King County
Department of
Natural Resources and Parks
Water and Land Resources Division
201 South Jackson Street, Suite 600
Seattle, WA 98104

McElhoe-Pearson Off-Channel and Floodplain Reconnection Project
YEAR 5 (2017) MONITORING REPORT

Prepared by: Josh Latterell and Laura Hartema.
June 29, 2018

Project Timeline:	**Project Team:**
Constructed: Summer 2012 Planted: Fall 2013 Monitored: 2012-2022	Project Supervisor: Diane Concannon Project Manager: Fauna Nopp, PMP Engineer of Record: Will Mansfield, P.E. Engineer: Carolyn Butchart, PE Ecologists: Dan Eastman, Laura Hartema Geologist: Todd Hurley WRIA 7 Watershed Steward: Mary Maier
Design & Construction Funding: Total Cost: $1,146,758 Construction: $623,717 Design & Permitting: $523,041 Thanks to a partnership with the Snoqualmie Tribe's Environment and Natural Resource Department, the project's design phase received US Environmental Protection Agency National Estuary Program tribal grant funding. Additional funding was contributed by the Salmon Recovery Funding Board and King County, including the Mitigation Reserves Program.	
Permits: NWS-2012-201; Water Quality Certification 9172 Washington Department of Fish and Wildlife Hydraulic Project Approval (HPA), 126995-1 King County Department of Permitting and Environmental Regulation Grading Permit L12CG033 Shoreline Exemption L12SX015	
Location: Parcels 0925079032, 1625079008; 47.65999 W longitude, -121.92582 N. latitude	

Suggested Citation: King County, 2018. McElhoe-Pearson Off-Channel and Floodplain Reconnection Project. Year 5 (2017) Monitoring Report. Prepared by J. Latterell and L. Hartema. King County Department of Natural Resources and Parks, Seattle, WA.

Executive Summary

What is this report about?

Post-project monitoring results for the McElhoe-Pearson Off-Channel and Floodplain Reconnection Project for Year 5 (2017).

Where is the project?

On eight acres of public land at River Mile 23 of the Snoqualmie River, north of the City of Carnation, Washington.

What was the purpose?

To benefit juvenile salmon and trout by providing access to and improving the condition of a floodplain wetland isolated behind a levee.

To offset impacts associated with Washington State Department of Transportation's Tokul Creek Emergency Project, via the King County Mitigation Reserves Program.

What actions were taken?

Notched a levee and excavated a channel to make off-channel wetland areas accessible for much of the year;

Deepened pools in the upper wetland to create summer refuge habitat;

Installed native trees and shrubs;

Installed large wood along the banks of a backwater.

Is the project meeting its goals?

Performance standards **met**:

Aquatic ecosystem functions protected;

Built per approved plan;

Wood clusters whole and intact;

Wetland connected to the Snoqualmie 40% of the year;

Cover targets in wetland re-establishment area;

Weeds under control.

Performance standards **not yet met**:

Cover in wetland enhancement and buffer enhancement areas.

What has the project done for salmon recovery?

Re-established access to off-channel habitat and enhanced riparian forests.

What lessons were learned?

Threatened salmonids may benefit from reconnecting wetlands behind levees, but relatively few fish have been seen using the newly-accessible habitats at this project site. No Chinook salmon or trout have yet been found using the project

Even though the hydrology of the wetland and buffer enhancement areas appeared sufficient for the selected plant species, the soils are so poor and compacted that amendments are required. Compacted soils with little organic material require roughening and amendment.

Summary

Performance standards for every project goal except vegetation cover are meeting expectations.

Given that relatively few threatened salmonids have been observed using the reconnected habitats, King County should consider more fish habitat studies to gain confidence that threatened salmonids will use and benefit from notching levees to reconnect isolated off-channel features in the Snoqualmie River.

Even though benefits to fish appear relatively uncertain, the project advanced salmon habitat recovery goals.

Future projects should capitalize on the **lessons learned** to ensure continuous improvement in project design.

1. Project Description

The McElhoe-Pearson Off-channel Wetland and Floodplain Reconnection Project breached the 1900-foot-long McElhoe Pearson Levee (ca. 1961) and an existing levee and access road to reconnect the Snoqulamie River and a wetland behind the levee. The site is located at River Mile 23 of the Snoqualmie River two miles north of the Tolt River (Figure 1). It is accessible from 310th Ave NE between NE Carnation Farm Road and NE 60th Street. The project was completed primarily for restoration purposes, but also included discrete elements that earn in-lieu fee mitigation credit.

This project was identified as Project 10 *in Snoqualmie 2015*[1], a 10-year vision to "safeguard the Snoqualmie's remaining natural resources and restore habitat for salmon listed under the Endangered Species Act". The project was intended to benefit juvenile salmon by providing access to and improving the condition of a floodplain wetland isolated behind a levee. The project notched the levee and excavated a channel to provide juvenile salmon to access the off-channel wetland areas for much of the year (Figure 2). The project also deepened a pool in the upper wetland to create summer refuge for coho salmon; installed native trees and shrubs; and installed large wood along the banks of a Snoqualmie River backwater.

The site also offset impacts associated with Washington State Department of Transportation's (WSDOT) Tokul Creek Emergency Project through King County's Mitigation Reserves Program. Mitigation elements included portions of the reconnected existing wetland, the side channel, the riparian planting, and the large wood (Table 1).

Table 1. Mitigation Credit-generating Project Features

Habitat Types	Acreage of Mitigation
Wetland Reconnection	0.58
Wetland Enhancement	0.23
Side Channel Establishment & Levee Breach	0.21
Riparian Enhancement	0.19
Large wood	9 Key Pieces
	1.21*

*Credits were generated using an area based method, not the credit/debit method and are exclusive of the regulatory buffer

[1] Snoqualmie 2015 aims to restore 5.5 miles of edge habitat, 125 acres of riparian forest, 70 acres of off-channel habitat, and complete 20 large wood installations.The Snoqualmie 2015 effort originated with the Snohomish Basin Salmon Conservation Plan, completed in 2005.

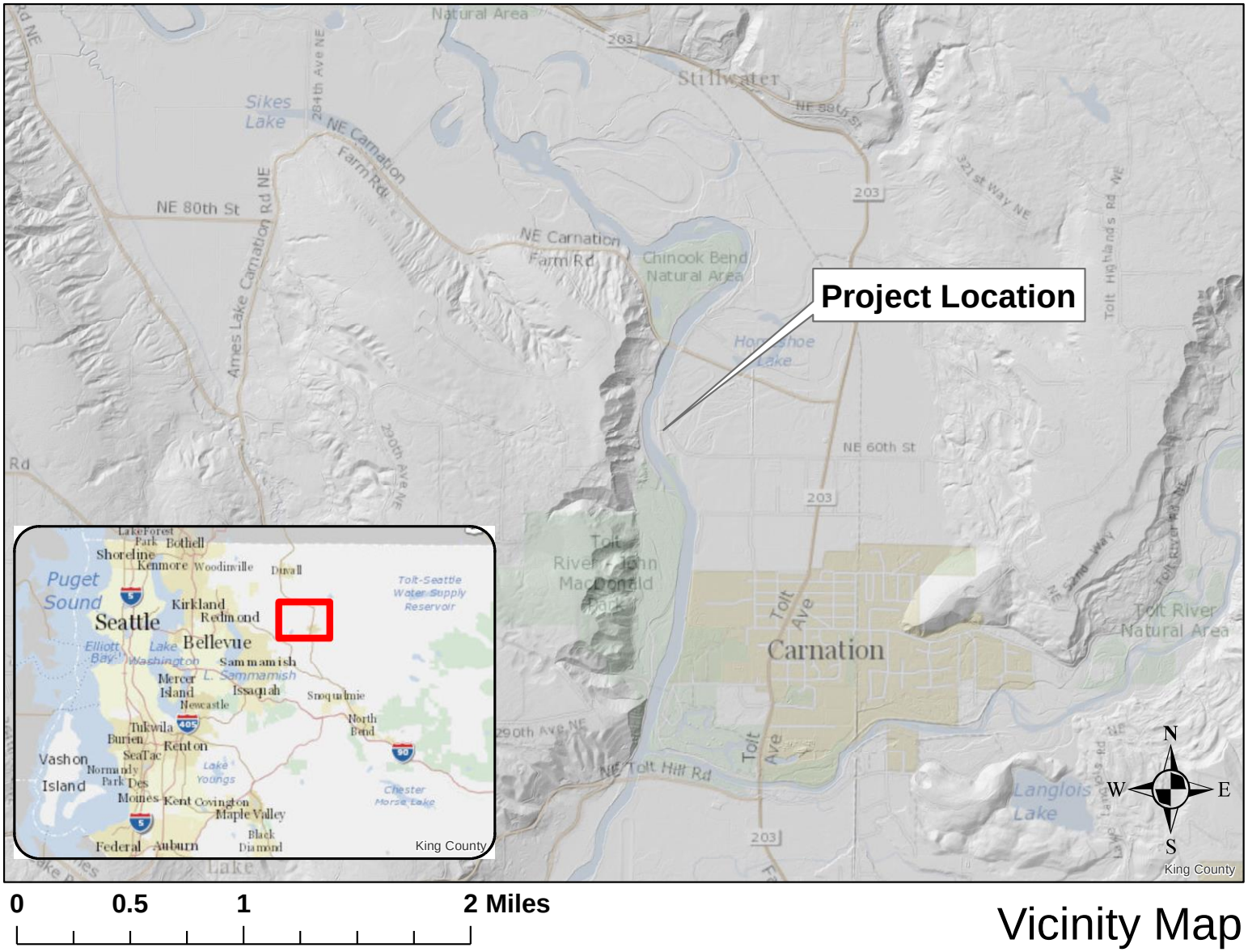

Figure 1. Vicinity map.

