Bureau of Environmental Services • City of Portland

Johnson Creek Restoration Projects Effectiveness Monitoring

Reporting on data collected from 1997 through 2010

DECEMBER 2012

Environmental Services
City of Portland
working for clean rivers

Dan Saltzman, Commissioner • Dean Marriott, Director

Acknowledgements

Implementation of the effectiveness monitoring program for restoration projects in the Johnson Creek Watershed has drawn on the expertise, support, and dedication of a number of individuals. We thank them for making this report possible.

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Introduction

In 2001, the Bureau of Environmental Services published the Johnson Creek Restoration Plan (JCRP). The JCRP divides Johnson Creek into 58 distinctive reaches and identifies conditions, opportunities, and actions for restoration in each reach. Actions are identified to address nuisance flooding (events that occur about every 10 years), water quality, and fish and wildlife habitat.

In 2005, the Bureau of Environmental Services developed the Portland Watershed Management Plan (PWMP). The PWMP identifies four watershed health goals with strategies and actions necessary to accomplish these goals. Taking an integrated approach to improve watershed health, the PWMP goals are:

- Hydrology: Move toward normative stream flow conditions to protect and improve watershed and stream health, channel functions, and public health and safety.
- Physical Habitat: Protect, enhance, and restore aquatic and terrestrial habitat conditions and support key ecological functions and improved productivity, diversity, capacity, and distribution of native fish and wildlife populations and biological communities.
- Water Quality: Protect and improve surface water and groundwater quality to protect public health and support native fish and wildlife populations and biological communities, and
- Biological Communities: Protect, enhance, manage and restore native aquatic and terrestrial species and biological communities to improve and maintain biodiversity in Portland's watersheds.

This document reports on the monitoring of BES projects in support of watershed health in Johnson Creek constructed from 1997 to 2010. It details specific project design criteria and methods used to monitor project performance, provides an analysis of the restoration project effectiveness, and discusses challenges and lessons learned.

Johnson Creek Overview

Johnson Creek originates near Boring, Oregon and runs 26 miles west through six jurisdictions before draining into the Willamette River in Milwaukie, Oregon. The Johnson Creek watershed covers an area of 54 square miles, much of which is highly urbanized. 38% of the watershed is within the City of Portland.

Johnson Creek provides critical habitat for coho and Chinook salmon, and steelhead trout, which are listed as threatened species under the Endangered Species Act. The creek has a history of flooding, on average, every two years. Dating back to the early 1900's various federal, state, and local agencies attempted to reduce or eliminate flooding in Johnson Creek. The most significant alteration, done in the 1930's as part of the Work Progress Administration (WPA), deepened, straightened, and armored the creek by installing large basalt rock lining along its banks and streambed. This disconnected the stream from its floodplain which previously absorbed, stored, and conveyed floodwater. The WPA work eliminated aquatic habitat such as riffles, pools, and large wood and impaired the streams ability to migrate and recruit gravels and large wood (see Photo 1).

The 2001 JCRP takes a comprehensive approach to the restoration of natural floodplain functions, focusing on nuisance flooding, water quality issues, and fish and wildlife declines related to flooding.

Photo 1: From 1931 – 1935, the Federal Government widened, armored and rock-lined portions of Johnson Creek as part of the WPA, in efforts to mitigate flooding.

The goals of the JCRP are to reconnect the floodplain; restore riparian, wetland, and aquatic habitat; and improve water quality. The Plan identifies various actions to achieve these goals including protecting and restoring natural function through land acquisition, fish passage barrier removal, stream bank reconstruction and stabilization, increasing instream complexity, mitigating water quality and hydrology impacts from stormwater outfalls, and vegetating riparian corridors.

The JCRP identified eight priority action areas, four of which are within the City of Portland. These areas include Tideman Johnson Natural Area, West and East Lents, and Powell Butte (Figure 1). By early 2010, BES completed six restoration projects in three of the priority action areas. The Tideman Johnson Natural Area project and Errol Creek projects are located in the Tideman Johnson target area (Figure 2). The Brookside Wetland Project is located in the East Lents target area (Figure 3), and the Kelley Creek Confluence project and the Schweitzer Restoration project are located in the Powell Butte target area (Figure 4). These projects are described in more detail in the following section. Restoration projects have not yet been constructed in the West Lents target area.

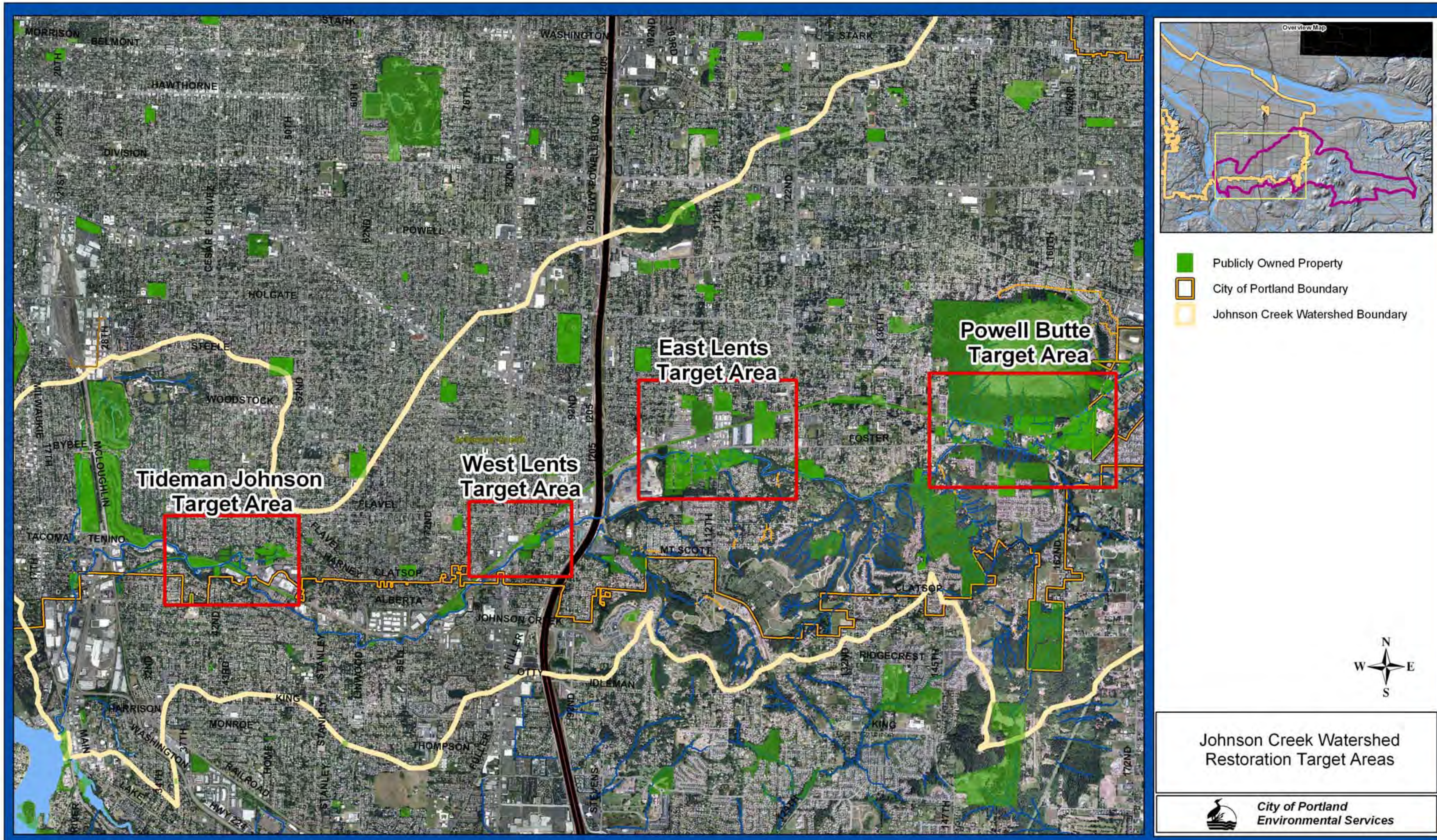

Figure 1: Four priority target areas within the City of Portland, identified in the Johnson Creek Restoration Plan

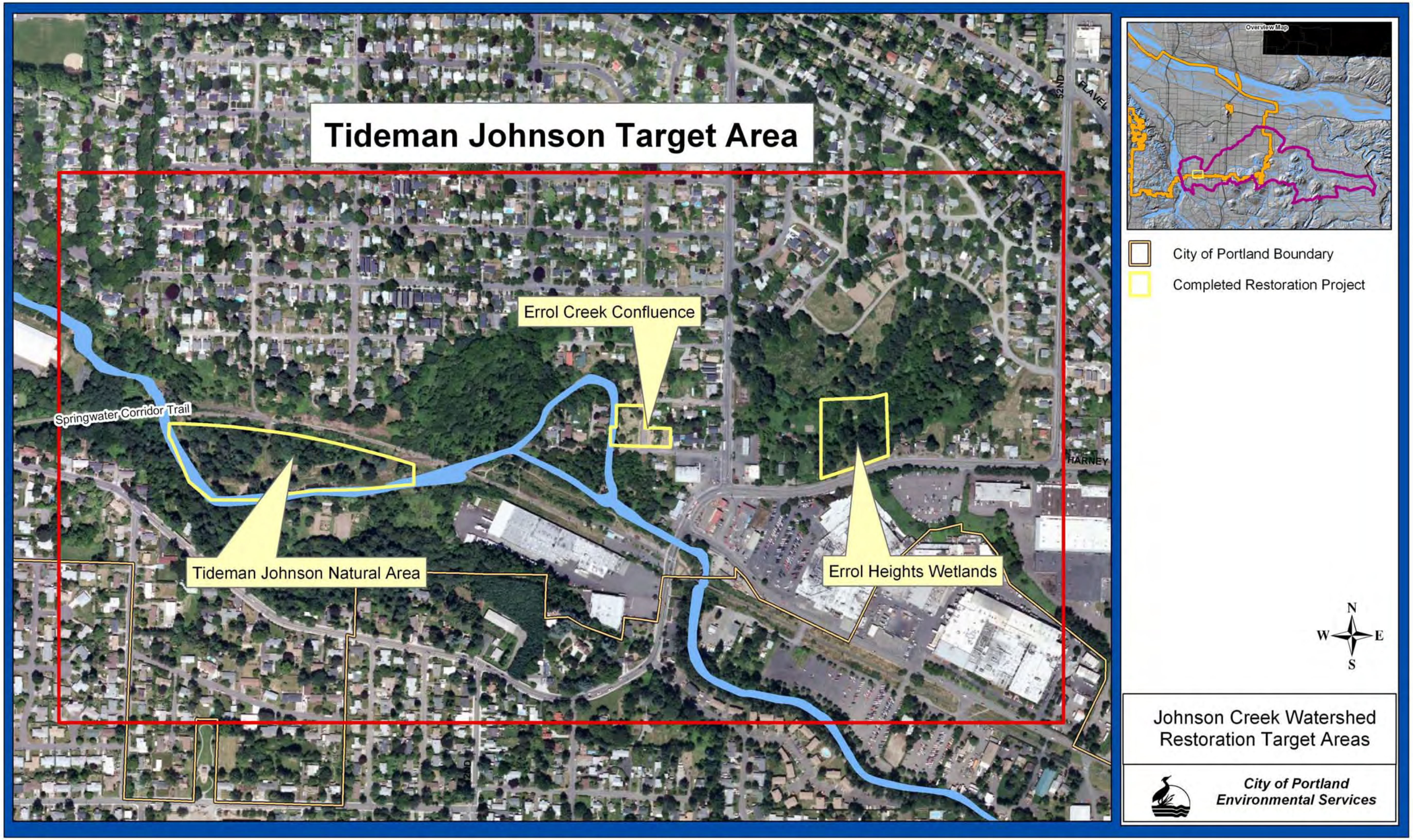

Figure 2: Three BES restoration projects constructed in the Tideman Johnson target area; two projects on Errol Creek and one in Tideman Johnson Park

