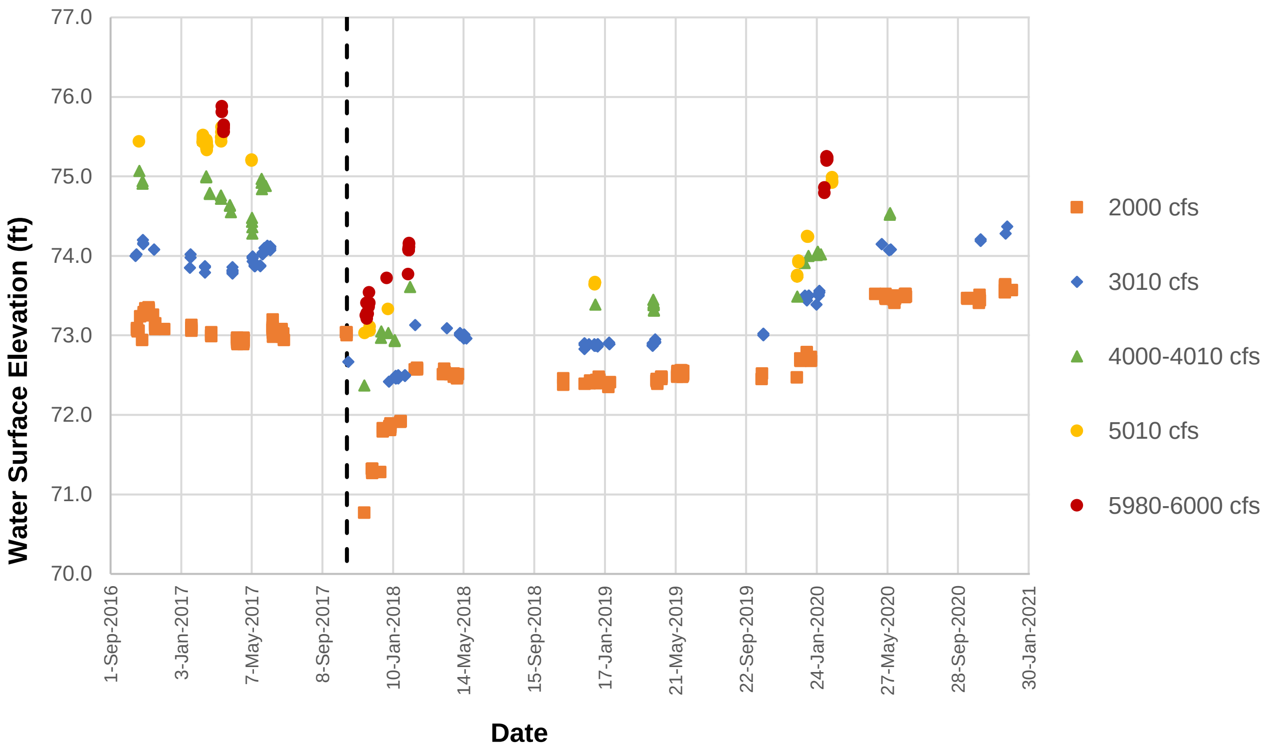


*Figure 22. Water surface elevation at USGS 12100498 White River at Pacific, WA. The river initially breached the lowered levee on October 21 2017 (dashed line).*

Flood flows since October 2017 and through 2020 were conveyed through the Countyline project area, as expected, and water surface elevations in the mainstem White River at USGS gage 12100498 at Pacific decreased at a given discharge, particularly at higher flows (Figure 22). Substantial reductions in water surface elevation in the mainstem White River were observed immediately after the river initially breached the levee and inundated the floodplain in October 2017; a larger proportion of flow was directed into the floodplain than the mainstem during the first flood season. Subsequent patterns of sediment deposition in the floodplain through the end of 2019 redirected the majority of flow back into the mainstem White River. The aggradation at the side channel inlet following the flood event in February 2020 resulted in another change in water surface elevations in the mainstem White at a given discharge; at lower flow, less water appears to be entering the left bank floodplain than in 2019, as inferred by higher water elevations in the mainstem (Figure 22). At higher flows (e.g., 5000-6000 cfs) mainstem water surface elevations remained lower than pre-project conditions, indicating that the project continues to provide improved flood conveyance in the Countyline reach.

# V. Conclusions

The Countyline Levee Setback Project met all monitored Year 3 performance standards under U.S. Army Corps of Engineers Permit No. NWS-2011-211. The project also continued to meet its habitat objectives; channel movement was observed, off-channel rearing habitat was maintained, flood refuge for salmonids was available via floodplain inundation, and riparian vegetation continued to grow and establish. The overall project goal of restoring riverine processes and functions was partially met through increased channel movement, sediment dynamics, water storage, and plant establishment; full restoration of riverine processes continued to be limited by ongoing flow regulation that limits natural flow variation and wood recruitment. Water surface elevations at high flow remained lower than those at baseline conditions, indicating the project continued to reduce flood risks despite ongoing channel aggradation in the mainstem. At this time, no adaptive management actions are recommended.

# VII. References


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