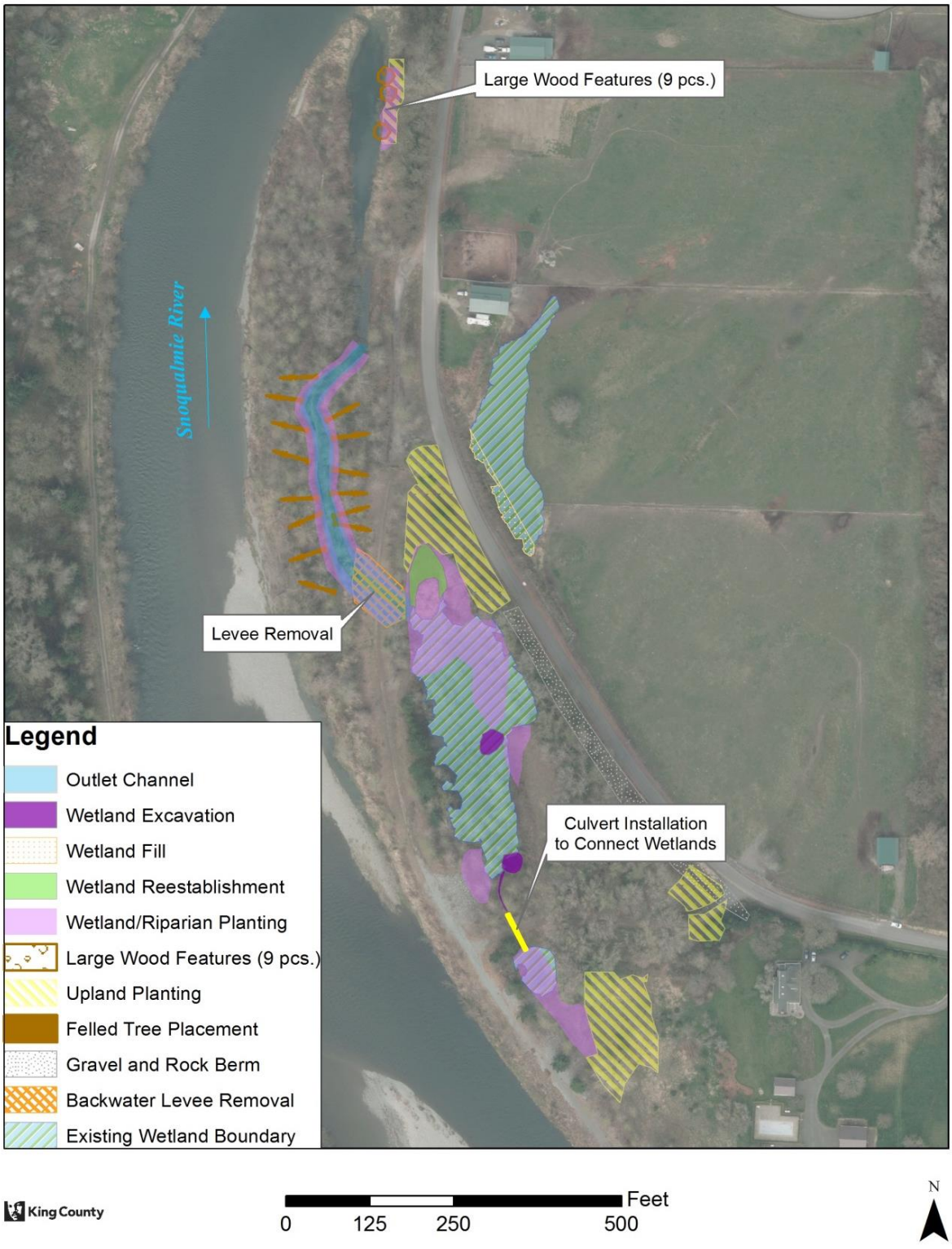

Figure 2. Project design elements.

Prior to construction, the site contained a 1.49-acre Category II palustrine scrub-shrub (PSS) and palustrine emergent wetlands (PEM). It was riverine, with a hydrology dominated by hyporheic upwelling. When flows exceeded 7,000 cfs (USGS 12149000), water from the Snoqualmie River passed through the levee in a small culvert at the upstream end of the site. When flow exceeded 60,000 cfs, floodwaters overtopped the levee. Existing vegetation was primarily reed canarygrass (*Phalaris arundinacea*) and pasture grasses. The middle of the wetland contained buttercup (*Ranunculus repens*), smartweed (*Polygonum sp.*) and bur-reed (*Sparganeum angustifolium).* Near the downstream end, the emergents included reed canarygrass, soft rush (*Juncus effusus*), buttercup and sedges (*Carex sp*.). The scrub-shrub area contained red twig dogwood (*Cornus sericea*) and Douglas spirea (*Spirea douglasii*). The forested portion was black cottonwood (*Populous balsamifera)* and Pacific willow *(Salix lucida)*. Invasives were prevalent, including reed canarygrass, yellow-flag iris (*Iris pseudacorus*), bittersweet nightshade (*Solanum dulcamara*) and purple loosestrife (*Lythrum salicaria*). Japanese knotweed (*Polygonum cuspidatum*) and Himalayan blackberry (*Rubus armeniacus*) were common riverward of the levee.

1.1. Project Goals and Objectives

Restoration and mitigation project goals were interrelated and are listed here together.

Goal 1. Protect aquatic ecosystem functions

Objective 1.1. Complete development of an approved mitigation plan.

Objective 1.2. Protect ecosystem functions on the site by placing IRT-approved restrictive covenant on the property.

Goal 2. Install habitat features

Objective 2.1. Reconnect the wetland, restore riparian area, excavate a side channel and install large wood according to IRT-approved plans[2].

Objective 2.2. Install plants according to IRT-approved plans.

Goal 3: Provide wildlife habitat features

Objective 3.1. Install nine pieces of large wood in three clusters along the margin of an existing backwater channel near the confluence with the mainstem river. Each is made of three large logs with rootwads, branches and small wood, and was designed to be submerged at 8,000 cfs (USGS 12149000).

[2] Including at least 0.81 acres of wetland reconnection within the OHWM, 0.19 acres of riparian vegetation, 0.21 acres of side channel, and nine key pieces of large wood.

Goal 4. Restore connectivity of the stream and riparian complex to reestablish dynamic river processes

Objective 4.1. Breach an existing levee and construct a 4-foot wide outlet channel (0.7 percent slope) through existing levee and 500 feet of existing floodplain to connect wetland to an existing backwater of the Snoqualmie River. A rock revetment was installed on the faces of the breached section to protect the remaining levee. The downstream invert and upstream invert elevations were set at 49.5 and 53 feet NAVD88, respectively. The aquatic habitat within the wetland was intended to be wetted and connected to the mainstem during much of the rearing period for juvenile Chinook (January - June), but not during low flow.

Objective 4.2. Install a four-foot diameter, zero-slope LCPE culvert beneath the levee access road to connect the lower and upper wetland areas and to ensure outlet channel has sufficient energy to evacuate sand and silt as floods recede to minimize need for future excavation. Culvert invert was set at elevation 51 ft (NAVD88).

Goal 5. Create off-channel, side-channel rearing, and flood refuge habitat for salmonids and other aquatic species

Objective 5.1. Provide opportunities for smolt egress and minimize excess stranding from the wetland area in late spring. The side channel was excavated to approximately 53 feet to allow the wetland to be continuously connected at all discharges exceeding 3,500 cfs [3] in the 'as-built' condition.

Objective 5.2. Provide cool-water refuge for over-summering salmonids by excavating the wetland to increase maximum depth in several areas. The wetland excavation area was graded to an elevation of 52 NAVD88 with intermittent ponds at elevation 48; approximately three feet lower than the summer minimum (51.5 NAVD88).

Goal 6. Plant native vegetation in riparian and wetland areas.

Objective 6.1. Increase woody native cover with 0.39 acres of riparian planting, including 0.19 acres of mitigation credit generating area.

Goal 7. Control Invasive Species.

Objective 7.1. Reduce invasive species cover throughout the project site, including mitigation areas.

Goal 8. Maintain flood protection and road stability for surrounding properties and infrastructure[4].

[3] USGS Station 12149000.
[4] Not a migitation goal

Objective 8.1. Construct a 600-foot-long, one to two-foot-tall berm along the lower elevation section on the east side of 310th Ave NE.

Objective 8.2. Stabilize the road prism by constructing a large rock fill slope along the east side of 310th Ave NE to buttress critical sections of the east side of the road and a gently-sloping gravel fill to protect over-steepened sections on the west slope.

2. Monitoring

The project site will be monitored for 10 years to document performance, prescribe maintenance, and guide adaptive management. The achievement of the project's performance standards will be documented in Years 1, 3, 5, 7, and 10.

