West Tributary Habitat Assessment

Final Report

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Submitted to:

The City of Bellevue

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MEMO

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From:	Merri Martz, Sara Townsend, Greg Woloveke, Tetra Tech, Inc.
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Subject:	West Tributary Habitat Assessment Final Technical Report

1.0 INTRODUCTION

The City of Bellevue (City) is implementing its strategic initiative of stream assessment, as characterized in the approved *Storm and Surface Water System Plan* (City 2016). Baseline habitat conditions within the City's streams have not been assessed for many years. The baseline conditions are necessary to prioritize streams for restoration. The first step in this process is to develop a standardized protocol for rapid habitat assessment and mapping of other important features in the stream corridors.

This study has two primary purposes; (1) to create a protocol for rapid habitat assessment that the City may use to characterize each of their streams, and (2) use the protocol to collect baseline data for the West Tributary and report the existing habitat conditions.

The City contracted with Louis Berger Group and Tetra Tech, Inc. (subconsultant) to develop a standardized assessment protocol and data collection system that could be easily imported into the City's GIS database. The City specified that this system would be based upon the Washington Department of Fish and Wildlife's *Fish Passage and Surface Water Diversion Screening Assessment and Prioritization Manual* (WDFW 2009). The City also requested collection of data beyond that required by the WDFW protocol as part of the baseline assessment. Additional data collection was requested by the City to include potential water pollution concerns, low-flow conditions and potential fish passage barriers, presence and function of large wood, armoring and erosion sites, Wolman pebble counts, and identifying and prioritizing actions to restore stream health.

This protocol was implemented and tested on the West Tributary, a tributary to Kelsey Creek, in 2016. This final technical report summarizes the assessment protocol, data collection methods, results of its application to the West Tributary, recommendations for future stream assessments within the City, and identifies and prioritizes opportunities within the West Tributary system to improve habitat conditions and fish passage, and more effectively manage stormwater runoff and sediment movement.

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2.0 METHODS

The basis for the habitat assessment protocol is described in Chapter 9 of the *Fish Passage and Surface Water Diversion Screening Assessment and Prioritization Manual* (WDFW 2009). The WDFW protocol was developed to assist the state in identifying and prioritizing fish passage and screening needs for the conservation of native fish species. These needs are prioritized based on the amount, quality, and potential fish use of habitats upstream of fish passage barriers.

The field assessment was planned based on 10 pre-delineated stream reaches, from downstream to upstream (Streams Segments: 76_04, 80_01, 80_02, 80_03, 80_03-Trib, 80_04, 80_05, 80_06, 80_07, 80_08). The City delineated the West Tributary into geomorphic reaches in 2001 using methods developed by the Washington Department of Natural Resources (WDNR). Reach breaks were located at major road crossings, where there were clear geomorphic changes, where stream characteristics change sufficiently to affect the potential for fish use and productivity, or where there were human-caused fish passage barriers. During the field assessment, pre-delineated reach breaks were ground-truthed. Recommendations for revisions to reach breaks are provided in the results section below.

The WDFW protocol requires that, for streams longer than 1 mile, a 60-meter sampling segment be inventoried for every 320 meters of stream, as long as it is considered to be representative of that 320-meter length. The first 60 meters of each 320-meter length was assessed for this study, unless that 60 meter segment was not considered representative or was not accessible. Reaches and reach segments are shown in Figure 1. Where reaches were longer than 320 meters, additional 60-meter reach segments were evaluated. For example, reach 80_01 was a total of 1,430 meters, resulting in three sets of data (80_01-1, 80_01-2, and 80_01-3). Goff Creek is a tributary to the West Tributary, but was not assessed for this study.

2.1 WDFW PROTOCOL

Based on the WDFW protocol, several habitat conditions were inventoried within each reach segment (additional data collected based on the City's request is described in Section 2.2). Characteristics that were inventoried are described below. In some cases, slight modifications were made to the WDFW protocol and are noted below.

Habitat Units. Beginning at the downstream end of each 60-meter segment, each habitat unit was measured with a measuring tape. Under the WDFW protocol these habitat units could be classified as pools, riffles, ponds, or rapids. Glides are characterized as either pools or riffles depending on depth and are not distinguished separately under the WDFW protocol. For the purposes of this project, glides were included as distinct habitat units and defined as areas that were too deep to be considered riffles, had no surface turbulence, and were too fast moving to be pools. The habitat units identified for this study included:

- Pools – relatively deep, low velocity water and smooth water surface.
- Riffles – rapid and shallow water flow with surface turbulence.
- Rapids – high gradient riffles with larger substrate and white water.
- Ponds – zero gradient with average width at least five times that of the average pool width and length.
- Glides – relatively fast water, deeper than riffles, with smooth water surface.

Each habitat unit was measured for wetted width, scour line width and average water depth at a representative cross section.

Substrate Composition. The river bed substrate was visually estimated, resulting in an estimated percent of each substrate type, including boulder, cobble, gravel, and sand or fines. Potential spawning habitat was defined for this assessment as areas of coarse substrate (i.e. gravel and/or cobbles) that had less than 26% fines, as visually estimated.

Gradient. The slope of the stream was measured via clinometer or using a stadia rod. In areas where gradient could not be assessed due to overgrown vegetation, gradients were determined using topographic maps.

Temperature. Celsius temperature of each habitat unit within each 60-meter segment was measured via thermometer.

Spawning and Rearing Habitat Quality. The quality of spawning or rearing habitat was evaluated at each habitat unit. These were qualitatively defined with a score of 0 (none), 0.33 (poor), 0.67 (fair), or 1 (good).

Spring Influence. Water volume may vary depending on the influence of springs or groundwater. The likelihood of spring influence was determined based on differences between wetted width and scour line width and channel morphology. Spring influence was scored as 0 (absent), 1 (slight), 2 (moderate), 3 (pronounced).

Canopy Composition. Each habitat unit was visually estimated for total percent canopy cover, assuming fully leafed out canopy conditions.

Instream Cover. Each habitat unit was visually estimated for the presence of instream cover elements such as large wood, undercut banks, boulders, or close overhanging vegetation. These were qualitatively defined with a value of low, medium, or high.

Juvenile Fish. Under the WDFW protocol, juvenile fish observed are to be identified, if possible, and counted. For this study we identified and counted juvenile and adult fish.

Total Culvert Length. Piped sections, or portions of the stream that flowed through culverts, were field verified and included in GIS mapping. Total culvert lengths were estimated using City mapping and aerial photography. In addition, outfalls or other pipe crossings were mapped. All outfalls identified in the field were observed to determine if any illicit discharges were occurring in order to notify the City.

2.2 ADDITIONAL DATA COLLECTION

Beyond the WDFW protocol, the following parameters were assessed at the request of the City for all habitat units in each 60-meter reach segment:

Wolman Pebble Counts. Pebble counts provide data to describe embeddedness and substrate composition within potential spawning habitat and to support hydraulic modeling.

Riparian Species Cover. In addition to the WDFW protocol to identify the percent canopy cover, the City requested the identification of percent shrub and herbaceous cover, and the dominant species that comprised each layer.

Non-Native Species Cover. The total percent cover of non-native species was visually estimated for each habitat unit.

The City also identified parameters to assess for the entire length of the stream; these parameters were not limited to the 60 meter reach segments, but were described for the entire reach, where streams were accessible.

Large Wood. The abundance, size, location, habitat forming function, and potential for causing a flood risk were evaluated for each reach.

Fish Passage Barriers. Any feature that would potentially block upstream fish passage was noted, its location marked on a map, and described. A blockage was considered a barrier if it created a drop of greater than six inches.

Low Flow Conditions. Reaches of stream with depths of less than 12 inches were noted and locations described.

Two datasheets were created for this assessment to be used easily with either tablet-based or hardcopy field data collection (Appendix A). One data sheet was used for each 60-meter reach segment, and included all the relevant elements from the WDFW protocol, as well as those that were modified by the City. The other data sheet was used to collect the additional non-WDFW protocol data of interest to the City.

All features were mapped using the PDF Maps application on the tablet and also using a Trimble GeoXH GPS to compare the relative accuracy between the two methods. In addition, numerous georeferenced photos were taken for each reach to document key features and general conditions.

This assessment did not include a summer illicit discharge investigation, but all outfalls observed were documented and identified as to whether anything other than groundwater or irrigation water appeared to be flowing from the outfall.

2.3 DATA MANAGEMENT

Data was collected under this protocol using an iPad tablet and handheld Trimble GPS unit. The same data can be collected on any model of tablet that supports the use of PDF documents (such as PDF Expert) and geotagged mapping (such as PDF Maps). Data sheets were produced prior to field work using Nuance Power PDF, but could also be built using Adobe or any other fillable form application. Also prior to field work, the tablet was outfitted with PDF Maps, PDF Expert, and Dropbox applications.

During field data collection, the multiple utility of the tablet allows for data sheet completion, photo collection, and GPS placemarking all within the same tool. Our tablet was also be outfitted with a case that is water and impact resistant, helpful for work in streams and wetlands. Fillable PDF data sheets were opened on the tablet using PDF Expert, a fillable form management application. The fillable forms can be directly completed in the field. Once the forms are completed, they are automatically saved within the PDF Expert application. To create a new data sheet, a copy is created and then renamed. Any number of field data forms can be stored on the tablet, with a file organization system similar to most desktop computers.

Although we collected data with a handheld Trimble GPS unit, we also used the tablet to monitor our location. Using PDF Maps, we were able to upload georeferenced project maps to the tablet, which would monitor the team's position. This allowed the team to see where they were in relation to GIS maps of the project, complete with project features, utilities, roadways, and other features of note. It was also used to create a placemark at a location of interest while conducting field work. For example, outfalls and pedestrian bridges that were not previously mapped were marked on the GIS project maps with a single tap on the tablet screen. Although the tablet GPS system is not as accurate as a Trimble unit, we found that we were able to locate placemarks accurately when the project maps were available to assist in determining locations. For example, property lines, roads, utilities or other reference points were used to accurately locate placemarks.

Once field data was gathered for the day, the tablet was wirelessly synced to a Dropbox account. This allowed wireless transfer of all data sheets to server storage provided by Dropbox. If the tablet has a mobile data account, data sheets may also be uploaded while in the field. Similarly, photos and placemark files can be exported to Dropbox at any time.

Once data is uploaded, fillable PDF forms can be exported to Excel for ease of data management and analysis. We found that Adobe Pro DC provided an export utility that created the most accurate replica of the PDF data sheet in Excel.

The next steps were to create KMLs (Keyhole Markup Language) that could be imported into Google Earth or any other GIS system, which would display the location of the geotagged photos and placemarks collected in the field. Photos were uploaded onto Picasa (a Google application), which allows geotagged photos to be uploaded directly into Google Earth from a Picasa web album for initial viewing. The KMLs can be imported to GIS as points that can be clicked on when viewing the GIS maps.

Below are the links to the applications that were used for data collection.

Nuance PDF. Created fillable forms.

Adobe Pro DC. Exported completed data to Excel spreadsheets. Would be more seamless to create forms in Adobe Pro and export with same software package.

PDF Expert. Fillable form management system on tablet, provides autosave and ability to wirelessly upload to server storage.

PDF Maps. Application that allows user to follow their location within predesigned project maps and to create placemarks within those maps to mark features of interest. The accuracy is approximately 10-15 feet, which is less accurate than a Trimble or similar GPS unit (< 3 feet). However, Trimble satellite coverage was often compromised by heavy tree canopy, making many points difficult to collect.

Google Earth. This application allows KML files to be imported, showing geotagged photos and placemarks on top of Google Earth aerial photography for quick scanning.

Picasa. Connected to Google, this application allows uploaded geotagged photos to be imported directly into Google Earth.

Dropbox. Server or "cloud" storage site, where data sheets were wirelessly transferred after each field day.

3.0 HABITAT ASSESSMENT RESULTS

3.1 WATER TYPING

The City provided GIS mapping that included water typing, based on City data and fish sampling conducted in 2001 and reported in the *City of Bellevue Stream Typing Inventory* (City 2009). Reaches 76_04 through 80-04 were designated as Type F (fish bearing) based on known fish presence and use, Reaches 80_05 and 80_06 and the unnamed tributary (Reach 80_03_01) were designated as Type NP (perennial non-fish bearing), and Reaches 80_07 and 80_08 were designated as Type NS (seasonal non-fish bearing). These designation were reviewed to determine if changes should be made.

The WDFW protocol indicates that to determine fish use, several methods can be used to identify if the stream has the potential to provide fish habitat. Meeting one or more of the criteria (in italics) qualifies the stream as fish bearing or potential fish habitat:

- *Watercourses having scour line widths greater than 2 feet (0.6 meters) in western Washington, if the gradient is less than 20 percent.* The West Tributary and the unnamed tributary both meet this criterion for their entire length.
- *Streams identified as fish bearing by the Washington Department of Natural Resources (DNR) Water Typing Project (as shown on the Forest Practices Application Mapping Tool).* The West Tributary is mapped as Type F (fish bearing) for its entire length. The unnamed tributary is not mapped.
- *Watercourses with documented salmonid use determined by visual observation, electrofishing, or verification by local biologists.* Juvenile salmonids were observed in Reaches 76_04 up through 80_04 in this assessment and had been documented by electrofishing in 2001 (City 2009).
- *Watercourses listed as fish bearing on the SalmonScape website.* Chinook, coho, and sockeye salmon have all been documented in Reaches 76-04 up through 80_04 to the Goff Creek confluence and all species are modeled to be present for the entire length. The unnamed tributary is not mapped.

The DNR Water Type Classification Worksheets were completed for the West Tributary and the unnamed tributary and are included in Appendix A. Based on the above criteria and the water type classification worksheet, the West Tributary should be classified as a Type F (fish bearing) stream for its entire length. The unnamed

tributary should be classified as a Type F based on the condition in June 2016, where it met the 2-foot bankfull width criterion. This stream should also be viewed in later summer to determine if it truly is perennial, or if it only has seasonal flow.

3.2 SUMMARY OF OVERALL STREAM CONDITIONS

The West Tributary is approximately 3.2 miles in length with one major tributary, Goff Creek that enters at river mile (RM) 2.0, and one unnamed small tributary that enters from the west at approximately RM 1.9; this small tributary is approximately 0.3 mile in length. Goff Creek was not assessed in this study, but will be assessed in a later separate study. The total length of the West Tributary that runs through culverts or pipes is approximately 2,560 feet (0.48 mile) or 16% of the total length. For the unnamed tributary, approximately 360 feet is conveyed in culverts or pipes, approximately 22% of its length. In general, the stream varies from a system with beaver ponds where no clear stream channel is visible, to a typical small order stream with interspersed pools and riffles, to large marsh-dominated areas with no defined stream channel. The most commonly encountered habitat type was glide, followed by pool and then riffle.

Overall, the results of this habitat assessment indicate that the West Tributary has very limited spawning habitat available and areas with suitably sized spawning gravels have substantial amounts of fine sediment that could limit survival of eggs if spawning occurs. Potential spawning habitat is generally only present downstream of NE 8th Street. Rearing habitat is available in most reaches, although during low flow conditions, water depths are quite shallow and there is a lack of cover in most reaches. Areas with beaver activity have the best quality rearing habitat in ponds and wetlands. Lengthy culverts likely prevent fish access above NE Bellevue-Redmond Road and 120th Avenue NE. Stormwater detention gates upstream of NE 8th Street also may hinder fish passage. No illicit discharges were observed. Riparian vegetation and shading conditions were highly variable in quality and non-native invasive species are present and dominant in most reaches. Large wood is limited in most reaches, but present in moderate quantities in areas of beaver activity. Water temperatures were high during the assessment and rose predictably throughout each day similar to air temperatures.

Spawning and rearing fish habitat quality were most often recorded as poor, with rearing habitat comprising a much larger proportion of habitat than spawning habitat. Rearing habitat was limited (degraded) most often by insufficient water depth, invasive vegetation that may prevent passage, and a lack of instream habitat cover such as wood, undercut banks and shade. The most influential factor in creating rearing habitat was beaver activity, which created backwater refugia and complex wetlands with relatively large amounts of wood. Spawning habitat of good quality was not observed, although patches of poor quality (0.33 score) were more common and a few fair (0.67 score) quality spawning areas were observed. Spawning habitat quality was limited by the high percentage of fines and embeddedness in riffles, as well as insufficient water depths and a lack of cover.

