Willow Creek Daylighting
Draft – Early Feasibility Study
Edmonds, Washington

April 12, 2013

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WILLOW CREEK DAYLIGHTING
DRAFT - EARLY FEASIBILITY STUDY
EDMONDS, WASHINGTON

1.0 INTRODUCTION

Willow Creek is a tributary to Edmonds Marsh, an estuarine tidal marsh located within the City of Edmonds (the City) (Figure 1). Willow Creek (393-acre basin) and Shellabarger Creek (378-acre basin) are the primary freshwater tributaries to Edmonds Marsh (SAIC, 2013). The current-day marsh flows along a 600-foot-long channelized ditch, "Willow Creek," then into a 1,600-foot pipe (with a vault and tidegate system) to a point 200 feet offshore of the City of Edmonds Marina Beach Park, discharging into the Puget Sound. The ditch, pipe, and tidegate system severely limit fish passage and tidal flow into Willow Creek and Edmonds Marsh. This early feasibility study evaluates the potential to restore tidal inflows and fish passage into Willow Creek and Edmonds Marsh. Several alternative alignments were evaluated, and a preferred alignment was selected for further evaluation of fish passage, marsh habitat improvements, and evaluation of potential floodplain effects. The feasibility study was performed for the City and EarthCorps (originally contracted with People for Puget Sound), and funded through a Salmon Recovery Funding Board Grant (Prism Project Number 11-1553N).

The marsh is currently bordered by State Route (SR) 104 to the east, Harbor Square to the north, the BNSF Railway Company (BNSF) railroad tracks to the west, and the Chevron/Unocal property (and 216th Street SW) to the south. The marsh is primarily owned by the City, with other bounding property owners including the Washington State Department of Transportation (WSDOT) (SR 104), the Chevron/Union Oil Company of California (Unocal) property to the south, BNSF property to the north and west, and Harbor Square property to the north. Edmonds Marsh receives freshwater flow from Willow Creek (to the south) and Shellabarger Creek (to the east).

1.1 Study Purpose and Scope

The Willow Creek Daylight project is currently in the "early" feasibility stage of development. The purpose and scope of this phase of study is to explore the feasibility of providing (and maximizing) Chinook salmon access to rearing habitat, and evaluate the potential size and habitat types in Edmonds Marsh. The specific early feasibility study objectives include:

- Document the existing conditions, topography, and hydrology of the Edmonds Marsh complex.
- Screen and evaluate three daylight alternatives based on:
  - Fisheries functional and biological response,
  - Coastal hydrodynamics, and
  - Engineering, cost estimates, infrastructure, and property and political constraints.
- For the preferred alternative:
  - Develop a conceptual plan and cost estimate of the alternative,
  - Perform hydrodynamic modeling of the daylight alternative,
  - Quantify future juvenile Chinook rearing habitat areas,
  - Assess water depths and hydroperiods of potential rearing areas,
  - Evaluate impacts on flood water surface elevations, and
  - Provide information and recommendations for future phases of restoration design and permitting.

1.2 Ecosystem Restoration Context

Edmonds Marsh and Willow Creek have been impacted by historical rail development, industrial development and urbanization of City of Edmonds. Urbanization of the City's shoreline is similar to the documented urbanization effects throughout the Central Basin of the Puget Sound (Collins, Sheikh, 2005). Habitat losses of the Central Basin shoreline include hydrologic modification of streams and tidal systems, restricted fish passage and access, filling, and fragmentation and significant losses of pocket estuary marshes and lagoon complexes. The Central Basin Puget Sound shoreline is dominated by loss of freely available sediment sources, restricted fish access to small watersheds, and significant loss of historical backshore and pocket estuary, marsh, and lagoon complexes.

During the 20th Century establishment of the Great Northern Railway; industrialization of the waterfront by the logging, sawmill and shingle industries; development of the Port of Edmonds (the Port), and the urbanization of the City, all have contributed to significant connectivity and habitat resource losses. This reflects similar trends in anthropogenic modifications and losses that have contributed to an estimated 40 percent loss of pocket estuaries throughout the Puget Sound (PSNERP, 2011). The historical marsh has been estimated to been more than 100 acres in size (Gersib 2008), extending from Point Edmonds north to Brackett's Landing, which today is the intersection of Main Street and SR 104. The current marsh area west of SR 104 is estimated at 27 acres, which is a loss of 73 acres and a 73 percent loss in historic marsh areas.

Edmonds Marsh was historically a pocket estuary marsh formed by a sand-spit barrier that formed from coastal sediment shoaling patterns from south to north at Point Edmonds. The sand spit provided protection from coastal wave and wind forces to Edmonds Marsh. Pocket estuaries are partially enclosed bodies of marine water that are connected to a larger estuary at least part time, and are diluted by freshwater runoff from tributary or groundwater source (Pritchard, 1967). Pocket estuaries typically are formed as shoreline features including embayments, lagoons and ponds that develop behind coastal geologic and depositional features and include sand spit and barrier embayments and coastal inlets (Beamer, 2005).

These pocket estuary habitats provide juvenile Chinook (and other salmonids, prey and forage fish) with rearing, feeding, shelter and osmoregulation functions (Beamer and others, 2003). The Shared Strategy for Puget Sound Chinook Recovery (Redman and others, 2005) identifies barrier estuaries and features like it on the shoreline to be invaluable as resting, feeding, and physiological transition zones for the smallest life history types of migrating salmonids, including juvenile Chinook. Historical use by non-natal juvenile Chinook for juvenile rearing was highly likely in the Willow Creek/Edmonds Marsh system. Even though the marsh is somewhat distant to large salmon bearing rivers, such as the Snohomish and Skagit Rivers, studies have documented migration to the City of Edmonds beach areas (Figure 2 - Adapted from King County 2004).

Willow Creek Daylight and Edmonds Marsh restoration represents a rare nearshore habitat resource, and prime restoration opportunity within the WRIA 8 nearshore area. The Willow Creek Daylight project is currently on the WRIA 8 three-year habitat work schedule (I.D. M233) and is listed as a Tier 1 project. Tier 1 designation indicates the highest quality remaining habitat, and the greatest Chinook use (WRIA-8, 2013).

2.0 HISTORICAL AND EXISTING SITE CONDITIONS

Historical conditions of the marsh have changed significantly since the marsh was originally mapped in 1870. Since that time, the railroad, sawmill industry, forestry, farming and city urbanization have changed the landscape of the marsh. A brief historical change analysis is provided for reference purposes.

2.1 Historic Physical Conditions

Edmonds Marsh was historically a sand-spit, barrier (pocket) estuary marsh. The 1870s Government Land Office T-Sheet map shows the sand-spit barrier running north from Point Edmund, heading north towards Brackett's Landing, which is north of the current Washington State ferry terminal (Figure 3). The location and orientation of the spit were due to sediment shoaling, transport, and deposition in a northward direction from Point Edmund. The historical body of the sand spit was likely located near, what is today, the central area of the Port of Edmonds Marina. The historical tidal channel outlet of the channel was likely north of the N-dock, near the Port's administration office.

2.2 Anthropogenic Impacts to Edmonds Marsh

Edmonds township was settled in the 1870s after the discovery of the town site by George Brackett, who is considered by many the "founder of Edmonds" (History of Edmonds, 2012), and the namesake of the Edmonds Ferry "Bracketts Landing" location. European settlement, port development, rail construction, industrial sawmills, oil and gas production, and commercial and residential development essentially began in the 1870s.

In 1891, the Great Northern Railway reached the Edmonds shoreline and was established along the waterfront and western edge of the marsh on the historical barrier sand spit. The railway brought the opportunity for greater transportation and commerce to the region.

From the 1890s until 1951, the Edmonds waterfront was dominated by heavy industrial operations including sawmills and shingle mills. The last shingle mill was closed in 1951. In the 1940s, the marsh area was farmed and used for cattle pasture (Figure 4). Of note, in 1944 the marsh had two large tidal channels with the tidal outlet in what is now the Port of Edmonds Marina. Sometime between 1944 and 1953, filling of the Harbor Square corner of Admiral Way started and by 1967 the fuel dock was in place (Figure 5).

In 1923, the first automobile ferry was established between Edmonds and Kingston. Private ferry services were operated through 1950, when the ferry was taken over by the State of Washington Ferry System. The ferry dock is now located at what was historically the northwestern corner of the marsh. A recent study was performed by the Federal Highway Administration, the State of Washington, and the City to evaluate the feasibility and environmental impacts for possible relocation and construction of a multi-modal facility (and new Washington State ferry terminal) near the current Edmonds Marina Beach Park. This project is not currently moving forward.

In 1962, the Port of Edmonds completed construction of the Edmonds Marina. This included rerouting of the Willow Creek drainage south (in its current alignment) through a series of pipes underneath the BNSF railway and Admiral Way, into a 48-inch reinforced concrete pipe that flows south towards Edmonds Marina Beach Park. At the park, the creek flows into a storm vault which has a steel, top-hinge tidegate. Currently, this tidegate is allowed full operation (closing on incoming tides) from late October/early November through early March. In early March, the City staff hoists open the tidegate, which is held in that position until the next fall (October). The configuration and operation of the pipe outfall system is described further in the existing conditions section of the report.

2.3 Chevron/ Union Oil Company of California (Unocal) Property

From 1923 to 1991, Unocal operated the Edmonds fuel station. Fuel would arrive by ship at the fuel dock. The historical fuel dock alignment is located underneath the south parking lot at today's Edmonds Marina Beach Park (Figure 5). Fuel would be transferred via pipeline over the railroad tracks to processing facilities and storage tanks located on top of the bluff at Edmonds Point. Fuel was then distributed via fueling trucks to the greater Seattle region. The Unocal site was also used for asphalt production for more than 25 years. The Chevron/Unocal site has petroleum and heavy metal contamination that requires cleanup and removal of contamination.

In 1993, Unocal entered into an "agreed order" with the Washington State Department of Ecology (Ecology) for remediation of the site (Chevron, 2013). In 2001, an interim cleanup plan was approved by Ecology and Unocal initiated cleanup work on the "Upper Yard," which was the processing and storage tank area on top of the bluff. One hundred and twenty-five thousand (125,000) tons of contaminated soils were removed from the yard. Ecology issued a letter confirming completion of the Upper Yard cleanup in 2003. Since that time, condominium units were developed on the Upper Yard, known as Point Edwards.

The second phase of cleanup was associated with the 23-acre Lower Yard which is south and adjacent to Edmonds Marsh. In the period of 2001 through 2003, several remediation actions were performed by Chevron. In 2004, Chevron assessed the extent of contamination in the Lower Yard and verified that surface water and sediment in the Willow Creek Drainage ditch adjacent to the site were contaminated with petroleum and heavy metals. In 2007 and 2008, Chevron conducted several remediation actions including excavation of more than 140,000 tons of contaminated soils and sediments exceeding Ecology standards, and removal of more than 9,000 gallons of petroleum product from the site. The project also included installation of a stormwater drainage system, regrading (fill), and planting native species on the site. Since 2008, Chevron installed 28 groundwater monitoring wells at the site. Data are being collected to determine if the remaining petroleum concentrations in the soil exceed the groundwater contamination standards. The monitoring efforts will be used to evaluate if additional cleanup actions are necessary at the site (Chevron, 2013). Monitoring is ongoing and communications with the Chevron consultant indicate that a draft report was in development and may be available in 2013.

In 2005, Unocal (Chevron) entered into escrow for transfer of the lower yard property to WSDOT to be used for mitigation in the Edmonds Ferry, multimodal facility. Recent discussions between the City of Edmonds and WSDOT have indicated that the lower yard areas may no longer be required for mitigation for the relocation of the ferry terminal.

2.4 Existing Watershed Conditions

The Edmonds Marsh is located in an urban/suburban watershed. Two streams, Willow and Shellabarger Creeks, are the main stream inputs to the marsh. The City of Edmonds, Dayton Street/SR 104 study indicates that the contributing watershed basin to the Marsh is 833 acres (SAIC, 2013). Approximately 393 acres drain the Willow Creek basin and 378 acres drain the Shellabarger Creek basin, not including other smaller basins such as Harbor Square or Edmonds Point basins. The following section is a detailed description of the Willow Creek drainage system. Shellabarger Creek is treated as inflow to the Edmonds Marsh and Willow Creek system at the SR 104 culvert crossings. From this point downstream, this report describes the project as the Willow Creek/Edmonds Marsh system. Photographs that accompany the existing watershed descriptions are included in Appendix A.

2.4.1 Freshwater and Stormwater Inputs

The Willow Creek headwaters has two distinct sub-basins. The first sub-basin originates southeast of the marsh in a residential neighborhood within the City of Edmonds near 224th Street SW and 97th Avenue SW, near Westgate Elementary School. The second sub-basin originates south of the marsh in the town of Woodway near N. Deer Drive. Willow Creek flows as a stream channel with some stormwater pipes in the upper system. The creek enters Edmonds Marsh through a culvert at Pine Street, near the Trout Unlimited hatchery (Photograph 1). Historically, Willow Creek flowed along the southern margin of the marsh and along the Chevron/Unocal stormwater pond and property (Figure 4). Over recent history, Willow Creek has filled with sediment and has a dispersed, unconfined flow pattern into the Edmonds Marsh freshwater emergent cattail vegetation. There has been some minor restoration and native revegetation activities along Willow Creek near the hatchery.