- Each monitoring report will be submitted to King County Department of Permitting and Environmental Review.
- Reports from Years 1 and 3 will be submitted to the Interagency Review Team (IRT) upon Mitigation Plan approval. In Years 5, 7, and 10, reports will be submitted by the end of April in the following year.

2.1. Performance Standards and Monitoring Protocols

Performance measures were established for all objectives. The following section outlines the required documentation and protocols for measuring achievement of each performance standard. The monitoring status is also listed for each set of performance standards.

Goal 1. Protect Aquatic Ecosystem Functions

Objective 1.1. Complete development of an approved mitigation plan.

Objective 1.2. Protect ecosystem functions on the site by placing IRT-approved restrictive covenant on the property.

Performance Standards for Administrative Functions	Documentation	Status
1.1. Complete development of an approved mitigation plan.	Mitigation plan approved by IRT and appended to Program Instrument.	Complete
1.2. Protect ecosystem functions on the site by placing IRT-approved restrictive covenant on the property.	IRT provided with a copy of recorded restrictive covenant.	

Goal 2. Install Habitat Features

Objective 2.1. Reconnect the wetland, restore riparian area, excavate side channel and install large wood according to IRT-approved plans[5].

[5] Including at least 0.81 acres of wetland reconnection within the OHWM, 0.19 acres of riparian vegetation, 0.21 acres of side channel, and nine key pieces of large wood.

Objective 2.2. Install plants according to IRT-approved plans.

Performance Standards for Construction	Documentation	Status
2.1. At least 0.81 acres of wetland reconnection within the OHWM, 0.19 acres of riparian vegetation, 0.21 acres of side channel, and nine key pieces of large wood.	Record drawings showing completed grading and earthwork approved by the IRT.	Complete
2.2. Planting of site completed according to IRT approved plans.	Record drawings showing completed planting approved by IRT.	

Goal 3. Provide Wildlife Habitat Features

Objective 3.1. Install nine pieces of large wood in three clusters along the margin of an existing backwater channel near the confluence with the mainstem river.

Performance Standards for Large Wood Habitat Features at Opening of Backwater Channel	Documentation	Status
3.1. Retention of 9 pieces of large wood in 3 large wood habitat features will be 100% (9 pieces) in Years 1, 3, and 5, at least 78% (8 pieces) in Year 7, and at least 67% (6 pieces) in Year 10.	Photo document the presence of constructed large wood habitat features and number of large wood pieces in their original location in Years 1, 3, 5, 7, and 10. Aerial photos may be used in lieu of ground photos to document the features.	Ongoing

Protocol for Measuring Wildlife Habitat Features

Orthoimagery interpretation: Locate and photograph installed large wood features. In lieu, visually inspect and count logs.

Goal 4. Restore Connectivity of the Stream and Riparian Complex to Restore Dynamic River Processes

Objective 4.1. Breach an existing levee and construct a 4-foot wide outlet channel (0.7 percent slope) through existing levee and 500 feet of existing floodplain to connect wetland to an existing backwater of the Snoqualmie River.

Objective 4.2. Install a four-foot diameter, zero-slope culvert beneath the levee access road to connect the lower and upper wetland areas and to ensure outlet channel has sufficient energy to evacuate sand and silt as floods recede to minimize need for future excavation. Culvert invert was set at elevation 51 ft (NAVD88).

Performance Standard for Connectivity	Documentation	Status
4.1. In Years 1, 3, 5, 7 and 10 a surface water connection exists between the wetland and the existing backwater of the Snoqualmie River when discharge is greater than or equal to 6,000 cfs at the Carnation gage.	Monitoring reports document the presence of surface water at the outlet of the wetland feature, including the frequency, timing, and duration of the connection if possible. Connectivity will be monitored in Years 1, 3, 5, 7, and 10, at a minimum.	Ongoing

Protocol for Measuring Connectivity

Time lapse cameras were installed near the wetland outlet[6] (Figure 5). Photos with time and date-stamps were taken every five minutes during daylight hours to capture images across a wide range of discharge levels. Dates and times of connection and disconnection were cross-referenced with water surface elevation measurements (described below) to determine the water surface elevation at which the wetland disconnects.

Water surface elevations (WSE) were measured at 15-minute intervals with loggers. Four loggers were installed; three remain active (Figure 5):

Well 2: Scour pool
Well 3: Backwater channel
Well 4: Wetland

Stage-discharge relationships between water surface elevations in the wetland (stage) and the mainstem discharge (USGS 12144500) were charted to identify when water levels rise above 53 feet NAVD88—the 'as-built' elevation—establishing a surface connection between the river and wetland via the outlet channel. The Snoqualmie gauge was used for this analysis because the Carnation has been unreliable.

[6] The IRT acknowledges there is a high risk of vandalism to and theft of the camera which may lead to unpreventable data gaps in the photo record. If so, King County intends to replace the camera and resume photo-documentation. Theft or vandalism will not prevent the IRT from releasing credits related to the connectivity performance standards. If theft is a recurring problem, field visits and photo documentation when flows are approximately 6,000 cfs may be used in place of time-lapse footage.

Figure 3. Locations of camera, loggers, and habitat units for fish sampling.

Goal 5. Create Off-channel, Side-channel Rearing, and Flood Refuge Habitat for Salmonids and other Aquatic Species.

Objective 5.1. Provide opportunities for smolt egress and minimize excess stranding mortality from the wetland area in late spring by excavating the side channel elevation to approximately 53 feet to allow the wetland to be continuously connected at all discharges exceeding 3,500 cfs [7] in the 'as-built' condition.

Objective 5.2. Provide cool-water refuge for over-summering salmonids by excavating the wetland to increase maximum depth in several areas. The wetland excavation area was graded to an elevation of 52 NAVD88 with intermittent ponds at elevation 48; approximately three feet lower than the summer minimum (51.5 NAVD88).

Performance Standard for Fish Use	Documentation	Status
5.1. At Year 1, juvenile salmonids are observed in the wetland and/or side channel during the freshwater rearing period (e.g., March-June).	Monitoring report documenting fish observations made by snorkel surveys, except in years in which natural turbidity makes sampling ineffective. Fish use of the wetland will be monitored in Year 1, at a minimum.	Complete. Supplemental surveys also done.

Protocol for Assessing Fish Use:

Juvenile salmonids were observed with snorkeling in Year 1, in the period ranging from March to June, except when turbidity severely limited visibility. Surveyors targeted the best habitat in the wetland and in the backwater, instead of sampling randomly, to maximize the likelihood of observing juvenile Chinook salmon.

Water temperatures were also evaluated, to determine whether the off-channel habitat areas were suitable for use by salmonids. Each water level logger recorded temperature every 15 minutes. These measurements were used to calculate the 7-day average daily maximum temperature, which has regulatory and biological significance (7dmax). Additionally, grab samples of air temperature, water temperature, dissolved oxygen (mg/L), and conductivity ($\mu S/cm^3$) were taken by Snoqualmie Fisheries staff on the following dates in 2013: June 10; August 1, 8, 15; and September 3.

Goal 6. Plant Native Vegetation in Riparian and Wetland Areas.

Objective 6.1. Increase woody native cover with 0.39 acres of riparian planting, including 0.19 acres of mitigation credit generating area.

[7] USGS Station 12149000.

Performance Standard for Native Woody Plant Cover	Documentation	Status
6.1. Crown cover of native trees and shrubs will be a minimum 25% in Year 5, 50% in Year 7, and 70% in Year 10 in riparian and wetland planting areas of the WSDOT mitigation area.	Monitoring report documenting measurements of native woody cover in riparian and wetland plantings in WSDOT mitigation area. Native woody plant cover will be measured in Years 5, 7, and 10, at a minimum.	Start sampling in Year 5 (2017)

Protocol for Measuring Native Woody Plant Cover

Crown cover of native trees and shrubs will be measured towards the end of the growing season but before leaf drop (e.g., mid-August to mid-September). Cover of native trees and shrubs will be calculated as the reciprocal of Crown-Free Projection or CFP (Bonham 2013). $CFP = (S/T)*100$, where S is the number of open-sky sightings and T is the total number of observations of the canopy made with the use of a two-way leveled periscope (i.e., a GRS densitometer) pointed toward the sky or the ground. Collect plant occurrence data at vertical intercepts located at each meter-mark along each transect, for a total of 20 sample points per transect. A sufficient number of transects will be established to demonstrate an adequate representation of the planted areas. At each interval, a “hit” on a species is recorded if a vertical line at the point would intercept the stem or foliage of that species. Only one “hit” is recorded for a species at a point even if the same species is intercepted more than once at the point.

In Years 5, 7, and 10, crown cover will be measured in the mitigation areas. However, in Year 3, cover was measured in 20 experimental study plots used to evaluate the effectiveness of frequent watering to promote cottonwood establishment from seed on mineral soils.

Estimate species diversity by determining the total number of “hits” for each species along the transect. The result is a list of species and their frequencies of occurrence along the line (Mueller-Dombois and Ellenberg 1974; Tiner 1999). Cover will be reported as percentages.

Goal 7. Control Invasive Species.

> **Objective 7.1.** Reduce invasive species cover throughout the project site, including mitigation areas.