Several potential fish passage barriers were present, including weirs and rock or debris accumulations, but these may only be barriers during low flow conditions. Generally low flow conditions were prevalent at the time of the field investigations. Several beaver dams were present, but were not considered to be fish passage barriers. Only one culvert with a drop at its outlet was observed at the very upstream end (Reach 80_08), all others that were observable were backwatered or without drops. The primary issue with passability at culverts is the very long lengths that are piped at NE Bellevue-Redmond Road and 120th Avenue NE.

Water temperatures ranged from 59.1°F (15.1°C) to 67.8°F (19.9°C), with higher temperatures recorded where streamflow was lower or in correlation with air temperature (i.e. water temperatures increased from morning to afternoon on each day of sampling). Temperatures above a 7-day maximum of 63.5°F (17.5°C) exceed Washington State Water Quality Standards for salmonid spawning, rearing and migration habitat (WAC 173-201A-200). While only spot checks of temperature were conducted in this assessment, it is highly likely that even higher 7-day maximum temperatures would be recorded later in summer (i.e. August) when flows are likely to be lower and air temperatures higher.

Water depths typically varied from a few inches to about 2 feet in most sections of stream channel; however, where beaver ponds were present, depths could exceed 5 feet. It is estimated that over 50% of the length of the West Tributary was flowing at depths less than 12 inches at the time of the field assessment and in areas that could be observed. In addition, much of this shallow 50% is only 6 inches deep or less. It is likely that depths would be even lower in later summer. The unnamed tributary may only have seasonal flow if investigated later in the summer during the lowest flows. Depths were typically only 2-3 inches at the time of the field assessment.

Wetted widths and scour width varied from 3 feet (0.9 m) to 130 feet (40 m) on the West Tributary, though only two widths were greater than 15 feet and were found where ponds were present. Wetted width on the unnamed tributary varied from 0.65 feet (0.2 m) to 4.9 feet (1.5 m) and scour width varied from 2.3 feet (0.7 m) to 5.9 feet (1.8 m). As defined in the WDFW protocol, spring influence appears to range from moderate (wetted width at least 2/3 of scour line width) to pronounced (i.e. wetted width essentially equaled the scour line width). A large portion of the stream has essentially the same wetted and scour line widths. Evidence of scour is limited in more confined reaches because armoring is present in most locations; evidence of scour is limited in unconfined reaches due to the presence of beaver ponds or larger wetland complexes. In more confined reaches, it appears that the water level increases vertically up an armored bank during storm flows, but does not show evidence of recent bank scour. The channel has likely incised in the past (when first developed) and riprap is present in the bed in many areas where it may have scoured off the banks in past events, but now this riprap is stabilizing the channel bed, along with installed weirs and armored substrate (i.e. cobbles). The presence of stormwater detention basins and beaver dams in the upper reaches of the stream may also reduce further channel incision.

Areas of erosion were most pronounced within the Glendale Country Club Golf Course (Reach 80_01), where the combination of a high groundwater table and stream forces on banks with limited vegetation have likely both contributed to bank slumps. No other substantial areas of erosion were observed. Armoring was abundant, particularly on private property in residential areas (Reaches 80_02 and 80_03).

Flood risk locations were observed at two sites; the NE 1st Street culvert on the West Tributary and the 126th Avenue NE culvert on the unnamed tributary that has partially collapsed. Both of these culverts are owned by the City of Bellevue. The box culvert at NE 1st Street is as wide as the channel width, but of very low clearance (<2 feet) due to extensive sediment deposition in the culvert. Small debris piles have also accumulated in the culvert. The property owners at this location indicated that large wood has blocked the culvert in the past and that they have reported this condition to the City previously.

Numerous outfalls and pipe crossings were observed and are shown in the reach figures (Figures 2-12). Although many of the outfalls conveyed water into the stream, no illicit discharges were observed. It is likely that most of the outfalls are from slope or curtain drains and convey groundwater. Some likely also convey irrigation runoff, such as in the golf course.

3.3 REACH DESCRIPTIONS

This section provides a review of the data collected by habitat unit (HU) for each reach segment, as well as for the entire reach. Table 1 provides a summary of the data for each reach segment surveyed. Narrative descriptions for each reach are in the following paragraphs. Figures 2 through 12 show the reaches, surveyed reach segments, and major features identified. GIS layers and photos have been provided electronically. In general, reaches were surveyed from the downstream end moving upstream. Data sheets are provided in Appendix A.

3.3.1 Reach 76_04

Reach surveys began in the downstream-most portion of the West Tributary, upstream of its confluence with Kelsey Creek. The majority of this reach can be characterized as a beaver pond complex. Dense vegetation growth and deep water prevented accessing all the way downstream to Kelsey Creek (normally, the downstream 200 feet [60 m] of a reach would be surveyed). Instead, the surveyed segment began approximately 330 feet (100

m) downstream of the upstream end of the reach. There was one reach segment surveyed (76_04-1), which included two habitat units, one pond and one glide. The glide area was only recently returned to a channel from a breached beaver dam. Wetted width and scour widths were the same at 11.8 feet (3.6 m). The average depth was 2 feet (0.6 m).

Vegetation was dominated by willow species (*Salix lasiandra, Salix sitchensis*), classified primarily as shrub cover. Non-native blackberries (*Rubus armeniacus*) were also present and reed canary grass (*Phalaris arundinacea*) was dominant in the understory. Herbaceous cover was generally about 75%. There was limited tree canopy cover (10-25%), although numerous standing snags were present (i.e. had been drowned by beaver activity).

This reach had low to medium instream cover that included large wood (an estimated 50 pieces, approximately half of those were submerged in deep water but encountered when walking) and overhanging vegetation. Substrate was 95 to 100% fines, thus no potential spawning habitat was present, and no Wolman pebble count was conducted. Beaver ponds and wetlands provide high quality rearing habitat for juvenile salmonids, lamprey, and other native fish species if cold water and good cover are present. Beaver ponds and wetlands also provide good winter refugia from high flows. Gradient was measured at 0%.

There were no fish passage barriers observed in this reach, nor was there armoring, areas of erosion, outfalls, or areas where the stream enters a culvert. Rearing habitat was available in this reach, but is limited by high water temperature (17.7°C), little habitat complexity, high organic materials in the substrate, and low to moderate instream cover. One juvenile cutthroat trout was observed in this reach. Tannic or turbid conditions prevented observation of any other fish.

3.3.2 Reach 80_01

Reach 80_01 begins at the southernmost pedestrian bridge in Kelsey Creek Farm Park. The stream runs through the park and then transitions into the Glendale Country Club Golf Course. This entire reach was walked and observed. Vegetation conditions are substantially different between Kelsey Creek Farm Park and the golf course and could be considered for revising into two separate reaches. However, because the geomorphic conditions are not substantially different, we do not recommend revising this reach, except at the upstream end, as identified in Section 5.3.

Reach 80_01 is quite lengthy, approximately 4,690 feet (1,430 m) and thus three segments were surveyed (80_01-1, 80_01-2, and 80_01-3). The Kelsey Creek Farm Park portion is a low complexity system, dominated by shallow riffles and short glides. Few pools are present and of limited depth. Two segments were surveyed within the park documenting three glides and two riffles. Wetted widths and scour widths were essentially the same at each habitat unit measured in the park, ranging from 7.5 feet (2.3 m) to 10.7 feet (3.3 m). Average depths in glides were 1.4 feet (0.4 m) and in riffles were 0.7 feet (0.2 m). At higher flows than observed, two side channels or backwaters are present, but were dry during the field assessment. Substrate was dominated fairly coequally by small gravel, cobbles and fines.

The most common trees within the park included red alder (*Alnus rubra*) and willows (*Salix* sp.). The City has done extensive riparian plantings in the park that are up to 20 years old and now provide good shading in the majority of the park. Other species include red-osier dogwood (*Cornus stolonifera*), Douglas' spirea (*Spirea douglasii*), Sitka spruce (*Picea sitchensis*), ninebark (*Physocarpus capitatus*), salmonberry (*Rubus spectabilis*), and jewelweed (*Impatiens noli-tangere*). At the upper end of the park, near the property boundary, the understory is dominated by blackberry.

Two riffles with potential spawning area were observed within the farm property. A Wolman pebble count was conducted that confirmed that fines in this area were 23%, resulting in a spawning HQM score of 0.33 (poor). The second segment surveyed within the park had been stabilized with the installation of large wood along the right bank. The wood served as bank protection, along with ballasting rock. This keeps the channel from meandering

into the more developed area of the park and provides a small amount of stream cover. Several juvenile cutthroat trout were observed within the park.

Three bridge crossing are present in the park and one spanning log that forms a small weir (< 6 inches). These are not likely to be fish passage barriers. The majority of the wood in the overall reach is located within the park, but is not generally influencing stream habitat, other than providing a limited amount of cover (larger logs installed along the bankline or larger logs spanning over the channel). A total of 37 pieces of wood were identified in this reach.

Within the golf course, the stream channel becomes narrower and more incised, with only glide or riffle habitat units present. In the surveyed segment within the golf course, only one habitat unit was measured, a 200-foot (60 m) riffle. Wetted width was 7.4 feet (2.3 m) and scour line width was 11 feet (3.4 m). Average depth was 0.4 feet (0.1 m). Substrate was dominated by small gravel, but with significant components of fines.

The most common tree along the stream in the golf course was Douglas fir (*Pseudotsuga menziesii*). Reed canary grass and other mowed grasses were dominant in the understory. The reach was classified by the City to end at the upstream-most pedestrian bridge, approximately 230 feet downstream of the property boundary. The creek begins to transition to higher banks and a more confined nature at this location, but as the confinement and management dramatically changes as the creek enters the upstream residential properties, we recommend extending Reach 80_01 to end at the upstream golf course property boundary. In this last section of the golf course, the vegetation had formerly been entirely blackberries, and had recently been mowed. The most significant degradation of habitat through the golf course is the lack of a riparian zone. The sparse Douglas firs lining a portion of the stream provide substantial shading that is lacking in nearly 2/3 of the golf course. The golf course maintains an unmowed buffer along the creek, but as it is dominated by reed canary grass, it is of limited value.

A Wolman pebble count was conducted in Reach 80_01 and indicated that fines were around 21%, which results in a spawning HQM score of 0.67 (fair). However, much of this reach was flowing at less than 6 inches deep. Other limitations to spawning habitat quality included the lack of instream cover and low instream complexity. Rearing habitat quality is poor (HQM score of 0.33) through this reach from lack of instream cover, low instream complexity, and high water temperatures (17.3°C). Numerous areas of armoring and erosion were present throughout the golf course, with significant stretches of bank slumping and riprap. This reach was the only reach on the entire stream with significant erosion occurring. There were four pedestrian bridges, but no culverts. These are not likely to be fish passage barriers. Numerous outfalls are present throughout the golf course that appear to drain groundwater and/or irrigation water and two pipe crossings (overhead) are present. Gradient was estimated as less than 1% (compared to 0.5% by City GIS).

3.3.3 Reach 80_02

This reach begins at the northern end of the Glendale Country Club Golf Course and stretches through residential areas to NE 3rd Street. The majority of this reach was walked and visually observed, excluding approximately 30% was not accessible due to unwilling landowners. As described above and in Section 5.3, we recommend moving the start of this reach to begin at the golf course property boundary. This reach becomes more confined into a ravine with bank heights at least 6 feet above the creek bed, and becoming higher approaching NE 3rd Street (approximately 15 feet high). Moving the reach break would shorten this reach by approximately 230 feet, from its current length of 1,374 feet.

Two segments were surveyed in this reach, including one that began in the golf course (80_02-1) and one just downstream of NE 3rd Street (80_02-2). The habitat units surveyed in this reach included pools, riffles, and glides, although the riffles accounted for the vast majority of the surveyed segments. Wetted widths ranged from 6 feet (1.8 m) to 9 feet (2.7 m) and scour line widths ranged from 7.5 feet (2.3 m) to 11.5 feet (3.5 m). Average depths in pools were 1.1 feet (0.33 m) and in riffles were 0.5 feet (0.15 m). Substrate was generally coequally dominated by gravels and fines, but cobbles were also present. At the upstream end of the reach, boulders (i.e. riprap) had

fallen into the creek in many locations. Large wood was generally sparse in this reach, with approximately 25 pieces identified (generally small pieces), and it does not provide habitat.

The riparian vegetation was dominated by ornamentals through private yards, although red alder, Western red cedar (*Thuja plicata*), big-leaf maple (*Acer macrophyllum*) and cottonwood (*Populus balsamifera*) were also dominant tree species. Other species included lady fern (*Athyrium filix-femina*), small-fruited bulrush (*Scirpus microcarpus*), and heavy dominance of blackberry and bamboo. For the most part, there is tree canopy cover and substantial shading through this reach. While ornamental vegetation is not high quality habitat, it does maintain shading and this may be the primary condition to maintain in this reach.

The vast majority of this reach is armored on both banks. We estimated that 90% of the reach is armored and did not identify individual armoring segments after the first properties. Armoring includes riprap, gabions, concrete blocks and a variety of debris. As a result of the extensive armoring, signs of erosion were not observed. This reach includes two culvert crossings (NE 1st Street and NE 3rd Street), one pedestrian bridge, and at least two fence crossings with low clearance. Of immediate flood concern is the sediment deposition in the NE 1st Street culvert. This culvert provides only 1.6 feet of clearance and appears to be accumulating debris. The adjacent landowner indicated that logs had been jammed in this culvert in the past (now removed) and they have notified the City of their concerns.

A Wolman pebble count was conducted in Reach 80_02 and indicated that fines were 16% or less, which is quite different from the visual observations of 20 to 30% fines. This is an overall difference noted between the WDFW protocol and the Wolman pebble count because the pebble counts can be skewed by the presence of larger cobbles and boulders that cover up fines (resulting in fewer fines being selected). The spawning HQM score was 0.33 (poor) from the high level of fines and the rearing HQM score was also 0.33 (poor). Other limitations to both spawning and rearing habitat quality included the lack of instream cover and low instream complexity. High water temperatures (up to 18.8°C) further reduce the quality of rearing habitat. A juvenile cutthroat trout and a larger juvenile or small adult cutthroat trout were observed in this reach.

Four drops greater than 12 inches were observed over weirs (2 upstream of 3rd Street and 2 downstream of 3rd Street) in the upstream 130 feet (40 m) of this reach. The culvert at NE 1st Street is likely to cause a velocity barrier to fish at higher flows due to its limited capacity. The culvert at NE 3rd Street does not appear to be a fish passage barrier as there is no drop at the outlet, the culvert is countersunk and the width is at least 75% of the average channel width. Gradient was estimated at 2% (as compared to 2.2% in City GIS).

3.3.4 Reach 80_03

Reach 80_03 begins approximately 65 feet (20 m) upstream of NE 3rd Street and continues upstream for approximately 2,450 feet (740 m) to the confluence with the unnamed tributary, joining from the right bank (west). Approximately 2/3 of this reach was walked and observed, but the middle portion was not accessible due to unwilling landowners. Two reach segments were surveyed (80_03-1, 80_03-2).

This reach is less confined with lower banks, approximately 3-4 feet typically, than Reach 80_02. This reach is also predominantly residential, so is similarly armored and manipulated for private yards in the majority of the reach. Two segments were surveyed in this reach and the habitat units surveyed included riffles and glides, with riffles occupying the majority of the length surveyed. Wetted widths ranged from 7.5 feet (2.3 m) to 11.2 feet (3.4 m) and scour line widths ranged from 7.5 feet (2.3 m) to 12.5 feet (3.8 m). Average depths in glides were 0.65 feet (0.2 m), and in riffles were 0.3 feet (0.1 m). Substrate was dominated by gravel, although fines ranged from 20-35% and cobbles were present. A few boulders were also present that had generally been placed or fell into the stream from adjacent banks. Large wood is very sparse in this reach, with only 6 pieces identified of medium size that are not contributing to habitat function.

The riparian vegetation was dominated by native trees, including red alder, cottonwood, Douglas fir, and big-leaf maple, but the understory was dominated by invasives such as ivy (*Hedera helix*), blackberry, and reed canary

grass, and ornamentals such as rhododendrons, with some natives such as lady fern. Some native shrubs such as willow and ninebark were also present. This reach also had generally good tree canopy cover and shading.

The vast majority of this reach is armored on both banks. We estimated that 80% of the reach is armored and did not identify individual armoring segments. Armoring includes riprap, gabions, concrete blocks and a variety of debris. As a result of the extensive armoring, signs of erosion were not observed. This reach includes two culvert crossings (NE 8th Street and a roadway to a gate structure) and at least six pedestrian bridges. Both banks are armored between NE 8th Street and the roadway with gate structure.