Shellabarger Creek is the next drainage system northeast of the Willow Creek, also originating near 224th Street SW and 95th Place W to the south and east, with Holly and Cedar Streets the general boundary to the north (Photograph 2). The Shellabarger system collects stormwater flows between Pine Park neighborhood. Shellabarger daylights near 4th Avenue S, flows in a confined channel between two apartment complexes, and discharges into a freshwater (stormwater) wetland east of SR 104. Shellabarger Creek flows beneath SR 104 in two 48- by 72-inch steel pipe arches just south of Harbor Square (and Dayton Street/SR 104 intersection). As Shellabarger Creek flows beneath SR 104, there is no distinct channel and the stream flows in an unconfined flow pattern into the Edmonds Marsh freshwater emergent cattail vegetation (Photograph 3). During large storm events, part of Shellabarger Creek flow travels north along the SR 104 east ditch towards the intersection with Dayton Street.

Hydrologic modeling data were made available from the City's, Dayton Street and SR 104 stormwater study for Willow and Shellabarger Creeks (SAIC, 2013).

Harbor Square is a commercial area to the north of the marsh that discharges stormwater to the marsh through a series of pipes and bioswales.

These aforementioned stormwater inputs are at the upstream, northern end of the marsh and would be the primary (current) contributors of stormwater contaminants to the marsh sediments, vegetation, and biota. Several additional stormwater inputs flow into the marsh at the downstream end (or intermediately) of the Willow Creek channelized section of stream (Photograph 4).

The Chevron/Unocal property also discharges stormwater into the Willow Creek/ Edmonds Marsh system. There is a pump and pipe operation from the stormwater pond. Shannon & Wilson observed stormwater overflows from the pond into Willow Creek on April 13, 2012 (Photograph 5).

WSDOT maintains a stormwater conveyance system that follows Edmonds Way/SR 104 south, and then east along the old Unoco Road. The southern extent of this basin has not been defined in the Dayton/SR 104 study. The basin may extend south a significant distance along 100th Avenue W. This pipe system crosses the Chevron/Unocal property along Unoco Road and then Willow Creek at the pipe outlet through the BNSF railway (see further description below).

At this location, the WSDOT pipe manhole has been observed to overflow and dislodge the manhole cover and discharge to the Willow Creek system (Shuster, 2012) (Photograph 6). Hydrologic inflows from the WSDOT pipe system have not been estimated and are not known at this time. The WSDOT pipe system crosses the BNSF railway and Admiral Way and flows south, parallel to the Willow Creek 48-inch concrete pipe and through the Marina Beach Park, eventually discharging offshore from the park beach into the Puget Sound.

The Edmonds Point stormwater system outlets from a 36-inch corrugated polyethylene pipe (CPEP) from the east, into Willow Creek at the same location where the creek crosses the BNSF railway (Photograph 7).

There are likely other stormwater inflows from the BNSF railway and rail yard to the west of the channel.

Major inflows from Willow and Shellabarger Creeks were assessed in this study. Additional inflow information is recommended for the Edmonds Point, Chevron/Unocal, and Harbor Square stormwater systems in future studies. It is recommended to also collect water quality data for each of the inflow and stormwater tributaries for future studies.

2.4.2 Marsh Vegetation and Stream Flow Hydraulics

Edmonds Marsh supports freshwater and salt-tolerant plant species, with a fairly distinct transition in vegetation type occurring midway along the marsh as observed running from the Harbor Square tennis courts to the eastern edge of the Chevron/Unocal treatment pond. Earlier studies have reported that the emergent salt marsh plants are restricted to lower elevations compared to other salt marshes in Puget Sound and attributed this to the constriction of tidal flow through the pipe and culvert system (Pentec, 1998). This is likely an effect of tidal muting, whereby significant conveyance losses occur in the stormwater pipes, vaults, and confined ditch and allow only a portion of saltwater tidal flow into the marsh. Also, the operation of the tidegate in winter months limits inflow and tidal exchanges that affect marsh vegetation and habitats. The existing marsh vegetation and habitat estimates include 3.2 acres of mudflats, 5.9 acres of low salt marsh vegetation, 11.4 acres of freshwater marsh, and 6.1 acres of forested wetland.

The downstream (western) portion of the marsh shows evidence of saltwater vegetation, tidal channels, and mudflats (Photograph 8). Distinctive tidal channels are observed running adjacent to the Chevron/Unocal treatment pond on the south side of the marsh, and a larger tidal channel originating at the northern edge of the marsh near the Harbor Square tennis courts.

Historically, Willow Creek flowed in a ditch along the western side of the marsh near the Chevron/Unocal stormwater pond. During recent stream reconnaissance, it was observed that Willow Creek has filled with sediment and there is no direct connection to this relict ditch. Instead, Willow and Shellabarger Creek both disperse flow in thick and dense cattails when the streams enter the marsh. There were no distinct stream channels observed in the marsh.

At the westernmost location of the marsh and northwestern corner of the Chevron/Unocal stormwater pond, Willow Creek flows into a 700-foot-long, confined, channelized ditch along the BNSF embankment (Photograph 4). The Chevron/Unocal website indicates that this area has been planted with native vegetation. Shannon & Wilson has observed little native vegetation with stands of invasive scotch-broom.

The channel has little to no overhanging vegetation, cover, or instream habitat (such as large woody debris). The channel appears to be wholly located within the Chevron/Unocal property, based on geographic information system information provided by the City (City of Edmonds, 2012). Recent communications with the City indicate that this section of the Chevron/Unocal property remains in escrow with WSDOT, who had originally planned to use the property for stream mitigation for the Edmonds Crossing project. We recommend the Chevron property ownership and escrow issues be researched to better understand the property ownership and easement conditions along the daylight channel proposed alignment.

2.4.3 Existing Marsh Discharge to Puget Sound

At the downstream end of the Willow Creek channel adjacent to the Chevron/Unocal property and the BNSF railroad tracks, there is an embankment spanning the channel with two pipes that have flow control gates. The easterly pipe is a 36-inch corrugated metal pipe (CMP) with a circular slide gate that was partially closed as shown on the Perteet survey sheet (Perteet, 2012). The second, westerly pipe is a 22-inch steel pipe that was fully closed as shown on the Perteet survey sheet (Perteet, 2012). The current understanding is that these pipes and gates are owned and operated by Chevron/Unocal as part of their stormwater management for the property. These pipes and gates, if they remain closed, can severely limit the amount of tidal flow into the marsh and drainage from the marsh. This study strongly recommends that the City's coordination and operation of the gates be more fully understood and considered. It may be the case that these gates are kept closed most of the time, and they could be contributing to the flooding of SR 104 by backing up the entire Willow Creek system. We recommend the City coordinate with Chevron to understand ownership and operation of these gates on Chevron / Unocal property.

Willow Creek then discharges westward through two 42-inch concrete pipes beneath the BNSF railway into a small pond between the railway and Admiral Way (Photographs 9 and 10). Willow Creek then enters the City storm vault I.D. 2401. The creek discharges into a 48-inch CMP that flows 600 feet southwest along Admiral Way and the BNSF railway south, towards Marina Park. This section of pipe is owned by the Port of Edmonds who charges the City a fee for its use. If the pipe is abandoned, the City may need to renegotiate the fees pertaining to this pipe. The pipe has been reported as aging and is in need of replacement, and likely contributes to the significant hydraulic losses and reduction in upstream tidal prism inflow and drainage (Shuster, 2012).

At the northeast corner of the Marina Park, parking lot, the CMP pipe connects with the City of Edmonds storm vault I.D. 2457 with the 48-inch, top-hinge steel tidegate leading to a 48-inch high-density polyethylene (HDPE) pipe (Photograph 11). The City of Edmonds stormwater department operates the gate for flood protection between late October and early March allowing the tidegate to open and close normally. From early March to late October, the City uses a truck and hoists open the flapgate at a 90 degree angle to the flow line. The City has reported that when in normal operation (fall/winter period) the gate closes, but is not watertight (Moles, 2012).

The tidegate vault then discharges south into the 48-inch HDPE pipe into a second vault located approximately 50 feet south near the Marina Park grassy area between the parking lots. This pipe outfall system was recently constructed in 2004 and extends approximately 1,000 feet to the west and discharges offshore into Puget Sound at an approximate elevation of -9.0 feet (NAVD88) (Photograph 12).

The Marina Beach Park and pipe outfall are located in an area that is part of the historical sand spit at Point Edward (Photograph 13). The site lies at the northern end of a 5-mile-long drift cell, identified as SN-3 (U.S. Geological Survey [USGS], 2010). This drift cell collects and transports sediment from feeder bluffs and stream deltas along the Puget Sound shoreline. Sediment is transported from as far south as Shoreline, Washington, whereby wind and wave action act in a northerly direction moving sediment along the shoreline to the Edmonds Point area.

Other elements of the Marina Beach Park include the BNSF Railway bridge which is located just east of the off-leash dog park area gate entrance (Photograph 14). The off-leash area and the south parking lot, and the treed and grassy knoll area are discussed further as part of the future park studies and possible daylight channel realignment locations (Photographs 15 - 17).

The tidal range at Edmonds is approximately 11 feet between mean lower low and mean higher high tides. The mean higher high water (MHHW) for the National Oceanic and Atmospheric Administration (NOAA) tidal station 9447427 is 10.94 feet (NAVD88).

2.4.4 Tidal and Stream Hydrology Data Collection

In support of the study objectives, tidal hydrology, water surface elevations, temperature, and salinity were collected for the project from September 2012 through March 2013. The data-collection period will extend through June 2013, and the data will be presented in a separate data report. The LTC-1 data logger is located in Edmonds Marina (Photograph 18). The LTC-2 data logger is located in the Willow Creek channelized section of the stream (Photograph 4). The Shellabarger Creek LTC-3 data logger is located just north of SR 104 near the culvert crossing (Photograph 2). Tidal hydrology data are summarized in Figures 6 through 8. Data collected indicates that the water elevations in Willow Creek are "muted" and less than the tide. This is a result of the operation of the tidegate and, when not engaged, losses through the stormwater pipe system and the Chevron/Unocal pipes and gates at the end of the Willow Creek channel. Daylighting the channel will likely effect the Willow Creek flow and water surface elevations, and is discussed further in the preferred restoration alternative. The data indicate that Shellabarger Creek marsh is disconnected and does not fully drain into the Edmonds Marsh, likely resulting from thick cattails and clogged culverts. This lack of drainage connection likely contributes to stormwater flooding of SR 104. Also, the data indicate that Shellabarger Creek is primarily freshwater and does not mix with the incoming tidal inflows. This is likely as a result of the thicket of cattails impeding flow exchange in the marsh. Finally, the Willow Creek LTC-2 data logger shows high spikes in temperature above 16 degrees Celsius in September. This is above the lethal limit for salmonids, and is likely a result of poor vegetative cover along the channel.

In working in tidal systems, it is important to document the project survey data. For the purposes of this study, the project vertical datum is the North American Vertical Datum of 1988 (NAVD88). Elevations in tidal environments (and from NOAA tidal stations) are often reported in mean lower low water (MLLW) datum. A vertical transformation of -2.09 feet was calculated using NOAA's VDatum v3.1 computer program (NOAA, 2012). The project elevations can be determined as follows:

MLLW Datum Elevation – 2.09 feet = NAVD88 Elevation

As an example, the MLLW elevation (MLLW datum) of 0.0 feet would be an elevation of -2.09 feet for the MLLW elevation (NAVD88).

2.5 Existing Fish Habitat Conditions

The fish community that has been documented utilizing existing habitats in the Edmonds Marsh and contributing creeks is comprised of coho salmon adults, an occasional chum salmon adult, resident and sea-run cutthroat trout, three spined stickleback, and sculpin (Pentec, 1998; WSDOT, 2004; O'Connell and others, 2009). The Willow Creek Hatchery historically raised coho salmon and Chinook salmon with annual releases of between 2,000 to 8,000 coho fry into Willow Creek (Pentec, 1998). More recently, the hatchery produces only coho fry, but none are intentionally released into the creek (WSDOT, 2004; Thompson, pers. comm., 2012). Low numbers of juvenile coho salmon have been observed in Willow Creek in 2012 (Rice, pers. comm.; Schlenger, pers. obs.). Prior to the early 2000s, it was estimated that approximately 20 to 40 adult coho salmon returned to the creek each year (WSDOT, 2004). However, more recently, no adult coho salmon have been observed in Willow Creek (Thompson, pers. comm., 2012). The following paragraphs describe existing habitat conditions for fish, in particular salmonids, in Edmonds Marsh starting from downstream and moving upstream through the marsh to Willow and Shellabarger Creeks.

2.5.1 Connectivity to Puget Sound

The fish habitat conditions in Edmonds Marsh are strongly influenced by the restrictions to the connectivity of the marsh to Puget Sound, as well as the development that has occurred in the surrounding watersheds. A primary consideration in characterizing fish habitat in the marsh is the blockage of fish movement between the marsh and Puget Sound that the pipe and culvert system poses. Available information indicates that until recent years, a small number of adult coho salmon and an occasional adult chum salmon or sea-run cutthroat trout will locate the outlet pipe in the lower intertidal zone and migrate upstream through the approximately 1,600 feet of the pipe and channel to enter the marsh system (Stay, pers. comm., 1995) as reported in Pentec (1998) (Thompson, pers. comm., 2012). Other salmonid life stages and other fish species are not known to enter the marsh from Puget Sound.

Aerial photographs and other mapping sources show macro-algae and eel grass beds near the beach shoreline (WSDOT, 2004) and the beach areas may be mapped as forage fish, surf-smelt spawning areas (PSNP, 2005). These conditions would indicate forage fish availability and habitat for both juvenile and adult salmonids. Future study phases should confirm nearshore macro-algae, eelgrass, and forage fish spawning conditions on the beach and nearshore area as it relates to habitat conditions, environmental documentation, and permitting.