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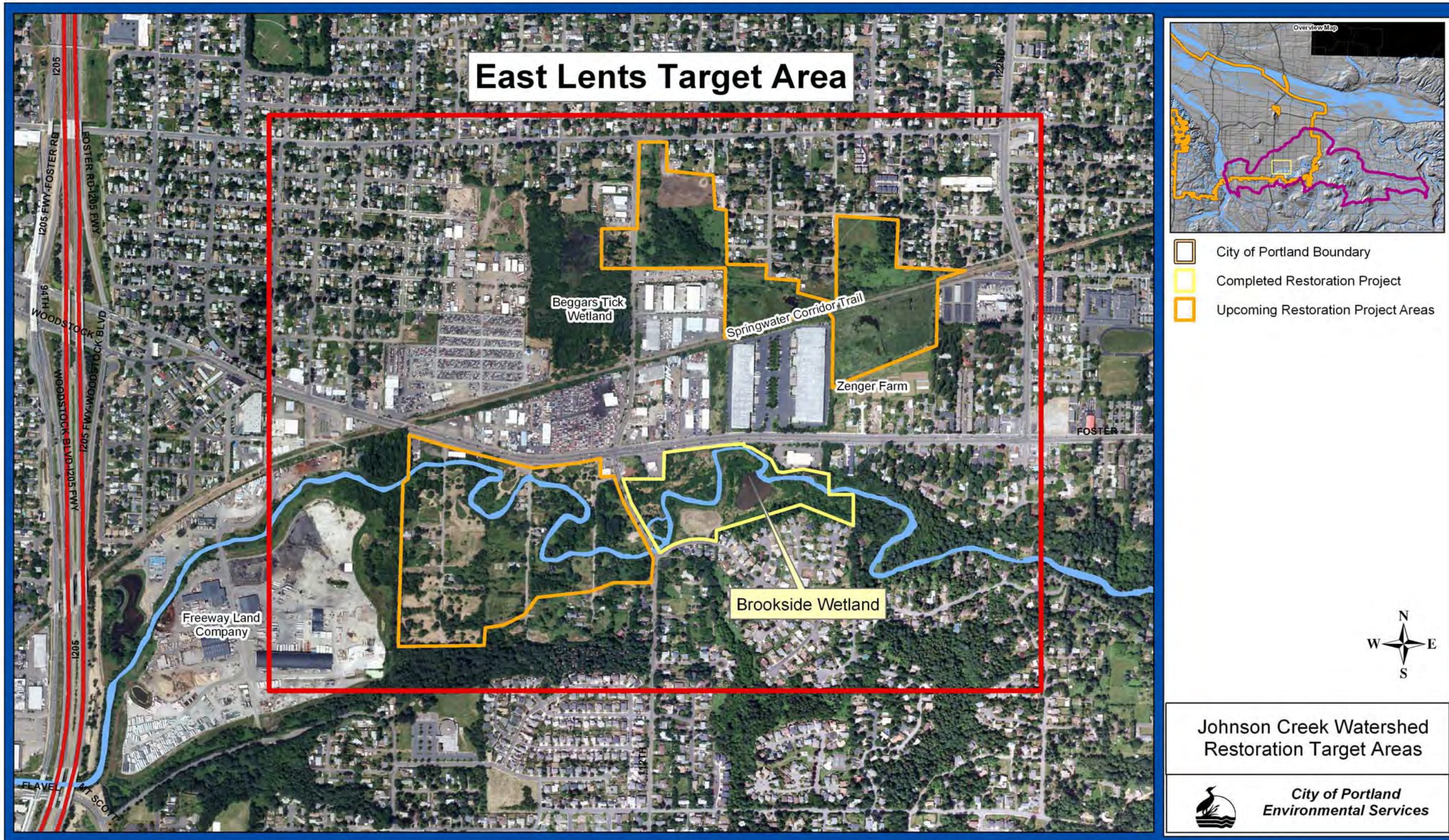

Figure 3: Brookside Wetlands, located in the East Lents target area.

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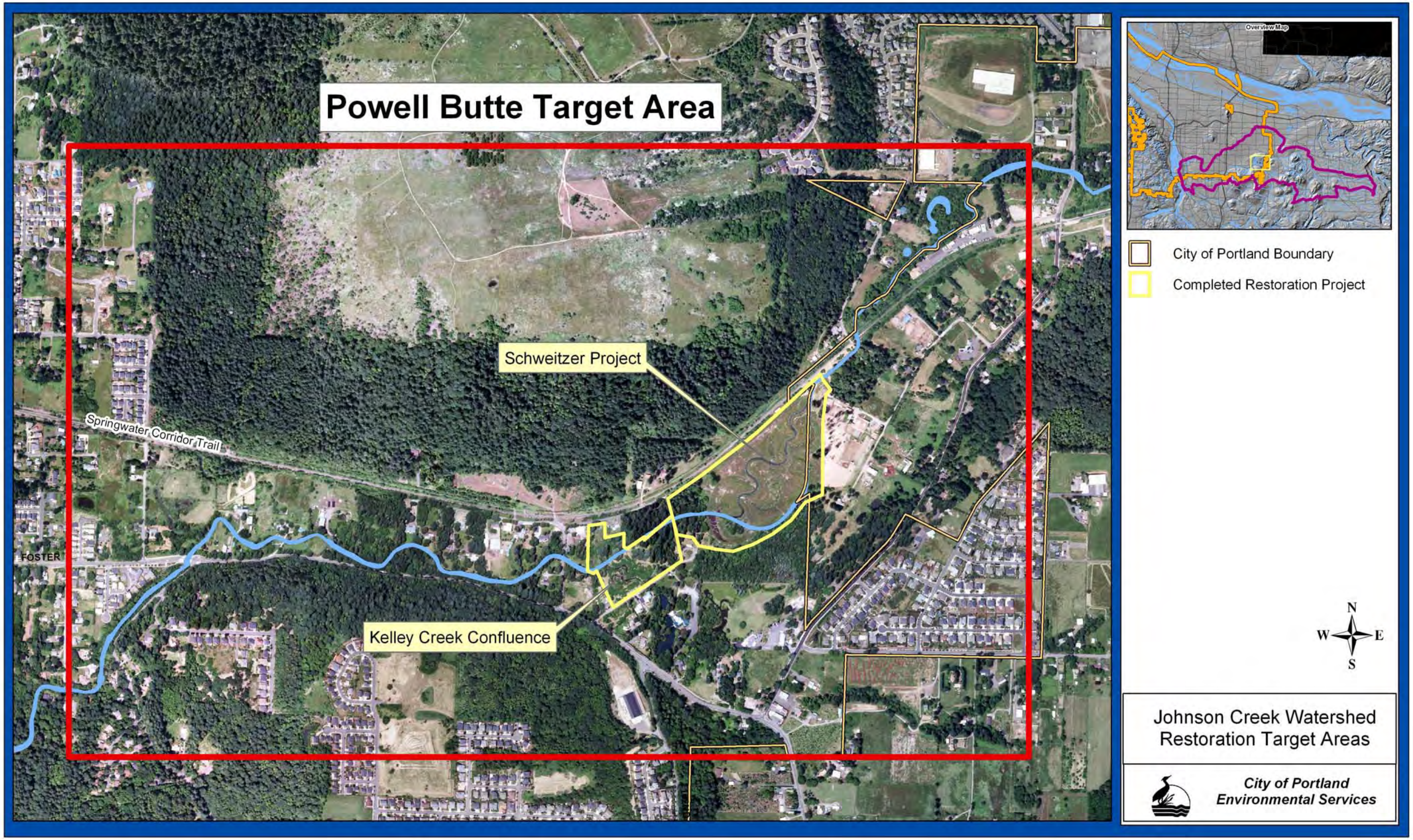

Figure 4: The Kelley Creek Confluence Project and the Schweitzer Restoration Project, located in the Powell Butte target area.

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The target areas are based on unique characteristics within the watershed. The Tideman Johnson target area is in the lower section of the watershed, which is a relatively steep section with relatively low flood storage capacity, greater ability to transport gravels and cobble through the system, and a higher potential for scour.

The East Lents and Powell Butte target areas are in the middle of the watershed within the flattest sections of Johnson Creek. East Lents has the largest area of floodplain (over 300 acres). A majority of these floodwaters flow to the flat, low-lying areas north of the creek. While the Powell Butte target area is flatter than East Lents it provides limited flood storage. Buttes on the north and south side of the stream create steep valley walls, restricting the floodplain area. Channel slope and profile are shown in Figure 5.

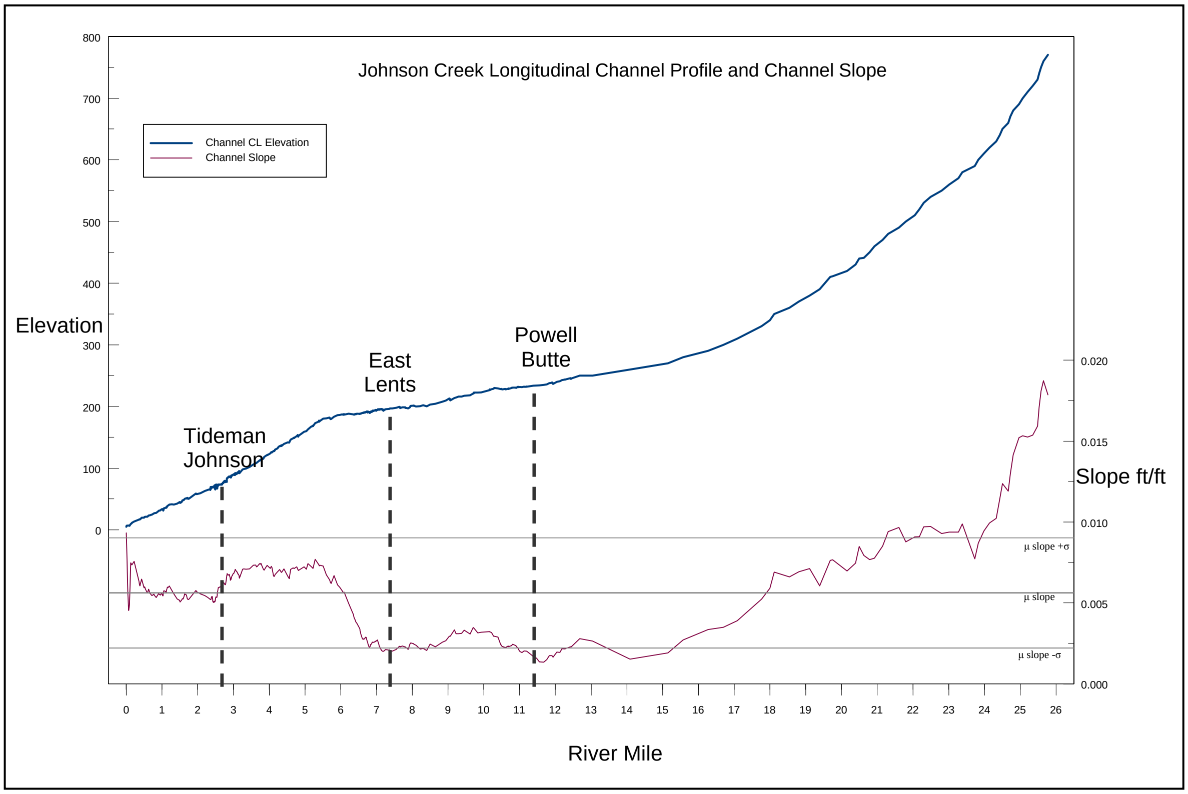

Figure 5: **Elevation and slope of the centerline of Johnson Creek**. The Tideman Johnson area is steeply sloped and has a higher potential for scour. The flattest sections of the creek, East Lents and Powell Butte areas have high flood storage capacity relative to Tideman Johnson and other sections of the watershed.

Project Effectiveness Monitoring Program

Overview

Our restoration projects are monitored to comply with federal, state, and local permits, to measure project performance, and to determine adaptive management needs. As part of permits or grant approvals, local, state, and federal agencies and granters require project monitoring. The monitoring requirements typically focus on vegetation and photo monitoring.

To support BES' substantial investment in restoration projects, it is also important these projects be monitored to determine if they perform as designed. As such, the monitoring protocols we have established are significantly more robust than what is required by other agencies. Three different timescales are considered for project effectiveness monitoring as described below.

<u>Phase I</u> - Immediately before and following construction and during the first five years, while the site is highly disturbed, lacking vegetation, and vulnerable to erosion and scour during storm and flood events.

<u>Phase II</u> – Five to 20 years, when wetland, riparian and upland plants are established, and trees mature but have yet to provide instream large wood habitat.

<u>Phase III</u> – 20 years and beyond when forested wetlands with mature trees provide a regular supply of large wood to the stream.

Most of our restoration projects are in Phase I of the monitoring timeline. The Kelley Creek Confluence project entered Phase II in Spring 2011. The Brookside Wetland project is in both Phase II and III. This is explained further in the project description and monitoring results Section 3.1.

During the first 10 years following construction, adaptive management may be necessary to correct conditions that threaten vegetation cover and channel stability. The data collected informs when adaptive management efforts are needed to make project repairs and informs future restoration project designs. Typically, after 10 years native trees and shrubs become established and dominate the site, and adaptive management is less necessary.

Monitoring Methods

Pre-construction monitoring is conducted at sites whenever possible to provide baseline data. Many JCRP projects involve relocating the stream channel, so for some criteria, comparisons between pre- and post-project are not appropriate.

Post-construction monitoring plans require data collection at each site at least two times per year. Protocol specifies methods for monitoring aquatic habitat, high flow refuge, hydraulic stability, and flood storage volumes.

Photo Monitoring

Photos provide visual documentation of the changes within the project site. Photos are taken at predetermined coordinates and bearings to show changes over time. Pre-project photo monitoring is conducted at each site for comparison purposes. Post-project photo monitoring is done at each completed restoration sites at varying intervals depending on the age of the project. Typically, monitoring alternates between leaf-on and leaf-off intervals. Leaf-on photos show changes in vegetation over time. Leaf-off photos allows better views through the vegetation cover to show changes in channel form or floodplain such as scour, erosion, or movement of large wood.