A Wolman pebble count was conducted in Reach 80_03 and indicated that fines were 12-18%, which is also different from the visual observations of 20% fines. This is an overall difference noted between the WDFW protocol and the Wolman pebble count because the pebble counts can be skewed by the presence of larger cobbles and boulders that cover up fines (so they are not selected). The spawning HQM scores were 0.33 (poor) with one score of 0.67 (fair) in the area of 12% fines and the rearing HQM scores were also 0.33 (poor). Other limitations to both spawning and rearing habitat quality included the lack of instream cover and low instream complexity. High water temperatures (up to 19.1°C) further reduce rearing habitat quality. No fish were observed in this reach, but one crayfish was observed.

No drops were observed in this reach, however, water depths were consistently less than 12 inches and often less than 6 inches. The culvert at NE 8th Street is likely to cause a velocity barrier to fish at higher flows due to its length and turns (~100 feet), although it has no drop at its outlet, is countersunk, and is at least 75% of the channel width. The two culverts at the road crossing to the gates would be fish passage barriers when the gates are closed for stormwater detention. Gradient was estimated at 1% in the lower half and 2% in the upper half (as compared to average of 1.2% in City GIS).

3.3.5 Reach 80_03-Trib

This unnamed tributary joins West Tributary on the right bank (west), just upstream of NE 8th Avenue. It is a first order stream that is very narrow, overgrown with invasive vegetation, passes through several culverts, and is bordered by private property throughout most of its length. The majority of this reach was inaccessible due to the vast distance of blackberries surrounding the stream and instead of surveying 60-meter segments, data was collected for the portions of the stream that could be reached. This resulted in two data collection points (80_03-Trib1, 80_03-Trib2). It is not known if these are fully representative of the entire stream, although it appears they are geomorphically similar to the areas not accessed. Visual observation of outfalls, large wood, and other reach wide assessments could not be made here.

The locations surveyed for the unnamed tributary were identified as glides, with a total length of 82 feet (25 m) surveyed. Wetted width varied from 0.65 feet (0.2 m) to 4.9 feet (1.5 m) and scour line widths varied from 2.3 feet (0.7 m) to 5.9 feet (1.8 m). Depths were less than 6 inches at all observed points (0.1 m). Substrate was coequally dominated by fines and gravel and was not considered spawning habitat. The rearing HQM was scored as 0.33 (poor) due to low to medium instream cover, high water temperature (up to 19.1°C), fines, and poor riparian conditions.

The riparian vegetation was dominated by red alder, blackberry, ivy, and reed canary grass. The dense cover provided shade, but little else of benefit. No wood was observed in the stream. At the locations observed, no armoring or erosion were evident.

This tributary is piped for approximately 280 feet (85 m) where it passes beneath NE 8th Street. The pipe first crosses NE 8th Street perpendicularly, then turns west to run along the south side of NE 8th Street. This culvert is likely to be a velocity barrier at high flows and a depth barrier at low flows; it is not countersunk and is of small size. Another culvert occurs beneath 126th Ave NE. The culvert entrance on the upstream side could not be located and may have collapsed or been buried under debris. Gradient was estimated at 1% (as compared to 2.6% in City GIS).

3.3.6 Reach 80_04

Reach 80_04 extends as a defined channel upstream of NE 8th Street, but becomes a densely overgrown field of reed canary grass for almost the entire reach. Within the reed canarygrass field, the vegetation has become too thick to visually locate the stream channel. Instead, the stadia rod was used to probe through the vegetation mat to find water. Numerous channels seem to have formed in the area, with no main channel. Fish passage is unlikely to be possible through this dense vegetation and shallow depths.

Two segments were surveyed in this reach (80_04-1, 80_04-2). Riffles, pools, and glides were identified, although glide occupied the majority of the length surveyed. Wetted widths ranged from 3 feet (0.9 m) to 13 feet (4 m) and scour line widths ranged from 3 feet (0.9 m) to 14 feet (4.3 m). Average depths in glides ranged from 0.3 feet (0.1 m) to 2 feet (0.6 m), and in pools 1.3 feet (0.4 m). Substrate was dominated by fines, although gravel was also a major component, but no spawning habitat was present. Rearing HQM scores included by 0.33 (poor) and 0.67 (fair), as canopy cover and instream cover were good in some locations. Water temperature was high (up to 17.8°C).

Riparian vegetation was dominated by cottonwood, red alder, willows, salmonberry, blackberries, and reed canary grass. Large wood was very sparse in this reach, and only 11 individual pieces were identified, although numerous small pieces were included in the beaver dam and more large wood could have been buried under reed canary grass. No erosion or armoring was observed in this reach.

The only culvert in this reach occurs beneath a dirt road behind apartments located at 126th Place NE that pass flow from the stormwater detention gates that would be a fish passage barrier when closed and may be a velocity barrier during high flows. Gradient was estimated between 1 and 2% (as compared to 2.2% in City GIS).

3.3.7 Reach 80_05

This reach flows entirely through pipes, a total length of approximately 1,292 feet (400 m), extending from Bellevue-Redmond Road to a point beneath an industrial area near the end of 127th Place NE. At this point, the piped section changes into Reach 80_06. No surveys were conducted for this reach. As the piped section is continuous into the lower portion of Reach 80_06, we recommend extending Reach 80_05 up to the pipe outlet at Parcel 15375. The adjoining property owner did not allow access and this piped portion was not confirmed. Such a long distance of pipe with multiple turns and complete darkness is certain to be a fish passage barrier and has been identified as such by the City in the GIS data provided for this study.

3.3.8 Reach 80_06

Reach 80_06 is a lengthy reach, approximately 3,504 feet (1,068 m) that begins in a piped section underneath the industrial area near the end of 127th Place NE. It extends a total of 220 meters before it becomes daylighted at Parcel 15375. As this piped section is continuous with the entirely piped Reach 80_05, we recommend extending Reach 80_05 up to the outlet into Parcel 15375. Then West Tributary daylights in Parcel 15375, entering a short piped section with a flood gate structure that controls the water level in a City detention basin. The detention basin was not ponded at the date of the field assessment. Measurements using aerial photography showed a representative pond width to be 130 feet (40 m). Upstream of the detention basin, the stream is piped for a short distance beneath 124th Avenue NE, and then emerges into the Metro Property.

Four segments were surveyed in this reach with glide and pool habitats identified (80_06-1, 80_06-2, 80_06-3, 80_06-4). For each segment, one long habitat unit (either glide or pool) occupied the entire length. Wetted widths ranged from 3.9 feet (1.2 m) to 5.6 feet (1.7 m) and were equal to the scour line widths. Average depths of glides ranged from 0.3 feet (0.1 m) to 1.6 feet (0.5 m) and the pool was 2 feet (0.6 m) in depth. Substrate was dominated by fines in all habitat units, although gravel was codominant in the glide at the downstream end (segment 1). No spawning habitat was present. Rearing HQM scores were 0.33 (poor) as canopy cover is low, instream cover is low to medium, fines, and high water temperature (up to 19.7°C).

Riparian vegetation was dominated by willows, reed canary grass, cattails (*Typha latifolia*), blackberries, and some red alder and cottonwood in the Metro property. A moderate quantity of large wood was present in this reach, associated with beaver activity and submerged in the detention pond area; 21 individual pieces were counted, but numerous small pieces were at/adjacent to the weir in the Metro property and there were recently-downed alder (by beavers) and possibly 10-15 buried pieces. No erosion was observed in this reach and the only armoring present was at the downstream ends of detention basin culvert (along the right bank) and downstream of the previously unmapped culvert on the Metro property. Potential fish passage barriers included a weir on the metro property (2 foot drop) and generally low flow depths (less than 12 inches in most of the reach). Gradient was estimated at 2% (same as mapped by City GIS).

This reach had the greatest length of piped flows, reaching a total of approximately 1,000 feet (330 m). This includes the initial 720 feet (220 m) of piped length, an approximately 65 foot (20 m) culvert at the downstream end of the detention basin, a 150 foot (45 m) culvert beneath 124th Ave NE, and a previously unmapped piped section located on the Metro Property, passing beneath the bus ingress road leading west from 124th Avenue NE, which is also approximately 150 feet (45 m) in length. None of these culverts had drops at their inlet, but were not countersunk, and were generally less than 75% of the channel width, thus likely presenting partial fish passage barriers at high flows and insufficient depths at low flows. Gradient was estimated between 1 and 2% (as compared to 0.4% in City GIS).

3.3.9 Reach 80_07

Reach 80_07 includes only the piped section that passes beneath 120th Avenue NE, which extends a total length of approximately 330 feet (100 m). This area was not surveyed. This culvert is likely to be a fish passage barrier with such a long distance of pipe. It is not countersunk and would likely be a velocity barrier at high flows.

3.3.10 Reach 80_08

Reach 80_08 is a short reach, approximately 137 feet (316 m) located upstream of 120th Avenue NE. This was the upstream-most reach surveyed. One reach segment was surveyed (80_08-1), with a single pool habitat unit identified. This reach is a beaver pond/wetland complex. A beaver dam approximately 5 feet high is located approximately 15 feet upstream of the culvert at 120th Avenue NE. No specific channel is present, except immediately upstream/downstream of the beaver dam, and multiple ponds/channels are present extending for a width of approximately 100 feet (30 m), equal to the scour width. Average depth was 1.6 feet (0.5 m). Substrate was entirely fines and organic muck (ponded areas could not be walked as fines/muck extended down 2 or more feet). No spawning habitat is present.

Riparian and wetland vegetation was more diverse in this reach than in any other reaches, and included cottonwood, willows, red-osier dogwood, cattails, and small-fruited bulrush. Notably, invasives including reed canary grass, blackberries, and purple loosestrife (*Lythrum salicaria*) were present in patches, although not as widespread as in other reaches. Large wood was fairly extensive in this reach, with an estimated 100 pieces present, including submerged wood. The rearing HQM score was 0.67 (fair) as the canopy cover and instream cover are moderate. Water temperature (not measured) and fines limit rearing habitat quality. Gradient was estimated as 0% (as compared to 0.1% in the City GIS).

At the upstream end of the reach there is no channel and there was no water present for approximately 75 feet (23 m) downstream of the railroad culvert. At approximately 75 feet downstream, the soil is saturated and the wetland begins.

There were no piped sections of stream in this reach as it ended at the railroad culvert. However, the railroad culvert is the only culvert in the West Tributary that is perched, with a drop of approximately 1 foot and a scour hole with small rock beneath. This culvert is also about half-filled with sediment and was dry (no flow) at the time of the field assessment. The beaver dam immediately upstream of the culvert at 120th Avenue NE poses a potential flood hazard as it could block the culvert, if breached.

Table 1. Reach segment data results.

Reach Segment	Habitat Unit	HU Length (m)	Wetted Width (m)	Scour Width (m)	Average Depth (m)	Temp (C)	Gradient (%)	Canopy Cover (%)	Instream Cover	Spring Influence	Spawning HQM	Rearing HQM	Substrate (%)				Riparian Cover (%)			Non-Native Cover (%)
													F	G	C	B	T	S	H	
76_04-1	Pond	11.5	15.0	15	1.2	17.7	0	5	Low	3	0	0.33	100	0	0	0	10	35	75	75
	Glide	48.5	3.6	3.6	0.6	17.5	0	10	Med	3	0	0.33	95	5	0	0	25	45	75	60
80_01-1	Glide	60	2.3	2.3	0.5	18.4	<1	50	Low	3	0	0.33	50	50	0	0	35	35	50	50
80_01-2	Glide	22.5	2.4	2.4	0.5	19.9	<1	80	Low	3	0	0.33	50	10	40	0	80	60	50	30
	Riffle	30.6	2.4	2.4	0.2	19.9	<1	85	Low	3	0	0.33	35	40	25	0	85	55	40	35
	Glide	10.5	3.3	3.3	0.3	19.9	<1	70	Low	3	0	0.33	50	10	40	0	70	50	30	30
	Riffle	18.9	2.7	2.7	0.2	19.8	<1	80	Low	3	0.33	0.33	30	65	5	0	80	50	40	40
80_01-3	Riffle	60	2.3	3.4	0.1	17.3	2	60	Low	2	0	0.33	55	40	5	0	60	0	90	40
80_02-1	Pool	3.3	2.7	2.7	0.3	17.6	2	0	Low	3	0	0.33	50	50	0	0	0	0	100	95
	Riffle	2.3	2.4	3.5	0.2	17.6	2	0	Low	2	0.33	0.33	50	50	0	0	0	0	100	95
	Pool	5.0	2.0	3.0	0.4	17.7	2	0	Med	2	0	0.33	50	30	20	0	0	0	100	95
	Glide	8.8	2.7	2.7	0.2	17.8	2	0	Low	3	0	0.33	40	20	35	5	0	0	100	95
	Riffle	41.0	2.3	2.3	0.1	17.8	2	0	Low	3	0.33	0.33	30	60	10	0	0	80	20	95
80_02-2	Riffle	60	1.8	2.7	0.1	18.8	3	75	Med	2	0.33	0.33	20	45	10	25	60	40	10	60
80_03-1	Riffle	16.6	3.1	3.9	0.1	19.0	1	40	Low	2	0.33	0.33	25	45	20	10	40	5	55	50
	Glide	7.0	2.7	3.0	0.1	19.0	1	40	Low	2	0	0.33	35	45	20	0	40	10	50	50
	Riffle	36.8	2.3	2.3	0.1	19.1	1	75	Low	3	0.33	0.33	25	40	30	5	75	30	25	40

Reach Segment	Habitat Unit	HU Length (m)	Wetted Width (m)	Scour Width (m)	Average Depth (m)	Temp (C)	Gradient (%)	Canopy Cover (%)	Instream Cover	Spring Influence	Spawning HQM	Rearing HQM	Substrate (%)				Riparian Cover (%)			Non-Native Cover (%)
													F	G	C	B	T	S	H	
80_03-2	Riffle	26.4	3.4	3.8	0.1	16.1	2	70	Med	2	0.67	0.33	20	75	5	0	70	60	30	40
	Glide	18.3	2.8	2.9	0.3	16.1	2	5	Med	2	0	0.33	30	65	5	0	5	15	35	30
	Riffle	12.3	3.0	3.0	0.2	16.3	2	65	Low	3	0.33	0.33	25	20	40	15	65	5	30	30
	Glide	16	2.4	2.4	0.2	16.3	2	35	Med	3	0	0.67	30	20	50	0	35	10	75	60
80_03-Trib-1	Glide	15	1.5	1.8	0.1	16.9	1	35	Med	2	0	0.33	50	40	10	0	35	60	30	90
80_03-Trib-2	Glide	10	0.2	0.7	0.1	15.1	1	90	Low	1	0	0	30	70	0	0	90	60	50	75
80_04-1	Riffle	9.4	3.3	3.3	0.1	16.0	1-2	20	Med	2	0	0.33	50	50	0	0	25	25	40	20
	Glide	20.9	1.8	2.1	0.1	16.1	1-2	30	Med	2	0	0.67	50	45	0	5	30	60	35	75
	Pool	3.1	3.2	3.8	0.3	16.1	1-2	75	Low	2	0	0.33	60	40	0	0	75	30	60	85
	Glide	17	4.0	4.3	0.1	16.1	1-2	50	Med	2	0	0.33	40	60	0	0	50	40	30	40
	Pool	16	3.2	3.2	0.4	16.1	1-2	50	Med	2	0	0.67	65	35	0	0	50	50	15	15
80_04-2	Glide	60	0.9	0.9	0.6	17.8	1	0	Med	3	0	0.33	100	0	0	0	5	5	100	95
80_06-1	Glide	60	1.2	1.2	0.3	-	2	10	Med	3	0	0.33	60	40	0	0	10	60	50	60
80_06-2	Glide	60	1.5	~40	0.1	19.7	1-2	20	Low	1	0	0.33	100	0	0	0	20	30	50	80
80_06-3	Pool	60	1.2	1.2	0.6	18.2	1-2	5	Med	3	0	0	100	0	0	0	5	5	100	95
80_06-4	Glide	60	1.7	1.7	0.5	17.0	1-2	50	Med	3	0	0.33	35	65	0	0	25	30	90	90
80_08-1	Pool	60	30	30	0.5	-	0	30	Med	3	0	0.67	>90	0	0	0	20	10	100	75

3.3.11 Prioritization Index (WDFW)

The WDFW prioritization index was used to estimate habitat and production potential above the identified fish passage barrier culverts and for the entire stream as a whole (even though there are no barriers below NE 8th Street). The downstream-most culvert that is likely a fish passage barrier is at NE 8th Street and the adjacent upstream culverts/gates at the detention basins. There is no spawning habitat on the West Tributary upstream of NE 8th Street, so the prioritization index only calculated rearing habitat upstream of that point. Inputs in the spreadsheet are directly from the field data.