Performance Standards for Invasive Species	Documentation	Status
7.1. In Years 1-10, the following weeds are absent from the WSDOT Mitigation Area: Washington State-listed or King County-listed Class A weeds designated for control by the County Weed Board; and non-native knotweeds identified on the King County noxious weed list.	Monitoring reports documenting presence or absence of listed weeds at Years 5, 7, and 10.	Start sampling in Year 5 (2017)
7.2. In Years 1-10, the combined ground cover (total cover of the target vegetation on an area of ground; Bonham (2013)) of the following plants does not exceed 10% in the project site: • Blackberries (*Rubus armeniacus and R. laciniatus*); Scotch broom (*Cytisus scoparius*); Thistles (*Cirsium arvense*, *C. vulgare, Carduus nutans, and Onopordum acanthium*); Purple loosestrife (*Lythrum salicaria*); Yellow-flag iris (*Iris pseudacorus*); Ivy (*Hedera helix* and *H. hibernica*); Butterfly bush (*Buddleia davidii*); Field bindweed (*Convolvulus arvensis*) and morning glory/hedge bindweed (*Convolvulus sepium)*; Any other Class B or C weeds designated for control by King County.	Monitoring reports documenting percent cover of listed invasive plants in each mitigation area at Years 5, 7, and 10.	

Protocol for Assessing Invasive Plant Cover

Site inspections will occur in Years 5, 7, and 10 to verify Washington State-listed or King County-listed Class A weeds designated for control by the County Weed Board and non-native knotweeds identified on the King County noxious weed list are absent. If they are present, King County will initiate appropriate control.

In Years 5, 7, and 10 the combined ground cover (total cover of the target vegetation on an area of ground; Bonham (2013)) of weeds in the mitigation areas will be visually estimated. Determine whether the combined ground cover of the listed invasive plants exceeds 10 percent in the mitigation credit area.

Goal 8. Maintain Flood Protection and Road Stability for Surrounding Properties and Infrastructure[8].

Objective 8.1. Construct a 600-foot-long, one to two-foot-tall berm was constructed along the lower elevation section of the 310th Ave NE.

[8] Not a migitation goal

Objective 8.2. Stabilize the road prism by constructing a large rock fill slope along the east side of 310th Ave NE to buttress critical sections of the east side of the road and a gently-sloping gravel fill to protect over-steepened sections on the west slope.

No performance standards were established for these objective.

On Site Mitigation Required by King County Department of Permitting and Environmental Review

In addition to the mitigation-related performance standards established by the IRT, additional mitigation was proposed by King County Department of Permitting and Environmental Review (DPER) to compensate for permanent and temporary project impacts (Table 2).

Table 2. Mitigation for project impacts approved by King County DPER.

Impacting Activity	Compensatory Mitigation	Acres
Wetland fill for road slope stabilization	Re-establish wetland conditions just north of the existing wetland	0.062
	Enhance lower wetland connectivity	0.248
Temporary disturbance within wetland and Snoqualmie River buffers	Restore and enhance vegetation	0.901

3. Permit Compliance in Year 5

This section summarizes the compliance of the McElhoe-Pearson project with permit conditions (Table 3).

Table 3. Compliance with permit conditions, reporting, and methodology.

Permit	Report Years	Reporting Requirements	Year 5 status
USACE NWS-2012-201 WDOE 401 Certification 9172	1, 3, 5, 7, 10	The Applicant shall monitor the project site as described in the McElhoe-Pearson Restoration Project Monitoring and Adaptive Management Plan, prepared by KCDNRP, dated March 20, 2012 or as revised and approved by Ecology.	Compliant
KC DPER L12CG033	1, 3, 5	The monitoring report shall describe the condition and functionality of the reconstructed wetlands, percent cover and survival of the plantings, and recommend any additional work needed to ensure the success of the project and plantings.	Complete
		Compensatory mitigation for wetland, aquatic area, and buffer impacts will be provided as explained in a July 26, 2012 memo from Dan Eastman, ERES/WLRD.	Complete
Shoreline exemption L12SX015	1, 3	Monitoring shall be conducted for a minimum of 3 years following the completion of the project, and an annual report submitted to DPER.	Complete
	none	All conditions of the HPA shall also be considered conditions of this shoreline exemption	Complete
		All conditions of any approval granted by the USCOE shall be considered conditions of this shoreline exemption.	Complete
KC Parks NRL SAP	1, 3, 5	Submit the monitoring report to Parks.	Complete
WDFW HPA 126995-1			Complete

4.1. Monitoring Results

Goal 1. Protect Aquatic Ecosystem Functions

Complete.

Goal 2. Install Habitat Features

Complete. Actual Year 5 areas are based on LiDAR digital terrain models from Spring 2016. No newer LiDAR topography is available. Since no geomorphic or hydrologic changes were noted, we concluded mitigation areas continue to meet or exceed the planned quantity for each project element (Table 4).

Table 4. Credit-generating mitigation areas.

Project Element[9]	Units	Required	Present in Year 5?
Wetland reconnection (area ≤ 55 ft NAVD88)	acres	0.58	Yes
Wetland enhancement	acres	0.23	Yes
Side channel establishment and levee breach	acres	0.21	Yes
Riparian enhancement	acres	0.19	Yes
Installation of LWD	pieces	9	Yes

Goal 3. Provide Wildlife Habitat Features

Performance Standards for Large Wood Habitat Features at Opening of Backwater Channel	Year 5 Results
3.1. Retention of 9 pieces of large wood in 3 large wood habitat features will be 100% (9 pieces) in Years 1, 3, and 5, at least 78% (8 pieces) in Year 7, and at least 67% (6 pieces) in Year 10.	TARGET MET: The logjams are 100% intact and functioning as intended (Figure 6). There has been no detectable loss or accumulation of material, so it still resembles the 'as-built' condition.

Figure 4. Aerial view of the logjams in 2013 (left) and 2017 (right).

[9] Some project elements will not generate mitigation credit.

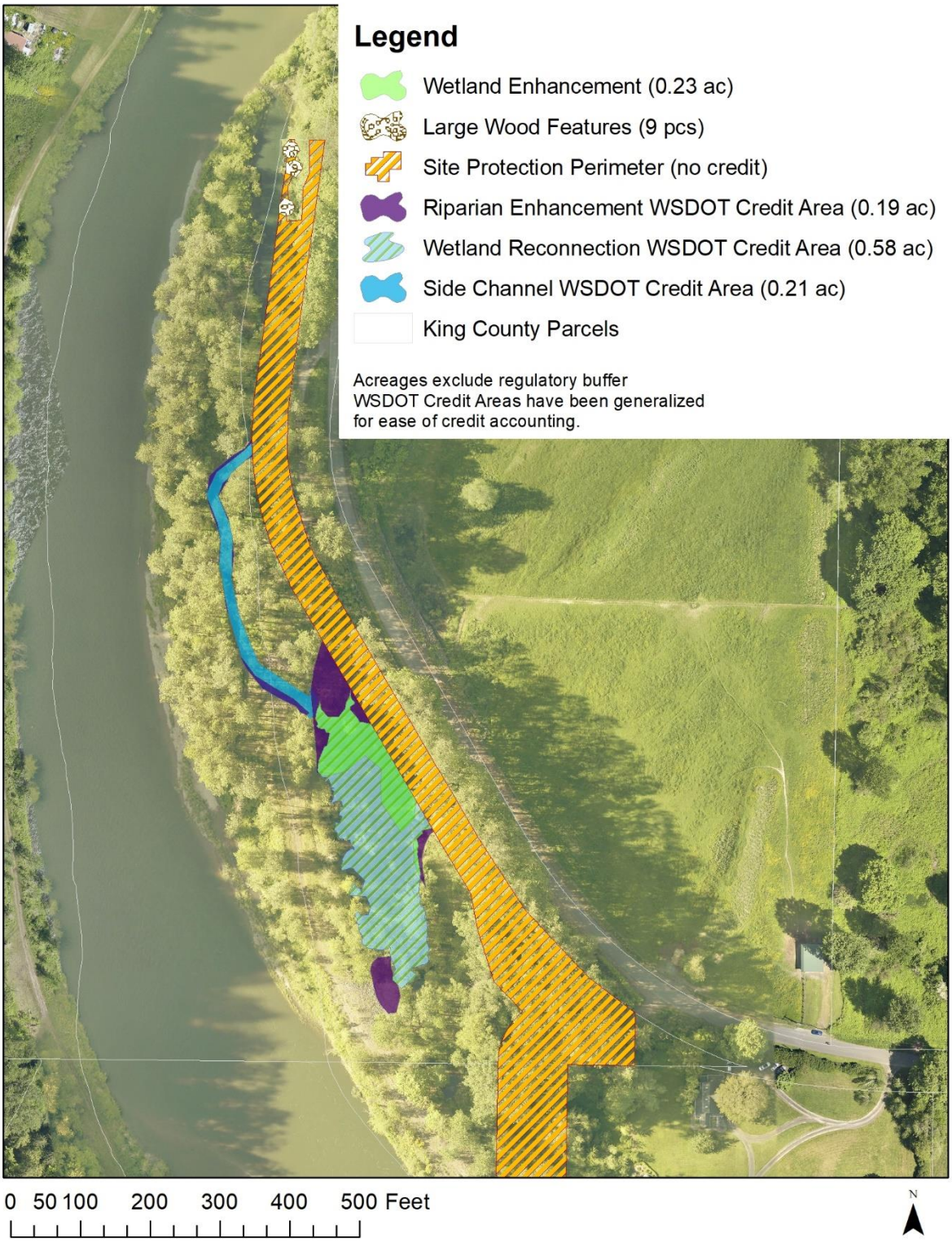

Figure 5. Credit-generating Mitigation Areas.