Habitat Monitoring

Aquatic habitat monitoring assesses high-flow refuge for salmonids in winter and low-flow spawning and rearing habitat in summer.

Habitat Availability

Physical habitat measures include habitat unit frequency, total habitat area, pool availability and quality, large wood, and substrate composition. Stream habitat measures include a subset of those described by the *ODFW Aquatic Habitat Monitoring Guidelines* (Moore et al. 2008) with modifications based on site-specific conditions and project objectives.

High-flow refuge

Measuring habitat conditions during high winter flows documents connectivity and extent of off-channel habitat for winter rearing and refuge habitat for juvenile salmonids. High-flow refuge is assessed by quantifying off-channel availability to salmonids during the approximated 9-month storm event.

The Northwest River Forecast Center website at: http://www.nwrfc.noaa.gov/river/station/flowplot/flowplot.cgi?SYCO3 uses instantaneous USGS flow data from their Sycamore gage located near Johnson Creek river mile 10.5 and rainfall forecasts to predict flows on Johnson Creek. The stream flow for the 9-month event is estimated at 690 cubic feet per second (cfs) at the Sycamore gage. These predictions inform when high-flow or flood events may occur. High-flow refuge monitoring is primarily conducted using on-the-ground photo documentation to determine if backwater and overflow channels are connected and to document the extent of inundation.

Hydraulic Design Monitoring

Hydraulic monitoring assesses flood storage capacity during high-flow events and channel stability during summer base flows. Flood storage monitoring estimated the volume of floodwater stored within the project during different storm events. Channel stability monitoring measures performance of grade control riffles, deformable banks, and channel planform. Hydraulic monitoring includes floodplain analyses, photo documentation, pebble counts, and longitudinal and cross-sectional survey.

Flood storage

Various methods can be used to monitor flood storage. During flood events, aerial photography is extremely useful, and is done when the timing of the event, weather, and available daylight conditions are conducive. We also conduct field flood investigations, which entails on-the-ground monitoring including photo documentation, measuring depths of floodwater and mapping flood extents and direction of flow. Collecting field data during events can be difficult. Flood events do not always occur during daylight hours. Aerial photographs can be difficult to get due to poor weather conditions and visibility. Mobilizing field crews during the peak of the flood can also be challenging and dangerous.

To improve our high-flow monitoring, we installed a staff gage and two crest gages in a backwater channel at the Schweitzer Restoration Project. During flood investigations, water levels can be read off the staff gage to determine instantaneous flood stage. The nested crest gages capture peak water levels at high flow events ranging from the 9-month event or 690 cfs to events larger than a 25-year event or 2500 cfs.

The crest gages consist of vertical piece of 2-inch galvanized pipe with a wood staff held in a fixed position with a datum reference. The bottom cap has six intake holes, which allow floodwater to enter the pipe. The top cap contains one small vent hole.

Re-granulated cork is placed in the bottom of the pipe, as water rises inside the pipe the cork floats on its surface. When the water reaches its peak and starts to recede, cork adheres to the staff inside the pipe, marking the crest stage of the flood. The height of a peak is obtained by measuring the interval on the staff between the reference point and the floodmark.

Using a stage-storage curve created during project design, we can estimate the volume of flood storage provided by the Schweitzer Restoration Project from the water level that corresponds to the instantaneous peak discharge. See Section 3.4.3 Flood Storage Monitoring, for the Schweitzer flood stage-storage curve.

Pebble Counts

Changes in stream flow regime and sediment supply result in natural variations in substrate composition. Fines may deposit on the streambed in reaches that are backwatered during flood events or in pools during lower flows. Natural armoring along riffles may form a resistant layer of relatively large particles resulting from removal of finer particles by erosion. Pebble counts are used to detect changes in substrate gradation and determine if grade control riffles are armoring or remaining intact. Pebble counts are conducted according to methods presented in *Sampling with the US SAH-97 Hand Held Particle Size Analyzer* (Potyondy & Bunte, 2000).

Over time, changes in the median particle size (D50) are tracked to determine if the constructed riffles are armoring. Hydraulic analysis suggests that riffles constructed with the 'mobile' substrate will armor over time in response to flood events. As armoring occurs, the median particle size increases, because finer particles wash away and the substrate becomes increasingly coarse. Even if the channel does not armor, natural variation in substrate gradations will occur. Pool scour and riffle deposition may occur during high flows, while the gradual erosion of riffles and deposition in pools occurs during lower flows. A discussion of the flood events that occurred during the previous winter should be considered when evaluating pebble counts.

Channel Survey

Cross-sectional and longitudinal surveys are used to determine channel stability. Cross-section surveys are typically taken at riffles to detect aggradation or erosion such as silt bar formations, headcutting or avulsion. Longitudinal profile surveys are conducted in areas with specific erosion concerns or areas of active headcut. Cross-sectional surveys are conducted using methods presented in Chapter 6 of *Stream channel reference sites: an illustrated guide to field technique* (Harrelson et. al., 1994).

Water quality

Johnson Creek is one of many urban streams that does not meet water quality standards under the Federal Clean Water Act. Total Maximum Daily Load, or TMDL, is a calculation of the maximum amount of a pollutant a waterbody can receive and still safely meet water quality standards. Johnson Creek has TMDL's established for several pollutants including: bacteria (e.coli), temperature, and total suspended solids (TSS) which carry toxins, such as DDT and dieldrin.

JCRP floodplain restoration projects address water quality issues associated with TSS in several ways. One method is to increase flood storage capacity allowing the stream to access the floodplain during high flows. As this happens, velocities reduce, allowing sediments to drop out onto the floodplain. Sediment deposits are photo documented after significant flood events.

TSS are also reduced by increasing bank and floodplain stability. Revegetation is a large portion of our restoration efforts at each restoration site. Established vegetation reduces the risk of erosion and stabilizes the banks and surrounding floodplain.

A strong correlation exists between stream temperatures and the amount and quality of riparian canopy. To comply with the temperature TMDL, The City of Portland is improving and increasing riparian canopy along Johnson Creek.

Canopy Cover

Canopy cover is monitored at each restoration site using a concave densiometer. This instrument consists of a spherical-shaped reflector mirror used to count and calculate the percent of overhead area occupied by canopy.

Visual inspections

Annual site inspections are important to observe site conditions for anticipated and unexpected changes that could affect the stability of the channel. Inspections are conducted throughout the entire site including the entire length of channel, backwater channels, large wood installations, and floodplain.

Restoration Project Descriptions and Monitoring Results

Projects in this report are discussed in order of location, starting from the western most, downstream project moving upstream and to the east.

Tideman Johnson Park Restoration/Lents Interceptor Repair

Project Overview

Environmental Services completed the Tideman Johnson Natural Area Restoration Project in November 2006 to repair the Lents Interceptor sewer. The Lents Interceptor is a 60” concrete pipe that conveys combined wastewater and stormwater from SE Portland to a pump station on McLoughlin Boulevard. The interceptor crosses under Johnson Creek in five locations, two of theses crossings are within Tideman Johnson Natural Area. When it was built in 1922, the pipe was buried about five feet below the creek bed. Since that time, erosion of the streambed exposed the upstream section of the pipe leaving it vulnerable to damage (Photo 2a).

Photo 2a: Exposed sewer pipe crossing Johnson Creek at Tideman Johnson Park before restoration.

In Summer 2006, construction crews diverted 1,800 linear feet of the creek around the site, and encapsulated the Lents Interceptor with concrete. The streambed was raised by importing gravels and cobbles to re-bury the pipe and provide valuable salmonid spawning habitat. Engineered logjams (ELJ) were placed in multiple areas downstream of the pipe to prevent future erosion. Large wood and boulders stabilize stream banks, reduce stream velocity and provide habitat. High flow channels and wetlands were added to increase habitat and flood storage (Photo 2b).

Photo 2b: Tideman Johnson Park post-restoration project. Pipe is re-buried, overflow channels were created, and large wood was placed in the channel.

After construction, the site was planted with over 1,800 trees, 5,000 shrubs, 1,200 wetland plants, and 37 pounds of grass and wildflower seed.

Design Criteria

The project design criteria for the Tideman Johnson Restoration Project were as follows:

1. Reconnect the floodplain and increase flood storage capacity
2. Create high flow refuge habitat
3. Create salmonid spawning and rearing habitat
4. Prevent channel incision and head-cutting to secure the Lents Interceptor
5. Improve riparian plant communities to prevent erosion and reduce stream temperature by shading the creek

Monitoring Parameters and Results

Habitat Monitoring

Habitat Availability

This project was constructed prior to a refined approach to effectiveness monitoring. Post-project monitoring has primarily been conducted with photo documentation and visual observation. Habitat unit data was collected in 2009. Future habitat data will be useful to show the changes in habitat units over time.

Beaver activity has been documented in this area for many decades. The newly constructed ELJ act as stout framework for recent dam construction. In 2009, two large dams were constructed within the ELJ's, along with a new beaver den. Additionally, several trees have fallen due to beaver chew. The largest dam, located at the uppermost ELJ measured over six feet tall (Photo 3).

The ELJ capture typical urban debris (e.g. trash, tires, vegetation) blocking stream flow. In come cases, the stream diverted around the ELJ, causing significant bank erosion. To alleviate this problem, Environmental Services trimmed logs within the ELJ, reducing the capacity for debris to build up and returning the thalweg of the stream to its designed location (Photo 4).

Photo 3: BES staff standing below upper most beaver dam in Tideman Johnson Restoration Site (see arrow).

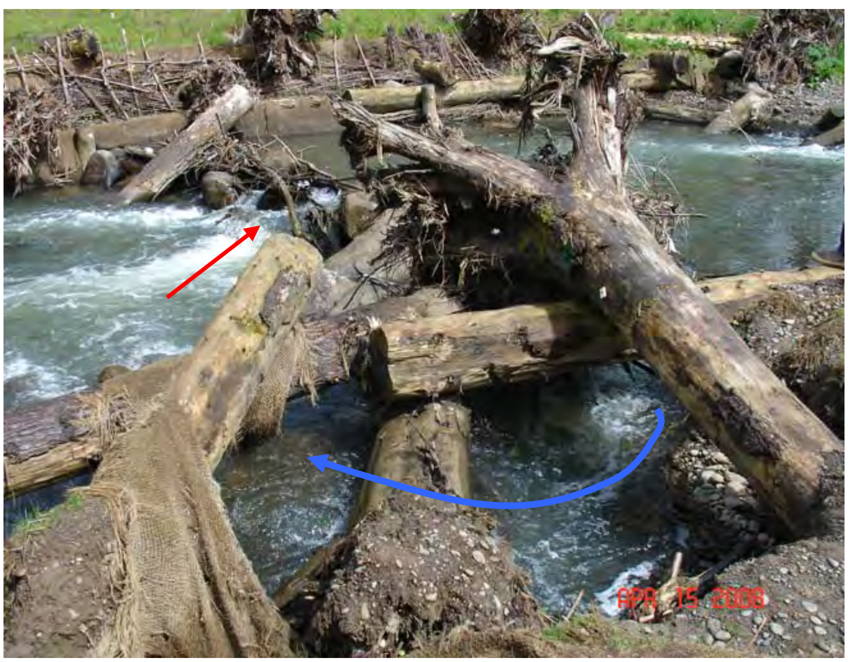

Photo 4: The lower most engineered logjam at the Tideman Johnson Restoration site. The red arrow shows the center of the stream which is being blocked by debris. The increase in resistance diverted stream-flow, causing bank erosion and exposing buried logs (blue arrow).

High Flow Refuge

High flow monitoring is conducted annually to determine the extent of inundation during various events. Overflow channels are monitored to determine the amount of flow necessary for inundation. Two overflow channels were designed to become inundated during a 1.5-year reoccurrence interval or approximately 1200 cfs at USGS Sycamore gage. Monitoring has shown that the upper overflow channel becomes inundated during more frequent events due to large beaver dams located immediately downstream. Notably, this channel also had minimal flows during the dry season. The lower overflow channel becomes inundated during events as low as 300 cfs, providing high flow refuge during smaller events. Photo 5 shows the upper-most overflow channel during a 9-month event in March 2010.

Photo 5: Tideman Johnson - March 2010, nine-month high-flow event.

Hydraulic Monitoring

The Tideman Johnson project is located on one of the steepest sections of the stream within the City of Portland. The steepness in slope increases stream velocity, reduces flood storage capacity, and increases the likelihood of erosion within the site (see Figure 5).

Flood Storage

This project changed the 100-year floodplain boundary slightly, shifting the floodplain onto an undeveloped area of an adjacent private property. Working collaboratively with the property owner, careful monitoring is done to ensure floodwaters do not extend beyond the boundary design. To improve our monitoring methods, two staff gages were installed on the impacted private property. During flood events, the gages are monitored to calibrate flows and floodwater depths. We also map flood extents during various flow conditions.