West Tributary (including unnamed tributary): Prioritization Index (PI) based on all reaches. Reaches 80_05 and 80_07 that are piped are included in the immediate upstream reach.

$PI_{total} = PI_{sockeye} + PI_{coho} + PI_{chinook} + PI_{steelhead} + PI_{cutthroat} = (8.9+3.7+4.6+2.3+3.1) = 22.6$

NE 8th Street. Prioritization Index based on Reach 80_04 only (only reach to be made accessible by only replacing NE 8th Street culvert and modifying culverts/gates to ensure fish passage):

$PI_{total} = PI_{coho} + PI_{chinook} + PI_{steelhead} + PI_{cutthroat} = (2.1+2.6+1.3+1.7) = 7.7$

Bellevue-Redmond Road. Prioritization Index based on Reach 80_06 only

$PI_{total} = PI_{coho} + PI_{chinook} + PI_{steelhead} + PI_{cutthroat} = (2.4+3+1.5+2.1) = 9$

120th Avenue NE. Prioritization Index based on Reach 80_08 only

$PI_{total} = PI_{coho} + PI_{chinook} + PI_{steelhead} + PI_{cutthroat} = (2.6+3.2+1.6+2.2) = 9.6$

4.0 RESTORATION NEEDS AND OPPORTUNITIES

Restoration and stormwater or flood reduction opportunities are available throughout West Tributary, although in the most urban portions, opportunities may be limited. The following sections describe the restoration opportunities at each reach, using their current numbering designations, and the limitations that exist. Figure 13 shows these opportunities on an overview map.

Reach 76_04. This reach is of moderate to good rearing quality overall with beaver ponds and wetlands. Part of this reach is protected within Kelsey Creek Park, but the upper half is within private properties. The primary opportunities for habitat enhancement and restoration within this reach are control of invasive plant species, primarily reed canary grass and blackberries, plantings of native trees and shrubs to improve shading and contribute to the long-term recruitment of large wood, and placement of large wood in the stream and wetlands. As the West Tributary overall appears to have a high groundwater table, it is important to maintain low water temperatures as much as possible in the stream, so additional shading and cover will help to maintain cooler water temperatures for high quality rearing habitat for juvenile salmonids and to benefit Kelsey Creek water temperatures.

Reach 80_01. This reach is of moderate to good rearing quality through Kelsey Creek Farm Park and of poor quality through the Glendale Country Club golf course. The primary opportunities for habitat enhancement and restoration within this reach are within the golf course and include sloping the creek banks back to minimize erosion and reduce the need for armoring, removal of armoring, replanting with native trees and shrubs and installation of bank logs to form pools and provide cover. The most important concerns for this reach are to provide shading to maintain cooler water temperatures and to reduce the input of fine sediments from bank erosion. Pedestrian bridges may need to be widened to accommodate bank layback. A riparian buffer will also filter fertilizers and herbicides that may be used on the golf course. If possible, restoring some meanders would also promote pool and riffle formation. This reach could provide potential spawning habitat if enhanced.

Reach 80_02. This reach primarily runs through residential properties and is confined by relatively steep and moderately high banks. The primary concerns in this reach are the flood-risk culvert at NE 1st Street, debris and armoring, and the need to maintain shading and tree canopy cover. As there are so many small residential property owners, enhancement opportunities may be limited. Replacing the culvert at NE 1st Street with a larger (both wider and higher clearance) culvert, but recreating a narrower low-flow channel through the culvert would help to convey sediment and reduce flood and debris jamming concerns. The property owner upstream of the culvert may be willing to allow better riparian enhancement if the flooding issues are resolved (they have been working with the King County Conservation District on limited riparian plantings). Working with landowners to remove riprap and other debris that has fallen into the stream would improve spawning habitat potential, and wood could be installed to replace this debris, primarily anchored into the banks. Removal of armoring would likely cause erosion of the banks as there is so little room available. The City could consider a tax incentive to landowners to maintain and enhance riparian vegetation or to retain trees and plant native shrub cover. Landowners with fences crossing the creek could be encouraged to find other property protection features such as thorny shrub hedges (i.e. native roses).

The weirs upstream and downstream of NE 3rd Street may have been installed to promote backwatering and stability of the culvert, but should be notched further or reconfigured to ensure passability by both juvenile and adult salmonids.

Reach 80_03. Similar to Reach 80_02, this reach primarily runs through residential properties and is confined by moderately high banks. The primary concerns in this reach are debris and armoring, and the need to maintain shading and tree canopy cover. As there are so many small residential property owners, enhancement opportunities may be limited. Working with landowners to remove riprap and other debris that has fallen into the stream would improve spawning habitat potential, and wood could be installed to replace this debris, primarily anchored into the banks. Removal of armoring would likely cause erosion of the banks as there is so little room available. The City could consider a tax incentive to landowners to maintain and enhance riparian vegetation, or to retain trees and plant native shrub cover.

The culvert at NE 8th Street is likely a partial fish passage barrier due to its length and velocities at high flows. This would be an expensive culvert to replace and would not provide access to spawning habitat in the West Tributary (although spawning habitat may be available in Goff Creek), but would provide access to rearing habitat in Reach 80_04. Low pedestrian bridges will likely be damaged during floods; the City could consider a tax incentive for landowners to raise or eliminate pedestrian bridges.

Reach 80_03_01. This unnamed tributary functions essentially as a drainage corridor from commercial and residential properties and it may only have seasonal flow (should be confirmed by observation in late summer). The culvert at NE 8th Street is likely a fish passage barrier due to its length, corners, and high velocities during high flows. There is little to no habitat potential in this reach, so providing fish access does not seem warranted. The primary concerns with this reach are to reduce fine sediment transport into the West Tributary and to maintain shading and provide a riparian buffer for filtering potential pollutants. The riparian corridor is entirely dominated by blackberries and ivy, although some tree canopy is present. The City could consider a tax incentive to landowners to maintain and enhance riparian vegetation, to retain trees, control invasive species, and plant native shrub cover.

The culvert under 126th Avenue NE may be buried or collapsed. This should be investigated to determine if it should be replaced as it could cause a flood risk concern.

Reach 80_04. This reach is of moderate quality and is primarily a wetland complex. The primary concerns in this reach are the lack of a defined channel due to reed canary grass invasion and the fish passage concerns with the culverts and gate structure. The key enhancement and restoration opportunities are control of invasive species, which could potentially be drowned out by impounding this reach by using the gates. Then, replanting with a dense and diverse mix of native trees and shrubs and herbaceous cover would help to prevent reed canary grass

recolonization. Placement of wood in the wetland complex (anchored) would provide cover and habitat for multiple species.

Reach 80_05. This reach is piped for its entire length. This would be a major expense to daylight and there is a limited corridor available. If there is an opportunity to daylight portions of this reach, the primary enhancement opportunities would be to provide a riparian corridor and create a coarse substrate channel to minimize inputs of fine sediment.

Reach 80_06. This reach is currently designated to include the piped segment between 127th Place NE and Parcel 15375, which we have recommended including in Reach 80_05. However, this segment of pipe may be most conducive to daylighting as there is lesser use of this area for various commercial activities.

The primary concerns in this reach are the lack of a defined channel due to reed canary grass invasion and the fish passage concerns with the detention gate structure. As there is no spawning habitat available in this reach or upstream, fish passage concerns are of a lower priority and the detention gates could potentially be used to drown out reed canary grass. Then, replanting with a dense and diverse mix of native trees, shrubs, and herbaceous cover would help to prevent reed canary grass recolonization. Placement of wood (anchored) in the wetland complex (downstream of 124th Avenue NE) would provide cover and habitat for multiple species.

In the Metro property, the potential for reconfiguring the weir or adding a secondary weir to reduce the drop height and replacing the culverted section with a bridge should be considered. Other primary enhancement and restoration opportunities would be to remove debris, control invasive species, and plant native trees and shrubs for canopy cover. It is important to maintain cooler water temperatures and minimize the input of fine sediments through this reach, even if fish passage is not a feasible option.

Reach 80_07. This reach is entirely piped along 120th Avenue NE. This would be a major expense to daylight and there is limited corridor available. If there is an opportunity to daylight this reach, the primary enhancement opportunities would be to provide a riparian corridor and create a coarse substrate channel to minimize inputs of fine sediment.

Reach 80_08. This reach generally is of moderate quality and functions as a headwater wetland complex. There is no spawning habitat available. The primary habitat enhancement and restoration opportunities are to control invasive species and enhance the diversity and shading of the wetland by planting native tree species around the perimeter and on planting mounds that could be placed in the wetland. There is the most large wood in the stream in this reach, so placement of additional wood is a low priority, but could be accomplished for any trees removed associated with invasives control or placement of planting mounds.

The culvert under 120th Avenue NE is likely a flood risk due to potential clogging by the beaver dam wood.

5.0 DISCUSSION AND RECOMMENDATIONS

The selected protocols and data collection tools were found to work in most cases, with only a few exceptions. This section describes the data collection protocols that were modified during field investigations and the reasons for those decisions, the utility of the tools used and recommendations for improving them, a review of the most time consuming components of the investigation effort, and recommendations for improvements.

5.1 CHANGES TO PROTOCOL

5.1.1 Data Collected and Effort Required

Large Wood. West Tributary has abundant beaver activity, resulting in an abundance of smaller sized wood and it was quickly decided that it would not be feasible to keep an accurate count using the Montgomery size class guide (Montgomery 2008). Instead, we noted the general presence of the smallest Montgomery size classes (A1)

and kept count only of the larger pieces, including B1 or greater size classes. Indications of numerous small pieces are described in the data sheets and reach descriptions.

Wolman Pebble Counts. Wolman pebble counts were only done in areas where coarse substrate was dominant. The narrowness of the channel and presence of boulders (riprap) made the accuracy of the counts lower than desirable as fine sediment was typically under larger particles, thus skewing the results toward larger gradations. This is acceptable for the purposes of hydraulic modeling (i.e. estimating channel bed roughness), but is not suitable for habitat quality assessment.

5.1.2 Field Equipment

Measuring Tape. We found that it was not necessary to use a hip chain to gain accurate measurements of the stream habitat units, as required in the WDFW protocol. Instead, a 60-meter measuring tape allows the habitat unit length to be measured and then quickly converted for measurement of smaller lengths, such as wetted width and scour width, reducing the number of measurement tools needed in the field.

Gradient. Gradient was difficult to accurately collect due to short sight distances from stream meanders or dense vegetation. Measuring short distances with a clinometer did not provide accurate, even when using a survey rod for sighting. Thus, gradient was visually estimated, but it is recommended that gradient be mapped using City topography in GIS. For the West Tributary, there were no significant grade breaks as all reaches were approximately 2% or less. Unless the City is aware of streams within their jurisdiction with significant grade breaks, we recommend only documenting drops at weirs or other features.

GPS Placemarks. In most cases, the Trimble GPS unit provided more accurate placemarking than the tablet GPS application. However, in many locations, the Trimble GPS was unable to collect satellite data due to heavy canopy cover and the tablet GPS application was a suitable alternative. Although the tablet GPS does not provide pinpoint accuracy, it was found to provide placemarks nearly as accurate as the Trimble GPS; this was best achieved by displaying georeferenced project maps into the application PDF Maps. PDF Maps provides a continual GPS location of the tablet within the predesigned project mapping, allowing users to see where they are in reference to known reach breaks, street crossings, or other known locations. The tablet user can drop a pin directly into the PDF Map, but also move that pin into a more accurate position, using the project maps as a guide.

Tablet. We found that the use of a tablet for this data collection effort was efficient during preparation, in the field, and in managing data after the field work was done. It provides one field investigator the ability to collect field data in a predesigned data sheet, to take photos, and to record placemarks. No separate camera or handheld GPS unit is needed. However, we did find that it was difficult and/or time consuming for one investigator to be responsible for recording all the data. It was determined that two solutions are possible; use two tablets or use one tablet and bring hardcopy data sheets. With two tablets, one field investigator can collect photos, placemarks and reach-wide data, while the other investigator collects the reach segment data. With one tablet and hardcopy data sheets, the same affect can be achieved without needing two tablets.

5.2 PROTOCOL CHALLENGES

Modified Full Survey Plus Additional Data Collection. The greatest challenge for efficient data collection was the need to walk the entire length of each reach. In particular, it was difficult to coordinate the collection of reach segment data (the 60 meters of every 320 meters under the Full Study described by the WDFW protocol) and then continue to try to characterize the remaining 260 meters of the reach for only a portion of those parameters.

Collecting the additional 260 meters of data takes a substantially greater amount of time; (1) simply from walking five times more stream length, (2) because many areas are densely overgrown and take substantial effort to clear a path, (3) switching from one location to another could require decontamination for preventing the spread of New Zealand mud snails, (4) logistics of walking both upstream and downstream to bypass parcels with no access

permission, and (5) to allow for stopping to placemark, photo, and/or describe each outfall, armoring or erosion locations, count each piece of wood, any fish observed, fish passage barriers, and potential spawning habitat.

Although many of these parameters fall outside the WDFW protocol, they are still important pieces of data and provide a greater understanding of stream conditions. A key decision point for the City will be whether a rapid assessment for habitat is more desirable than a more comprehensive data collection of more features. To conduct only the WDFW habitat assessment, the time required is an average of 1.5 hours for each segment surveyed (depending on density of vegetation or difficulty to access), which translates to approximately 1 mile of stream sampled per day. For reaches that are entirely accessible (i.e. entirely within public land), up to 1.5 miles could be sampled in one day. Adding the additional data collection increases time to 2.5 hours per 1,050 feet (200 m), translating to one and a half days per mile.

Wolman Pebble Counts. Conducting Wolman pebble counts is particularly time consuming, since at least 100 measurements must be made within each riffle and because West Tributary is narrow and requires a high number of transects to complete the counts. We estimated that this added about 30 minutes to data collection at riffle habitat units. Wolman pebble counts should be a more reliably accurate estimation of fines and embeddedness when compared to visual estimation, which can vary widely between investigators. Visual estimations of fines for this protocol require that an entire HU be assessed for fines, while the pebble count typically considers a smaller area. It is recommended that one pebble count be conducted per reach along with visual estimation at habitat units, to provide the better estimation of potential spawning habitat.

Accessibility/Rights-of-Entry. Because West Tributary is an urban stream system there were challenges to gaining access to the entire stream length of interest. In particular, several segments could not be observed as a result of lacking rights of entry or from the presence of densely overgrown vegetation. These are described above in each reach description. However, even without observing these segments, the data collected is representative of each reach and adequately describes conditions.

5.3 PROPOSED REACH BREAK MODIFICATIONS

Reach 80_02. As described, this reach would be the portion of West Tributary that runs through the golf course. Currently, Reach 80_02 begins at a point approximately 50 meters from the end of the golf course property. However, the change in the stream conditions between the golf course and the adjacent residential area is distinct. It is recommended that this reach begin where the golf course ends and the home properties along NE 1st Street begin. With the new Reach 80_02 through the golf course, this new reach would become 80_03 and subsequent reaches would need to be renumbered.

Reach 80_05. Following confirmation that the entirety of Reach 80_05 is piped, it would make sense to extend that reach through the rest of the piped portion that is currently considered Reach 80_06. Reach 80_06 would then be revised to begin where Parcel 15375 begins.

All other reach breaks were confirmed to represent reasonable changes in geomorphic conditions.

6.0 REFERENCES

City of Bellevue. 2009. Final Report City of Bellevue Stream Typing Inventory. Prepared by the Watershed Company. Available at: https://www.bellevuewa.gov/pdf/Utilities/Streamtyping_Report.pdf.

City of Bellevue. 2016. Storm and Surface Water System Plan. Available at: http://www.ci.bellevue.wa.us/storm-surface-water-plan.htm on the Web.

Montgomery, D.R. 2008. A Simple Alphanumeric Classification of Wood Debris Size and Shape. Stream Notes; Rocky Mountain Research Station. Available at: http://gis.ess.washington.edu/grg/publications/pdfs/Montgomery_StreamNotes_Oct2008.pdf.

Washington Department of Fish and Wildlife (WDFW). 2009. Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual. Washington Department of Fish and Wildlife Habitat Program, Olympia, WA. Available at: http://wdfw.wa.gov/publications/00061/ on the Web.

Washington State Legislature. 2016. Fresh water designed uses and criteria. WAC 173-201A-200. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A-200.