Goal 4. Restore Connectivity of the Stream and Riparian Complex to Restore Dynamic River Processes

Performance Standard for Connectivity	Year 5 Results
4.1. In Years 1, 3, 5, 7 and 10 a surface water connection exists between the wetland and the existing backwater of the Snoqualmie River when discharge is greater than or equal to 6,000[10] cfs at the Carnation gage.	TARGET MET: Surface water connections were established and lost when water surface elevations were 53 feet (NAVD 88); 3,500-4,000 cfs (Snoqualmie[11]), assuming a four hour lag. Accordingly, the wetland was connected to the mainstem—either through inflow from the upstream culvert, or from backwatering from downstream—approximately 40% of the time in WY2017 (Figure 7, Photo 1).

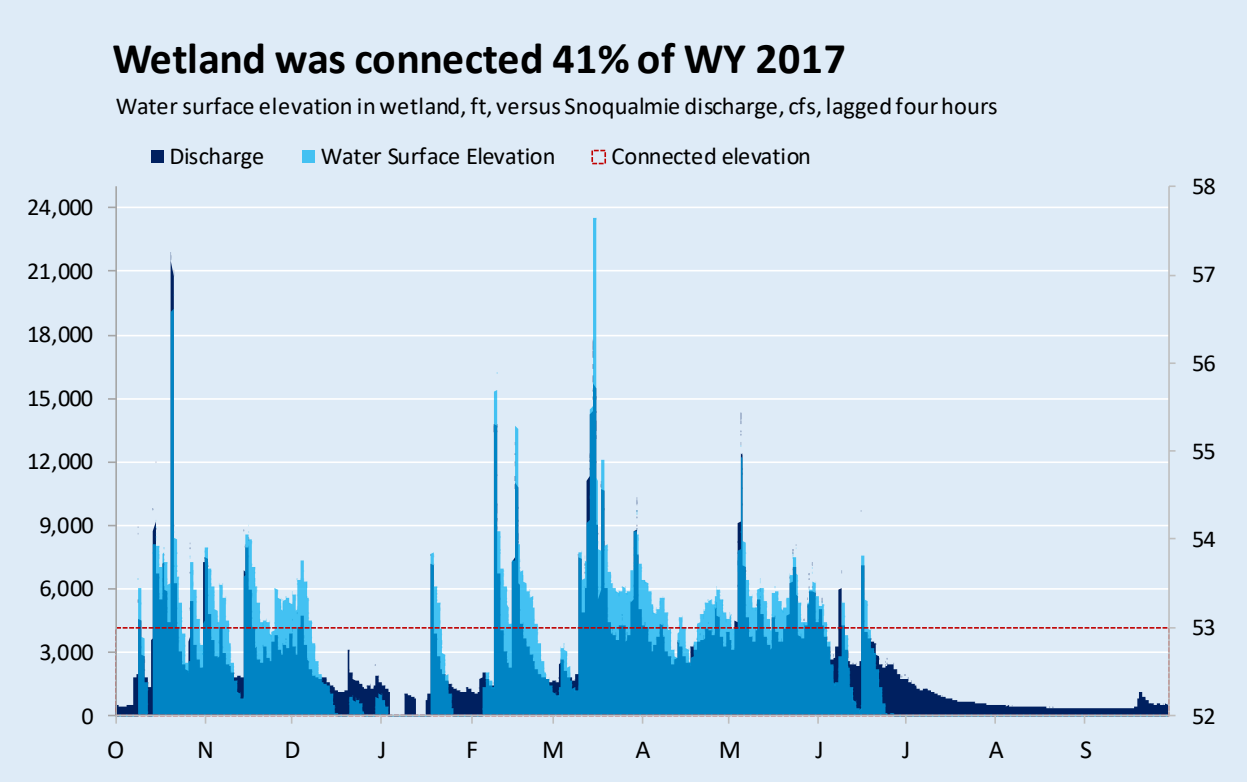

Figure 6. Relationship between water surface elevation (WSE) in the wetland and discharge in the Snoqualmie River (USGS 12144500).

[11] Note the original connectivity target was benchmarked to the Carnation gage, but it has been unreliable. Using the Snoqualmie gage is more conservative.

Low-flow: 9-5-2017, approx. 300 cfs at Snoqualmie	
High-flow: 10-22-2017, approx 34,000 cfs at Snoqualmie	

Photo 1. Example time-lapse photos at low and high flow.

Goal 5. Create Off-channel and Side-channel Rearing and Flood Refuge Habitat for Salmonids and Other Aquatic Species.

Performance Standard for Fish Use	Year 3 Results (no new results for Year 5)
5.1. At Year 1, juvenile salmonids are observed in the wetland and/or side channel during the freshwater rearing period (e.g., March-June).	NO TARGET: No fish survey was needed in Year 3, but a survey was completed anyway on March 11, 2015 at night, when discharge was 1,600 cfs (USGS 12149000; Table 4). Water temperatures were generally suitable for salmonids (Figure 8). On March 11, 2015—during very low winter flows (935 cfs) coho dominated the fish community. The wetland was disconnected from the mainstem, as it had been for nearly one month, though it was to be reconnected only four days later. Juvenile Chinook salmon were only found in the habitats nearest to the mainstem river and were not observed within the site interior. A majority of the coho were observed in the backwater channel, which remained connected to the mainstem. Even so, coho were observed in both the main wetland pond, and the upper wetland pond, both of which had been disconnected from the mainstem for many days. On July 14, 2016, a large concentration of minnow-like fish, believed to be peamouth (*Mylocheilus caurinus* (Richardson)) were observed in the wetland area. Underwater video was used to observe and identify them. Abundance was not quantified, but there appeared to be thousands of fish. Fish were consistently 80-100mm TL.

Table 5. Post-project fish survey, March 11, 2015; 930 cfs USGS 1214500.

Species	Size class (mm)	Existing features			Reconnected habitats		
		Confluence channel	Backwater channel	Backwater pond	Outlet channel from wetland	Main Wetland pond	Upper Wetland pond
Chinook	<50	1	5	2	No water	0	0
Coho	<50	2	0	0		0	0
	50-100	0	44	22		17	15
	>100	0	92	17		0	1
Rainbow trout	1+ (>100)	0	0	0		0	0
Sculpin		4	26	1		1	0
Stickleback		0	50	28		1	2
Sunfish	50-100	0	82	2		2	1

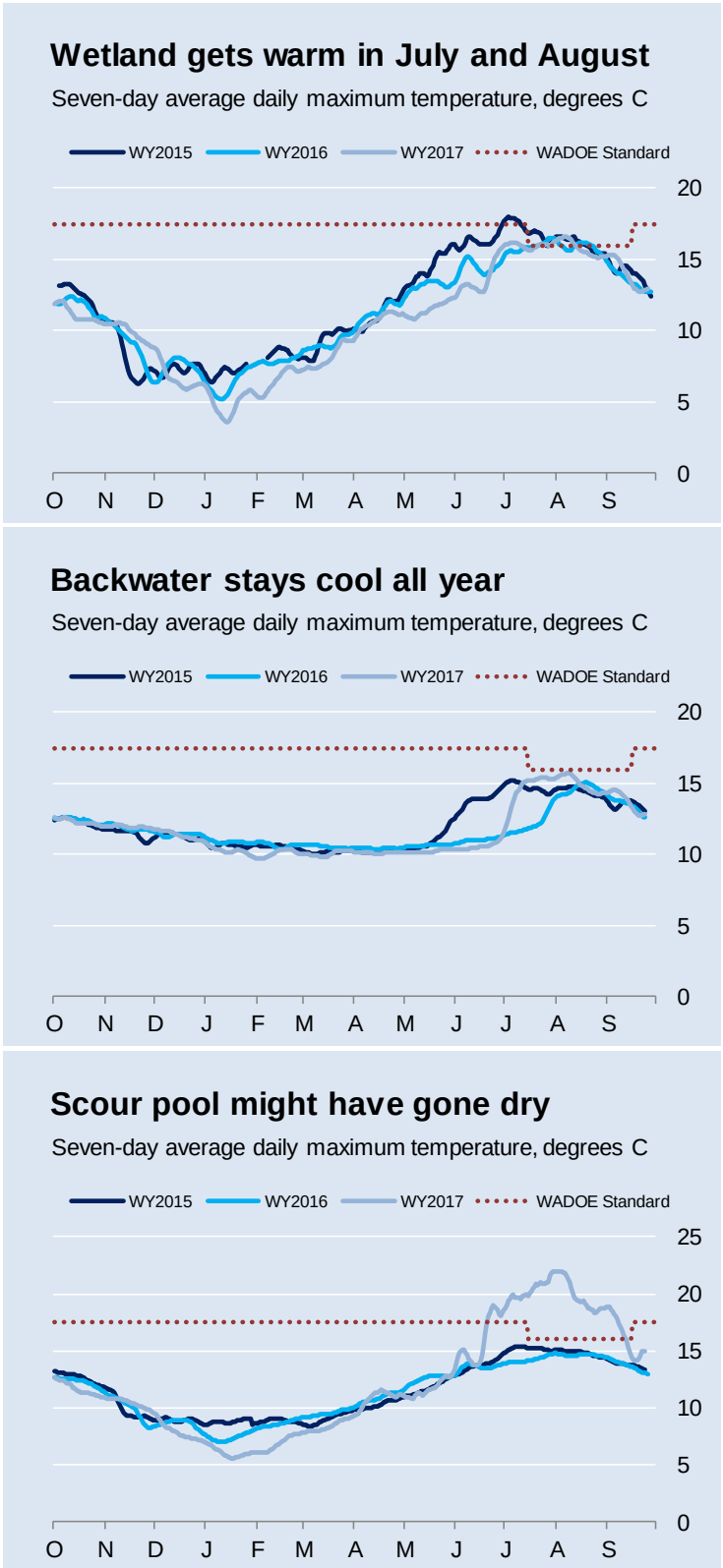

Figure 7. Seven-day average of the daily maximum temperature (7DADMax).