Adult salmonids migrating upstream into the marsh, after exiting the pipe from the low intertidal zone to the railroad tracks, encounter the 700-foot-long confined channel that leads to the marsh. Since the mid-2000s, no adult salmonids have been documented entering the creek and migrating all the way to the Willow Creek hatchery (Thompson, pers. comm., 2012). It is possible that low numbers of adult salmonids have entered the marsh during this time, but not migrated up to Willow Creek. The straight channel that upstream migrating fish encounter after migrating up the outlet pipe is poor habitat for salmonids as it offers no instream structure or overhanging riparian vegetation. WSDOT (2004) described the confined channel bottom as having "exclusively muck and the water is uniformly shallow, warm, and exposed." Shannon & Wilson field staff observed a sandy substrate with occasional gravels in the confined channel in summer 2012.

We found no current documentation of current juvenile Chinook salmonid habitat use in the marsh.

2.5.2 Existing Marsh Habitat Conditions

In the main body of Edmonds Marsh, habitat conditions range from freshwater to brackish. The extent of saltwater inundation, the vegetation communities along the salinity gradient, and the overall shape of the marsh are controlled by the tidal exchange through the tide gate and stormwater pipe system, the inputs of freshwater from the surrounding watershed, and the development that has encroached on the marsh's historic footprint of nearly 100 acres. The marsh includes a distinctly estuarine area extending across approximately the western third of the marsh and a freshwater wetland in the remaining areas. Although there is a gradient in the salt tolerance of plants within the estuarine portion, there is a fairly abrupt transition between the estuarine and freshwater portions of the marsh. The estuarine portion of the marsh supports a variety of native plant species in higher salinity areas (e.g., seashore saltgrass and pickleweed) to lower salinity areas (e.g., saltmarsh bulrush and Lyngby's sedge) (Pentec, 1998). The more salt-tolerant plant species occur primarily along the drainage channels in the estuarine portion of the marsh (O'Connell and others, 2009). Pentec (1998) reported that the high tide elevations in the marsh are lower than those documented in nearby shoreline areas with unrestricted tidal exchange due to tidal muting. As a result, the distribution of estuarine emergent plants in the marsh is limited to tidal elevations that are lower than observed in other comparable salt marshes in Puget Sound (Pentec, 1998). The estuarine portion of the marsh includes unvegetated areas and shallow tidal channels, as well as an open channel along the margin of the Chevron property to the south of the marsh. The remaining two-thirds of the marsh area on both sides of SR 104 support freshwater vegetation. Dense growth of cattail vegetation, along with purple loosestrife and climbing nightshade are reported (Pentec, 1998). Purple loosestrife has now been nearly extirpated from the area due to biological controls. Recent surveys of the marsh show that there are no direct channels connecting the streams with the saltwater tidal channel sections of the marsh (Perteet, 2012). As a result, there is no channel route for fish to move between the creeks and the estuarine marsh. Furthermore, filling of drainage channels in the freshwater wetland due to siltation from the upper watershed has limited saltwater inundation and enabled the freshwater marsh to expand to the west (City of Edmonds, 2008).

Pentec (1998) characterized the fish habitat in the estuarine portion of the marsh as "marginal to fair rearing habitat" citing the lack of instream structure and marginal water quality in summer months (due to high water temperatures). The estuarine portion of the marsh area provides some rearing habitat for juvenile salmonids and other small fish that are able to survive in saltwater. In considering the quality of the habitat, the availability of prey items for fish is an important consideration and the estuarine portions of Edmonds Marsh can be expected to produce an abundance of prey items because salt marshes are typically highly productive habitats. During high tide, the marsh provides habitat for fish to move throughout the inundation area. During low tide, the marsh drains until only the tidal channels, the channel along the Chevron property, and marsh outlet channel are available. WSDOT (2004) characterized the open channel habitats between the marsh outlet and the upper extent of the Chevron property as "poor" or "very poor" habitat.

Fish access to much of the freshwater portions of the marsh appears limited, except in the approximately 600-foot-long channel along the southern margin of the marsh. This channel is not fully connected with the confluence of Willow and Shellabarger Creeks due sedimentation and establishment of freshwater cattails in the upper marsh. In the area near the confluence of the creeks, the channel is "highly braided and difficult to follow as it filters through thick cattail intertwined with purple loosestrife and ~~deadly~~ <u>climbing</u> nightshade" (Pentec, 1998). Water depths vary substantially in this area, ranging from a few inches to more than 4 feet (Pentec, 1998). As noted previously, there is currently not a channel to allow fish to move between the creeks and the estuarine portion of the marsh. Pentec (1998) characterized the fish habitat in this portion of the marsh as suitable for winter rearing by salmonids, but with potential water quality limitations in the summer due to high water temperatures and low dissolved oxygen.

2.5.3 Upstream Creek Channels

Upstream of the marsh, Willow and Shellabarger Creeks are small creeks that provide some habitats suitable for fish rearing and spawning for at least several hundred feet until obstructions block further upstream fish passage. Pentec (1998) characterizes Shellabarger Creek fish habitat as "fair to good" for rearing and "good spawning potential for salmonids." In Willow Creek, fish habitat was characterized as excellent for rearing (Pentec, 1998), but interpretations of spawning habitat availability differ as Pentec (1998) characterizes the habitat as poor and WSDOT (2004) described the creek as providing "fair to good" spawning habitat.

2.5.4 Contaminant Impacts to Habitat

In addition to the preceding description of primarily physical and biological features comprising existing fish habitat conditions, consideration of potential chemical contamination of water or sediments is necessary. Stormwater and previous industrial operations adjacent to the marsh are two routes of potential contamination. Together, the sources may input metals, polyaromatic hydrocarbons, total petroleum hydrocarbons, Light Non-aqueous Phase Liquids, and nutrients. These inputs can affect the productivity of the marsh habitats. The contaminants pose a risk for creating a contaminated prey base, which could bioaccumulate in fish. Thus, the quality of fish habitat within the marsh should be considered impaired to some degree by chemical contaminants, unless it is demonstrated otherwise that the cleanup remediation actions are comprehensive and complete. The amount of potential effects on fish is unknown at this time, and is not considered in this current early feasibility study. Potential contamination mitigation measures including cleanup of contaminated soils excavated for the daylight channel, or isolation of the site using geotextile liners, may be required. Studies to evaluate contaminated soils are part of later phases of the project.

Overall, the fish habitat conditions in Edmonds Marsh and the contributing tributaries are "fair" with a great deal of improvement possible through restoration actions.

3.0 DAYLIGHT ALTERNATIVE ALIGNMENTS

Three alternative alignments have been identified to discharge Willow Creek from the tidal marsh into the Sound (Figure 1). These alternatives were identified in previous studies (Pentec, 1998), and also for this study as potential locations to daylight and realign Willow Creek. All three alternatives involve daylighting either portions of, or the entire, creek channel downstream of the marsh and increasing the tidal connection to Puget Sound. Daylighting in this context is referred to as realigning the creek from a pipe into an open channel. All alternatives will need to cross the BNSF railroad tracks and go through property owned by either the Port, the City, or both. Alternative 1 involves the Chevron/Unocal property which has an easement under escrow with WSDOT. The following sections describe the alternatives evaluation approach and findings in detail.

The screening analysis evaluates each of the three proposed alternatives through a qualitative review of habitat modifications and impacts; coastal hydrodynamics; and a compilation of engineering, infrastructure, and property issues. The primary evaluation components of the screening analysis include fish habitat and biological response, using a set of technical criteria developed specifically for the project, and a pros/cons analysis of coastal/tidal hydrodynamics and sediment transport conditions, infrastructure constraints, drainage effects, potential costs, and social-political factors for the alternatives.

A key step in the assessment includes the evaluation of the likelihood of juvenile Chinook and other salmonids to use and access into the daylighted alternative alignments. The following biological response criteria and definitions were used in the screening analysis.

- **Likelihood of juvenile Chinook salmon encountering the marsh outlet**
  - *Explanation of Criterion:* This criterion is a qualitative assessment of the likelihood of juvenile Chinook moving in close proximity to the shoreline of each marsh outlet alignment.
- **Likelihood of the marsh outlet connection remaining open and accessible for juvenile Chinook salmon**
  - *Explanation of Criterion:* Qualitatively assess the potential for sediment transport and/or large wood accumulations to block the access channel to the marsh for juvenile Chinook during the spring and early summer outmigration timeframe.
- **Suitability of marsh outlet and channel for juvenile Chinook salmon passage into restored marsh**
  - *Explanation of Criterion:* Consider the marsh outlet features and their affect on juvenile Chinook salmon's ability or willingness to migrate into the marsh. Considerations include access channel length, generally anticipated flow velocity conditions throughout tidal cycle, number/length of overwater structures (or remaining culvert reaches), and potential habitat features within access channel.
- **Potential to integrate with future restoration**

— *Explanation of Criterion:* Assess whether the marsh outlet would accommodate potential future restoration opportunities along the outlet channel and in the vicinity of the marsh outlet.

A second component of the screening analysis includes a review of coastal and tidal hydrodynamics in the context of maintaining a permanent connection between Edmonds Marsh and Puget Sound. This review includes a qualitative coastal engineering discussion of tidal hydrodynamics, future marsh conditions, local sediment transport, deposition, and shoaling effects on the alternatives.

The third component of the screening analysis focuses on engineering, property, and socio-political issues. These include a qualitative discussion of infrastructure constraints, drainage effects, potential costs, landowner willingness, and social-political factors for the alternatives from a hydraulic/civil engineering perspective.

3.1 Alignment Alternative 1 – Edmonds Marina Beach Park

Daylighting Willow Creek at the Edmonds Marina Beach Park would involve constructing a new channel across the beach park area from the BNSF railway. Depending on the alignment, the length of the park beach channel would vary from 350 feet if located in the dog park area to the south, or up to 700 feet if located north through the existing parking lot and grassy areas of the park. Appropriate habitat features would be included to make the channel both biologically functional and aesthetically pleasing to park users. For example, instream wood, step pools, and riparian vegetation would improve flow complexity and cover conditions in the channel. Currently, the City is considering the daylight alignment as part of a separate park master planning study.

At the BNSF railway, the daylighted creek would cross under the railroad embankment through a bridge installed by BNSF and Sound Transit during recent railway expansion work in 2010. The bridge installation was completed in anticipation of the future daylighting work as part of the Edmonds Crossing multi-modal project mitigation (Photograph 6). As-builts for the bridge installation have been provided by BNSF; however, supporting bridge flow and scour design information for the daylighted flow alignment has not been obtained at this time. Additional research and coordination with BNSF, Sound Transit, and WSDOT would be required to determine the structural and hydraulic sufficiency of the existing structure. If not adequately designed, retrofit and modification may be necessary.

Upstream from the BNSF bridge, Willow Creek would be daylighted. The exact configuration of the daylighted channel is unknown. In its simplest form, the channel would be 700 feet long flowing straight next to the BNSF railway and on the Chevron/Unocal property. CH2M Hill proposed a meandering alignment, as part of the Edmonds Crossing Final Environmental Impact Statement (WSDOT, 2004), that flows east away from the railway onto the Chevron property, and connecting with the downstream channelized stream near the current stormwater pond. For the purposes of this study, we evaluated a straight channel daylighting on the beach, passing underneath the railroad, and then following a relatively straight alignment to the existing confined channel. The plan form configuration of the channel may be revised in later phases of feasibility and design work, depending upon the availability of the Chevron property for realignment.

3.1.1 Alternative 1 – Fisheries

Improving the connection of Edmonds Marsh to Puget Sound by an outlet alignment through the Edmonds Marina Beach Park offers a great deal of potential for fish movement between Puget Sound and the marsh, including juvenile Chinook salmon and adult salmonids such as coho salmon, sea-run cutthroat trout, and possibly chum salmon. The large marsh can provide favorable rearing conditions for migrating juvenile salmon and promote rapid fish growth, which improves likelihood of survival to adulthood.

In this alignment, the marsh outlet would be located in a small beach area which already is a favorable location for fish because it is one of the more natural beach areas along this stretch of Central Puget Sound. Much of the Central Puget Sound shoreline is armored with protective riprap. Juvenile Chinook salmon tend to remain in close association with the shoreline during their early marine life stage before moving into deeper water and eventually migrating to the ocean (Fresh, 2006). The Edmonds Marsh outlet would be between approximately 8 and 15 miles from the closest Chinook salmon bearing rivers, the Cedar River via Lake Washington Ship Canal, and the Snohomish River, respectively. Given these distances, the marsh may not be as heavily used as it would if it were closer to one of the major rivers; however, some juvenile Chinook salmon do remain in close proximity to the shoreline over long distances in Puget Sound. Several studies of juvenile Chinook salmon distributions in the Puget Sound nearshore have documented the fishes' use of shoreline habitats such as the Marina Beach Park at far distances from their river of origin (e.g., Brennan and others, 2004; Dorn and Best, 2005; Fresh and others, 2006; Beamer and Fresh, 2012). It is likely that juvenile Chinook salmon would locate and utilize the marsh, particularly given this alignment alternative, which would position the marsh outlet along a sandy beach that provides favorable foraging habitat for the fish. It is reasonable to conclude that more juvenile Chinook salmon would encounter the marsh outlet at the Marina Beach Park compared to the alternative alignment through the marina (See Alternative 2 discussion). For adult salmonids returning to Puget Sound, the marsh outlet in the Marina Beach Park is more likely to be encountered compared to the likelihood of the adults entering the marina. There is higher potential for the fish to detect the odor of the freshwater source from a greater distance if it flows across the beach rather than into a marina which has a variety of boating related discharges.