7.0 FIGURES

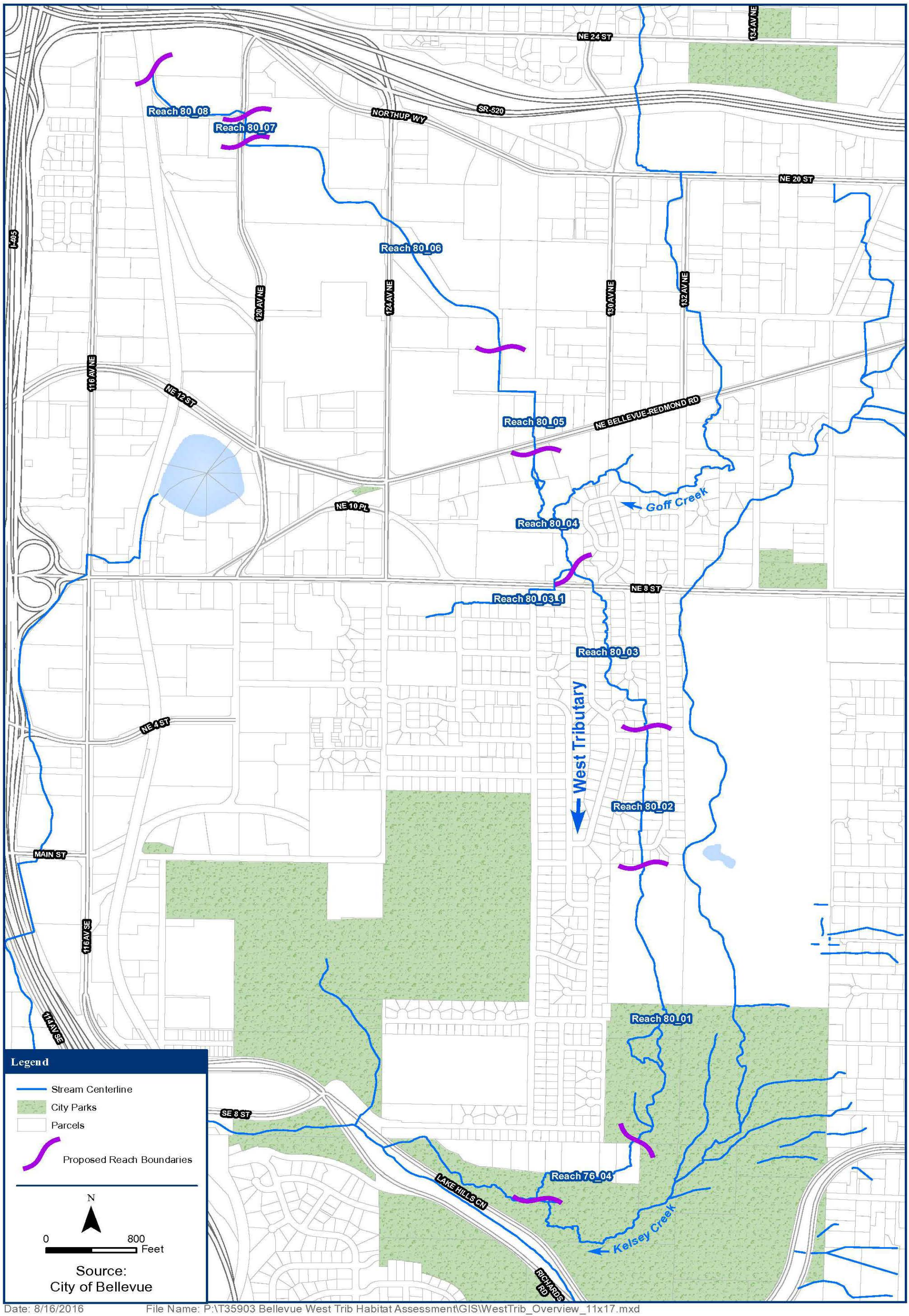


Figure 1. Overview of Reaches on West Tributary Stream

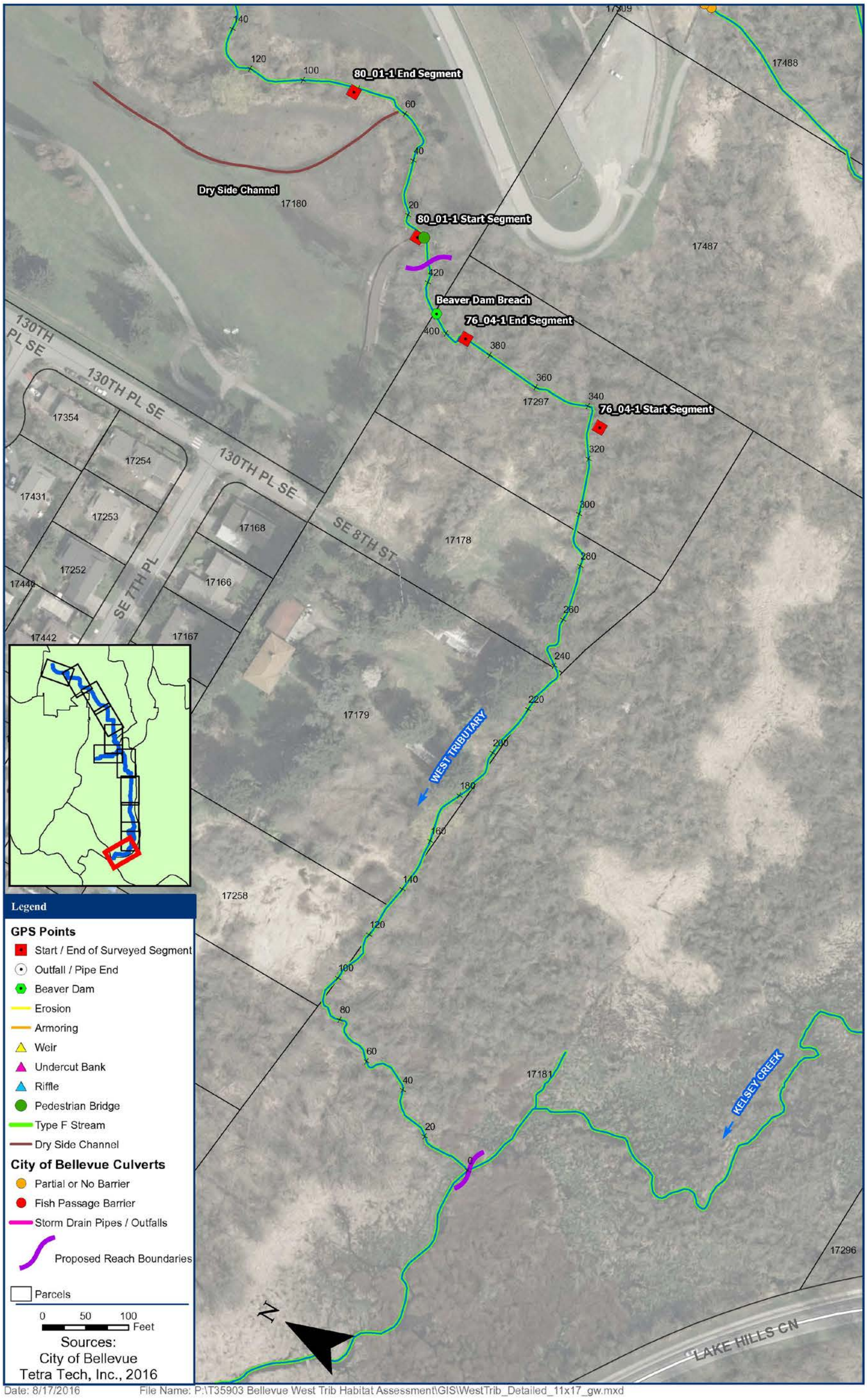


Figure 2. Detailed Reach Segment and Features Map 1 of 11

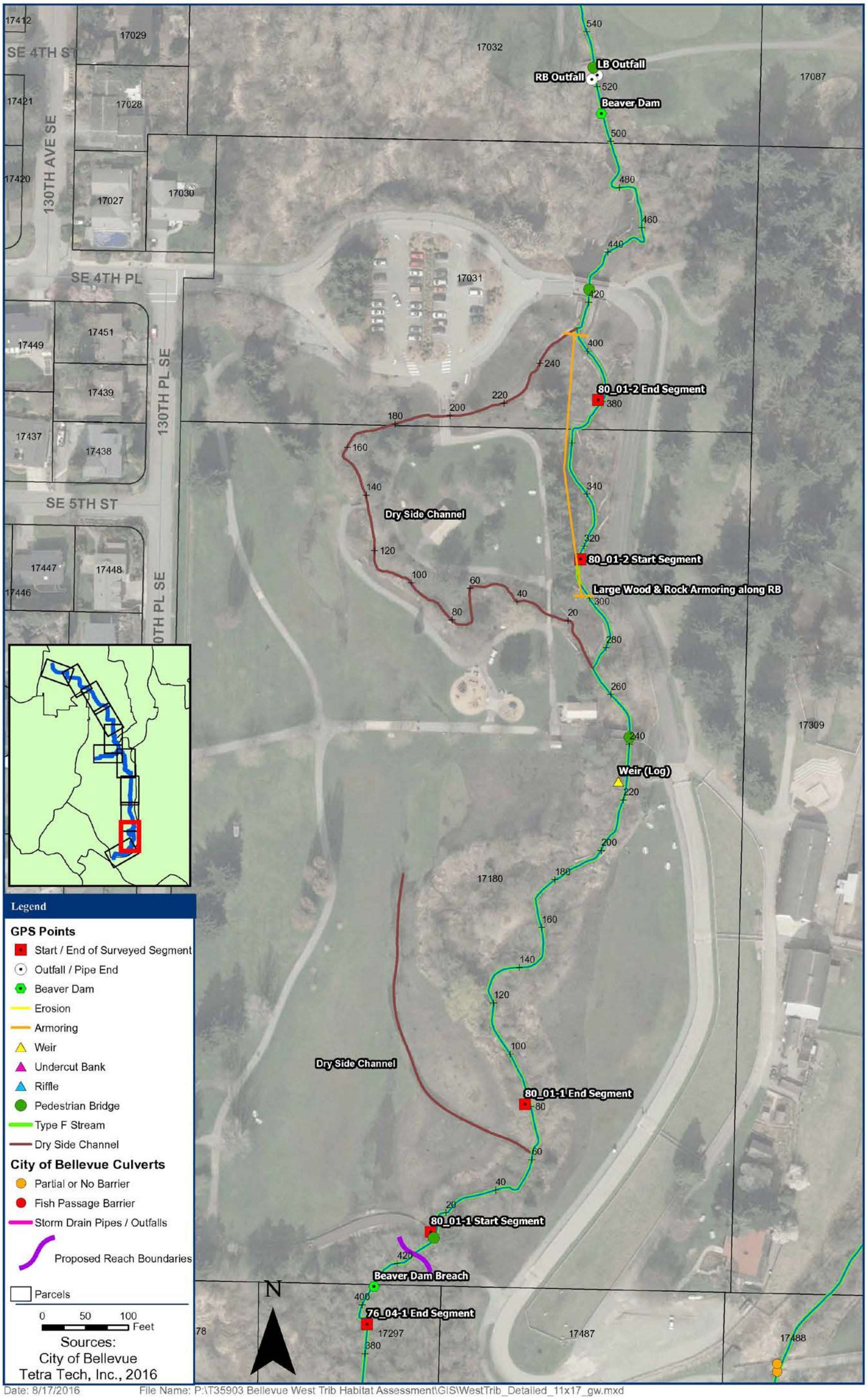


Figure 3. Detailed Reach Segment and Features Map 2 of 11

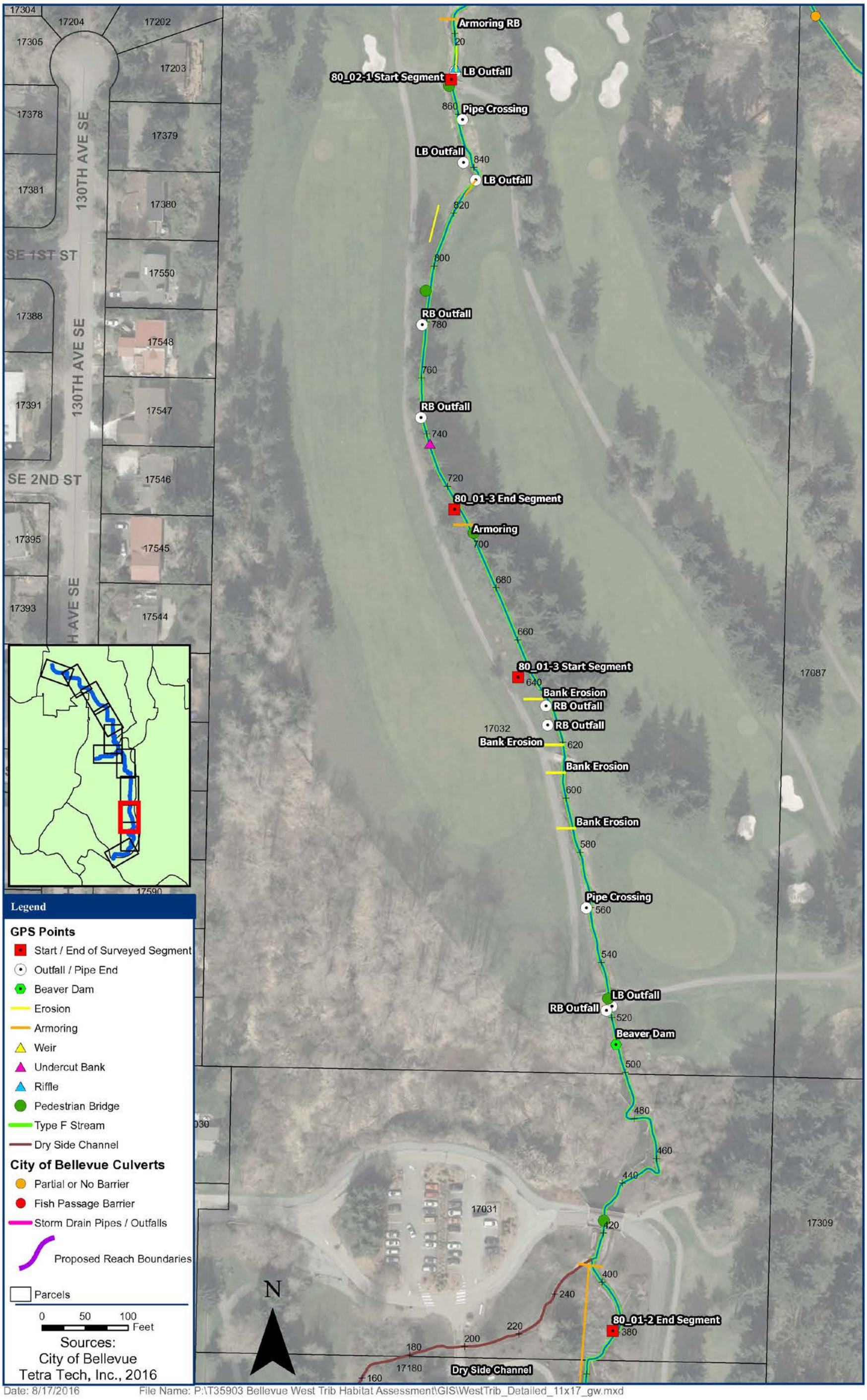