Goal 6. Plant Native Vegetation in Riparian and Wetland Areas.

Performance Standard for Native Woody Plant Cover	Year 5 Results
6.1. Crown cover of native trees and shrubs will be a minimum 25% in Year 5, 50% in Year 7, and 70% in Year 10 in riparian and wetland planting areas of the WSDOT mitigation area.	TARGET MET Cover in wetland re-establishment area: 45%
	TARGET NOT MET Cover in wetland enhancement area: 15%. Amendment plantings installed in 2018.
	TARGET NOT MET Cover in riparian buffer: 4% Amendment plantings installed in 2018

Point-intercept surveys were completed on August 9, 2017 in each of the two wetland areas and in the riparian buffer mitigation area. Cover was evaluated at a total of 254 points.

> **Wetland re-establishment area**: Cover was 45% (37 of 83 points at 1 meter spacing). Cottonwood and willow composed 57% and 35% of the cover, respectively. Ninebark was also present but uncommon. Volunteer plants were abundant.
>
> **Wetland enhancement area**: Cover was only 15% (15 of 100 points at 1 meter spacing). Willow was the only species. Soils appear to be very rocky and poor at this location.
>
> **Riparian area**: Cover was only 4% (2 of 54 points); new plants had been recently installed and though they appeared to survive at a high rate, they were not establishing canopy very quickly. Sitka spruce and willow were the only two species present.

In addition to point surveys, the project site was used as the site of a controlled experiment to determine whether frequent watering of naturally-occurring cottonwood seeds on bare soils could successfully establish a dense stand of volunteers (Appendix A).

Goal 7. Control Invasive Species.

Performance Standards for Invasive Species	Year 5 Results
7.1. In Years 1-10, the following weeds are absent from the WSDOT Mitigation Area: Washington State-listed or King County-listed Class A weeds designated for control by the County Weed Board; and non-native knotweeds identified on the King County noxious weed list.	TARGET MET
7.2. In Years 1-10, the combined ground cover (total cover of the target vegetation on an area of ground; Bonham (2013)) of the following plants does not exceed 10% in the project site: Blackberries (*Rubus armeniacus and R. laciniatus*); Scotch broom (*Cytisus scoparius*); thistles (*Cirsium arvense*, *C. vulgare, Carduus nutans, and Onopordum acanthium*); purple loosestrife (*Lythrum salicaria*); yellow-flag iris (*Iris pseudacorus*); ivy (*Hedera helix* and *H. hibernica*); butterfly bush (*Buddleia davidii*); bindweed (*Convolvulus arvensis* or *sepium)*; Any other Class B or C weeds designated for control by King County.	TARGET MET

4.2. Onsite Mitigation Monitoring Results (for DPER)

All onsite mitigation requirements have been met or exceeded in Year 5 (Table 6). No change since Year 3.

Table 6. Year 5 status of mitigation for project impacts for King County DPER.

Compensatory Mitigation	Acres Required	Acres created	Requirements met?
Re-establish wetland conditions just north of the existing wetland	0.062	0.24	Yes
Enhance lower wetland connectivity	0.248	1.40	Yes
Restore and enhance vegetation	0.901	1.35	Yes

4. Discussion

4.1. Are the project goals being met?

The project is currently meeting Year 5 performance standards for logjams, connectivity, weeds, and vegetation cover in the wetland *re-establishment* area:

- Aquatic ecosystem functions are protected;
- The project was built per the approved plan;
- Large wood clusters are whole and intact;

- The wetland is connected to the Snoqualmie approximately 40% of the year, and water temperatures are mostly within state standards for salmonid rearing uses;
- Native trees and shrubs are well-established in the wetland re-establishment area;
- Weeds are under control.

However, Year 5 performance standards for native woody cover were not met for wetland *enhancement* and buffer enhancement areas, even though additional plants were installed. The wetland and riparian enhancement areas become inundated early in the fall until water levels drop in early summer, during which the area remains extremely dry through the summer months. This makes it very difficult to establish plants during the dormant season. Amendment plants were planted once in early fall 2016, but they were immediately flooded and inundated through most of the winter. Plants were also installed in early summer after flows dropped low enough to plant, but it is a challenge for them to flourish through a dry summer.

4.2. How have juvenile salmon and trout responded to the project?

Most of the juvenile salmonids using the project site are coho salmon. Coho are using the existing backwater channel, though a small number were found using the main and upper wetland ponds. Chinook salmon were only observed next to the Snoqualmie River mainstem; none were found in the constructed and reconnected habitats. No trout have been observed.

The largest numbers of fish using the wetland appear to be peamouth, which were found there in high numbers in Year 4 (2016).

4.3. What critical lessons were learned?

Although further study is warranted to more fully characterize fish use of the reconnected wetlands, especially as flood refugia, observations so far suggest notching the levee and reconnecting the wetland did not produce obvious, significant habitat benefits for either juvenile Chinook or coho salmon during low to moderate flows typical of the freshwater rearing period. Before similar projects are implemented in the future, additional study of fish response to this project is warranted, so the potential benefits, or lack thereof, can be established.

The wetland enhancement area becomes inundated early in the fall until water levels drop in early summer, and then the area remains extremely dry through the summer months. Therefore, it is unrealistic to establish plants ideally during the dormant season. Amendment plants were planted once in early fall, but they were immediately flooded and inundated most of the winter. Plants were also installed in early summer, but it is a challenge for them to flourish through a dry summer. This ground surface would have benefited from roughening and mixing in soil amendments during construction.

5. Maintenance Plan

The goal of the maintenance plan (Table 7) is to ensure the mitigation project performance standards are met and the site is free from trash and excessive human disturbances. The maintenance plan will be in effect for the first ten years after construction, and the long-term management plan will be in effect thereafter. Maintenance activities will involve a mixture of chemical, mechanical, and manual weed control as determined by King County staff in each year. In most cases, suitable herbicides (e.g., glyphosate, triclopyr or imazapyr) will be used to treat invasive weeds. Methods may include broadcast spraying, spot-treatment, injection of herbicide shells, and others as needed. All applications will be performed by licensed applicators and in accordance with the manufacturer's label and King County's Best Management Practices for invasive weeds. In large occurrences of invasive weeds, mowers, weed trimmers, and brush hogs may be used for safety and efficiency. Careful use of these tools will be necessary to prevent damage to native plants. Hand tools may be used to control weeds or grasses around plantings until they are established.

Table 7. Maintenance Activities

Tasks	Description	Effort	Frequency
Public Access	Assess	Report any informal trails, encampments or unauthorized use to Parks, and address any vandalism	On monitoring visits
Trash Removal	Remove trash	Report to Parks	On monitoring visits
Signage	Maintain and repair	As needed	n/a
Weed Assessment & Treatment	Control all invasive weeds identified in performance standards	Control chemically, mechanically or manually	As needed to meet performance standards
Plant Replacement	Replace dead plants and/or add new plants if performance standards unmet	Adjustments to quantity and size will be made to obtain crown cover performance standards.	Years 3, 5, 7, 10 or as needed to meet performance standards
Maintenance Logs	Keep maintenance records and logs	Document activities; timing, cost, results	At least annually; submitted in same timing as monitoring report

6. Adaptive Management Plan

As described in the Adaptive Management and Contingencies Planning in *Appendix O* of the Program Instrument[12]:

> *"Adaptive management plans included with mitigation plans will necessarily lack specific measures to address underperformance, since the type of underperformance will not be known at the time the Mitigation Plan is developed. Specific corrective measures will be developed if and when underperformance details become clear. Any and all adaptive management measures will be appended to the Mitigation Plan and the IRT will review and comment on any additions or amendments to Mitigation Plans."*

If monitoring results indicate performance standards are not being attained for any monitoring year, adaptive management actions (as outlined in the monitoring plan) will be necessary. King County Mitigation Reserves Program will contact the permitting agencies to discuss what contingencies may be necessary. An onsite meeting may be held to inform decisions and support discussion.

Example Scenario: Potential response to loss of connectivity

If connectivity is lost or not conforming to performance standards, King County will consult with the IRT to identify and select the most appropriate response. Example responses are listed below, in order of increasingly intense intervention:

1. Further roughen areas adjacent to the outlet channel to promote scour in the channel.
2. Excavate inlet to the outlet channel to increase overbank flow and promote scour.
3. Install a lower, larger culvert through the levee within the upper wetland area to increase the amount of water in the outlet channel and promote scour.
4. Add wood to the mainstem to promote floodplain side channel development.
5. Excavate the inlet to the outlet channel.