The 2009 flood extent was determined by observing flood debris lines. The 29-year event stayed within the mapped FEMA 100-year floodplain boundary.

Cross-Sectional Survey

As previously mentioned, this restoration project is located in a relatively steep section of Johnson Creek. This section of stream is often referred to as a transport reach in that there is a much greater likelihood of scour, which recruits gravel to the system and transports them downstream. This dynamic was confirmed shortly after project completion, as evidence of scour began to appear. Bank avulsion occurred at the lower extent of the project. Bundles of willow stakes were placed in the bank to prevent further erosion (Photo 6). Erosion concerns prompted the need to conduct cross-sectional survey throughout the site.

The first year of cross-sectional surveys were conducted in Summer 2007 in areas thought to be most vulnerable to scour (Figure 6). Cross-sectional survey data from 2007 to 2010 have produced valuable information revealing the extent of erosion within surveyed areas. The most significant erosion occurred in the lower overflow channel (Photo 7). Cross-section 3b captured the extent of erosion that has occurred in the overflow channel (Figure 7). To monitor the progression of the headcut within the overflow channel a survey of the longitudinal profile (Figure 8) and cross- section 3C were added to the monitoring protocol in 2008.

Photo 6: Tideman Johnson; erosion at lower extent of project began shortly after project completion on right bank. Willow stakes were place in the bank to prevent further erosion.

Native gravels within the overflow channel have migrated downstream into the mainstem of Johnson Creek. Gravel deposits noted near the mouth of Johnson Creek are suspected to have been sourced from this scour.

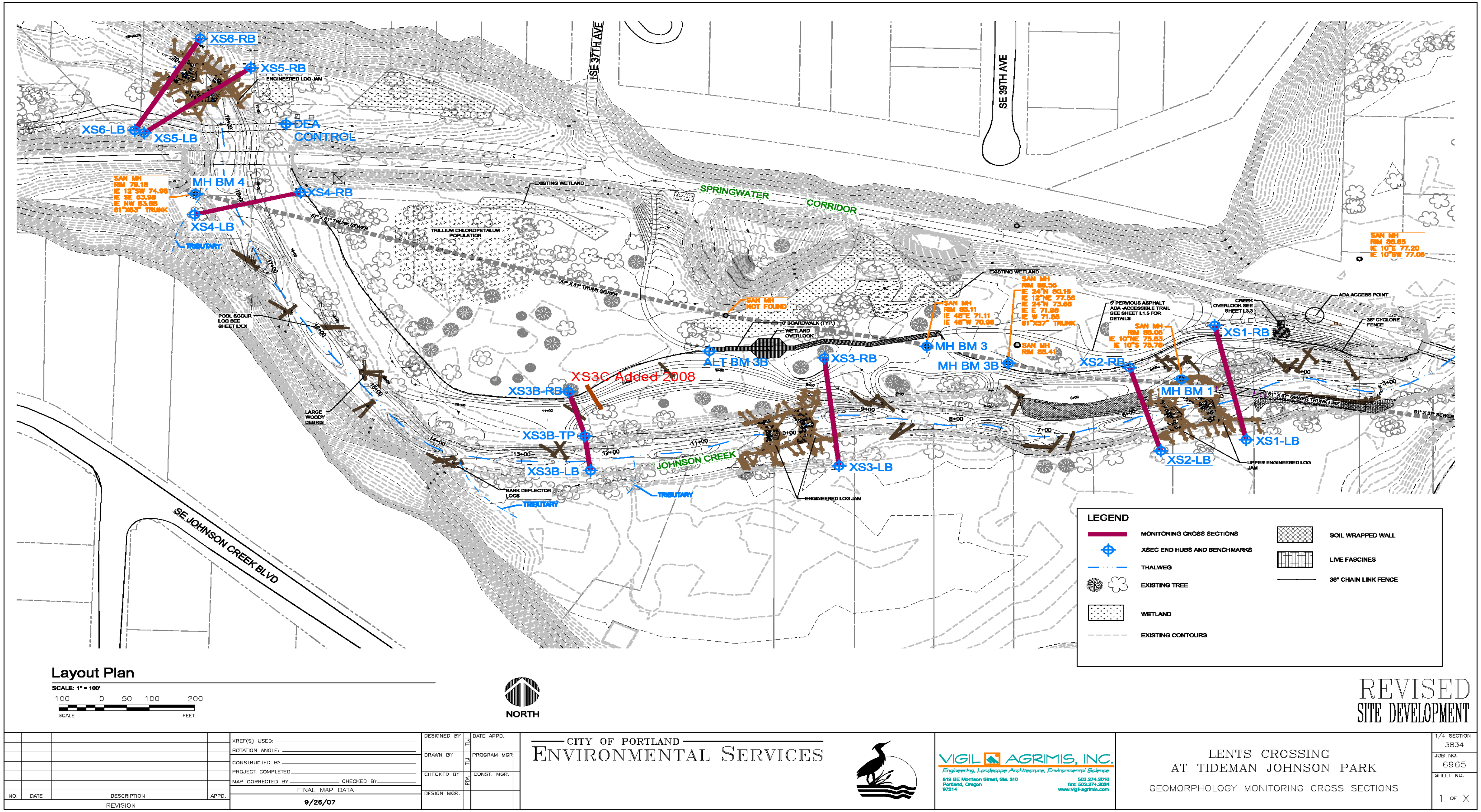

Figure 6: Tideman Johnson Cross-Sectional Survey locations

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Photo 7: Scour hole at Tideman Johnson Park, in lower overflow channel.

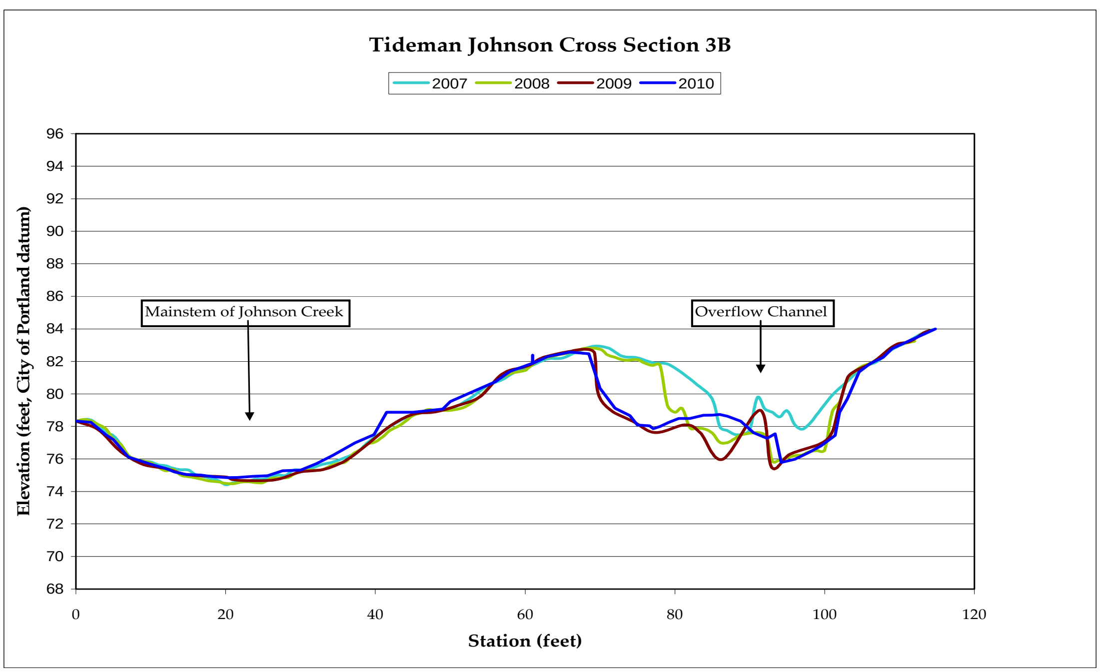

Figure 7: Cross-section 3B showing the erosion occurring within the overflow channel in the Tideman Johnson Restoration Project from 2007 to 2010.

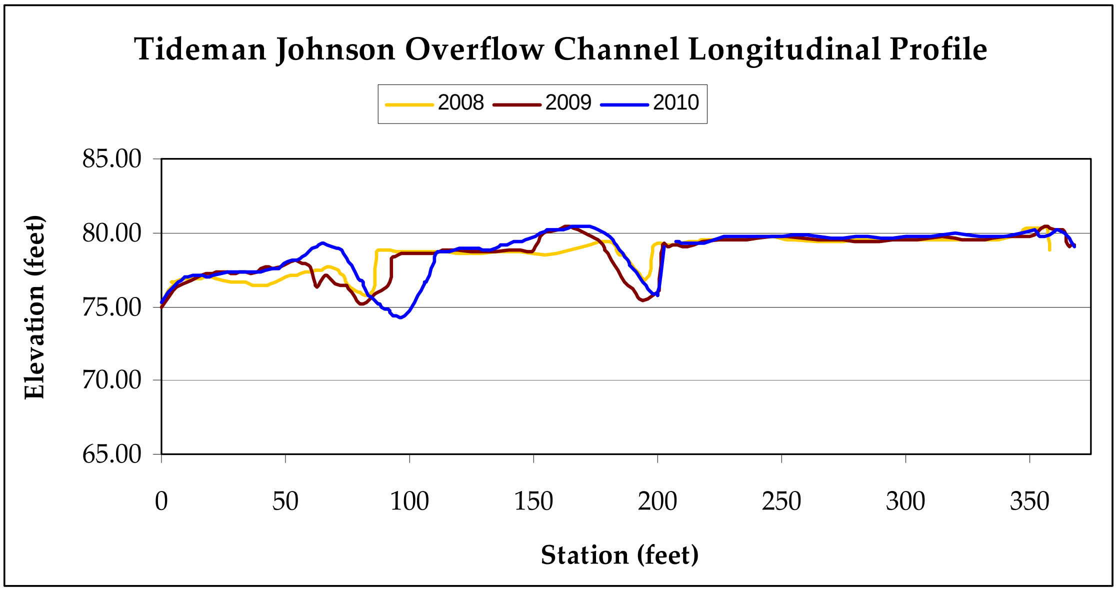

Figure 8: Longitudinal Profile of overflow channel at Tideman Johnson Park 2008-2010

In 2008, BES staff considered repairing the scour holes in the lower overflow channel. Oregon Department of State Lands (DSL) deemed the repairs to be below the 50 cubic yard threshold and therefore, not within the DSL jurisdiction. U.S. Army Corp of Engineers (USACE) determined the work could proceed through a minor modification to the original permit. The City of Portland's Bureau of Development Services (BDS) regulations require the proposed repair to be in substantial conformance with the original permit application before the repair could be approved. It was determined that the repairs did not meet the substantial conformance criteria and would require a new City permit. BES Engineering Services determined the repair to be non-critical in its current state. Since then, scour continues to occur during annual high flow events. Continued monitoring will determine whether the scour threatens re-exposure of the upstream sewer pipe. Should repairs be required to stabilize the area, necessary permits will be obtained to restore the site as needed.

Visual Inspections

Erosion has occurred in multiple areas throughout this site. The restoration project area is significantly constrained by the Springwater Corridor Trail and utility towers and pipes to the north and private property to the south, limiting the degree to which high flows can be dispersed laterally. Erosion on the right bank compromised the root structure of a mature Douglas fir tree, causing it to fall across the creek and onto private property (Photo 8). To reduce potential of further erosion to the site caused by debris collecting on the channel-spanning log, a portion of the tree was cut and moved to the left bank while the rootwad remains on the right bank.

Photo 8: Tideman Johnson Restoration Project. Bank scour around root zone resulted in Doug fir falling across Johnson Creek.

Challenges and Lessons Learned

Channel spanning log jams have the potential to collect debris that can restrict or redirect channel flows. Beaver often utilize these log jams and build large dams compounding the impacts. The dams cause increased resistance to stream flow, diverting flow around the structures, causing bank erosion and potential for channel migration. Maintenance has been required to remove excess debris and reduce the size of the logs in the ELJ.

In steep reaches of Johnson Creek, the likelihood for erosion increases, and these transport reaches should be monitored more robustly than areas that tend to backwater.

When large pools form behind the dams, pool depths are too great to gain access for cross-sectional surveys, resulting in data gaps in low flow monitoring data.

Errol Creek Confluence Restoration Project

Project Overview

BES completed construction on the 1.4-acre Errol Creek Confluence Project in October of 2009. Errol Creek is spring fed and a valuable cold-water source to Johnson Creek. The creek runs on average, three degrees cooler than Johnson Creek during low-flow summer months. In the course of development in the area, the creek was straightened and rock-lined, inundated with invasive species, and contained two fish passage barriers (Photo 9a). The project increased instream complexity, habitat for fish and wildlife, and created wetland benches to mitigate flooding near the confluence of Johnson Creek.