Figure 4. Detailed Reach Segment and Features Map 3 of 11

Figure 5. Detailed Reach Segment and Features Map 4 of 11

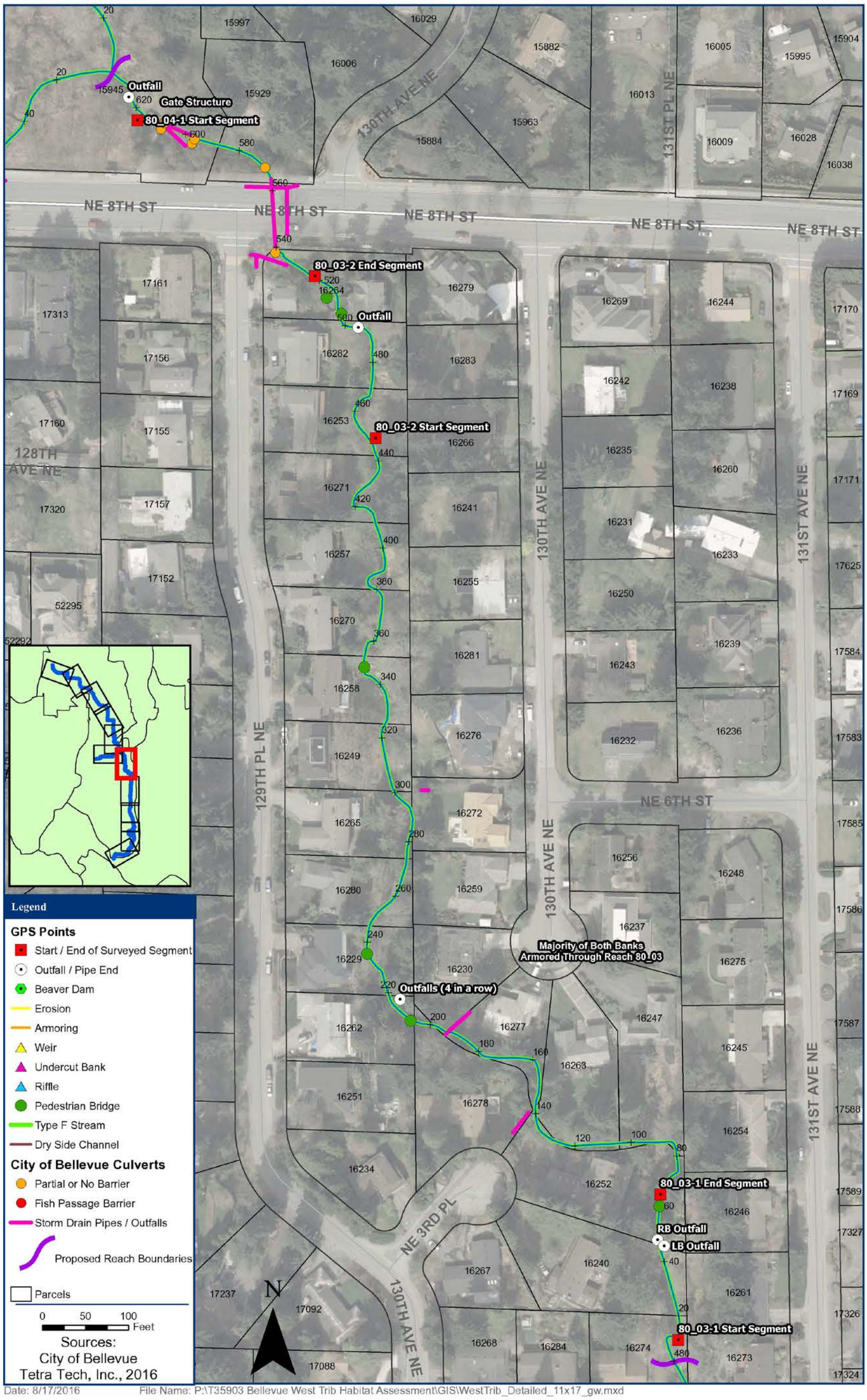
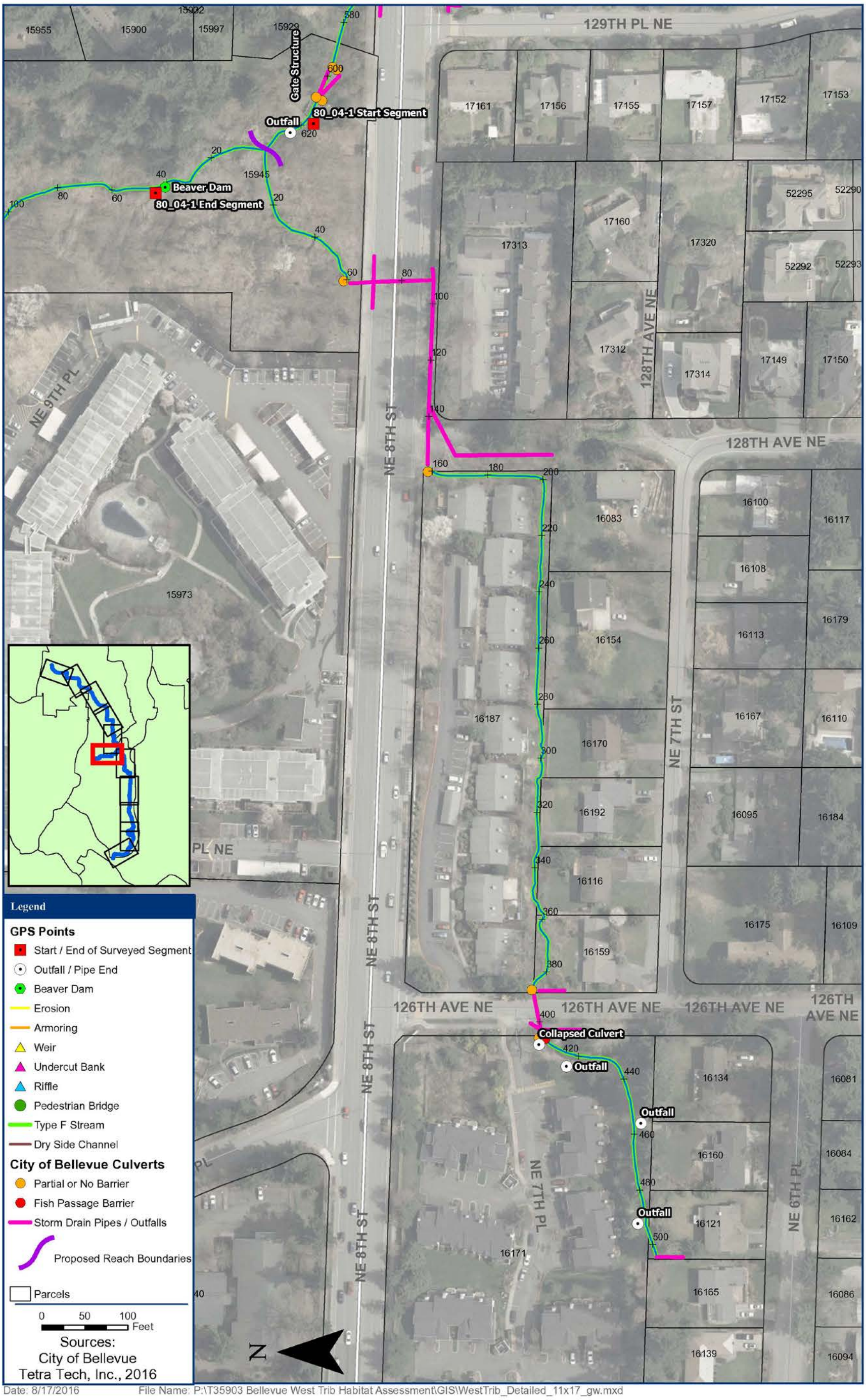


Figure 6. Detailed Reach Segment and Features Map 5 of 11



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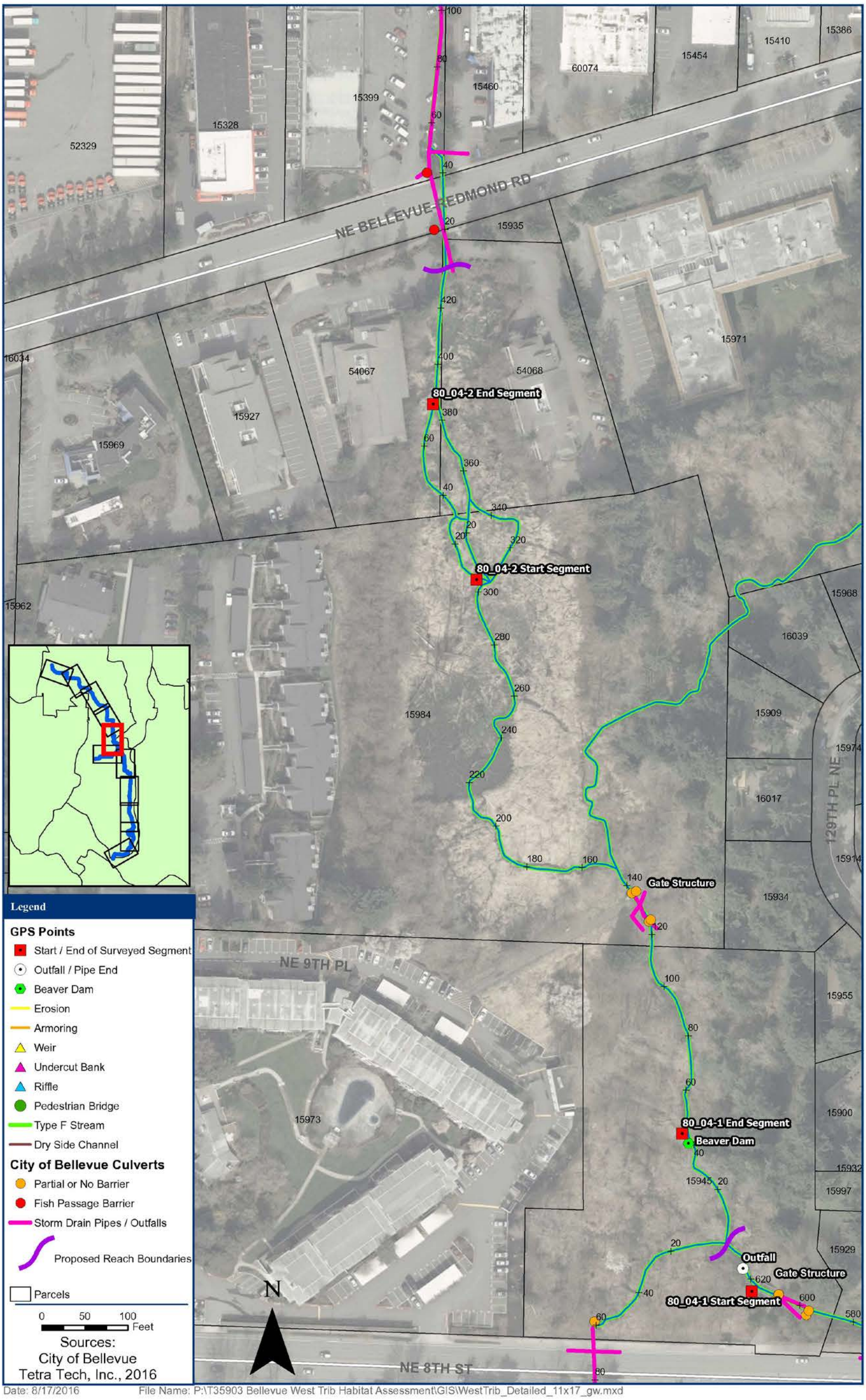