A marsh outlet in the Marina Beach Park would be exposed to the wind and wave conditions of Central Puget Sound and, depending on the outlet configuration, some shifting of the outlet should be expected. As long as the design does not detrimentally impact expected adjacent park uses, such movement of the outlet channel across the beach face is a favorable condition such as naturally occurs at other marshes and tributary outlets. Currently, the upper beach accumulates drift logs that come and go with storm events. Beach logs, as well as shifting beach sediments, may partially impede access to the marsh during some time periods, but it is expected that the force of outflows from the marsh will maintain migratory routes for juvenile Chinook salmon and adult salmonids to move between Puget Sound and the marsh.

Fish locating the marsh outlet will need to swim several hundred feet from the beach to the marsh. The alternative includes a short portion of overwater structure as the channel runs under the BNSF railroad track, otherwise the access channel would be entirely open with the opportunity for habitat features to be included in the design to provide favorable in-channel conditions. Juvenile Chinook salmon and adult salmonids can be expected to migrate this distance to access the marsh habitat. The short distance of overwater structure would not be expected to markedly affect the likelihood of fish entering the marsh entrance channel. The habitat conditions in the entrance channel can be improved by including instream wood, pools, and riparian vegetation.

The Marina Beach Park outlet channel realignment could support future restoration of property along the former Unocal site, east of the BNSF railway. The restored marsh entrance channel could potentially be expanded in size and/or realigned further to the east. The rationale for these modifications is related to the fact that a straight daylight alignment along the BNSF right of way will have sharp turns at the bridge, which can be problematic from a hydraulics and fish passage perspective. Also, expansion or realignment to the east would allow for developing a meandering channel planform more similar to natural channels, and allow for native riparian plantings on both sides of the channel. This would require that at some point in the future some of the former Unocal site property becomes available and suitable for habitat restoration. This would reduce some of the problems identified with the BNSF railway culvert crossing configuration being perpendicular to the tracks. There are no plans for such expanded restoration at this time and possible contamination of soils in the former site may limit potential inclusion of channel restoration and realignment in this area.

3.1.2 Alternative 1 – Coastal Hydrodynamics

Alternative 1, which includes the alignment through the Marina Beach Park, is the only alternative that does not require the connection between Puget Sound and the marsh to be placed (at least partially) through pipes or culverts. The use of open channels for nearly the entire alignment (except for the BNSF railway bridge) will allow for larger volumes of natural tidal prism exchange and marsh inundation (both filling and draining) of the marsh compared to the other proposed alternatives. The proposed outlet, as mentioned above, is located along a relatively natural, nearshore reach with minimal shoreline armoring. The connection can, therefore, be designed as a continuous sloping channel from the marsh down to lowest tidal elevations at Puget Sound. This mimics the type of channel that historically existed connecting the nearshore area with the marsh; although the historic location of the outlet is to the north of the location proposed as part of Alternative 1. The channel could be designed as a relatively unconfined inlet to the marsh or could be designed as an engineered channel to better control in-channel velocities and minimize movement of the channel location due to nearshore processes depending on park maintenance requirements. Littoral transport along the shoreline in this area is from the south to the north (USGS, 2010). The shoreline to the south is armored; however, there is a local source of sediment to the system from Deer Creek that discharges one mile south of the proposed outlet. The natural drift process has the potential to deposit sediments in the proposed outlet channel during extended periods of low flow from the upstream marsh to the beach. This may result in some limited access to the channel for fish at lower tides during portions of the year. However, it is anticipated that higher flows from the marsh, as well as coastal storm events, would have the ability to flush a majority of the deposited sediment out of the channel. The orientation and sediment dynamics of the Willow Creek outlet on the beach should be studied further if this alignment is selected.

This site is subject to direct impact from storm waves from the west and southwest. Depending on the tide level at the time of the storm event, these impacts could include erosion of nearshore sediments at the mouth of the creek, transport, and deposition causing infilling of the mouth of the creek by deposition in the channel, and/or lateral migration and changes in channel location and or depth of the mouth of the creek due to these sediment movements.

The proposed outlet for Alternative 1 has the potential to be the most natural of the proposed alternatives, based on historical understanding of the marsh outlet. In addition, there are opportunities to enhance nearshore restoration activities at the Marina Beach Park mouth that would benefit the marsh restoration project and provide additional nearshore fish habitat.

3.1.3 Alternative 1 – Engineering, Infrastructure, and Property

The Alternative 1 daylight mouth originates in the Marina Park, travels through the BNSF railway, and then northward along the BNSF railway on the Chevron property. As such, there are various infrastructure and property ownership considerations for this alignment.

Within the park, a southern alignment would need to address the existing dog park facilities (Photograph 8). As dogs and a freshwater salmon habitat may not be compatible features, exclusion fencing and vegetation screening may be necessary to protect and shelter fish from external stimulus and allow the fish to migrate through the dog park area. Adjacent to the northern edge of the dog park is a gravel parking lot, which may be impacted if geotechnical bank reinforcement, shoring walls, or earthwork grading encroach into the parking area (Photograph 9).

A northern channel alignment through the park would need to address potential loss of parking spaces and grass landscape areas, and stormwater infrastructure conflicts. The alignment would cross the park access road and parking spaces, and likely flow through the grassy “knoll” and onto the beach at the north (Photographs 10 and 11). This general alignment is near the existing Willow Creek stormwater outfall pipe alignment, as well as other underground utilities. A northern alignment could become a natural setting for the stream restoration, but could potentially involve significant changes in the park landscape and uses, which would translate into additional project costs. Additional evaluation of both a southern and northern channel alignment would need to be conducted as part of a future park planning study, if this alternative is chosen.

At the upstream end of the park, the stream would flow under the BNSF bridge. This stream crossing is currently perpendicular to the tracks and may have an abrupt change in flow direction due to turning the corner and crossing underneath the railway. This configuration is not an optimal alignment for Willow Creek daylight restoration, unless space can be provided for the transition associated with the proposed channel approaches. Also, the bridge width may not meet current fish passage design guidelines for no-slope or stream simulation widths (WDFW, 2003). Options for improvement include modifications to the existing channel alignment, or looking at channel meander patterns and approach directions both upstream and downstream from the bridge that allow room for transitioning the channel through the bridge. It is not known if the current bridge subgrade and foundation were designed and constructed to protect the BNSF railway from the future scour conditions from a daylighted channel. A bridge hydraulics and design report has not been identified at this time. It is noted that this structure may need to increase in width (to the east) if BNSF expands the second rail line through the Edmonds area.

Known utilities for Alignment 1 include the City stormwater pipeline and vaults, a fire hydrant line that extends south into the dog park, as well as buried communication lines beneath the BNSF railway. A full investigation of utility locations is needed for final design.

Property ownership for Alignment 1 is limited to the City, BNSF, and Chevron/Unocal. The park area and the marsh are owned by the City, the bridge and railroad right of way by BNSF, and the upstream daylight channel would most likely be located on Chevron/Unocal property.

In summary, Alternative 1 would include a new channel excavation downstream from the current confined channel between the BNSF and Chevron/Unocal property, for which contaminated soils remain a concern. There are additional restoration opportunities to the east on the Chevron property, if the owner is amenable, which also have similar contamination potential. The existing BNSF bridge is helpful in that it could reduce the cost of a new bridge or culvert; however, the alignment may not be ideal. Research and gathering engineering reports and plans for the bridge crossing would be helpful. The bridge alignment needs to be considered in evaluation of the two Marina Beach Park proposed alignments. The Marina Beach Park realignment(s) have infrastructure such as stormwater pipes, water supply pipelines, and parking areas that need consideration, for which we recommend a park planning study.

3.2 Alignment Alternative 2 – Port of Edmonds Dock F

The Port of Edmonds Dock F alternative alignment would divert the stream towards the north into an existing storm drainage pipe alignment, and then cross Admiral Way to the west through the Edmonds Marina parking lot (Figure 1). The estimated length of this realignment from the Marsh to the waterline in the marina is 400 feet. In the 1998 report for the Port of Edmonds, Pentec (1998) describes a possible open channel configuration as:

> *"…a slightly sinuous open channel into the marina between existing Slips F and G, a lineal distance of approximately 275 ft. Appropriate in-channel structures could be installed to make the channel both biologically functional and aesthetically pleasing to*

the Edmonds community. For example, a series of step pools with appropriate spacing would facilitate fish access over potentially prohibitive low-tide gradients, while providing nice stream habitat for public enjoyment."

This alignment would include keeping the existing piping under the railroad tracks and modifying storm drainage piping along and underneath Admiral Way, and would have a daylighted channel through the existing marina parking lot. The discharge location would be inside the existing marina between Docks F and G (Photograph 7).

3.2.1 Alignment Alternative 2 – Fisheries

Like Alternative 1, an Edmonds Marsh outlet alignment through the Edmonds Marina would offer a great deal of potential for fish movement between Puget Sound and the marsh, including juvenile Chinook salmon. The marsh would be a productive habitat for fish entering the system. With a marsh outlet in the marina, somewhat fewer juvenile Chinook salmon would be expected to encounter the marsh entrance than an outlet to the beaches north or south of the marina (Alternatives 1 and 3, respectively). Not all fish are expected to enter the marina as they navigate past it, and there are few if any forage areas in the marina. This expectation stems from the fact that the marina is a partial obstruction to juvenile Chinook salmon that tend to migrate along shallow portions of the shoreline and avoid deep water (until they grow larger).

The marina requires the fish to swim around the outside of the marina and either cross the deep water marina entrance or enter the marina. Juvenile Chinook salmon migrating from south to north would be expected to encounter the marsh outlet if it was located in the Marina Beach Park. A marsh outlet in the marina may not be encountered by as many fish because some may not enter the marina as they navigate around the outside of it. Those fish that enter the marina would encounter poor habitat conditions including extensive overwater coverage, deeper water, modified shoreline within the marina, and potential exposure to chemical contaminants (petroleum), and boat and marina noise. These conditions affect the foraging opportunities, prey base quality, as well as increase predation risks.

A marsh outlet in the marina would need to be a highly engineered channel and culvert that is fixed in place to maintain and protect existing marina infrastructure. The channel would be designed to provide suitable depth and velocity conditions to enable fish to move between Puget Sound and the marsh. Due to the fixed position of the outlet and the anticipated design to provide suitable flow conditions for access, this marsh outlet is more certain to remain open and accessible to juvenile Chinook salmon and adult salmonids that encounter it. Any step pool feature to provide access to the channel during low tides would be more accessible to adult salmonids than it would for juveniles. A marsh outlet alignment through the marina would also provide the shortest access channel distance to the marsh, which implies improved fish access to the marsh. However, this alternative requires a hardened channel and pipe system, which offsets potential gains from a shorter system. There are no clear advantages to fish habitat for the marina location.

3.2.2 Alignment Alternative 2 – Coastal Hydrodynamics

Alternative 2, which includes the alignment through what is now a parking lot and into the existing marina basin, would consist of an engineered hardened channel outlet into the marina with an upstream pipe or culvert connections to the marsh due to site constraints (as discussed above). The use of pipes and culverts within the channel system between the marsh and the sound will result in some attenuation of the tide into the marsh, as well as some delay in draining of the marsh system during periods of low tide. The proposed outlet would be through what is now a parking area and would terminate within the marina directly into relatively deep water. Therefore, the channel would need to be graded in such a way to ensure the mouth of the creek is below MLLW or the outlet of the creek may be perched above lower tidal levels due to the lack of an intertidal beach area (low tide bench) at the proposed outlet to support a low tide channel. This would result in higher than desired in-channel velocities during low tides which could be an access problem for fish into the marsh, during the low tide conditions.

Littoral transport along the shoreline in this area is designated as “no appreciable drift” (USGS, 2010), which means that there is either little to no sediment drift at this location or there is no appreciable net drift (however, there could be gross transport north and south during different times of the year). At the location of the proposed outlet for Alternative 2, there is most likely little to no shoreline sediment transport due to the presence of two breakwaters which shelter the marina from waves. However, there would likely be sediment transport and deposition that would occur from upstream marsh sediment supplies. This additional sediment transport into the marina is undesirable and would increase maintenance dredging requirements for the marina. It is not likely that the amount of sedimentation would block the channel, rather, the rate of sedimentation in the marina would increase, thereby requiring more frequent marina dredging.

3.2.3 Alignment Alternative 2 – Engineering, Infrastructure, and Property

The Alternative 2 daylight outlet in the marina is located within an array of infrastructure. Infrastructure includes buildings, walls, piles, stormwater pipelines, sewer, water supply, electrical (possibly gas), car parking, and boat docking areas. This amount of infrastructure would likely require a significant amount of engineering design, as well as coordination and protection of infrastructure during construction. Additionally, construction would likely occur during the busiest times at the marina, and could impact marina operations. The amount of adjacent infrastructure implies a rather large cost for installation of a new daylight channel. Also, the daylighted channel (if not in a pipe) would eliminate a number of parking spaces for the port and marina.

Bob McChesney of the Port of Edmonds was contacted during coordination activities for installation of the project data logger in the marina. At that time, he was asked about the viability of daylight channel exiting into the marina between Docks “F” and “G.” His response was firmly that the Port did not support a Willow Creek daylight alternative with an outlet into the marina (B. McChesney pers. comm., August 22, 2012).

Further east, the channel would need to cross beneath Admiral Way, where the road tees and heads east near the Port parking lot. This would require traffic control and coordination during construction, which also implies additional costs.

Upstream of the Admiral Way road culvert crossing, the channel would follow the road. If a stream channel is designed in this area, it would likely encroach upon the parking area to the east. This may be done without impacting parking, but could potential require the removal of existing trees and vegetation.

Finally, the daylight channel would need to cross the BNSF railroad embankment. This will require installation of a new culvert or bridge structure and protection of the railroad embankment, as well as continue to provide rail service during construction. The new culvert or bridge would likely higher costs than a typical roadway bridge or culvert crossing. Construction in the BNSF railway right-of-way (ROW) requires special easements and permits from BNSF, as well as special construction contract specifications for safe-zone working along the railroad. This applies for any alternative where construction through, in, and around the embankment and within the ROW is required.