To improve opportunities for fish passage between Johnson Creek and Errol Creek, the project removed fish barriers and day-lighted the section of Errol Creek that previously ran under SE 44th Ave. (Photo 9b). The confluence of Johnson Creek and Errol Creek was moved 50 feet south. The original mouth of Errol Creek remains intact and acts as a backwater channel to provide high flow refuge and flood water storage from Johnson Creek.

Photo 9a: Errol Creek runs under SE 44th. The culvert is a barrier to fish passage.

The project increased instream complexity by creating approximately 300 feet of new tributary habitat. The surrounding riparian and floodplain habitat were enhanced by creating wetland benches, and placing large wood along the banks and in the floodplain. The project creates high-quality rearing habitat, summertime cold water refuge, and winter off-channel habitat for federally-listed threatened juvenile Chinook and coho salmon, and steelhead trout as well as state-listed cutthroat trout (Photo 9c). The site was planted with over 920 trees, 1,800 shrubs, 2,500 wetland plants, and 41 pounds of grass and

Photo 9b: Errol Creek post-construction. Vacating SE 44th Ave allowed Errol Creek to be daylighted and fish passage to be restored.

wildflower seed.

Design Criteria

The design criteria for the Errol Creek Confluence project included:

1. Create summertime cool water and winter off-channel refuge
2. Create salmonid rearing habitat
3. Remove bank armoring and reconnect the floodplain
4. Provide storage for Johnson Creek floodwater
5. Create and enhance wetland habitat
6. Allow gradual lateral migration while preventing channel avulsion
7. Improving wetland, and riparian plant communities, to improve habitat, prevent erosion and reduce water temperature

Photo 9c: Errol Creek Confluence Restoration project shortly after project completion from SE Harney Rd.

Monitoring Parameters and Results

Habitat Monitoring

Habitat Availability

Prior to construction, the stream consisted of a series of manipulated step pools within a confined and straightened channel. Post-project habitat is composed primarily of riffle habitat with two isolated ponds, which become connected during high-flow events. Two years of post-project habitat monitoring suggest this riffle habitat and ponds remains intact.

The larger, uppermost pond has the potential to support pond-breading amphibian populations. Egg masses have not yet been observed during monitoring. This may be due to limited amounts of aquatic vegetation within the pond or surrounding habitat fragmentation. Establishing plantings in the pond and riparian area may improve the habitat function of the pond. High nutrient concentrations were a suspected cause of the lack of amphibian populations. These suspicions were alleviated after water quality sampling revealed normal levels of nitrogen and phosphorous. Pond-breeding amphibian egg-mass monitoring will inform the viability of this area for amphibian use as aquatic vegetation establishes.

High-flow refuge

Most of the habitat benefits of this project occur during high flow events when Johnson Creek backwaters into Errol Creek providing flood storage and high-flow refuge.

Annual high-flow monitoring revealed the channel provides valuable refuge as designed. As Johnson Creek approaches 690 cfs at the USGS Sycamore gage it backwaters into Errol Creek and its floodplain (Photo 10).

Photo 10: Johnson Creek backwaters into Errol Creek during high-flow event providing high-flow fish refuge.

Hydraulic Monitoring

Flood storage

Flood storage monitoring was conducted during and after the January 2009 flood. Aerial photos and flood debris lines showed evidence that not only did Johnson Creek backwater into Errol but floodwater entered the Errol Creek floodplain by way of overland flow from upstream Johnson Creek (Photo 11).

Photo 11: Aerial of January 2009 flood. Johnson Creek accesses flood storage at Errol Confluence via backwater and overland flow.

Cross-sectional Survey

Two years of cross-sectional surveys suggest that the Errol Creek and its floodplain remain stable.

Pebble Counts

Pre-project pebble count data showed the substrate primarily consisting of fine sediment. Pebble count data collected shortly after project construction shows a significant increase in the amount of gravel/cobble composition (28% pre-project to 79% post-project). 2010 pebble count data showed evidence of fine material moving into the project in some areas, though the cumulative particle size distribution remains constant. This suggests that fines are deposited and removed from the system during different flow regimes.

Water Quality

Canopy Cover

Pre-project monitoring, conducted in 2007, showed a 44% canopy cover. Construction activities required removing several of the mature trees within the project area decreasing the canopy cover by 40%. 2010 data showed a 10% increase in cover from 2009. It is anticipated that it within the first five years of project monitoring the canopy cover will surpass pre-project cover of the small creek, which does not require tall vegetation to provide cover from direct solar heat.

Bank Cover

Bank cover monitoring began immediately after project completion and prior to vegetation planting. At that time, 95% of the banks had no cover. Continued monitoring shows the banks are nearly 100% covered with overhanging vegetation, aquatic vegetation, or large wood with very little area having no cover. Bank cover will continue to be monitored annually.

Challenges and Lessons Learned

Since Errol Creek is a small, low gradient creek with consistent flow, there is little risk of erosion. It may not be necessary to conduct cross-sectional surveys annually. We will consider doing cross-sections and habitat unit monitoring bi-annually or after significant storm events.

Aquatic vegetation makes it difficult to conduct pebble counts in various sections of the stream. The vegetation may also provide roughness, forcing sediments to settle out and prevent it from washing out during higher flows. We may need to consider adaptive management measures to remove instream vegetation at key locations to allow monitoring access and reduce instream roughness.

Errol Heights Wetlands Restoration Project

Project Overview

BES completed the Errol Heights Wetlands restoration project in 2007. This small, rare group of wetlands encompasses about 2.5 acres that feed Errol Creek. Errol Heights Wetlands was designated a high priority restoration area because of its abundant cool water springs and location as headwaters of a tributary near spawning habitat in Johnson Creek. Errol Creek is ideal rearing habitat, summertime cold-water refugia, and winter off channel habitat for anadromous fish.

Photo 12a: Prior to restoration, private drive over stream creates fish passage barrier at Errol Heights Wetlands.

Four fish passage barriers along Errol Creek prevent anadromous fish passage into the wetland restoration area. This project removed the barrier furthest upstream, created by a private road off SE Harney Drive. The culvert was almost entirely submerged and was considered a complete barrier to juveniles and adult fish. The project removed drain tiles and 744 cubic yards of fill material on .63 acres of the site to restore 839 sq ft of wetland pond/emergent habitat and 6,276 sq ft of wetland scrub-shrub habitat. The project also restored 7,053 sq ft of riparian hardwood habitat, and 11,699 sq ft of mixed conifer/hardwood upland habitat (see before and after Photos 12a and b). Over 400 trees, 700 shrubs, 1,000 live cuttings and 25 pounds of grass and wildflower seeds were planted throughout the project.

Photo 12b: Errol Wetlands post-construction, culvert is removed and multiple ponds are created in the wetland.

Design Criteria

The design criteria for the Errol Heights Wetland project included:

1. Remove a fish passage barrier
2. Create summertime cool water and winter off-channel refuge
3. Create salmonid rearing habitat
4. Restore and enhance wetland habitat
5. Create and enhance amphibian breeding and upland habitat
6. Improving wetland, and riparian plant communities, to improve habitat, prevent erosion and reduce water temperature

Monitoring Parameters and Results

Photo Monitoring

Post-project monitoring has primarily been conducted with photo documentation and visual observation. Pre and post-project monitoring suggests that vegetation is establishing, providing shade and bank stabilization.

Some photo points were removed in late 2011 since vegetation has become dense and photo locations are no longer accessible. Other photo points were added to better monitor changes to stream channel and ponds. Photo 13a was taken just after project completion in September 2007, prior to re-vegetation. Photo 13b is in the same location taken in Summer 2011. Vegetation is well established and blocks the view of the constructed ponds.

Photo 13a: Errol Wetlands in 2007, post construction, prior to revegetation. Ponds are clearly visible.

Photo 13b: Errol Wetlands in 2011, vegetation is established and blocks view of constructed ponds.

Visual Inspection

Multiple site visits during amphibian breeding periods discovered no egg-masses in the constructed ponds or the upstream wetlands despite observing several adult tree frogs within the project area. Water quality tests revealed high levels of phosphorous, which may be the reason amphibians are not utilizing the site for breeding.

Challenges and Lessons Learned

Changes to the bank and bed-form downstream of the restoration area have been noted and will continue to be monitored to determine if stabilization actions are necessary. Old drain tiles continue to drain area wetland. One of the pipes running under the stream broke open causing much of the stream to flow subsurface into the pipe. The pipe is slowly filling with gravels, cobbles, and fine sediment forcing the flow back into the stream channel. Some erosion has resulted from the changes in flow. Photo points were added to continue to monitor these changes. Future restoration efforts may address the issues with remaining drain tiles.

New photo points were added closer to the constructed pond and within the stream channel to better monitor changes to these features and to lessen the problem of mature, dense vegetation blocking these views. Other photos points that are completely obstructed by vegetation have been eliminated. Photo points were established within the stream channel to improve monitoring of constructed features as vegetation matures.

Brookside Wetland Restoration Project

Project Overview

The Brookside Wetland Restoration Project, completed in 1997, was Environmental Services' first major flood mitigation project. The project covers 18.6 acres and includes an overflow pond for flood storage, swales for stormwater management and public open space (Photos 14a and b).

Photo 14a: Brookside wetland four years after project completion.

Construction included removal of 90,000 cubic yards of fill to create over 35 acre-feet of flood storage. Large wood was placed instream and on the floodplain to improve bank stability and habitat. Swales on the southeast of the project receive stormwater from the housing development to the south. Previously, this runoff drained directly to Johnson Creek.

Photo 14b: Brookside Wetland ten years after project completion.

After construction, BES planted about 30,000 native woody plants, more than 10,000 native wetland plugs, and 100 pounds of native grass seed, which enhance habitat for native wildlife.

Design Criteria

The project consisted of three specific design criteria:

1. Increase flood storage
2. Improve water quality
    a. Stabilize eroding banks
    b. Create stormwater swale to treat runoff from adjacent properties
3. Improve fish and Wildlife habitat

Monitoring Parameters and Results

Phase I monitoring began after project completion and was concluded in 2002. The project was initially monitored primarily to comply with permit and grant agreements. At the time this project was constructed, few examples of project performance monitoring methods existed. Monitoring protocol typically consisted of photo documentation, vegetation monitoring and visual inspections. A report submitted by Environmental Services to the Department of State Lands in 2002, states that the project was performing well, banks were stabilizing, vegetation was establishing, and stormwater swales appeared to be functioning as designed.

Currently the project is in Phase II and Phase III monitoring. Phase II monitors the vegetation planted at project construction. Trees planted at that time are well established, but typically are not mature enough to fall and provide instream large wood. Several mature trees preserved during construction have fallen into the stream and provide instream habitat. Phase III monitoring assesses the impacts of large wood jams. Since 2006, two large deciduous trees have fallen into the creek within the project area. A large amount of woody debris and trash accumulated behind the fallen trees. These debris jams diverted flows sufficient to significantly scour to the stream banks.

In addition to the bank scour directly associated with the fallen trees, bank scour was observed 80 feet downstream of the debris jam. This scour appears to be a head-cut created by high flows overtopping a saddle-shaped depression between the pond and a downstream section of the creek (see Photo 15). This saddle shaped high-flow bypass feature mimics a meander scar and was designed as part of the Brookside Wetland Restoration Project.

Photo 15: Brookside Wetland, large wood recruitment and scour locations.

Johnson Creek lacks channel features like well-defined riffles and pools, and channel complexity created by woody debris. This lack of complexity is largely due to the WPA stream channelization work of the 1930's followed by decades of removing large wood from the creek as a perceived measure of flood prevention. The JCRP calls for leaving log jams in place and allowing the channel to naturally migrate, increasing channel complexity where it can be done without causing harm to private property.

Hydraulic Monitoring

Flood storage

To monitor the success of floodplain restoration, the project must experience high flow or flood events. The Brookside Project has experienced multiple 9-month events, but no flood events occurred during the first five years after project completion (Figure 9). The site experienced its first flood event in 2003 and two more events in 2007 and 2009. Flood storage monitoring was conducted during each event. Flood investigation teams mapped flood extents and aerial photographs were taken when feasible.