Figure 8. Detailed Reach Segment and Features Map 7 of 11

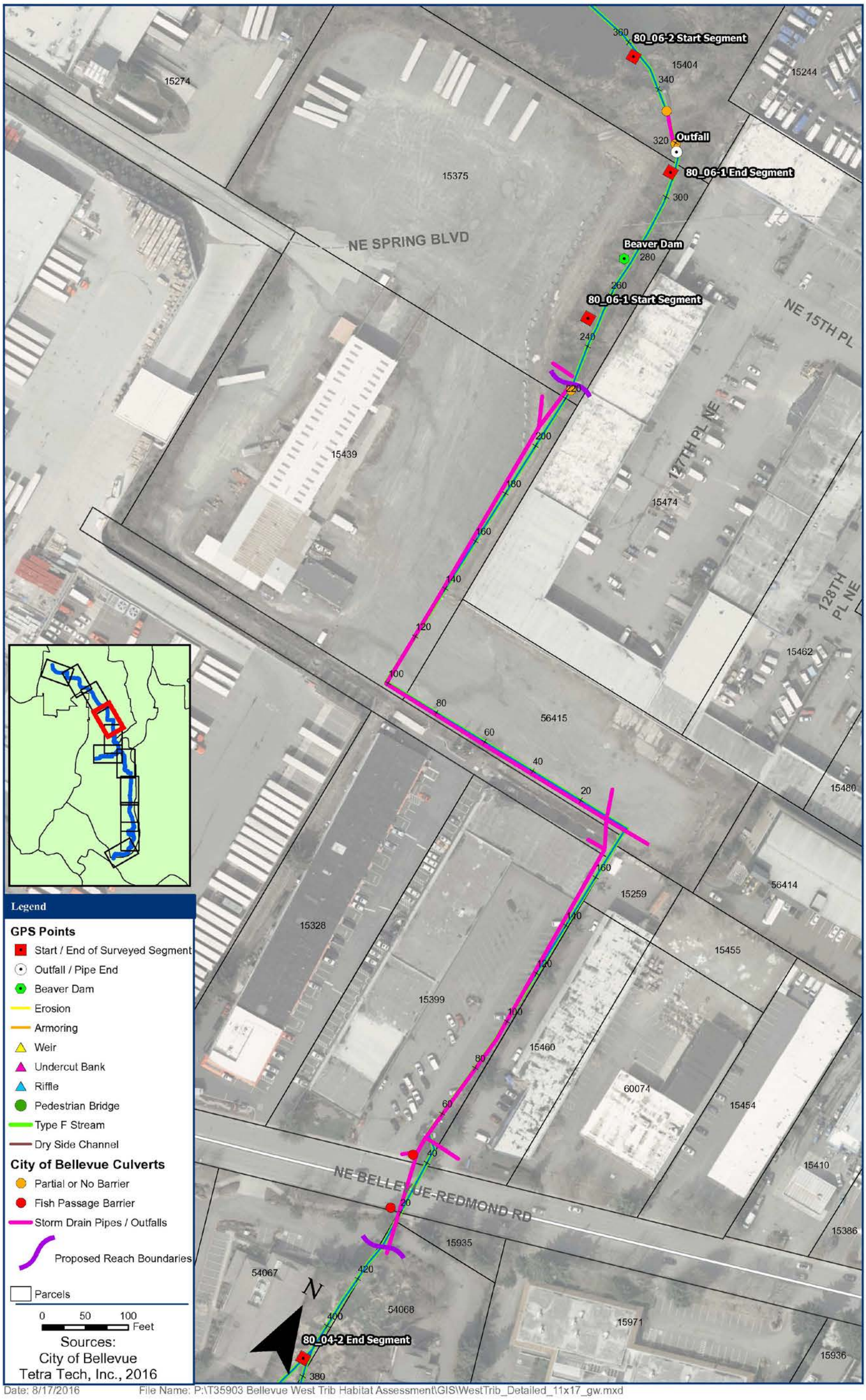


Figure 9. Detailed Reach Segment and Features Map 8 of 11

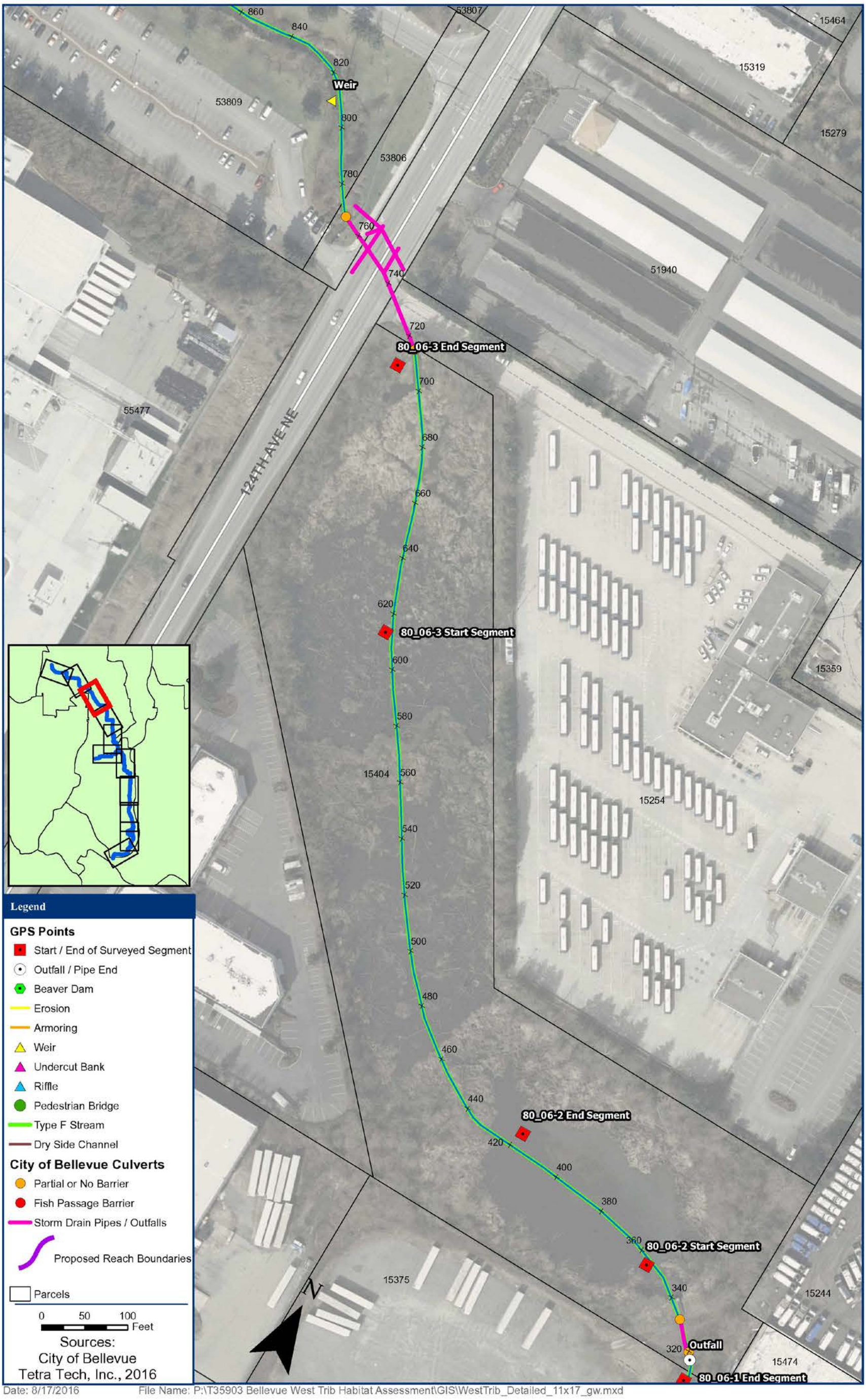


Figure 10. Detailed Reach Segment and Features Map 9 of 11

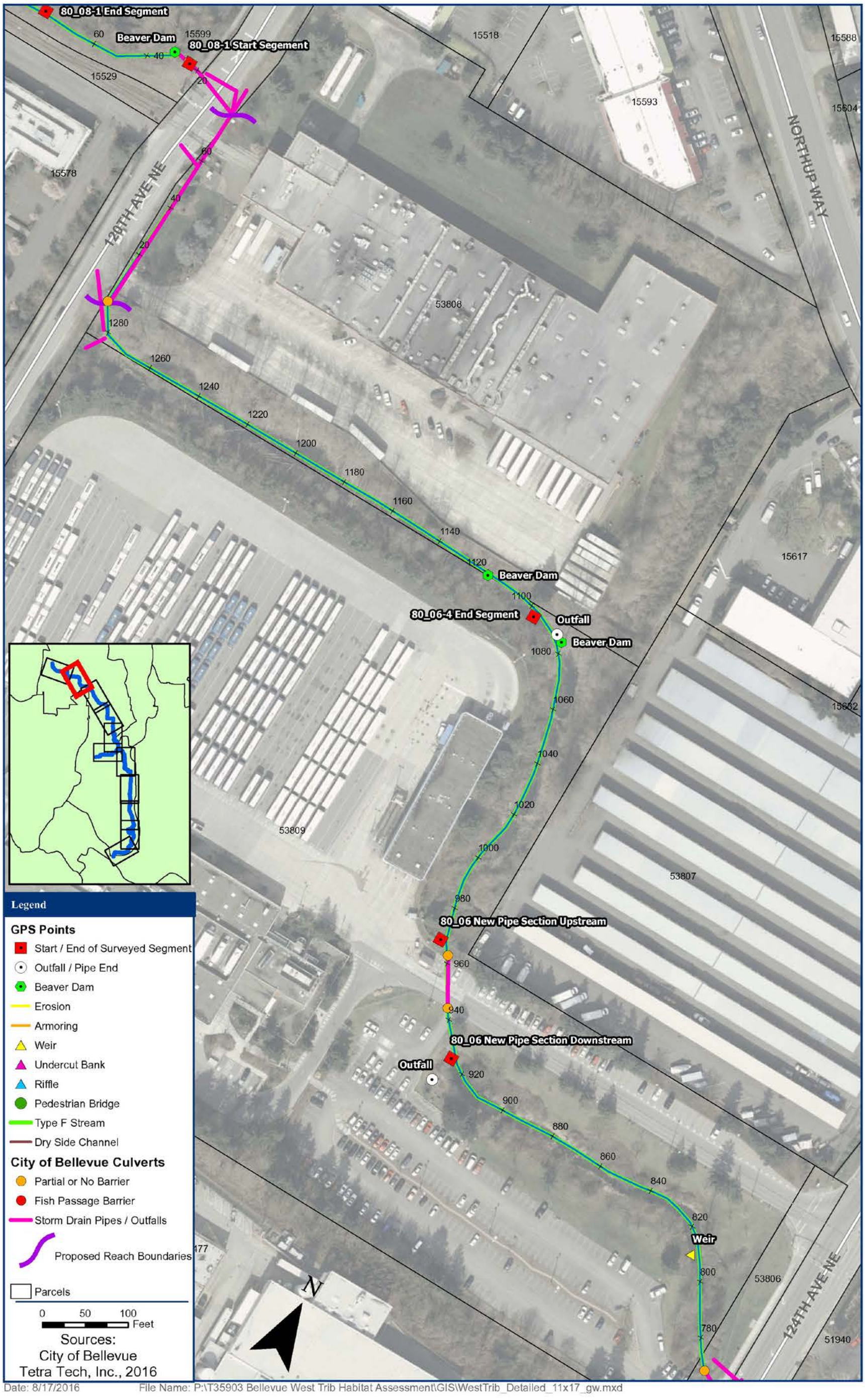


Figure 11. Detailed Reach Segment and Features Map 10 of 11

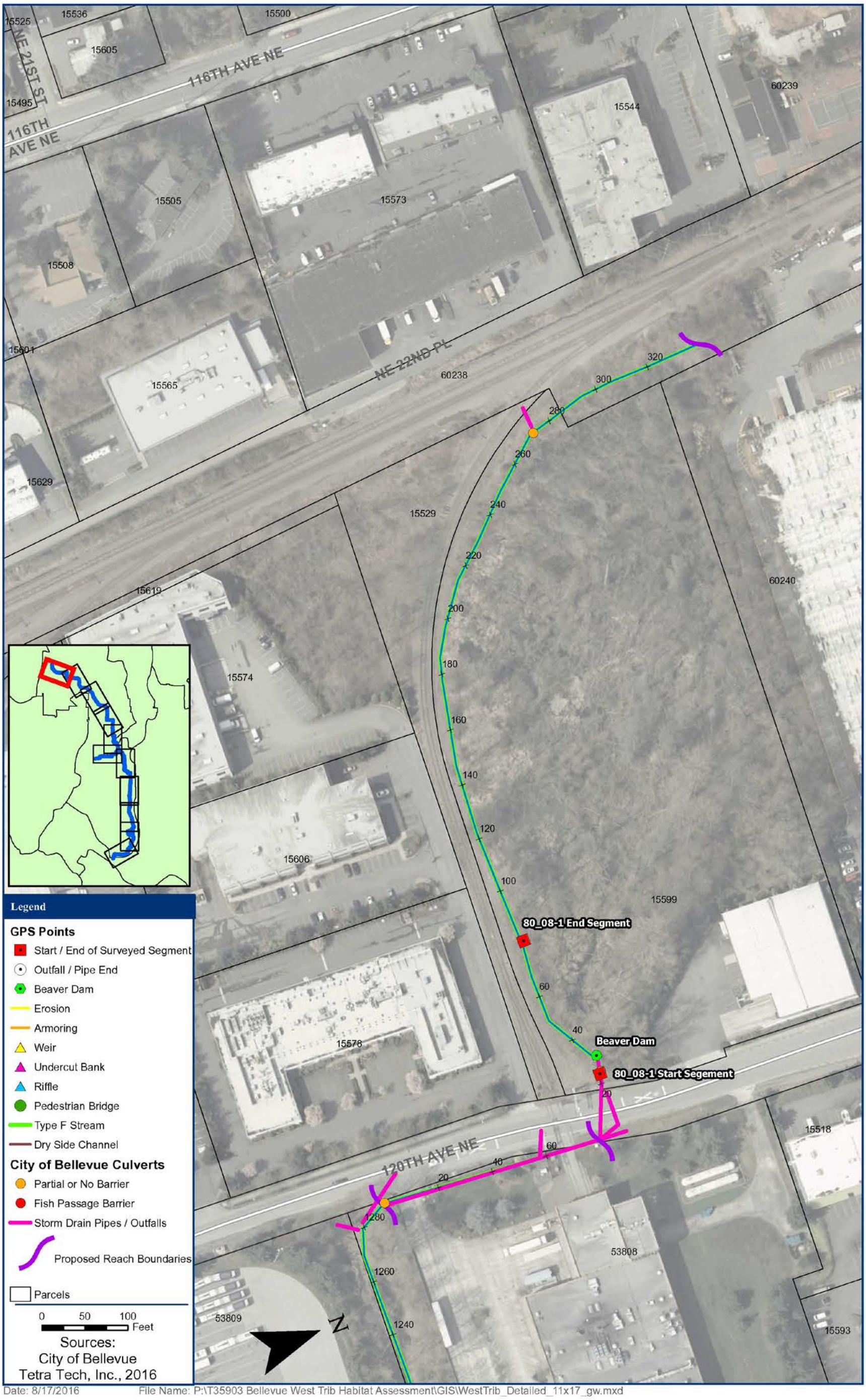


Figure 12. Detailed Reach Segment and Features Map 11 of 11

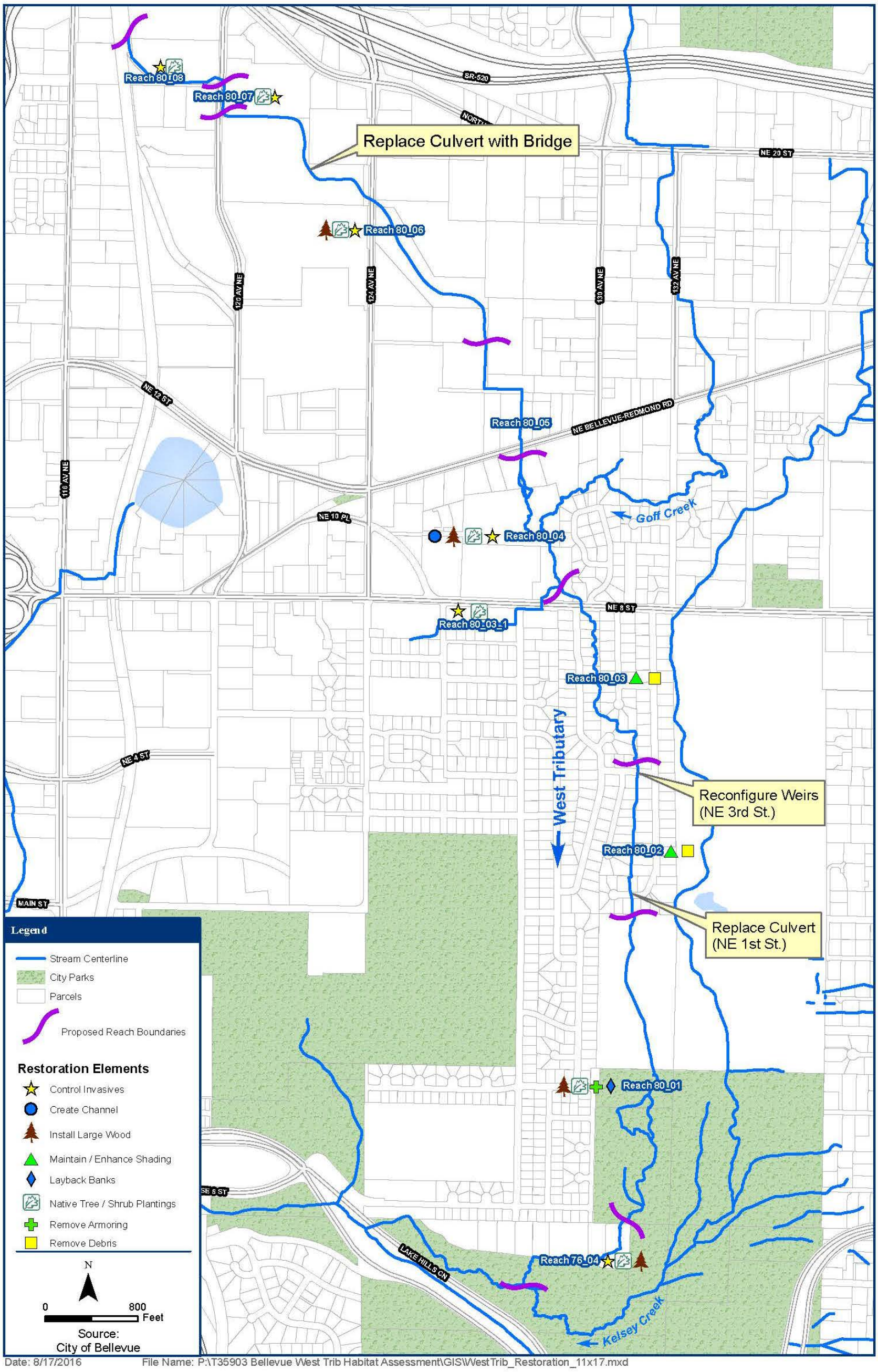


Figure 13. Proposed Restoration Measures Map

APPENDIX A – PDF DATA SHEETS
(EXCEL DATA SHEETS PROVIDED ELECTRONICALLY)

APPENDIX B – REPRESENTATIVE PHOTOS BY REACH

NOTE: Photos below are presented by reach, moving from downstream to upstream. Photos are representative of conditions at each reach, not all photos are shown here. Photos have been imported to GIS and are provided electronically.

Reach 76_04

Reach76_04-1 Beaver Pond Left Bank

Reach 76_04-1 Beaver Pond

Reach 76_04-2 Glide Habitat Unit

Reach 76_04-2 Glide Habitat Unit

Reach 80_01

Reach 80_01-1 Glide Habitat Unit

Reach 80_01-2 Large Wood

Reach 80_01 Golf Course Glide Habitat Unit

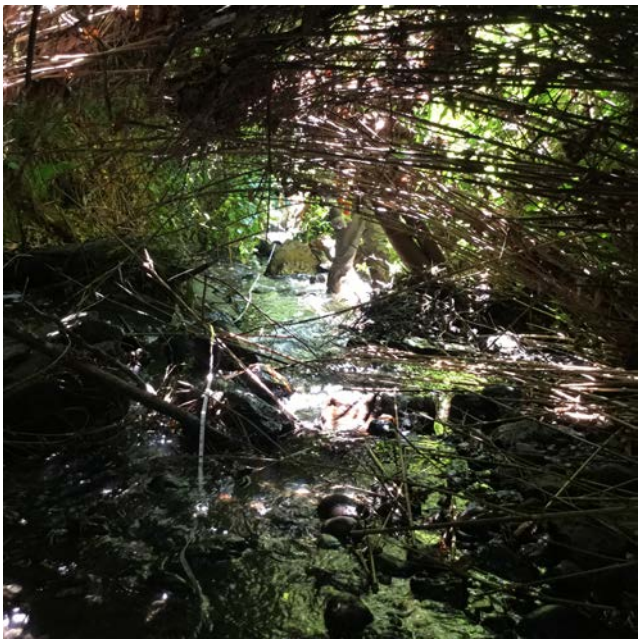
Reach 80_01 Golf Course Bank Erosion

Reach 80_02

Reach 80_02-1 Riffle and Armoring in Residential Area

Reach 80_02 Armoring and Fence in Residential Area

Reach 80_02-2 Overgrown Bamboo Over Riffle



Reach 80_02 Culvert at NE 3rd Street

Reach 80_03

Reach 80_03 Drop Structure in Residential Area

Reach 80_03-2 Low Bridge and Armoring

Reach 80_03-2 Glide Habitat Unit

Reach 80_03 Culvert at NE 8th Street

Reach 80_03_01-Trib

Reach 80_03_01 Culvert Emerging from NE 8th Street

Reach 80_03_01 Trib Beneath Blackberry

Reach 80_03_01-2 Collapsed Culvert at 126th Ave NE

Reach 80_03_01-2 Uppermost Reach of Trib

Reach 80_04

Reach 80_04 Gate Structure North of NE 8th Street

Reach 80_04 Culverts Downstream of Gate Structure

Reach 80_04 Beaver Dam

Reach 80_04-2 Reed Canary grass Obscures Stream

Reach 80_06

Reach 80_06-4 Glide Habitat Unit

Reach 80_06-2 Channel in Detention Basin

Reach 80_06-2 Wood and Cattails in Detention Basin

Reach 80_06 Culvert Outlet at 124th Ave NE

Reach 80_08

Reach 80_08 Culvert at 120th Ave NE

Reach 80_08-1 Pool Habitat Unit

Reach 80_08-1 Pool Habitat Unit Vegetation

Reach 80_08-1 Left Bank Vegetation

APPENDIX C – WOLMAN PEBBLE COUNTS

Wolman pebble counts (WPC) were conducted at West Tributary in the City of Bellevue to provide an assessment of substrate size classes. Data sheets are attached at the end of this Appendix. The procedure is appropriate to determine spawning substrate availability in salmon bearing streams. There were a total of four reaches with potential spawning substrate, including riffles primarily comprised of gravels, including 80_01, 80_02, 80_03, and 80_04 (Table 1). WPCs were not done on the other reaches as they were dominated with fines.