Property ownership along Alignment 2 is the City, the Port, and BNSF. It is doubtful that a viable agreement could be reached with the Port, considering their stated position on the

Alignment 2 alternative. Alternative 2 alignment is considered a high social-political risk and is not recommended.

3.3 Alternative 3 – Sunset Beach Alignment

The Sunset beach alignment would relocate the outlet of Willow Creek to the northwest corner of the marsh and would approximate the mapped historical outlet (Figure 1*)*. The estimated length of this proposed realignment alternative would be approximately 900 feet. This alignment would require installation of a new culvert or pipe underneath the BNSF railway. The alignment would then run northwest through an open gravel parking lot owned by the Port. We have assumed that a property sale or exchange with the Port is not a viable element of the project for a full daylight channel and, therefore, a nearly 600 foot long pipe would need to be installed underneath the gravel parking lot, or a daylight channel agreed to through the parking lot by the property owner. The pipe would then cross underneath W. Dayton Avenue/Admiral Way and daylight on Sunset Beach between the Edmonds Marina breakwater near the fishing pier access and onto the beach.

3.3.1 Alternative 3 – Fisheries Perspective

Reconnecting Edmonds Marsh through this alignment would offer some potential for fish use of the marsh; however, the extensive channels and lengthy pipe system necessary to connect the beach to the marsh would limit the likelihood that juvenile Chinook salmon and even adult salmonids would enter the system. The extended pipes would have to be designed to provide suitable depth and velocity conditions to allow fish passage; however, fewer fish would be expected to enter compared to an open channel. This is a significant factor limiting the potential benefits associated with this alignment.

The Sunset Beach alignment of the marsh outlet is in a slightly more protected location than the Marina Beach Park alignment because the marina blocks the strong wind and waves from the south. As a result, the Sunset Beach alignment can be expected to have fewer issues with partial outlet closure than the Marina Beach Park. For fish, this means the Sunset Beach alignment would provide clearer access at the mouth for fish moving between Puget Sound and the marsh.

The Sunset Beach location for a marsh outlet would be located in a sand and gravel beach area adjacent to the marina. This is a favorable foraging area along the beach where prey forage fish are found on the beach sands, macroalgae and eel grass beds. Also the marsh outflow would transport prey items to fish along the beach. However, based on the adjacent marina and buildings, the marsh outlet would likely have to be engineered to remain in a fixed position which would limit the opportunity to provide a natural marsh outlet. In this way, the Sunset Beach alignment is more like the marina outlet alternative than the Marina Beach Park alignment.

While the proposed outlet for Alternative 3 has limited spatial extent in the nearshore compared to Alternative 1, there may be some limited opportunities to conduct beach/nearshore restoration activities at the Sunset Beach outlet location, such as placement of large wood debris and native plantings. This would also benefit the marsh restoration project and provide additional nearshore fish habitat.

3.3.2 Alternative 3 – Coastal Hydrodynamics

Alternative 3, which includes a northern outlet alignment through Sunset Beach, would consist of an engineered hardened channel with upstream pipe/culvert connections to the marsh due to site constraints (as discussed above). While the location of the outlet for this alternative coincides with its historical location, as with Alternative 2, the use of pipes/culverts within the channel system between the marsh and the sound will result in some attenuation of the tide into the marsh, as well as some delay in draining of the marsh system during periods of low tide.

The proposed outlet is located along at Sunset Beach; a small intertidal beach area is backed by shoreline armoring above MHHW and adjacent to one of the breakwaters for the marina (located south of the proposed outlet location). The outlet channel can likely be designed as a continuous sloping channel from the marsh down to lowest tidal elevations at Puget Sound; similar to Alternative 1. However, the nearshore area at this location is significantly smaller than that of Alternative 1 due to the physical constraints of the area (adjacent armoring and upland property).

Littoral transport along the shoreline in this area is designated as "no appreciable drift" (USGS, 2010). At the proposed outlet location, the lack of appreciable drift is likely due to the interaction of the site with the large breakwater to the south, which shelters the area from storm waves from the south, southwest, and west, which are the most significant storm directions for this area. There would likely be minor sediment transport and deposition from the marsh. It is more likely that the outlet of this channel will remain open and free of sediment deposition than Alternative 1.

This site is subject to direct impact from storm waves from the northwest and north, but is sheltered from all other storm wave directions. The presence of the breakwater is anticipated to greatly limit the impact of storm waves on the proposed outlet in terms of sediment transport and infilling. However, it is possible that storm events from the north and northwest could impact the site in similar ways (influencing the channel to migrate in one direction or another) as described for Alternative 1.

3.3.1 Alignment Alternative 3 – Engineering, Infrastructure, and Property

The Alternative 3 daylight outlet at Sunset Beach, to the north would encounter a variety of infrastructure and property owners. This alternative alignment most closely represents the historical marsh mouth to the Puget Sound. Significant development and changes to the landscape have occurred in this area.

Immediately upstream (south) of the beach, the daylight channel would encounter Admiral Way or Dayton Street at the corner. This would require a pipeline, and would need to be built around existing stormwater drainage utilities among other existing underground utilities. This pipeline would need to be a significant structure and would likely have associated significant construction costs.

South of the Admiral Way street corner, the stream channel would flow into a partially used gravel lot which is owned by the Port. The channel could daylight through the parking lot, but would require elimination of overflow parking in this area. This lot was under consideration for the Edmonds Crossing project as an alternative alignment for SR 104, but was not identified as a recommended alternative. The Port was not interviewed regarding this alignment.

At the southeastern corner of the lot, the realigned channel would then flow through a culvert or pipe through the BNSF embankment and directly into the marsh. This would likely require construction of a bridge or culvert similar to the existing bridge for Alternative 1. The limitations associated with this bridge are similar to those discussed as part of Alternative 2.

Property ownership along Alignment 3 includes the City, the Port, and BNSF. A significant amount of the project is located on Port of Edmonds property. The daylight channel would require a lengthy easement or purchase of the current gravel parking lot area on the corner of Admiral Way and Dayton Street. It is unlikely that a viable agreement could be reached with the Port, considering their stated position on daylight channel realignment on Port property. We would recommend confirming this position with the Port, if Alternative 3 is identified as having merit warranting further investigation.

3.4 Preferred Alignment Recommendation

From a fisheries perspective, all three of the alignments would improve shoreline conditions and expand the saltwater influence in the marsh so it functions more like a natural salt marsh and can provide fish access. The Marina Beach Park alignment is the most beneficial to fish because it provides an open channel connection that can be designed to provide good habitat for fish moving between Puget Sound and Edmonds Marsh. In addition, the marsh outlet into the Marina Beach Park would add a beneficial feature to an area that provides favorable nearshore rearing conditions for juvenile Chinook salmon, especially compared to the extended section of riprapped shoreline to the north and south. The concerns of the Port Dock F alignment are the increasing rearing time in the marina for juvenile Chinook salmon that enter the marina and the extended pipe length the fish must navigate associated with the Sunset Beach alignment. These factors limit the suitability of a Sunset Beach marsh outlet.

From a coastal hydrodynamics perspective, all three of the alignments would provide connectivity between the marsh and Puget Sound, and likely improve tidal inflow and drainage from the marsh. Each alternative has distinctly different littoral drift sediment conditions. Alternative 1 will have design challenges related to littoral drift and sedimentation in the channel that could potentially cause fish access issues at low tides. This, however, is a similar condition observed at other natural stream mouths throughout Puget Sound, and would likely only occur periodically. Alternative 2 would impact maintenance in the Port marina by increasing maintenance dredging. Alternative 3 would require long pipe runs that would be difficult and costly to design for fish passage. Based on these observations, Alternative 1 has the best potential to both improve tidal inflow and drainage from the marsh, while still providing hydraulic conditions conducive to fish passage, relative to Alternatives 2 and 3, which both include lengthy pipes as part of the proposed the alignments.

From engineering design, infrastructure protection, and property ownership perspectives, Alternative 1 requires the least amount of new infrastructure to complete the proposed alternative. Alternative 1 is the only proposed outfall location that has an existing BNSF bridge, although additional approach work may be required. Alternatives 2 and 3 would require contending with significant Port, marina, and City roadway and drainage infrastructure, which implies increased costs for construction, easements, property purchases, and negotiations. Based on direct discussions with the Port, they would not support Alternative 2, which would outfall in the Port-owned marina. Alternative 3 has a long alignment through Port property. Acquiring or purchasing an easement could be difficult, which would significantly increase project costs.

In summary, it is our opinion that Alternative 1, realigning the Willow Creek outfall through the Edmonds Marina Beach Park, is the most logical location, given the urban area site and property ownership constraints. This alternative will:

- Provide the best attractants for juvenile salmonids at a natural beach area,
- Allow for potential additional beach restoration benefits,
- Improve saltwater tidal inflow and marsh drainage conditions,
- Has the least amount of existing infrastructure constraints,
- Is located in a position acceptable to the BNSF railway.

Alternative 1 is not without challenges, including:

- Identification and design of a preferred alignment within the park that meets multiple user requirements,
- Potential modifications needed at the pre-constructed BNSF bridge
- Location of the realigned stream adjacent to the Chevron/Unocal property with known contamination.

The study team recommended the early feasibility study evaluate the Preferred Daylight Plan, Alternative 1 – Edmonds Marina Beach Park alignment. Our findings are presented in the following section of the report.

4.0 PREFERRED DAYLIGHT PLAN

The preferred daylight plan was further evaluated to assess fish habitat and flooding conditions if the daylight channel were built. The following section includes an expanded description of the conceptual daylight design plan, an evaluation of the tidal hydraulics, benefits to fish and potential effects to localized flooding and potential infrastructure impacts (Figure 9).

4.1.1 Marina Beach Park Area

The Marina Beach Park area is the logical outlet of the daylight channel to Puget Sound. The exact alignment and configuration through the park is not known at this time. The City is planning to perform a park planning and public study to finalize the daylight channel alignment. The Marina Beach Park channel daylight alignment will start at the pre-constructed BNSF railroad bridge. From this location, there are two logical directions for the daylight alignment;

- A south alignment through the off-leash dog area
- A north alignment through the park including the south parking lot, and possibly the treed and grassy knoll and beach areas

The alignments will be finalized in future phases of work. For the purposes of this study, the South Alignment through the dog park was analyzed for fish passage and flood effects (Figure 8).

The conceptual plan includes a gently meandering channel through the off-leash dog area. The conceptual beach outfall channel will flow from the BNSF railway bridge to the MLLW elevation of -2.09 feet. The beach channel would be approximately 350 feet long, with a top width of 50 to 70 feet on the beach and 30 to 40 feet through the bridges. The depth of the channel will vary from 12 feet deep (upstream near the bridges) to 15 feet (downstream).

At the upstream end of the beach channel, the invert of the channel elevation was selected to match the invert shown in the BNSF as-builts provided by the City (BNSF, 2010). The plans show a 38 foot bridge span with 1.5 horizontal to 1 vertical (1.5H:1V) side slopes, protected by rock. The invert of the channel elevation is 4.26 feet. This invert elevation was held at 4.26 feet, and the channel excavated downstream to match the MLLW elevation of -2.09 feet (NAVD88). There is little supporting documentation as to the bridge design hydraulics, erosion, scour, and fish passage conditions. Future studies will need to consider these bridge related factors on the restoration channel.

The channel bed and side slopes (particularly the northern bank) may require grading and stabilization, which is unknown at this time. The proposed channel will also migrate due to the natural sediment shoaling conditions along the shoreline. The bank next to the parking lot and bridges will need scour and erosion protection. A mechanically stabilized, geotextile soil lift and vegetated embankment next to the parking lot is envisioned with rock placement as needed to protect existing infrastructure from excessive erosion and scour.

Dog access to the outfall is likely in conflict with fish habitat restoration, so the dog area and fencing will need to be modified and relocated away from the daylight beach channel. If the dog park area is moved to the south, then a pedestrian and maintenance vehicle bridge will be needed to cross the daylight channel.

The pedestrian and maintenance vehicle bridge will be needed to allow access from the parking lot to the north, to the dog park and beach area to the south. The City Parks and Recreation Department will need to specify the vehicle loads for the bridge. The span of the bridge will match the 38-foot-wide BNSF railroad bridge. The abutments of the pedestrian bridge will likely be founded on piles, and need to have bank erosion and scour protection measures to prevent undermining of the bridge approaches.

It appears that the BNSF bridge has pile foundations but no channel or erosion protection materials were installed at the time of construction. Channel erosion protection will likely be needed from the park pedestrian bridge extending upstream from the BNSF bridge and corner where the daylight channel turns from north-south to northeast-southwest direction. The BNSF bridge design will also need to consider if BNSF plans a rail expansion to the east of the existing rail and bridge crossing. The Conceptual Design Plan in this report assumes an alignment and geometric configuration of the channel that accommodates a potential rail expansion (Figure 9). The costs of the second bridge are assumed to be BNSF's and not part of this daylight project.

The northern edge of the dog park, along the south parking lot, is the historical Unocal fuel transfer pier. The study team currently understands that this structure was built on creosote timbers that were filled in and not removed during construction. Excavation, as well as beach channel erosion and migration, may encounter these piles, which may need to be removed and disposed of at a facility that can handle creosote waste. Also, there may be potential oil- and gas-related contaminant in the beach soils and park area. Future studies will test and evaluate if contamination exists in the beach daylight area.

Utility relocates may also be part of the Marina Beach Park daylight alignment. Near the pedestrian bridge there may be a water main crossing as there are fire hydrants in the dog park. However, the hydrants may be "ornamental" for the dogs' use. Regardless, other utilities may be encountered in the excavations and should be located in the next phase of design.