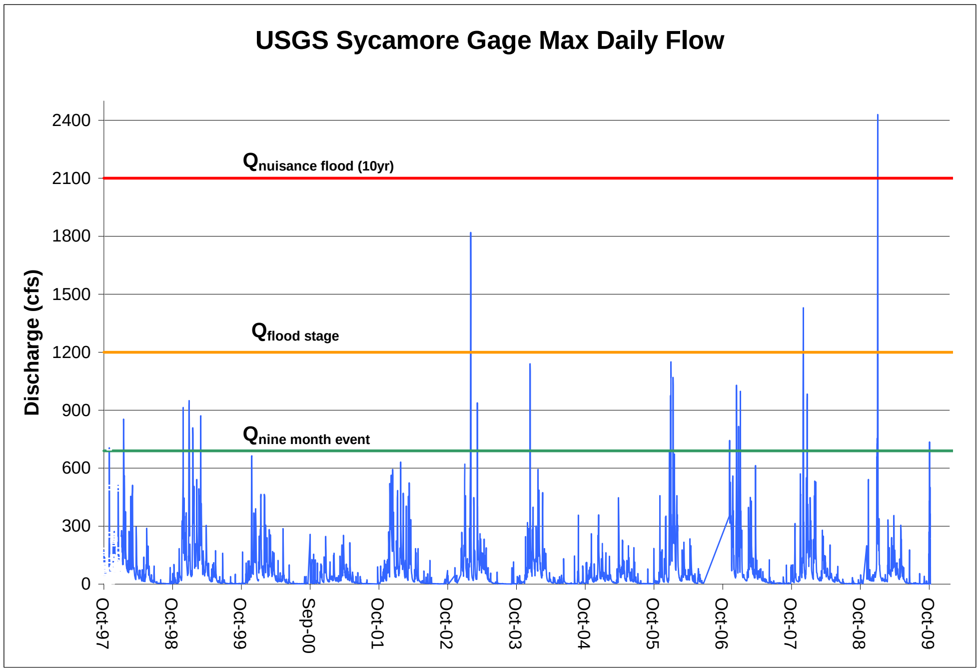

Figure 9: Hydrograph shows occurrence of high flow events at the Brookside Wetland since project completion through October 2009. It has experienced multiple 9-month events or larger and three flood events.

In January 2009, the site experienced a 29-year event. Aerial photos were taken during the peak of the event to show the extent of flooding (Photo 16). The photo shows that floodwater inundated the site. SE Foster Rd, adjacent streets, and private property experienced significant flooding.

Photo 16: Brookside Wetland during the peak of the January 2009 flood which filled the project to capacity.

Challenges and Lessons Learned

Brookside Wetland was a pilot project that served as a valuable reference for work that followed. As an early proto-type, the project design was one of the first in the area to re-grade stream banks and imbed large wood for habitat and hydrology benefits. The design focused on specific sections of the channel and the pond, and created moderate flood storage to the north of the creek. In the 10+ years since Brookside was constructed, funding, design, and construction goals support a higher level of service then was feasible with a pilot project.

WPA armoring was left in place through much of the reach and limited amounts of large wood were incorporated into the project. The large pond was originally an off-line stormwater detention facility and was incorporated into the project as an 'in-line' feature. The instream pond increases residence time allowing direct solar heat gain to increase stream temperatures during low flow conditions.

Visual inspections and photo documentation discovered sediment bars forming within the pond. Vegetation has been planted in these bars to encourage more sedimentation with the expectation of cutting off the pond from the stream channel during summer low-flow (Photo 17). The vegetation will also shade the stream and pond, reducing solar heat gain and enhancing amphibian and turtle habitat.

Photo 17: Sediment bars forming in Brookside embayment pond, 2008 aerial.

Kelley Creek Confluence Restoration Project

Project Overview

Environmental Services completed construction of the Kelly Creek Confluence project in Summer 2004. The six-acre project, at the confluence of Kelley and Johnson creeks, restored natural floodplain functions, increased flood storage, and improved water quality and habitat conditions (Photo 18a and b).

Photo 18a: Kelley Creek Confluence pre-project, 2003 aerial.

Construction crews removed about 24,000 cubic yards of soil to create more than 13 acre-feet of flood storage. The new channel meanders provide an additional 205 feet of cold water spawning and rearing habitat for steelhead, cutthroat trout and coho salmon. Two backwater channels were created on the mainstem of Johnson Creek and one was added to the new Kelley Creek channel to provide wetland habitat, high flow refuge for fish, and floodwater storage.

Photo 18b: Kelley Creek Confluence post-project, 2009 aerial.

Design Criteria

The Kelley Creek Confluence project design criteria included:

1. Reconnect the floodplain and increase flood storage capacity
2. Create high flow refuge habitat
3. Create salmonid spawning and rearing habitat
4. Prevent channel incision and headcutting to protect channel grade and upstream bridge foundation
5. Improve native plant communities to prevent erosion and reduce water temperature by shading the Creek

Monitoring Parameters and Results

Habitat Monitoring

BES staff completed the first five years of project effectiveness monitoring at the Kelley Creek Confluence project in 2010. Analysis of the 2006 - 2010 data suggests the project is performing well for all parameters and is providing the key benefits of the project design, as described below:

Habitat Availability

The project was designed to have residual pool depth of 0.5 meters or greater and 40% or greater percent wetted area at a flow of 0.5 cfs. Kelley Creek flow is monitored and posted by the USGS; real time data can be found at http://or.water.usgs.gov/johnsoncreek/.

In 2006 and 2007, low-flow monitoring was conducted at .28cfs and .18csf respectively. Residual pool depth and percent wetted area measurements taken for these events were lower than the design targets. This was likely due to the timing of the monitoring (July and August vs. June target flows). In 2008, habitat monitoring was conducted near the recommended base flow; all parameters exceeded design criteria, including pool depths and percent wetted area.

In 2008, beaver built three dams within the project site and one downstream on the mainstem of Johnson Creek. These dams created deep pools. Because beaver dams temporarily altered habitat units, monitoring protocol was modified to collect data on the dams. The dams were measured for height, width and length. Stream temperatures were taken in various locations within each pool to detect any changes caused by the dams. No significant temperature variations were detected.

In January 2009, flood water washed away the large uppermost dam. Beaver continue to rebuild dams throughout the project area. These dams are monitored to determine their affect on localized flooding and fish habitat.

High-flow refuge

High flow refuge monitoring is conducted during the project's channel design event, or an event that begins to overtop the stream bank, which is calculated to be approximately 690 cfs at the Johnson Creek USGS Sycamore gage or at 210 cfs at the USGS Kelley Creek gage. From Fall 2004 to Fall 2010, the Kelley Creek Confluence project experienced over a dozen channel design events or larger, and two flood events (Figure 10).

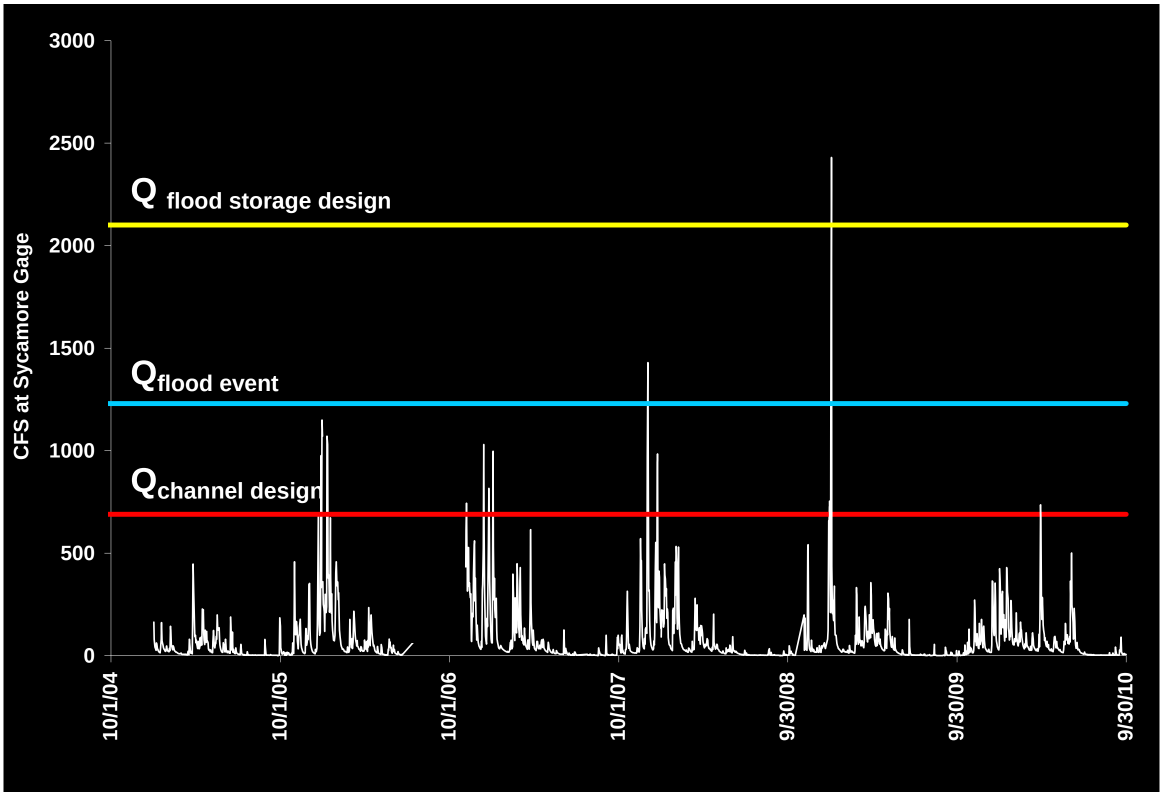

Figure 10: Hydrograph shows daily maximum stream-flow data since the completion of the Kelley Creek confluence project in 2004 to September 2010. Real time data is from USGS Sycamore gage located on Johnson Creek, downstream of project site. Floodwater accesses the floodplain at channel design flows (Q ≈ 690 cfs). Johnson Creek overbanks at Q≈ 1,230 cfs and the Kelley Creek project was designed to store up to the 10-yr event (Q ≈ 2,100 cfs).

High-flow refuge habitat monitoring is performed using visual observation and photo documentation**.** Below are multiple photos of various flow conditions at Kelley Creek. For comparison purposes, Photo 19a shows conditions during low-flow. Stream flow is contained within the channel with a clear view of the floodplain. Photo 19b, at a slightly different angle and focal length, was taken in 2006 during a high-flow event that did not exceed the Johnson Creek banks. Photo 19c was taken in December 2007 during a two-to-three-year flood event and shows new vegetation beginning to obstruct the view of the floodplain.

Photo 19a: Kelley Creek Confluence - May 2006, low-flow conditions.

Photo 19b: Kelley Creek Confluence - January 2006, Johnson Creek was at bankfull.

Photo 19c: Kelley Creek Confluence - December 2007, 2 to 3-year flood event for Johnson Creek.

Hydraulic monitoring

Flood Storage

The Kelley Creek Confluence project is designed to provide flood storage for a flood event with a 10-year recurrence interval or 2,100 cfs (Figure 10). Flood storage monitoring is conducted during any over bank event. Photo 20 was taken during the peak of the January 2, 2009 flood, estimated to be a 29-year event. During each high-flow event, Johnson Creek backwatered into Kelley Creek and floodplain areas inundated, providing flood storage and off channel, low-velocity refuge for salmonids.

Photo 20: Kelley Creek Confluence - January 2009, 29-year flood.

Cross-sectional Survey

Cross-sectional surveys, conducted from 2005 through 2010, show the stream channel has undergone minimal changes since project completion. A silt bar formed at the mouth, a result of Johnson Creek backwatering into Kelley Creek during high-flow events (Figure 11). Cross-sectional surveys were not conducted in 2008 or 2009 because station markers could not be located. Multiple high flow events displaced or buried several wooden markers. A majority of the stations were relocated in 2010 and marked with rebar and aluminum caps. These markers can now be readily located using a metal detector.

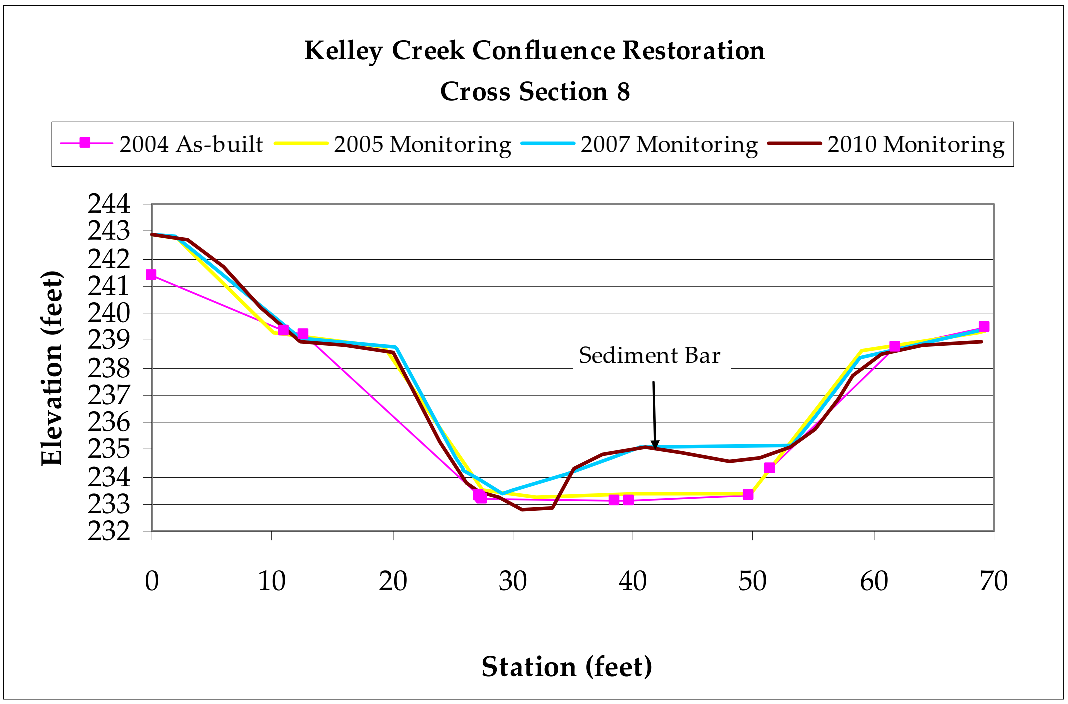

Figure 11: Cross-sectional data for Kelley Creek Confluence, survey is conducted closest to the confluence of Kelley and Johnson Creeks. A sediment bar has formed on the right bank as shown in the graph.