All adaptive management actions will be approved by the IRT and may be subject to additional permit requirements.

[12] King County Mitigation Reserves Program – In Lieu Fee Program Instrument.

Appendix A. Irrigation Experiment

The context for this experiment was as follows:

- River restoration projects often create large areas of bare, disturbed soils (Photo 1).
- Disturbed soils usually need to be re-vegetated with native woody species.
- Plants are usually installed at considerable cost.
- Extremely high rates of establishment by pioneering broadleaved trees (e.g., red alder) have been observed at other restoration sites in the Snoqualmie River basin (i.e., Carlin Levee Removal Project).
- Cottonwoods produce large quantities of seeds, but only a tiny fraction establish successfully (Photo 2).
- Survival of cottonwood seedlings is often limited by the availability of soil moisture.

PHOTO 1. Spoils at the site of the experiment prior to planting (Oct 2012).

The restoration experiment used a completely randomized, balanced design:

- 10 dry (unwatered) plots, 10 wet (irrigated) plots; each bare plot was planted with native woody species.
- 12 x 12-foot (144 ft^2) plots separated by 10-foot buffers on all sides to prevent accidental irrigation overspray.
- Irrigation treatment was randomly assigned to individual plots.
- Treatment was to water each wet plot twice per week with a small but consistent amount (roughly 15 gallons per plot or about 0.17” per event).
- Cottonwood seeds were counted before each watering treatment, across all plots; seedlings were counted after germination, across all plots.
- Soil moisture and other field observations were recorded during each treatment.
- Treatment started on June 7, 2013 (at the time of anticipated peak seed drop; R. Stettler, *pers. comm*.) and continued at twice/week until early July, then once per week from July 2013 through August 2013.

Seed Density

Cottonwood seed densities were estimated for each plot prior to each watering treatment. To quantify seed abundance, plots were classified under one of five ranges: 0, 1-10, 11-100, 101-1000 and >1000 seeds. Peak seed drop values were estimated and compared between wet and dry plots. Additionally, the date of peak seed drop was determined for each plot.

Soil Moisture

Three soil-moisture measurements were taken within each wet plot before and after each watering treatment, for a total of six measurements per plot. Likewise, three measurements were taken within each dry plot for a total of three measurements per plot. Average pre-treatment soil moisture for each plot was calculated over the course of the study.

Seedling Density

Cottonwood seedling densities were estimated for each 144 ft^2 (13.4 m^2) plot by subsampling the plot area with five 0.5 m^2 quadrats, totaling 2.5 m^2 (18.7% of the plot area). A total of 100 quadrats were sampled. The quadrats were evenly spaced throughout each plot in the same layout as a number five die; four corners and one center location. The quadrat frame was fitted with a monofilament grid forming 50 individual cells (5x10 cm), which were used to visually subdivide the sampled area and enhance precision and accuracy of count data. The identity of the seedlings was photo-documented and field- verified by Dr. R. Stettler, Professor Emeritus of Dendrology, University of Washington.

The first count was performed on July 1, 2013 corresponding to three weeks after the peak of cottonwood seed drop (June 7) or five weeks after seed drop begins (May 22 R. Stettler, *pers.comm*.). This was assumed to allow for sufficient time for most viable seeds to germinate, but would allow counts to be made before large numbers of seedlings began to die. Seedling counts were averaged across quadrats, and the average seedling density was estimated on a per-square meter, hectare (ha) and per-acre basis (Photo 3).

The second count was performed on September 10, 2013. A simple *t*-test was used to compare the mean seedling densities in wet and dry plots, to determine if the mean values differed at a significance level of p=0.05 in either July or in September. Weather conditions, treatment duration, and equipment status were also recorded after each treatment event (Photo 4).

PHOTO 3. Cottonwood seedlings during the first count in July 2013.

PHOTO 4. Researchers counting seedlings in a 0.5-m quadrat in September 2013.

Results of Irrigation Experiment

Frequent, shallow watering of excavated spoils significantly increased the density of cottonwood seedlings by the end of the summer. Average seedling densities in watered plots were higher than unwatered plots by a factor of 3.7 or 370%. The average number of cottonwood seedlings present at the end of the first summer (2013) was 577,000 seedlings per acre (143 per m^2) in wet plots, compared to 155,000 seedlings per acre (38 per m^2) in dry plots. This result was highly significant (p = 0.002, meaning there is only a 1 in 500 chance of seeing a difference this large owing to chance alone). Total mortality over one summer was 65% of the seedlings in the wet plots. In the dry plots, 87% died.

- These findings demonstrate that watering the bare alluvial soils (spoils pile) through the summer produced an extra 422,000 cottonwood seedlings per acre, on average, by the end of the first summer.

Notably, the average seedling densities in wet and dry plots were statistically indistinguishable at p=0.05 when the first count was made on July 1st, 2013.

Seed counts confirmed that cottonwood seed pods began dropping in late May (Fig. A1). By June 7th, seed abundance had peaked in 35% of the plots. The remaining 65% of the plots did not reach peak seed abundance until June 24th.

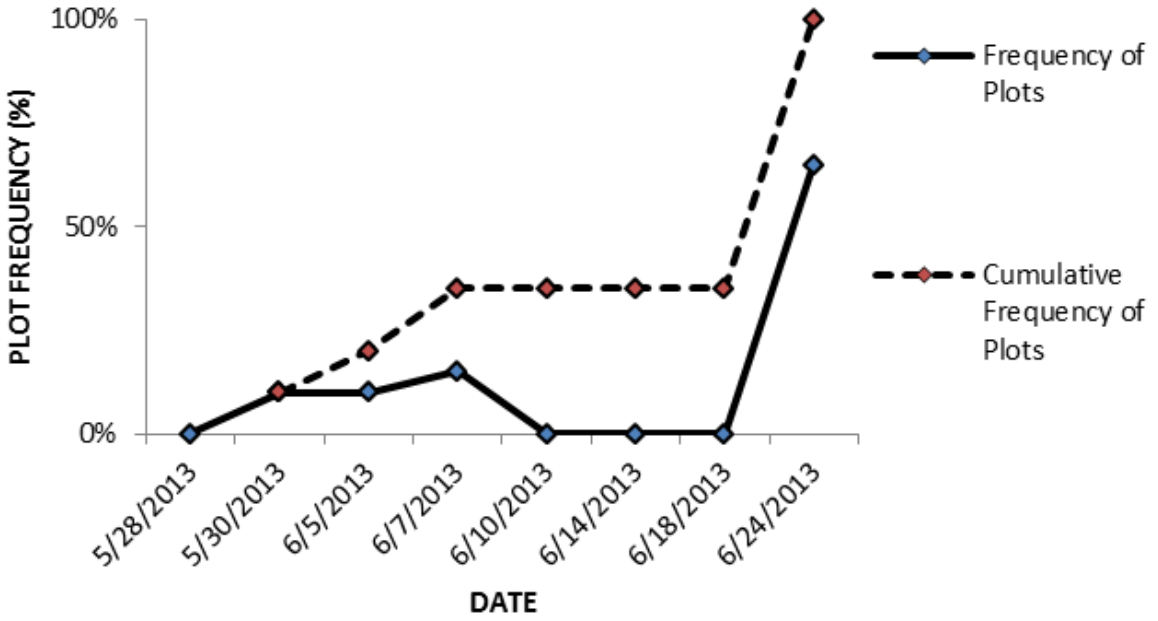

Figure A1. Timing of peak seed abundance in Wet and Dry study plots (combined) in 2013.

Seeds may have reached higher abundances in wet plots than in dry plots (Fig. A2). Maximum seed counts exceeded 1,000 (regardless of date) in seven of ten wet plots, but only in three of ten dry plots. These results suggest that uneven seed distribution may have contributed, at least in part, to the difference in seedling densities observed in this study.

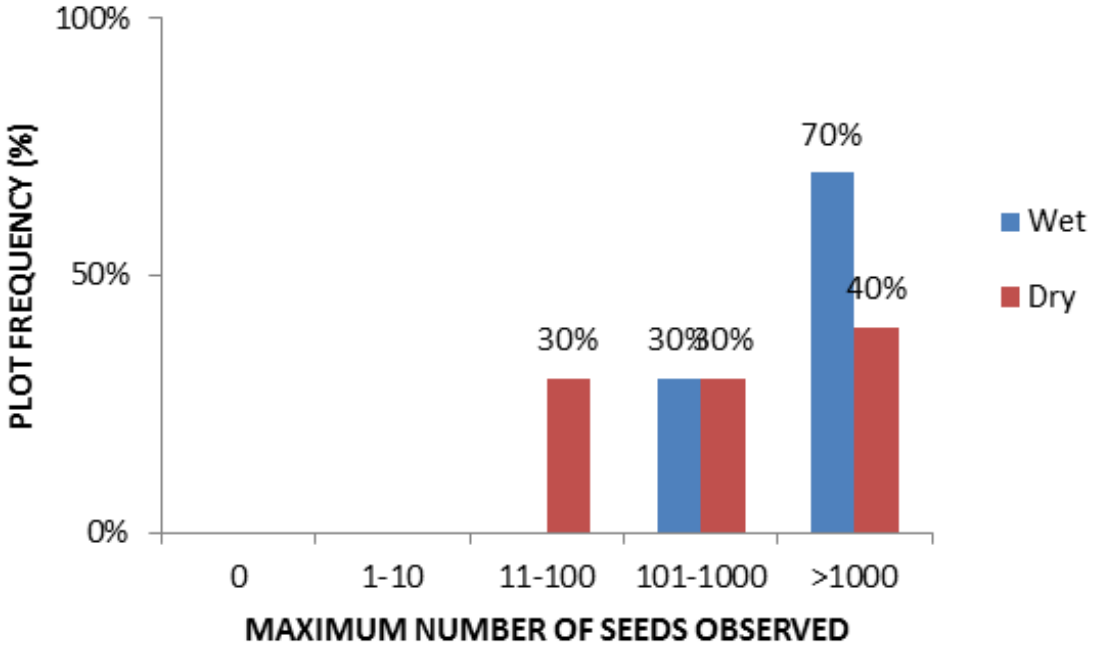

Figure A2. Comparison of the maximum number of seeds observed in wet and dry plots.