For each of these reaches, WPCs were conducted in one or more representative riffles, for a total of 7 pebble counts (Table 1). At all WPC sites, visual estimation of fines was also made for comparison. Total size class distribution for each of these sites is reported in the attached WPC data sheets, along with percent of each size class in Table 1, and cumulative particle size distribution graphs in Figure 1. Total measurements taken and transects walked are reported in the attached data sheets.

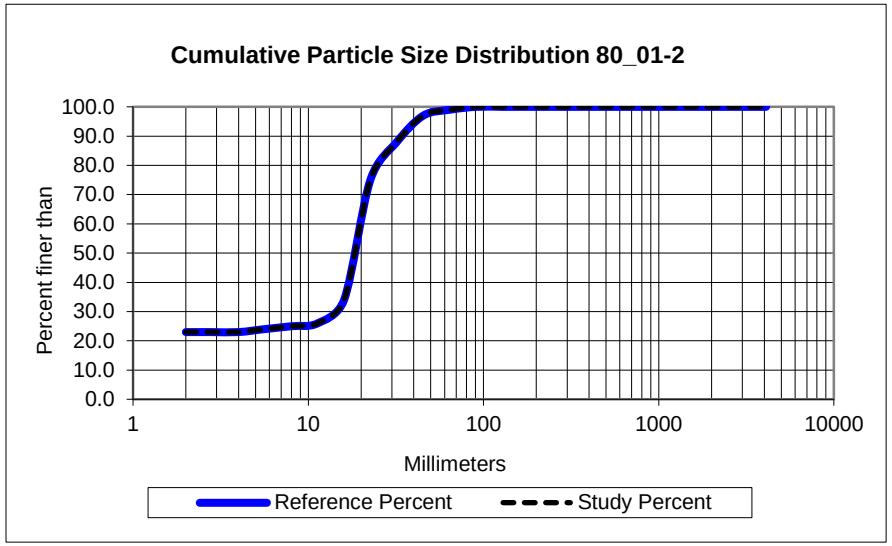
Reach 80_01. Within this reach, there were two suitable spawning substrate areas, located within segments 2 and 3. Dominant particle size classes within the reach included gravels, then fines, then cobbles. Within reach segment 80_01-2, 74% of all particles selected during the WPC were gravel, followed by 23% fines, and 3% cobble. Fines were estimated at 30% through visual estimation. Reach segment 80_01-3 had 77% gravel, 21% fines, and 1% cobble. Fines were visually estimated at 20%. Bed roughness is estimated as n = (0.28+0.02+0.0+0.005+0.05)1.0 = 0.36.

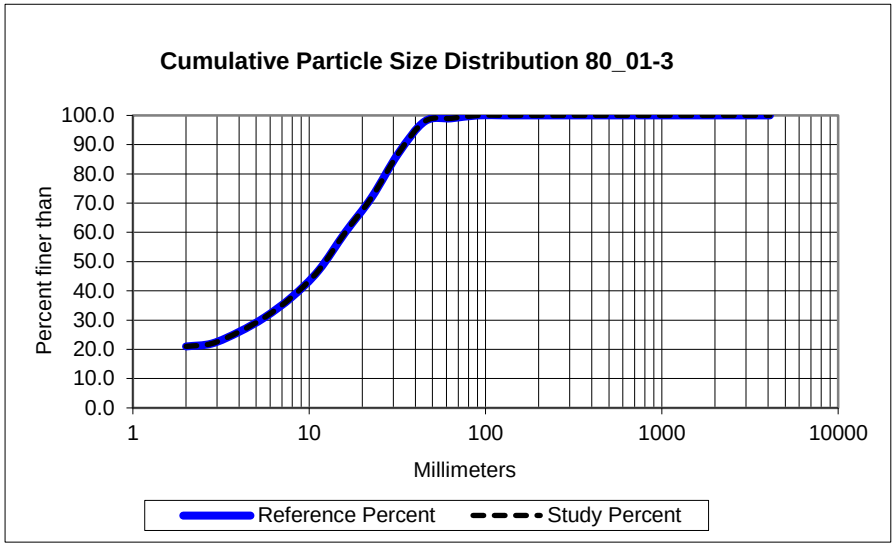
Reach 80_02. In this reach, there were two riffles with potential spawning substrate. Reach segment 80_02-1 substrate size classes were primarily gravels at 71.1%. Fines made up 15.8% and cobbles comprised 13.1%. In comparison, visual estimates of fines was 30%. Reach segment 80_02-2 had mostly gravel at 55%, a larger percentage of cobbles at 22%, boulders present at 20% and only 3% fines. In this case, visual estimation of fines was much higher than the WPC outcome, at 20%. The greater visual estimation of fines is most likely the result of the length of the riffle. The overall fines percent for the entire 60-meter habitat unit (HU1) was estimated, while the WPC was conducted in only one portion of that segment. Bed roughness is estimated as n = (0.30+0.02+0.0+ 0.01+0.05) 1.0 = 0.38 in the lower section and n = (0.40+0.02+0.0+0.02+0.1) 1.0 = 0.54 in the upper section (more boulder debris and dense bamboo).

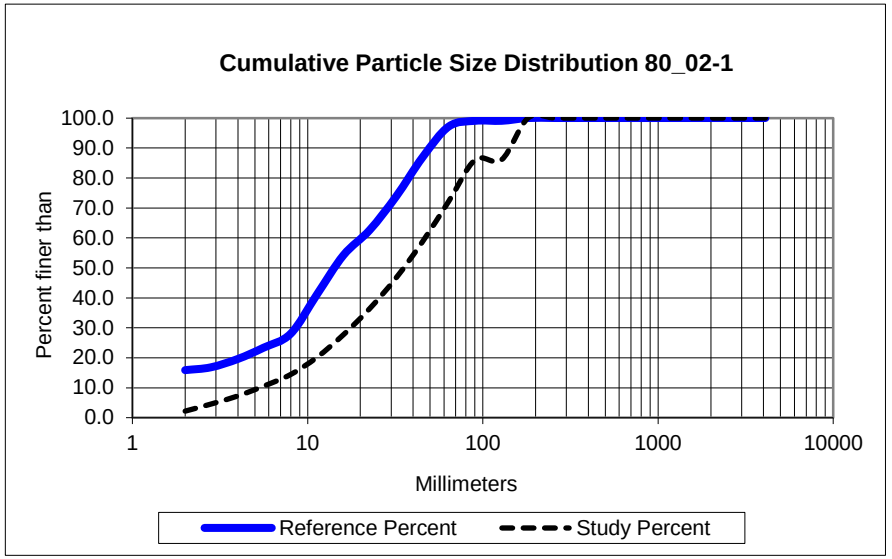
Table 1. Visual and Wolman pebble count results for substrate size class percentages.

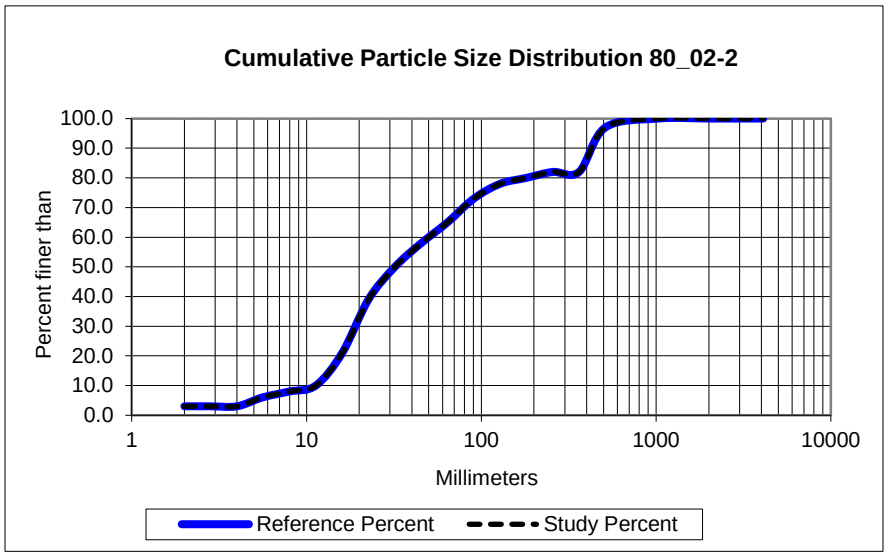
Segment	HU	Visual Estimate of Fines	Boulder	Gravel	Cobble	Fines	HQM Value
80_01-2	4	30	0	74	3	23	Poor
80_01-3	1	20	0	77	1	21	Poor
80_02-1	5	30	0	71.1	13.1	15.8	Good to Excellent
80_02-2	1	20	20	55	22	3	Good to Excellent
80_03-1	3	25	1	77	10	12	Good to Excellent
80_03-2	1	20	<1	74.9	6.1	18.1	Fair
80_04-1	1	50	0	67	1	32	No Value

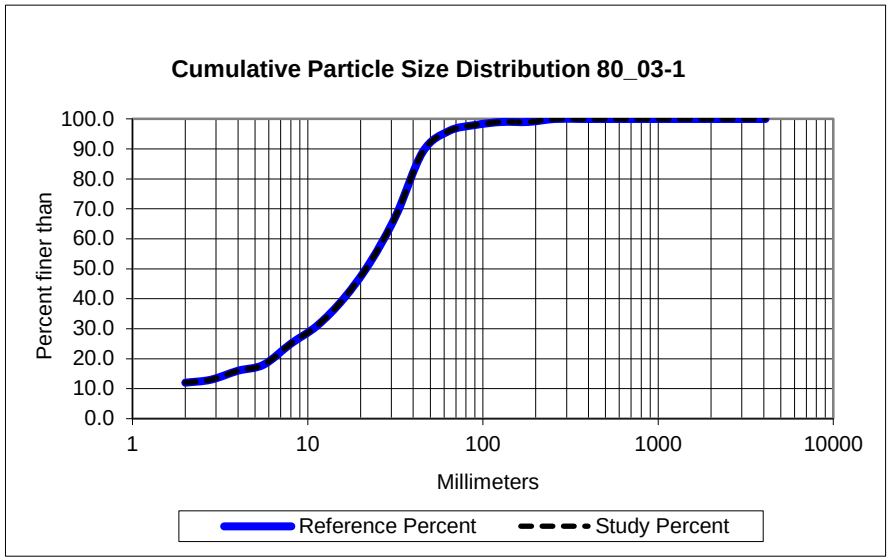
Figure 1. Cumulative Particle Size Distribution for Each Wolman pebble count Site

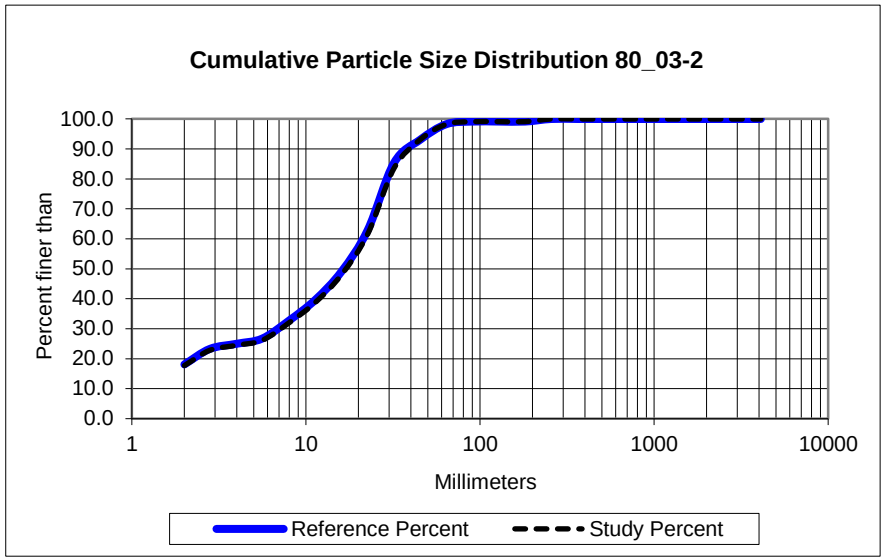


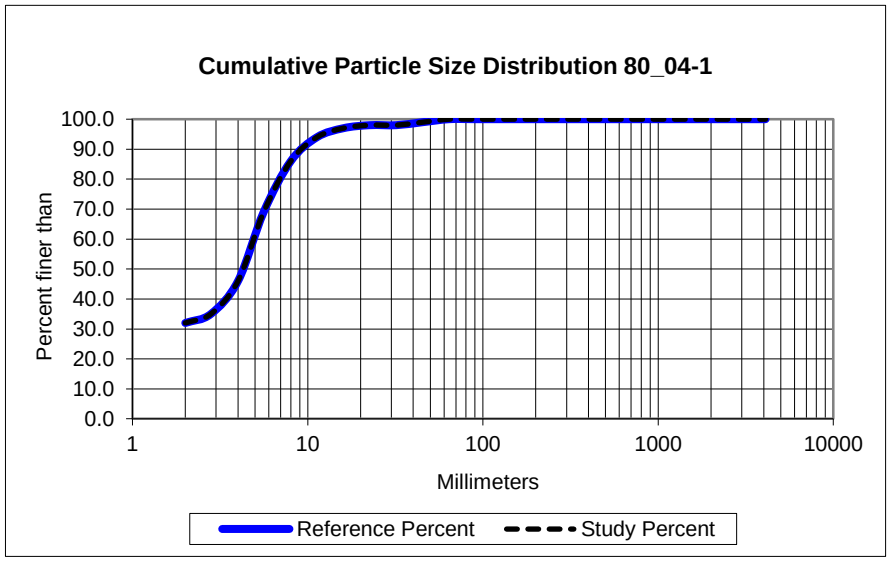







Cumulative Particle Size Distribution 80_03-1
Percent finer than
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
1
10
100
1000
10000
Millimeters
Reference Percent
Study Percent


Cumulative Particle Size Distribution 80_03-2
Percent finer than
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
1
10
100
1000
10000
Millimeters
Reference Percent
Study Percent


Cumulative Particle Size Distribution 80_04-1
Percent finer than
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
1
10
100
1000
10000
Millimeters
Reference Percent
Study Percent

Reach 80_03. Pebble counts in segment 80_03-1 resulted in a total of 77% gravel, 12% fines, 10% cobble and 1% boulders. Visual estimation placed fines at 25%. Segment 80_03-2 had 74.9% gravel, 18.1% fines, 6.1% cobbles, and <1% boulders. Visual estimation for this site was 20% fines. Bed roughness is estimated as n = (0.28+0.02+0.0+0.01+0.05)1.00 = 0.36.

Reach 80_04. At this site only one segment had a suitable riffle for a pebble count at 80_04-1. Total gravel was 67%, fines were 32%, and cobble was 1%. Visual estimation placed fines at 50%. Bed roughness is estimated as n= (0.28+0.01+0.002+0.04+0.05)1.0 = 0.38.

In cases where the visual estimation of fines was larger than the WPC percent of fines, it is most likely the result of two factors: 1) the presence of larger particles covering the fines, so fines are not selected in a pebble count; and 2) a significant difference in the area that is being evaluated. For visual estimation, the percent of fines is estimated for the entire segment. For the WPC, the area is typically only one riffle habitat unit. The visual estimation then provides an overall evaluation of the spawning substrate condition, while the WPC represents the channel bed roughness.

In Table 1, WPC fines are shown to range from 3% to 23%. These results indicate the best possible spawning habitat potential within the associated stream segment. Visual estimations for the entire reach are higher, ranging from 20-50%. The Habitat Quality Modifier (HQM) for spawning habitat criteria, which is to be used to determine the Priority Index (PI) for restoring fish bearing streams, results in No Value at sites with fines >26%. HQM is poor at sites where fines are 21-26%, and fair when comprising 16-21% of substrate. WPC results indicate that there are at least three spawning habitats of good to excellent quality and one fair quality site in the West Tributary.