Pebble Counts

Pebble count data suggest some change in substrate composition throughout the site (Figure 12). The most significant change occurred at the lowermost riffle (Riffle 4). This riffle is at the confluence with Johnson Creek. Beaver dams, downstream on the mainstem of Johnson Creek, slow stream flows allowing sediment to drop out into the riffles. The dams will continue to be monitored to determine their effects on salmonid habitat.

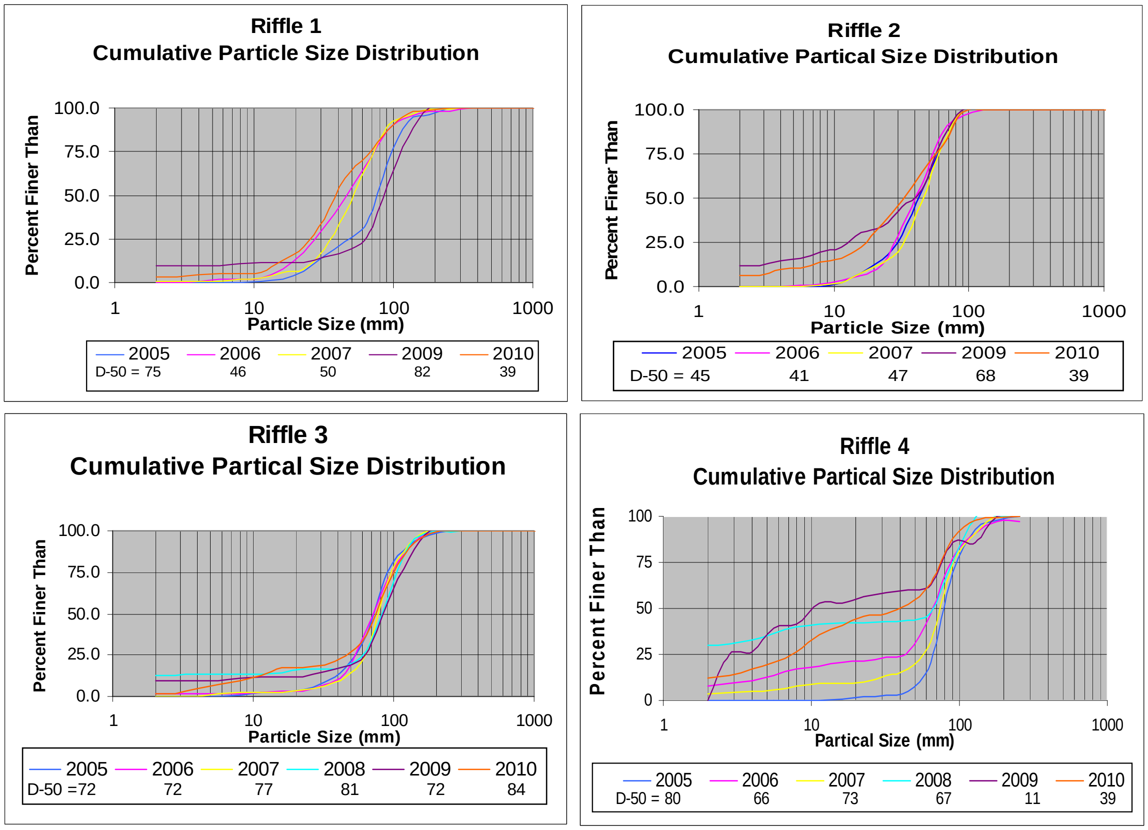

Figure 12: Cumulative particle size distribution for all four riffles at the Kelley Creek Confluence Project. Riffle one starts at the top of the project near the 159th street bridge and riffle four is located just upstream of the confluence with Johnson Creek.

Water Quality

Canopy cover

Since project completion, the canopy cover at Kelley Creek Confluence has grown considerably. Several hundred alder naturally recruited in the site, creating dense cover that grows quickly. The canopy has changed from primarily open after project construction to 37% cover in 2010.

Challenges and Lessons Learned

Kelley Creek Confluence was the first Johnson Creek Restoration Project to be extensively monitored. Funds from an Oregon Watershed Enhancement Board monitoring grant made the effort possible. Protocols for monitoring this project were developed based on project specific design criteria and technical memorandums from the project engineer.

The monitoring plan went through several iterations to develop the plan in place today. Initially, habitat measurements were divided into 10-meter reaches often splitting habitat units. ODFW protocols were employed to remedy this.

Environmental Services initially hired outside agencies to conduct the cross-sectional surveys. Overtime, BES staff developed expertise and obtained the necessary equipment to conduct surveys. Wooden survey stakes were initially used to mark cross-section locations. These stakes washed away, became buried or otherwise lost. Environmental Services staff replaced wooded stakes with rebar and aluminum caps, which can be readily located using a metal detector.

The monitoring methods developed for this project serve as a foundation for subsequent projects and emphasized the need to develop monitoring plans during project design that are tied directly to project design criteria.

Schweitzer Natural Area Restoration Project

Project Overview

BES completed the Schweitzer Restoration Project in 2007. This 35-acre floodplain restoration project reduces localized flooding, improves water quality, and increases habitat for fish listed as threatened under the Endangered Species Act (ESA). The project created a new meandering creek channel and diverted the creek from a rock-lined, trapezoidal channel built by the WPA in the 1930's (Photo 21a).

Photo 21a: Pre-project aerial of the Schweitzer Natural Area. Johnson Creek runs along the east side of the site along the tree line.

The project added about 74 acre-feet of flood storage and added backwater high-flow refuge by removing approximately 138,000 cubic yards of soil. To enhance salmonid spawning, rearing, and refuge habitat, several tons of gravel and cobble were imported in the re-meandered channel and about 500 pieces of large wood were installed within the channel and surrounding floodplain. The site was planted with over 15,000 trees, 25,000 shrubs, 7,900 wetland plants, and 890 pounds of grass and wildflower seed were planted to establish riparian, wetland, and upland vegetation (Photo 21b).

Photo 21b: The Schweitzer Natural Area. Johnson Creek now meanders through the site mimicking a more natural system. Backwater channels provide high-flow refuge.

Design Criteria

The project design criteria for the Schweitzer Restoration Project included:

1. Reconnect the floodplain and increase flood storage capacity
2. Create high flow refuge habitat
3. Create salmonid rearing habitat
4. Create and enhance wetland habitat
5. Allow gradual lateral migration while preventing channel avulsion

6. Improving upland, wetland, and riparian plant communities, which provide habitat, prevent erosion and reduce water temperature

Monitoring Parameters and Results

Habitat Monitoring

Habitat Availability

The first year of habitat monitoring was conducted in Summer 2009. The project was designed to have a sequence of seven pools and six riffles. Beaver dams within and just downstream of the project have caused pooling within majority of the channel.

Off-channel habitat was monitored during low flow. Beaver dams have caused several of the backwater channels to remain inundated. Six of the eight backwater channels remained connected to the main channel. The old, abandoned stream channel now acts as a backwater channel, which was inundated 254 meters upstream with an average wetted width of 7.2 meters. The beaver dams created approximately 3,500 square meters of wetted habitat. Large numbers of small fish (primarily red-sided shiners) have been observed in these connected backwater channels.

In 2010, staff conducted amphibian egg-mass monitoring in the backwater channels. Multiple egg-masses were observed in three of the four backwater channels on the north side of the stream, including Red-legged frog, Long-toed salamander and Northwester salamander. Egg masses were not found in the south backwater channels.

High-flow Refuge

High-flow refuge monitoring is conducted annually. During high-flow events, backwater channels become inundated, reduced flows provide refuge and allow sediment to fall out and deposit at the mouth of the backwater channels. All backwater channels remain intact. Further monitoring will be required to ensure sediment deposits do not disconnect the backwaters from the mainstem and cause fish stranding as high waters recede.

Hydraulic Monitoring

Flood Storage

One staff gage and two crest gages were installed in a backwater channel to monitor high-flow events to determine flood storage at each event higher then 690cfs at the USGS sycamore gage. In December 2008, with the USGS Sycamore gage at 754 cfs, the floodwater at the crest gage read 3.35 ft. According to the flood stage-storage curve, created by project design engineers, this site provided approximately 50-acre ft of flood storage during this event (Figure 13). The site provided approximately 140-acre feet of flood storage during the January 2009 event. This event was calculated to have approximately a 29-year rate of return (Photo 22).

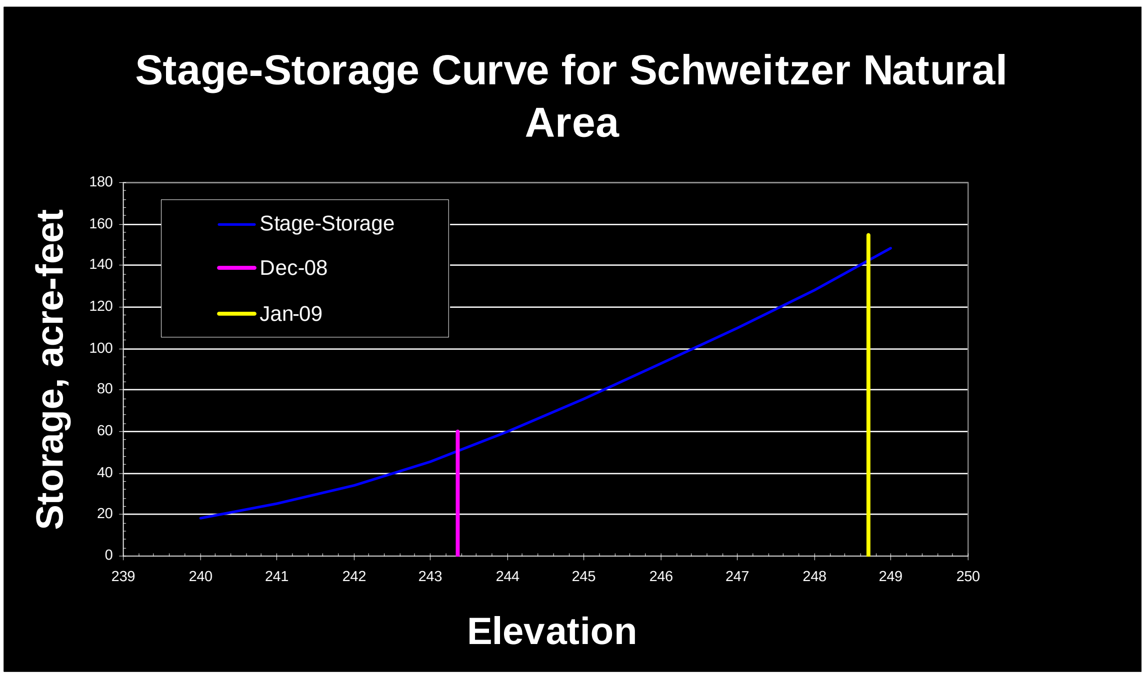

Figure 13: Flood Storage curve created for the Schweitzer Natural Area shows flood storage in acre-feet for two different high-flow events.

Photo 22: Aerial photo of the Schweitzer Natural Area during the January 2009 – 29-yr flood.

Cross-Sectional Surveys

Cross-sectional surveys have been conducted annually since the project was completed in 2007 (Photo 23). Cross-sectional data shows little change within the stream channel. Some sediment deposition occurred on portions of the banks in the middle of the project area. In 2008, scouring was noted beyond the top of bank on the south side of the channel at cross-section 5. This scour is occurring around the large wood structures on the floodplain. The cross-sectional survey area was extended to include this portion of the floodplain to monitor any increase in scour. Cross-sectional data shows scour is slowly increasing. Further monitoring is necessary to determine if adaptive management measures are required (Figure 14).