Soil Moisture

Slight but consistent differences were observed in the average soil moisture between wet and dry plots (where for wet plots, measurements were taken prior to watering) over the course of the study (Fig. A3).

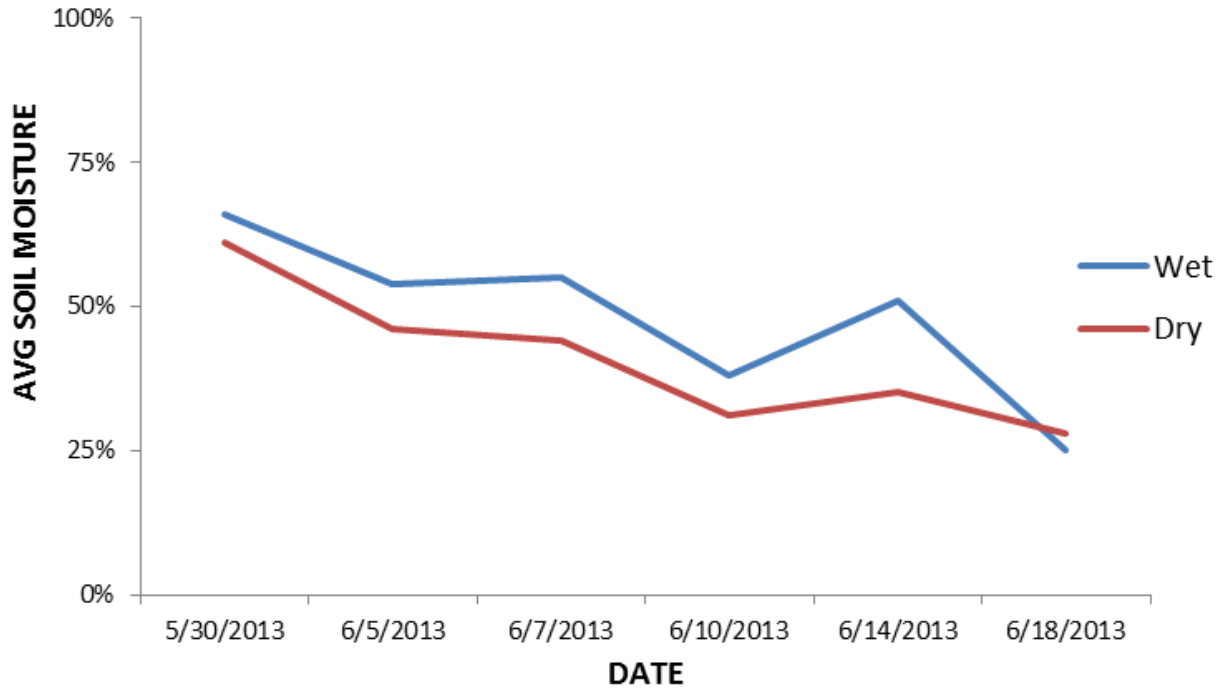

Figure A3. Changes in observed soil moisture over time.

There was a consistent increase in average soil moisture among wet plots post-watering, and a larger increase with the greater the volume of water used (Fig. A4). The soil moisture probe malfunctioned repeatedly which required recalibration frequently throughout each day. On June 18th, 2013, the soil moisture probe broke and readings were not collected thereafter. Several important qualifications are warranted:

- Soils: The spoils were a mixture of gravel, cobble, and silt/sand.
- Sun: The site ranged from full to partial sun.
- Seed sources: Seed trees surround the study area and seed was abundant.
- 2013 Rainfall: Precipitation was highly variable but average to above average, overall, based on Sea-Tac precipitation records:
    - June rainfall (1.30 inches total or 0.04 inches per day) was near the annual average.
    - July rainfall (trace) was far below average.
    - August rainfall (1.35 inches total or 0.04 inches per day) was above average but within the interquartile range.
    - September rainfall (6.17 inches total or 0.21 inches per day) was the highest ever recorded in 68 years of measurements.
- 2013 Air temperature:
    - June was 3.9 degrees (F) warmer than average (avg RH = 63%)

- July was 2.4 degrees (F) warmer than average (avg RH = 61%)
- August was 3.3 degrees (F) warmer than average (avg RH = 64%)
- September was 2.2 degrees (F) warmer than average (avg RH = 73%)

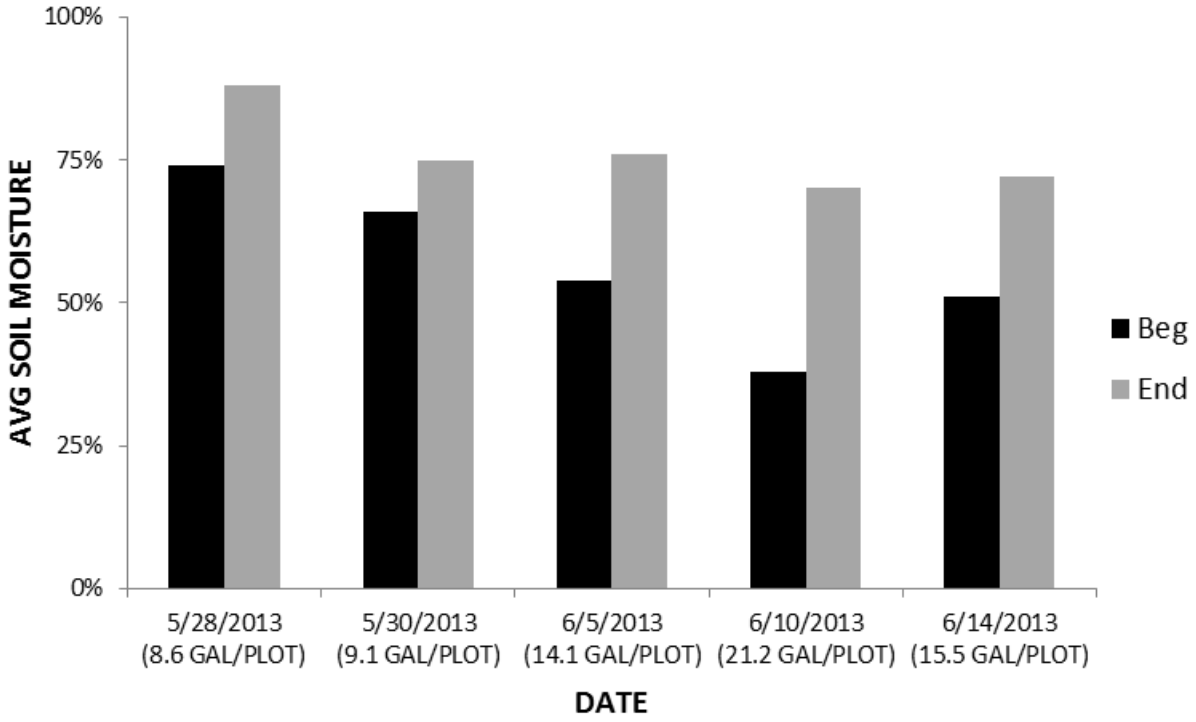

Figure A4. Average soil moisture in wet plots at the beginning (before) and end (after) watering treatments

Conclusions

Watering increased the survival rate of cottonwood seedlings, but it is too soon to know whether the watering regime is a viable method for establishing tree cover on alluvial spoils.

- The experiment provided strong evidence for a watering effect on seedling survival.
- Seedling counts in each plot are relatively imprecise, being based on the average of five 0.5-m subplots. Obtaining accurate counts within each subplot required painstaking effort, so the resulting estimates of seedling density are probably as precise as is feasible.
- Results are potentially confounded by the observation that more wet plots contained >1000 seeds (at peak levels) than dry plots, even though the assignment of watering treatments was spatially randomized among plots. However, seed counts, like seedling counts, were relatively imprecise, making it difficult to draw any strong inferences from comparisons of those values.

- The findings are representative of river spoils in mostly-full to partial sun, surrounded by seed sources. The rainfall was average to above average across the growing season – but no rain fell in July – and the summer air temperatures were slightly warmer than average.

Recommendations

- In future studies, consider evaluating the effect of the distance from plots to seed-producing cottonwood trees, which could have a positive influence on seedling densities in plots.
- Consider changing survey methods from quadrat-based subsamples, which are suited to very small plants, to a census of cottonwood seedlings, if feasible.
- Only count seedlings at the end of the summer, for efficiency (one sample instead of two).
- Consider using other (e.g., *in-situ*) technology for measuring changes in soil moisture in future studies.