Replacement of the existing tidegate using a self-regulating tidegate (SRT) may be necessary. This study considers the tidegate an option at this time. The current tidegate was installed to provide coastal flood protection to the marsh interior areas. Future studies would need to consider the effects and operational criteria of the tidegate, which may be similar to existing operations by the City. Additional discussion of this structure is included in the hydraulics assessment of the preferred plan below.

4.1.2 Daylight Channel Area

The daylight channel is proposed to extend upstream (north) from the existing BNSF railway bridge, running between the BNSF rail and the Chevron/Unocal property to the open areas of Edmonds Marsh proper. It is assumed, for the purposes of this early feasibility study conceptual design, that the channel will be constructed in a straight alignment, with a length of approximately 750 linear feet. The channel is located primarily on the Chevron/Unocal property with some encroachment on the BNSF railway ROW. The channel configuration will be an approximate 14-foot-wide bottom width, side slopes of 2H:1V, and a top width of 40 to 50 feet. The profile of the channel is 0.0012 foot/foot. It is assumed that the daylight excavations will encounter some level of petroleum-related, hydrocarbon contamination. Contaminated soil handling and disposal will likely be required. Installation of a geotextile/polyvinyl chloride liner may be necessary along the daylight channel to protect from potential contamination. Coordination with the Chevron/Unocal property and cleanup study will be necessary. Alternative daylight alignments to the east, further onto the Chevron/Unocal property, may provide better opportunity for improving the daylight channel alignment through the BNSF railway bridge, and increase riparian plantings. Currently, the existing channel experiences large temperature fluctuations that are not observed in the marsh wetland or tidal beach areas. However, this expansion of the daylight channel realignment location onto the Chevron/Unocal property remains speculative at this time.

4.1.3 Edmonds Marsh Area

Upstream in the Edmonds Marsh area, the study proposes to excavate tidal channels and reconnect Willow and Shellabarger Creeks. Currently, the channels are filled with sediment. Stream flow disperses through dense cattail vegetation without a direct connecting channel. Optional elements of the conceptual design are removal and mowing of the dense vegetation stands, and native marsh plantings. Increases in salt water inflow will likely reduce the area of cattail growth, but this could take a long period of time and vegetation removal may be desirable. These options will be investigated further in future feasibility and design phases of the project.

4.1.4 Cost Estimate

The preliminary engineer’s opinion of probable cost is approximately $4.35 million (M) with a 30 percent contingency. An additional $1.1M is estimated for feasibility studies, engineering design, and permitting. These costs do not include real estate costs. There are numerous uncertainties in the cost estimate including property ownership and land transfer, contaminated soils conditions and handling and disposal requirements, BNSF railway bridge abutment, and foundation conditions, stormwater inflows and structure protection and realignments, utilities relocations, cultural and archaeological preservation.

5.0 TIDAL HYDRAULICS ASSESSMENT OF THE PREFERRED PLAN

The preferred daylight plan was further evaluated to assess fish habitat and flooding conditions if the daylight channel were built. A tidal hydraulics assessment was performed for existing and proposed conditions to evaluate the effects on project site habitat and flood conditions. A detailed hydraulics report was developed by Anchor QEA and is included in Appendix B (Anchor, 2013).

5.1.1 Tidal Hydraulics Modeling Setup

Modeling efforts included development of a one-dimensional, unsteady flow hydraulic model for both existing and proposed conditions. The models were used to evaluate tidal inundation, water depths, and in-channel velocities for the beach, daylight channel, and marsh, for both existing and future proposed conditions based on typical low flow (tidal) and approximate 100-year flood flow conditions. The model used for the evaluation was HEC-RAS with software developed by the U.S. Army Corps of Engineers Hydrologic Engineering Center River Analysis System (USACE, 2010).

Tidal inflow and elevation data for the model include NOAA tidal data from the Seattle, Elliot Bay Station (NOAA Station 9447130). The tidal data from the Elliot Bay station was compared to the Edmonds Marina station (LTC-1) for the project (S&W Data Logger Memo, Appendix C). The comparison analysis indicated that the Edmonds Marina LTC-1 station was very similar to the Seattle Elliott Bay Station (NOAA Station 9447130) with minor shifts in tidal cycles (on the order of minutes) and elevations (on the order of tenths of a foot). The project therefore used the NOAA Seattle Elliot Bay Station 9447130 tidal data for modeling downstream boundary conditions of tidal water surface elevations for time periods outside the completed project data collection efforts.

A typical spring tidal flow condition was selected from May 2008. This month of May was selected because fish trap and juvenile chinook data indicate peak juvenile migration from the Skagit and Snohomish deltas occurs sometime in mid-April (Beamer pers. comm. with WDFW for Fir Island Farm Estuary Restoration, 2010). We selected early to mid May to account for travel times from the river deltas to the Edmonds area. Stream inflow data were provided by the SAIC stormwater HSPF model outputs. Low flows were selected for Willow and

Shellabarger Creeks at (0.3 and 0.5 cubic foot per second) that were selected from other representative low flow modeling periods.

Flood inflows were selected for the December 2007 event, where observations were made at SR 104 and the Chevron/Unocal stormwater pond, both of which were flooded and overtopping. The NOAA tide station and HSPF modeling data (SAIC, 2012) were used as inputs for the December 2007 event.

Modeling geometry for the existing conditions used a geographic information system (GIS) surface compiled by Shannon & Wilson from existing LiDAR and ground survey data (Shannon & Wilson GIS Surface Memorandum, Appendix C). Additional bridge survey data were used to model the BNSF bridge based on as-built drawings provided by BNSF to the City. Modeling geometry for the preferred daylight and conceptual design plan used a similar surface that was modified to include the daylight channel along the beach, Chevron/Unocal property margin, and channel excavations in Edmonds Marsh. Additional details regarding the modeling setup are provided in Appendix B.

5.1.2 Tidal Hydraulics Modeling Results

The tidal hydraulics model was evaluated for existing and preferred daylight – conceptual design alternative conditions for the spring - May 2008 fish migration period, and the flood – December 2007 period. Figures 1 and 9 (main figures) show the predicted inundation areas for the spring tidal inundation periods for existing and proposed conditions. Based on the results of spring migration modeling, the marsh inundated areas will moderately increase from 16.8 to 19.2 acres. This is somewhat limited by the model's ability to assess flow inundation characteristics in the dense thicket of the freshwater cattail areas.

Figures 10 through 17 in Appendix B show the potential changes in channel velocities. Channel velocities in the upper Edmonds Marsh area decrease due to the increased size of the channels from dredging and excavation. The proposed peak velocities drop from 1.3 feet per second (fps) (existing) to 0.6 fps (proposed) for Shellabarger Creek. The proposed peak velocities drop from 4.8 fps (existing) to 0.7 fps (proposed) for Willow Creek.

Immediately downstream from the Willow Creek/Shellabarger Creek confluence, the channel velocities are higher for the proposed condition. They increase from 0.1 fps (existing) to 0.4 – 0.6 fps (proposed). Further downstream in the Willow Creek (Channelized) section of the stream, the velocities increase from 0.2 fps (existing) to 0.6 fps (proposed). In the proposed daylight channel near the railroad bridge, peak velocities can be as high as 1.5 to 2.0 fps (in either flood or ebb direction). Along the beach channel, peak velocities can be 0.5 to 1.0 fps for flood tide, and as high as 5.0 to 6.0 fps for ebb tide.

Figure 19 in Appendix B shows the results of the hydraulic modeling output for the December 2007 flood event. The model predicts significant reductions in peak flood water surface elevations from and estimated 12.7 feet (NAVD88) to an estimated 10.7 feet (NAVD88). This is a significant reduction in flood water surface elevations likely resulting from improved drainage and flow along the daylight channel versus the confinement and losses of the existing stormwater pipe and tidegate.

6.0 FISH HABITAT ASSESSMENT OF THE PREFERRED PLAN

The following information is the analysis of fish habitat conditions that would be provided through the proposed restoration options in the City's Willow Creek Daylighting project. This proposed fish habitat analysis complements the earlier analysis on existing fish habitat conditions that was included in the alternatives analysis. It is expected that this proposed fish habitat analysis will be used as a section of the project team's preliminary feasibility report.

6.1.1 Access to the Marsh

The proposed daylighting of Willow Creek will achieve its primary objective of restoring the connection between Puget Sound and Edmonds Marsh. A surface water connection routed through the City's Marine Park and under the BNSF railroad tracks via a recently constructed bridge will provide water depth and velocity conditions that will enable juvenile salmon, other fish, and other nearshore fauna to enter the marsh system during portions of the tidal cycle. As described below in more detail, the accessibility of the marsh to fish will vary throughout the tidal cycle. There will be times when tidal water will be moving into the marsh which provides the easiest access for fish, and times when access would require fish to swim upstream as the marsh system drains. Overall, access to the marsh will be provided during almost every high tide period with some additional access during limited periods of falling tides immediately after high flood slack.

The restoration design used in the hydrodynamic modeling assumes the thalweg of the proposed entrance channel is +4.26 feet NAVD88 (+6.2 feet MLLW). With this proposed design elevation, it is estimated that water levels in Puget Sound (on an annual basis) will be high enough to inundate at least the lower part of the marsh entrance channel up to 60 percent of the time if no tide gate is used. For incoming flood tides, fish will be able to access the marsh for tide elevations above the inlet elevation.

When the tide is at high slack or a falling tide, the net direction of flow in the entrance channel will reverse outward to Puget Sound. Entrance and accessibility to the marsh will be limited to those times when suitable depths and velocities are available in the entrance and daylight channel. The National Marine Fisheries Service (NMFS, 2011) design criteria for juvenile salmonid upstream passage is a maximum average velocity of 1 fps, calculated based on the 50 percent exceedance flow, and minimum water depth of 0.5 foot.

The modeling results for the May 1 to 15, 2008, period indicate that juvenile salmon access to enter the marsh system will be limited to an approximately 1- to 2-hour period after slack high tide for ebb tide conditions. The tidal hydraulics modeling output data were used to assess juvenile fish passage at three locations along the daylight channel to the marsh and one in the beach area downstream of the BNSF bridge. Depending on the location within the entrance channel, maximum water velocities out of the marsh are predicted to be between 2 and 3 fps. Water velocities in the restored channel across the beach are estimated to range even higher, up to 5.0 to 6.0 feet per second. Fish that enter the channel early in the flood tide cycle would have access to the marsh and daylight channel up to 60 percent of the time. Juvenile fish that access the entrance later in the tidal cycle will have diminished percentage of time in the daylight channel and marsh, depending upon how late they enter compared to the tide reversal.

Based on preliminary hydraulic modeling, it appears that fish entering the marsh during higher tides would have channels and vegetated areas to remain in even during low tide periods. The modeling predicts that tributary base flows (based on average spring flows) will provide residual depths of more than 0.5 feet and 1.5 feet deep in portions of Shellabarger and Willow Creeks respectively. Fish migrating from Puget Sound into the main marsh area would likely be able to rear in the marsh for longer than a single tidal cycle.

Depending on the restoration design in the beach area, storms may deposit large quantities of sediment and large wood that impacts fish access to the marsh until marsh outflows are sufficient to clear the channel entrance. A design that promotes natural processes of sediment movement and large wood accumulation, while maintaining fish passage is a desirable approach. Engineering of the channel outlet may be needed to protect adjacent infrastructure such as the south parking lot, and the railroad bridge foundations. These natural processes and site infrastructure constraints will be considered further in subsequent phases of design.

6.1.2 Puget Sound Shoreline Function

The proposed daylighting of Willow Creek is expected to improve the rearing conditions along the Puget Sound shoreline for juvenile salmon. By restoring a surface water connection to the marsh, the brackish marsh water and all the prey items and detritus (decaying plant and animal material) will enter the marine nearshore. Currently, all of these inputs enter Puget Sound via a subtidal pipe and may therefore be largely undetected or unavailable to the surface-oriented juvenile salmon rearing and migrating along the shoreline. Regardless of whether the fish enter the marsh system, these inputs can be expected to improve the habitat conditions for juvenile salmon. More prey items will be available in the upper portion of the water column near the shoreline. These prey items will include numerous insects that offer particularly high caloric content and foster rapid fish growth. The brackish water will also provide fish access to lower salinity water to provide a physiological refuge while the juvenile fish continue their acclimation to the marine environment.

6.1.3 Habitat Structure in the Marsh

Habitat conditions for juvenile salmon in the marsh will be improved by the daylighting of the creek and the proposed channel excavation between the creeks and the greater marsh area. The combination of these actions is expected to expand the portion of the marsh that will support salt-tolerant vegetation and improve the connectivity to the Willow and Shellabarger Creek watersheds.

As described in the existing conditions section of this report, the western third of Edmonds Marsh currently supports salt-tolerant vegetation and there is an abrupt transition to a dense thicket of cattails with no discernible surface channel to the creeks. The conceptual restoration design is expected to expand the extent of salt marsh vegetation and accessible habitat for fish, including the creek systems draining into the marsh. The daylighting of the creek to Puget Sound will increase tidal exchange within the marsh to more natural levels, especially if no tide gate is included in the design. The daylighted creek would be expected to allow high tide inundation elevations to match the water surface elevations along the Puget Sound shoreline, thus alleviating the tidal muting issue observed for existing conditions. This increased tidal exchange and restored channel connections in the marsh will promote the expansion of the area of salt-tolerant vegetation species in the marsh.