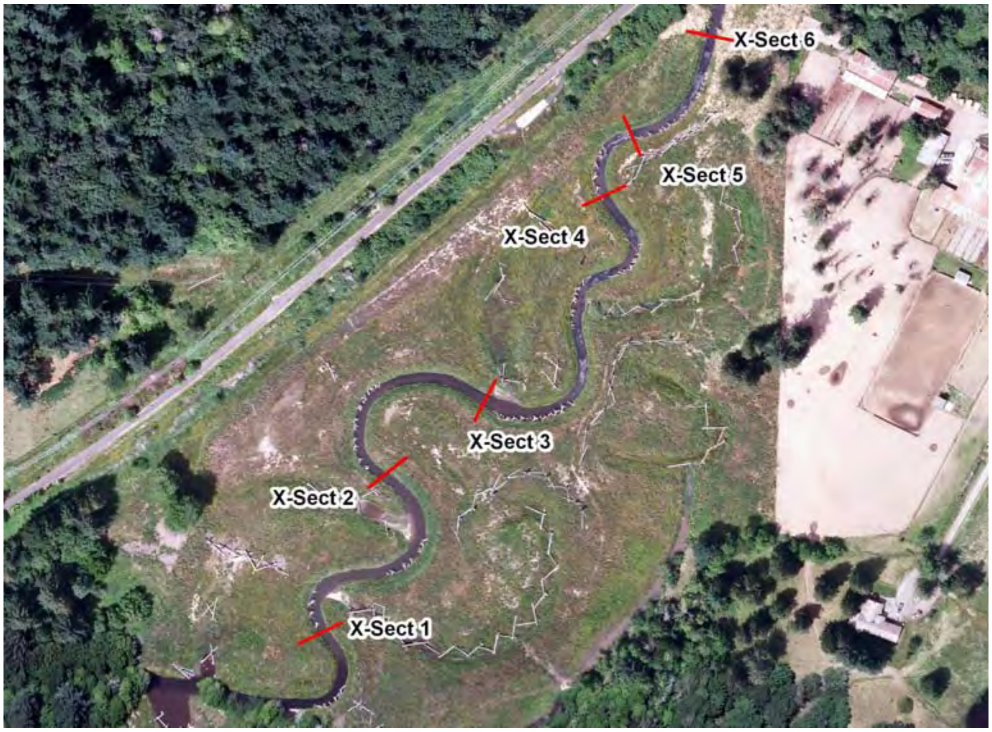

Photo 23: Location of cross-sectional surveys as Schweitzer Natural Area.

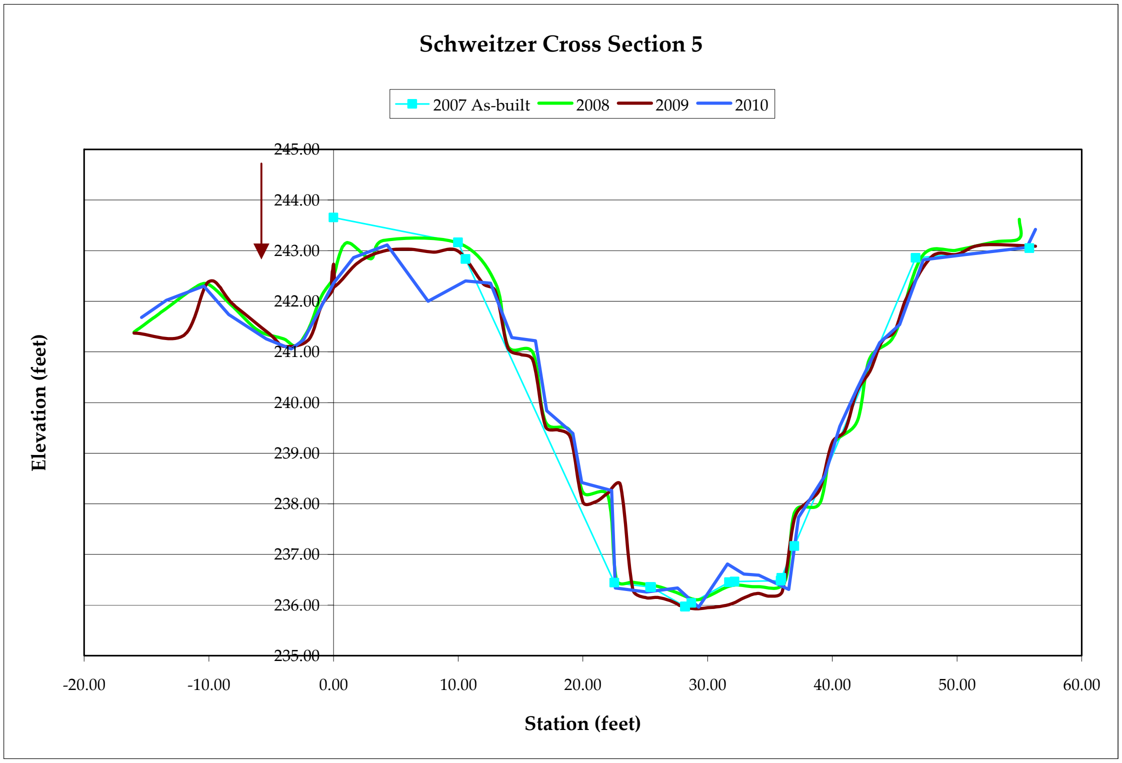

Figure 14: Schweitzer Natural Area cross-sectional survey data for Section 5, shows scour occurring around large wood structure on the left bank floodplain (red arrow).

Pebble Counts
The beaver dams constructed within and downstream of the site have created pools too deep to at times to conduct pebble counts at several locations. Annual high-flow events typically wash away beaver dams, which are usually rebuilt by spring. The pebble counts that have been conducted suggest that, while the riffles are frequently inundated, they remain intact, and are performing as designed.

Water Quality
Canopy cover
As part of this project, the stream channel was relocated to meander through an existing open meadow with limited canopy cover. Revegetation began in Spring 2008. The 2010 canopy data shows the channel remains mostly open with 2.25% cover. It will take several years for the vegetation to mature enough to provide the necessary cover to reduce solar heat gain to the stream.

Bank cover
During construction, willow and ninebark were placed between the soil lifts along the banks. This allowed vegetation to establish readily. The 2009 bank cover data showed that less than 10% of the banks had no cover.

Challenges and Lessons Learned

Numerous beaver dams constructed downstream of and within the site, change instream habitat from a pool/riffle sequence to a series of dammed pools. The dammed pools make it impossible to measure the lengths of the constructed pools and riffles. Deep pools also inhibit large wood counts by means of visual observation. Cross-sectional surveys and visual assessment of stream banks suggest the stream channel and large wood remains intact as designed. If the beaver dams wash away, it is likely the pool and riffle habitat would return.

The Schweitzer Restoration Project has experienced two flood events since project completion. The first, approximately a 6-year event in 2007, just after construction completion, caused a scour hole in the floodplain at the uppermost extent of the project area. The second in 2009, of much greater magnitude (29-yr), caused further scouring (Photo 24a). It was determined that repair was necessary. Repairs were completed in Summer 2009. Large wood was incorporated into the repair to slow flows and reduce the likelihood of recurring scour (Photo 24b).

Photo 24a: Schweitzer Natural Area. Scour hole began to form at the upstream extent of project.

Photo 24b: Schweitzer Natural Area. Scour hole repair.

There is potential for erosion around large wood placed on the floodplain. This is especially true at the upstream extent of the site where floodwater has a higher velocity entering the floodplain before dissipating its energy.

Summary

Overall Project Performance

In general, JCRP projects are meeting the goals laid out in the Plan and are performing as expected, with the exception of erosion issues at isolated locations. Adaptive management was required to repair erosion as the Schweitzer and Tideman Johnson Natural Area. Further monitoring will determine if additional repairs are required at Tideman Johnson Park.

Habitat performance

Habitat availability has significantly improved at each of our restoration sites. The projects restored over 6,000 linear feet of stream and added over 585 linear feet of channel length to Johnson Creek and it tributaries. Nearly 1000 pieces of large wood have been added instream or within the floodplain. Sixteen backwater or high-flow refuge channels have been added and four fish passage barriers have been removed (see Table 1). Habitat units are performing as designed with some temporary changes to habitat types due to beaver damming. Beaver dams transform pool-riffle habitat to dammed pool habitat. Annual high water events typically wash away all or part of these dams allowing the habitat to function as designed.

Hydraulic performance

The projects remain largely intact and functioning in accordance with original designs. No evidence of headcutting has been identified within the stream channel at any of the project sites. Areas of bank failure and scour in the floodplain have been identified and addressed as needed. Some of these areas have been repaired, such as the scour hole at Schweitzer and the ELJ at Tideman Johnson. Other areas require further monitoring to determine if adaptive management measures are required, and continued monitoring will identify new areas of unexpected erosion or aggradation.

Water quality

Successful revegetation has taken place at each restoration site. Cumulatively, over 29,000 trees, 70,000 shrubs, 21,000 wetland plants and 1,200 pounds of grass and wildflower seed has been planted. Plants are at various levels of establishment, and are providing bank protection and stabilization. While canopy cover is limited at most sites, trees are establishing and will provide canopy cover to reduce solar heat gain over time.

Table 1: Johnson Creek Restoration Projects. Summary of individual and cumulative restoration project attributes.

Johnson Creek Restoration	Tideman Johnson	Errol Confluence	Errol Wetland	Brookside Wetland	Kelley Confluence	Schweitzer	Totals
Year Constructed	2006	2009	2007	1997	2004	2007	
Project Size (acres)	6	1.4	0.63	18.6	6	22	54.63
Flood Storage Added (acre-feet)	Not Quantified	Not Quantified	0	35	13.6	74	122.6
Stream Length Enhanced (linear ft)	1,800	386	62	2,350	537	1,680	6,815
Trees	1,847	920	492	10,000	2,323	14,269	29,851
Shrubs	5,090	1,840	1,720	20,000	7,175	34,260	70,085
Wetland Plugs	1,200	2,500	0	10,000	0	7,952	21,652
Seed (lbs)	37	41	25	100	162	897	1,262
Backwater Channels (#)	3	1	0	2	3	7	16
Large Wood Pieces	196	77	0	50	150	500	973

Overview of Challenges, Lessons Learned

Our understanding of monitoring needs and protocol has increased greatly in the 10+ years since we began the Johnson Creek Restoration Program. As a result of the work outlined in this report, we base monitoring plans on project design criteria and ideally, develop a monitoring plan as part of the design process. Project design engineers have the best sense of where a project is most vulnerable to failure and what elements are most critical for success. It is important that the monitoring methodology is cost-effective, repeatable, and can be implemented by bureau staff.

Natural processes such as large wood recruitment and beaver dams may require adapting the monitoring protocol to include these features to determine their effect on the project design.

Projects with steeper slope and higher velocities are more vulnerable to bank erosion, headcutting and incision. These areas should have a more rigorous monitoring plan. Areas that tend to backwater during high-flow events are typically at less risk of these failures and may only require monitoring after significant high-flow events. This holds especially true in streams that also have consistent flows such as Errol Creek, where less rigorous monitoring is needed. In the 6-month period directly after construction, projects are particularly vulnerable to erosion and some level of maintenance and repair can be expected.

Future Monitoring Recommendations

Current monitoring protocols focus primarily on hydrology, water quality, and salmonid habitat. To better evaluate the efficacy of restoration projects on other biological communities, benthic macroinvertebrate (BMI), amphibian, and wildlife monitoring should be added to the Phase I effectiveness monitoring protocol.

Macroinvertebrates are key biological indicators of stream health. Two methods are generally considered for BMI sampling. The first evaluates BMI populations in the field and returns live specimens to stream. This method requires BES staff be trained to properly identify BMI to the family level. The second method requires staff follow a simple sampling procedure. Samples would be sent to an outside lab to identify BMI to the genus level, providing a more detailed analysis. Funding is not currently available for detailed, external analysis.

Our restoration projects also typically provide high value terrestrial habitat. Pond breeding amphibians frequently utilize backwater channels to lay eggs. Limited monitoring at restoration sites revealed egg-masses of Northern Red-legged frog, Northern Pacific treefrog, Northwest Salamander, and Long-toed Salamander as well as American bullfrog tadpoles. Where appropriate, pond breeding and terrestrial breeding amphibian monitoring should be added to the protocol.

Each restoration site shows some evidence of wildlife activity such as beaver chew and slides, dear browsing, and scat. Staff frequently observe a variety of avian species during site visits such as kingfisher and pileated woodpecker at Schweitzer Restoration Project and bald eagles at Brookside Wetlands. Wildlife monitoring protocol should be developed to better document species presence. To implement this protocol, resources will need to be dedicated to train staff to identify species or evidence of species. Partnerships with organizations such as Audubon Society of Portland, Xerces Society, Portland State University, Johnson Creek Watershed Council and volunteers may also be resources.

As Phase I monitoring closes out on several restoration projects, protocol must be developed for Phase II monitoring. Phase II monitoring begins after the first five years of intense monitoring and continues through the first several decades as projects mature and wetland, upland, and riparian vegetation become established. In this phase, projects become more stable, but are not mature enough to recruit large wood into the stream.

Phase III monitoring protocol should be further developed for projects such as Brookside and Tideman Johnson, which left a majority of surrounding mature trees intact, some of which are being recruited in the stream as large wood. Resulting debris jams create valuable habitat and typically cause bank erosion. These issues should be carefully monitored for impacts to the project or neighboring properties.

To further meet the goals of the JCRP, BES continues to purchase and restore land within the high priority target and key habitat areas. As restoration projects are constructed, the effectiveness monitoring protocol will continue to be refined based on each project's specific design criteria. This data will allow us to learn from our challenges and successes, and will influence the design of future restoration projects.

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