Salt marshes typically support a wide range of vegetation species with transitions in vegetation community occurring depending on salinity, inundation patterns, and elevation conditions, as well as other environmental parameters. To generally characterize the changes in the vegetation community that can be expected through restoration, anticipated elevations in the marsh were used to estimate the vegetation community that can be supported in different areas in the marsh. General salt marsh vegetation zones based on elevation were applied using vegetation observations in the Snohomish River system (Rice and others, 2012) and other Puget Sound locations[1]. Areas with elevations between the mean tide level and mean high water (MHW) are likely to support low marsh vegetation species, such as Lyngby's sedge (*Carex lyngbyei*), three-square bulrush (*Scirpus americanus*), pickleweed (*Salicornia virginica*), and seashore saltgrass (*Distichlis spicata*). High marsh vegetation will be supported in elevations from MHW to above MHHW. Common high marsh vegetation species include tufted hairgrass (*Deschampsia caespitosa*), Puget Sound gumweed (*Grindelia integrifolia*), Pacific silverweed (*Potentilla anserina*), American beachgrass (*Elymus mollis*), and common cattail (*Typha latifolia*).

Based on the NOAA tidal data for Edmonds (Station #9447427), the project site's approximate range for low marsh vegetation is between 4.4 and 8.0 feet NAVD88 (6.5 and 10.1 feet MLLW). By this approach, the high marsh range is between 8.0 and 8.8 feet NAVD88[2] (10.1 and 10.9 feet MLLW). These elevations are approximate and would likely have ranges of establishment of low and high marsh vegetation. Available elevation data in the marsh indicate that much of the western two-thirds of the marsh area provide elevations suitable to support low marsh vegetation species. Compared to existing conditions, this is a substantial expansion in area. As a result of this anticipated expansion in the low marsh, an equivalent contraction of the high marsh can be anticipated. It can also be expected that some of the currently vegetated low marsh areas transition to unvegetated tide flats. Overall, the marsh can be expected to shift from a cattail-dominated system to a more diverse vegetation assemblage.

With these anticipated changes in the vegetation structure in the salt marsh, a shift in prey production can be expected as different insects and invertebrates are associated with different vegetation types and elevations. The availability of these prey types will be substantially increased through both the fish access to the marsh and the outflow of the marsh into the Puget Sound shoreline. However, the amount of prey production would be expected to be similar between existing and proposed conditions (Cordell pers. comm., April 2, 2013).

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[1] Additional salt marsh vegetation observations were used from the Skagit River estuary (Hood 2009; Shannon & Wilson, 2010), Duwamish (Hummel pers. comm., April 2, 2013), Nisqually (Belleveau 2012), and Commencement Bay (Thom and others, 2000).

[2] Upper end of range approximated as one foot above MHHW.

The restoration design could include the removal of cattails in the central portion of the marsh where the vegetation community is expected to transition from the dense growth of cattails (high marsh) to more of a low-marsh plant assemblage. While this could potentially accelerate the natural transition process that is expected, there is some uncertainty estimating the extent of the transitional area, and caution is advised. It is recommended that cattail removal is either: 1) not included in the initial construction, but instead considered as an adaptive management measure to be implemented if the salt marsh does not develop as expected, or 2) conducted only in a very limited area along the western extent of the cattail area currently.

6.1.4 Access to Willow and Shellabarger Creeks

The conceptual restoration design includes the excavation of channels to provide clear connections between the creeks and the salt marsh. Since there currently are no well-defined channels, this is expected to improve fish access to the creeks. Due to the increase in tidal exchange and flushing of the marsh, there is expected to be sufficient energy for the channels to be sustainable over time. Sedimentation will likely occur at the new tidal – freshwater interface. This depositional zone could fill with sediment over time and limit fish passage at certain flow conditions.

Upstream connectivity to Willow and Shellabarger Creeks is beyond the scope of this early feasibility study. The City and their community partners do have plans, separate from this project, to incrementally improve upstream fish passage and connectivity in the Willow Creek and Shellabarger watersheds.

6.1.5 Contaminant Impacts to Habitat

As described in the existing conditions section, sediment and water quality may be contaminated through stormwater and previous industrial operations and adjacent land remediation conditions. The quality of fish habitat within the marsh should be considered impaired to some degree by stormwater and site contamination. The sources and types of contaminants are only generally known with little supporting data. Stormwater should be assumed to continue to introduce contaminants to the marsh system. Since the contaminants levels in the marsh and in the stormwater are not known at this time, the potential effects of contaminants on fish in the marsh are unknown. This potential impact to habitat quality was not considered in this current early feasibility study. Additional stormwater quality and contamination assessment are necessary steps in the next phase of study.

7.0 PRELIMINARY FINDINGS AND RECOMMENDATIONS

Overall, the early feasibility study demonstrates that the Willow Creek daylight preferred restoration plan will improve fish passage to the marsh. A summary of findings and recommendations for the project is as follows:

- The proposed daylighting of Willow Creek will restore the connection between Puget Sound and Edmonds Marsh and provide conditions that will enable juvenile salmon, other fish, and other nearshore fauna to enter the marsh system during portions of the tidal cycle. Generally, access to the marsh will be provided during almost every flood tide above elevation 4.0 feet, and high slack period, with some additional access for fish during short periods of ebb tides.
- The thalweg elevation (selected by the BNSF bridge thalweg elevation) of 4.26 feet would be inundated approximately 60 percent of the time. If juvenile fish enter the channel early in the tidal cycle, they would have access to the marsh up to 60 percent of the time. If fish enter later in the flood tidal cycle, their access will be limited starting 1 to 2 hours after high slack tide due tidal outflow velocities being too high for juvenile fish to navigate.
- The distribution of salt-tolerant vegetation in the marsh will adjust to the restored tidal exchange. It is expected that there will be a larger areas of both unvegetated mud flat and vegetated low marsh, while the vegetated high marsh area will diminish in size. As a result, there will be a smaller area of cattails (high-marsh plant) and more of a variety of low-marsh vegetation species.
- Access to the salt marsh will provide juvenile salmon a productive estuarine prey base. The production of insects and other invertebrates can be expected to shift with the changes in vegetation and tidal inundation, but the amount of prey produced may or may not increase with the restoration.
- Fish access to Willow and Shellabarger Creeks will be restored.
- The increase in conveyance from the daylight channel does not appear to increase flood water surface elevations as modeled for the December 2007 flood event, and may actually reduce flood water surface elevations.
- Tidal water surface elevations in the marsh are controlled by the tidegate and pipe system. If the tidegate and pipe system are removed, the daylight channel and marsh will see water surface elevations up to the high tide on almost a daily basis. As an example, existing marsh high tide water surface elevations range from 7 to 8 feet in elevation (NAVD88). Proposed conditions would increase daily tidal inundation elevations up to 9 feet (NAVD88) and higher on a daily basis. Removal of the tidegate and pipe system will also improve daily drainage in the marsh and less ponding may occur.

The results of the preliminary tidal hydraulics and fish habitat assessment for this project were based on the best available data at the time and targeted to meet the specific needs of the early feasibility study. There are several uncertainties and limitations to the evaluations performed for this study. The following recommendations are provided to finalize the feasibility study prior to engaging in final design:

- A tidegate was not analyzed, as the study team wanted to first evaluate system response without a tidegate. The without-tidegate daylight channel analysis preliminary results indicate that flood peak water surface elevations at SR-104 will be reduced, without having a protective tidegate at the downstream end of the system. A tidegate could be installed on the project to limit extreme tides and storm surge flows into the marsh. Evaluation of tidegate alternatives and operating conditions is recommended for future phases of study and design.
- Flow data were provided by a run-off model completed by SAIC (SAIC, 2012); there are no stream flow data available for project area. Some stormwater inflows to the marsh are not currently quantified. Flow data collection is recommended. Additional hydrologic inflow data are needed from the HSPF model and data collection for the WSDOT manhole overflow, Edmonds Point, and Harbor Square stormwater systems.
- Multiple sources of topography information, with different spatial resolutions, coverage areas, and collection times, were used to create the digital elevation models used to develop both existing and proposed conditions hydrodynamic (HEC-RAS) models. There needs to be additional survey in the freshwater vegetation areas of the marsh to confirm ground elevation in dense cattails, and to locate other marsh channel features and reconcile the various sources of survey data. Collect more comprehensive and accurate vegetation and elevation data in the marsh to support more detailed understanding of existing conditions and the potential changes through restoration design.
- The existing conditions model was not calibrated based on synoptic measured flow and water level data in the Marsh, due to lack of data. Calibration and validation of the model is recommended.
- Additional coastal engineering and geomorphologic studies are needed at the beach channel area to account for shoreline littoral drift, wind waves, and storm surges on the beach channel in a park setting.
- Conduct hydrodynamic modeling of multiple scenarios in entrance channel upstream and downstream from BNSF railroad bridge and evaluate the channel invert elevations to assess potential to reduce water velocities and increase the amount of time the marsh would be accessible to juvenile salmon.

- Determine the extent of stormwater, groundwater, and soil contamination that may affect fish habitat. Assess the impacts to aqueaous food web bioaccumulation toxicity that may occur.

8.0 LIMITATIONS

This early feasibility study was prepared for the exclusive use of the City, and their representatives for specific application to the Willow Creek Daylight project. Our judgments, conclusions, and interpretations presented in the report should not be construed as a warranty of existing site conditions, nor future estimated conditions.

The data presented in this report are based on limited survey and hydrologic data, and by the early feasibility study phase of the project. Shannon & Wilson is not responsible for conditions or consequences arising from relevant facts that were concealed, withheld, or not fully disclosed at the time the report was prepared. We also note that the facts and conditions referenced in this report may change over time, and that the facts and conditions set forth here are applicable to the facts and conditions as described only at the time of this report. We believe that the conclusions stated here are factual, but no guarantee is made or implied.

This report was prepared for the exclusive use of the City, and its respective representatives, and in no way guarantees that any agency or its staff will reach the same conclusions as Shannon & Wilson, Inc. We have prepared the report within the limitations of scope, schedule, and budget. The conclusions and recommendations presented in this report were prepared in accordance with generally accepted professional geotechnical and environmental engineering principles and practices in this area at the time this report was prepared.

The data presented in this report are based on limited survey and the current phase of early feasibility study development. We believe that the conclusions stated here are factual, but no guarantee is made or implied.

We have prepared Appendix D, “Important Information About Your Environmental Site Assessment/Evaluation Report,” to help you and others in understanding our reports.

SHANNON & WILSON, INC.

David Cline, P.E.
Senior Associate

DRC; KK; PS/drc

9.0 REFERENCES

Anchor QEA, 2013, (Draft) Tidal Marsh Hydrodynamics Report, Willow Creek Daylight Early Feasibility Study. Prepared for Shannon & Wilson Inc, March 2013.

Beamer, E., McBride A., Henderson R., and Wolf, 2003, Methods for Evaluating Historic Change in Skagit Bay Pocket Estuaries, Skagit River System Cooperative, LaConner, Washington.

Belleveau, L., 2012, Determining the influence of soil salinity and tidal inundation on the growth, distribution, and diversity of salt marsh vegetation: implications for the restoration of the Nisqually Delta, Washington. Masters Thesis at Evergreen State College.

Beamer, E., and Fresh, Fresh, 2012, (Draft) Juvenile Salmon and Forage Fish Presence and Abundance in Shoreline Habitats of the San Juan Islands, 2008-2009: Map Applications for Selected Fish Species.

Beamer, E.R., 2006, Habitat and Fish Use of Pocket Estuaries in the Whidbey Basin and North Skagit County Bays, 2004 and 2005, for the Samish Nation.

BNSF Railway, 2010, As-builts for Final Design for Sound Transit Commuter Rail, Seattle to Everett, Washington, Grading and Structures.

Brennan, J.S., Higgins, K.F., Cordell, J.R., and Stamatiou, V.A., 2004, Juvenile Salmon Composition, Timing, Distribution, and Diet in Marine Nearshore Waters of Central Puget Sound in 2001-2002: King County Department of Natural Resources and Parks, Seattle, Washington.

Chevron, 2013, Cleanup Project at the "Edmonds" Former Unocal Fuel Terminal. http://www.unocaledmonds.info/

City of Edmonds, 2012, Property, parcel and stormwater infrastructure shapefile provided by the City of Edmonds.

City of Edmonds, 2008, Edmonds Marsh Channel Improvements. www.ci.edmonds.wa.us/EngCIP/2008/ProjectDescriptionsPDF/Fund_412-200/2008-412-200.EdmondsMarshChannel.Improv.pdf.

Collins, B.D., and Sheikh, A.J., 2005, Historical reconstruction, classification, and change analysis of Puget Sound tidal marshes: Olympia, Wash., Washington Department of Natural Resources, Aquatic Resources Division, Project completion report.

Dorn, P., and Best, P., 2005, Integration of Joint City of Bainbridge Island/Suquamish Tribal Beach Seining Results into Shoreline Management and Salmon Recovery Efforts in Kitsap County, Washington.

Fresh, K.L., 2006, Juvenile Pacific Salmon in Puget Sound, Puget Sound Nearshore Partnership Report No. 2006-06: Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

Fresh, K.L., Small, D.J., Kim, H., Waldbillig, C., Mizell, M., Carr, M.I., and Stamatiou, L., 2006, Juvenile salmon use of Sinclair Inlet, Washington, in 2001 and 2002: Washington Department of Fish and Wildlife Technical Report No. FPT 05-08.

Gersib, 2008, Edmonds Marsh "Aerial" Photograph Interpretation: Internal Memorandum by Washington State Department of Transportation (WSDOT) regarding Edmonds Marsh historical conditions.

History of Edmonds, 2012, Website with information on the history of the township and City of Edmonds establishment. http://www.historicedmonds.org/Edmonds_History.html.

Hood, G., 2009, Estuarine habitat restoration with global climate change and rising sea-levels. Presentation at the 2009 Northwest Straits Commission Annual Conference. Presented by Greg Hood of the Skagit River Systems Cooperative.

King County 2004, Juvenile salmonid composition, timing, distribution, and diet, in marine nearshore waters of Central Puget Sound in 2001 and 2002, August 2004.

Moles, Todd, 2012, City of Edmonds Stormwater Department staff personal communications regarding Willow Creek tidegate.

O'Connell, K., Myers, D., and Owens, B., 2009, Biological condition of the edmonds waterfront and preliminary feasibility considerations for nearshore ecosystem restoration: Prepared for The Maria Norbury Foundation, Edmonds, WA, Prepared by People for Puget Sound, January 31.

Pentec, 1998, Evaluation of habitat benefits and impacts associated with the proposed daylighting of the outlet from edmonds marsh.

Perteet, 2012, Dayton St. and SR 104 Storm Drainage Alternatives Study, City of Edmonds, Wash.

Pritchard, DW., 1967, What is an estuary: Physical viewpoint, Pages 3-5 *in* GH Lauff, ed. Estuaries. American Association for the Advancement of Science, Publication 83, Washington DC.

Puget Sound Nearshore and Ecosystem Restoration Project (PSNERP), 2011, Implications of observed anthropogenic changes to the nearshore ecosystems in Puget Sound. Technical Report 2011-03.

Puget Sound Nearshore Partnership (PSNP), 2007. Marine forage fishes in Puget Sound, Prepared in Support of the Puget Sound Nearshore Partnership. Dan Pentilla, Washington Department of Fish and Wildlife. Technical Report 2007-03.

Redman, S.; Meyers, D.; and Averill, D. 2005, Regional Nearshore and marine Aspects of Salmon Recovery in Puget Sound, Shared Strategy for Puget Sound, June 28, 2005.

Rice, C., Chamberlin, J., Zackey, T., Hall, J., Zox, H., and Roni, P., 2012, What have we learned from pre-breach monitoring of Qwuloolt? Presentation at the Estuary Restoration Workshop convened by Snohomish County Public Works Surface Water Management. Presented by Casey Rice of the National Marine Fisheries Service, November 29.

Rice, C., Pers. Comm, 2012, Personal communication between Casey Rice, National Marine Fisheries Service, and Paul Schlenger, Confluence Environmental Company, regarding Edmonds Marsh restoration and recent fish observations. Telephone conversation August 31.

SAIC, 2013. Draft report, Dayton Street and SR 104 storm drainage alternatives study: Prepared for the City of Edmonds Stormwater Division, March 2013.

Schlenger, P., Pers. Obs., 2012, Personal observation by Paul Schlenger, Confluence Environmental Company, of juvenile salmonids in Willow Creek during site visit on August 31.

Sea-Run Consulting, TetraTech, Inc., Reid Middleton, Inc., and Pentec, 2007, City of Edmonds; Shoreline Master Program Update; Shoreline Inventory & Characterization: SMA Grant Agreement No. 60600108. Prepared for City of Edmonds, November.

Shannon & Wilson, 2010. Vegetation Assessment and Wetland Reconnaissance Technical Memo for the Fir Island Restoration Feasibility Study, Skagit County, Washington.

Shuster, Jerry, 2012, Pers. comm. with City of Edmonds Stormwater Manager Jerry Shuster regarding Willow Creek pipe, tidegate and WSDOT overflow manhole conditions.

Stay, pers. comm., 1995, Personal communication as reported in Pentec, 1998.

Thom, R.M., Borde, A.B., and Woodruff, D., 2000, Tidal wetland plants distribution and primary control factors in Commencement Bay, prepared for NOAA Damage Assessment and Restoration Center NW, Prepared by Battelle Marine Sciences Laboratory.

Thompson, W. Pers. Comm. 2012. Personal communication between Walter Thompson, Willow Creek Hatchery Manager, and Paul Schlenger, Confluence Environmental Company, regarding recent fish observations in Willow Creek and Edmonds Marsh. Telephone conversation August 29, 2012.

U.S. Army Corps of Engineers Hydrologic Engineering Center, 2010a, River analysis system, HEC-RAS (v. 4.1): January, available: http://www.hec.usace.army.mil/software/hec-ras/hecras-download.html.

U.S. Geological Survey, 2010, Puget Sound Shorelines and the Impacts of Armoring – Proceedings of a State of the Science Workshop, May 2009, Scientific Investigation Report 2010-5254.

U.S. National Oceanographic and Atmospheric Administration, 2012. VDatum Software, Vertical Datum Transformation, http://vdatum.noaa.gov/

U.S. National Oceanic and Atmospheric Administration – National Marine Fisheries Service (NMFS), 2011. Anadromous Salmonid Passage Facility Design, NMFS, Northwest Region, Portland, Oregon.

Washington State Department of Fish and Wildlife, 2003, Design of Road Culverts for Fish Passage.

Washington State Department of Transportation (WSDOT), 2004, Edmonds Crossing final environmental impact statement, Prepared by CH2M Hill, Bellevue, Washington.

WRIA-8, 2013. WRIA-8 Project Scoring Criteria – Guidance Narrative.

TABLE 1
PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COST
WILLOW CREEK RESTORATION

Item	Description	Quantity	Units	Unit Cost	Item Cost[1]
1.0	Mobilization and Demobilization	1	LS	$ 50,000.00	$ 50,000.00
1.1	Contractor Administration, Submittals, Closeout	1	LS	$ 100,000.00	$ 100,000.00
1.2	Stormwater Erosion Control	1	LS	$ 100,000.00	$ 100,000.00
2.0	Beach Outfall Channel Construction				
2.1	Demolition and Removal (existing tidegate and water main)	1	LS	$ 50,000.00	$ 50,000.00
2.2	Utility Relocations	1	LS	$ 25,000.00	$ 25,000.00
2.3	Dewatering	1	LS	$ 50,000.00	$ 50,000.00
2.4	Channel Excavation	8,000	CY	$ 10.00	$ 80,000.00
2.4.1	Haul and Dispose Excavated Material (uncontaminated)	3,900	CY	$ 10.00	$ 39,000.00
2.4.2	Haul and Dispose Excavated Material (50 percent contaminated)	3,900	CY	$ 95.35	$ 372,000.00
2.5	Erosion Protection Rock (12-inch Riprap)	900	CY	$ 60.00	$ 54,000.00
2.6	Shoring along Parking Area	500	VSF	$ 81.50	$ 41,000.00
2.7	Vegetated Reinforced Soil Wall	500	VSF	$ 81.50	$ 41,000.00
2.7	Pedestrian Bridge				
	Structure Excavation	540	CY	$ 7.00	$ 4,000.00
	Cast-in-Place Concrete	30	CY	$ 300.00	$ 9,000.00
	Pedestrian/Maintenance Bridge	600	SF	$ 200.00	$ 120,000.00
2.8	Self-regulating Tidegate (Option)	1	LS	$ 250,000.00	$ 250,000.00
2.9	Channel and Shoreline Habitat Features	1	LS	$ 50,000.00	$ 50,000.00
2.10	Revegetation	1	LS	$ 25,000.00	$ 25,000.00
3.0	Daylight Channel Construction				
3.1	Channel Excavation	6,800	CY	$ 7.00	$ 47,600.00
3.2	Dewatering	1	LS	$ 100,000.00	$ 100,000.00
3.3	Haul and Dispose Excavated Material (contaminated)	6,800	CY	$ 95.35	$ 648,000.00
3.4	Demolition, Protection, Modification of Stormwater Structures	1	LS	$ 250,000.00	$ 250,000.00
3.5	Channel Liner for Contaminant Protection	45,000	SF	$ 2.50	$ 113,000.00
3.6	Import Clean Liner Backfill	1,700	CY	$ 16.20	$ 28,000.00
3.7a	Railroad Crossing Special Operating Provisions	1	LS	$ 50,000.00	$ 50,000.00
3.7b	Erosion Protection Rock Bedding Material	250	CY	$ 60.00	$ 15,000.00
3.7c	Erosion Protection Rock (12-inch Riprap)	500	CY	$ 60.00	$ 30,000.00
3.8	Revegetation	1	LS	$ 25,000.00	$ 25,000.00
4.0	Marsh Improvements				
4.1	Clearing and Grubbing (remove cattails)	1.4	AC	$ 3,500.00	$ 5,000.00
4.2	Channel Excavation/Dredging	970	CY	$ 50.00	$ 49,000.00
4.3	Haul and Dispose Excavated Material (uncontaminated)	485	CY	$ 10.00	$ 5,000.00
4.4	Haul and Dispose Excavated Material (contaminated)	485	CY	$ 95.35	$ 46,000.00
4.5	Marsh Habitat Features	1	LS	$ 25,000.00	$ 25,000.00
4.6	Revegetation	1	LS	$ 25,000.00	$ 25,000.00
				Equipment, Labor, and Material Costs	$ 2,922,000.00
				Taxes (9.5%)	$ 278,000.00
				Bonding & Insurance (5%)	$ 146,000.00
				Contingency (30%)	$ 1,004,000.00
				Construction Cost	**$ 4,350,000.00**
				Real Estate (TBD)	$ -
				Feasibility, Engineering, Permits (25%)	$ 1,088,000.00
				Project Costs	**$ 5,438,000.00**

1 - Costs are rounded to nearest thousand.

Willow Creek Daylighting
Edmonds Marsh
Edmonds, Washington

EXISTING CONDITIONS

April 2013 21-1-12393-206

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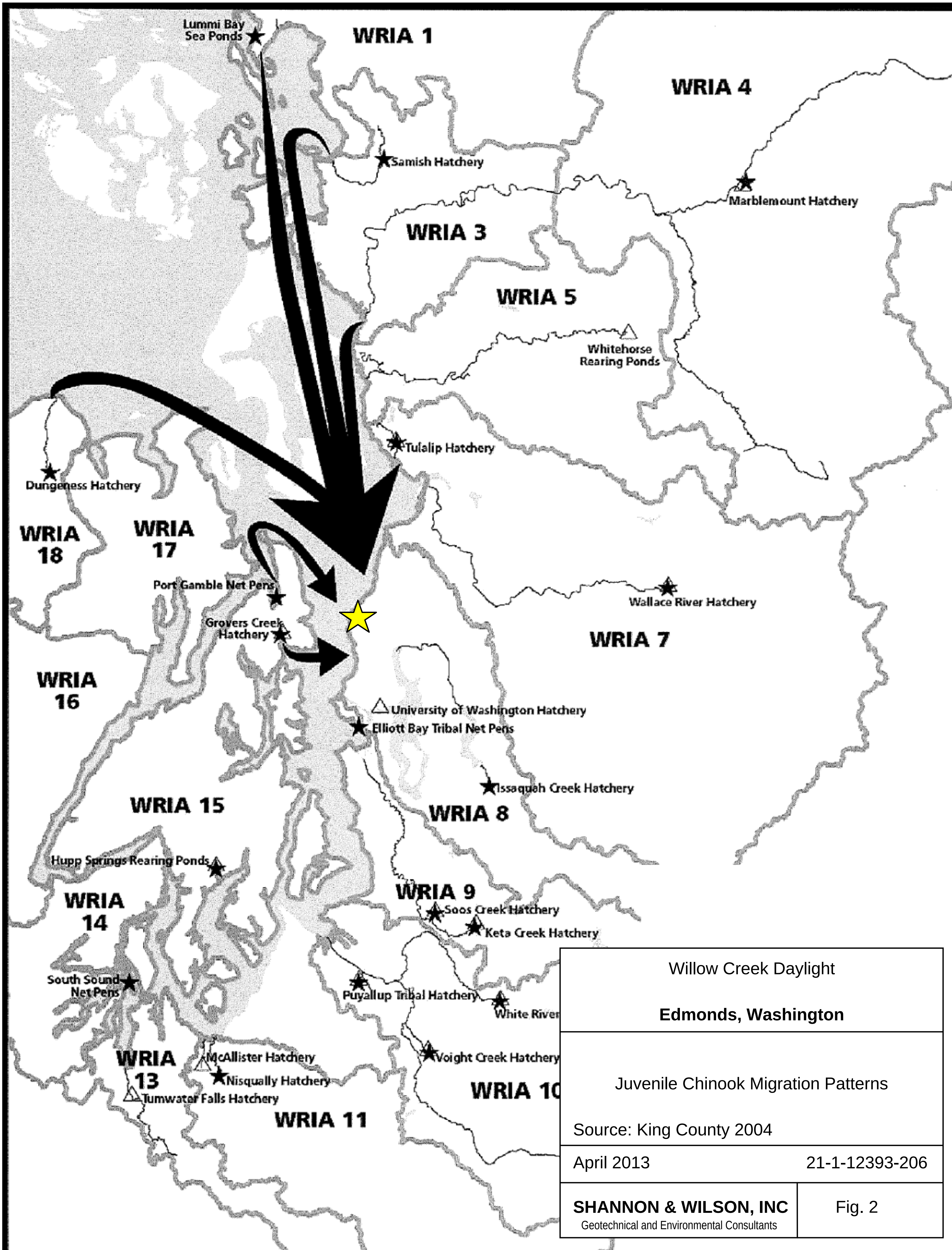
FIG. 1



Willow Creek Daylight **Edmonds, Washington**	
Juvenile Chinook Migration Patterns Source: King County 2004	
April 2013	21-1-12393-206
SHANNON & WILSON, INC Geotechnical and Environmental Consultants	Fig. 2

Willow Creek

Edmonds, WA

1870 HISTORIC MARSH

April 2013 21-1-12393-003

SHANNON & WILSON, INC.

FIG. 3

FIG. 3

FIG 4.

Willow Creek

Edmonds, WA

1944 Edmonds Marsh

October 2012

21-1-12393-003

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG 4.

FIG 5.

Willow Creek

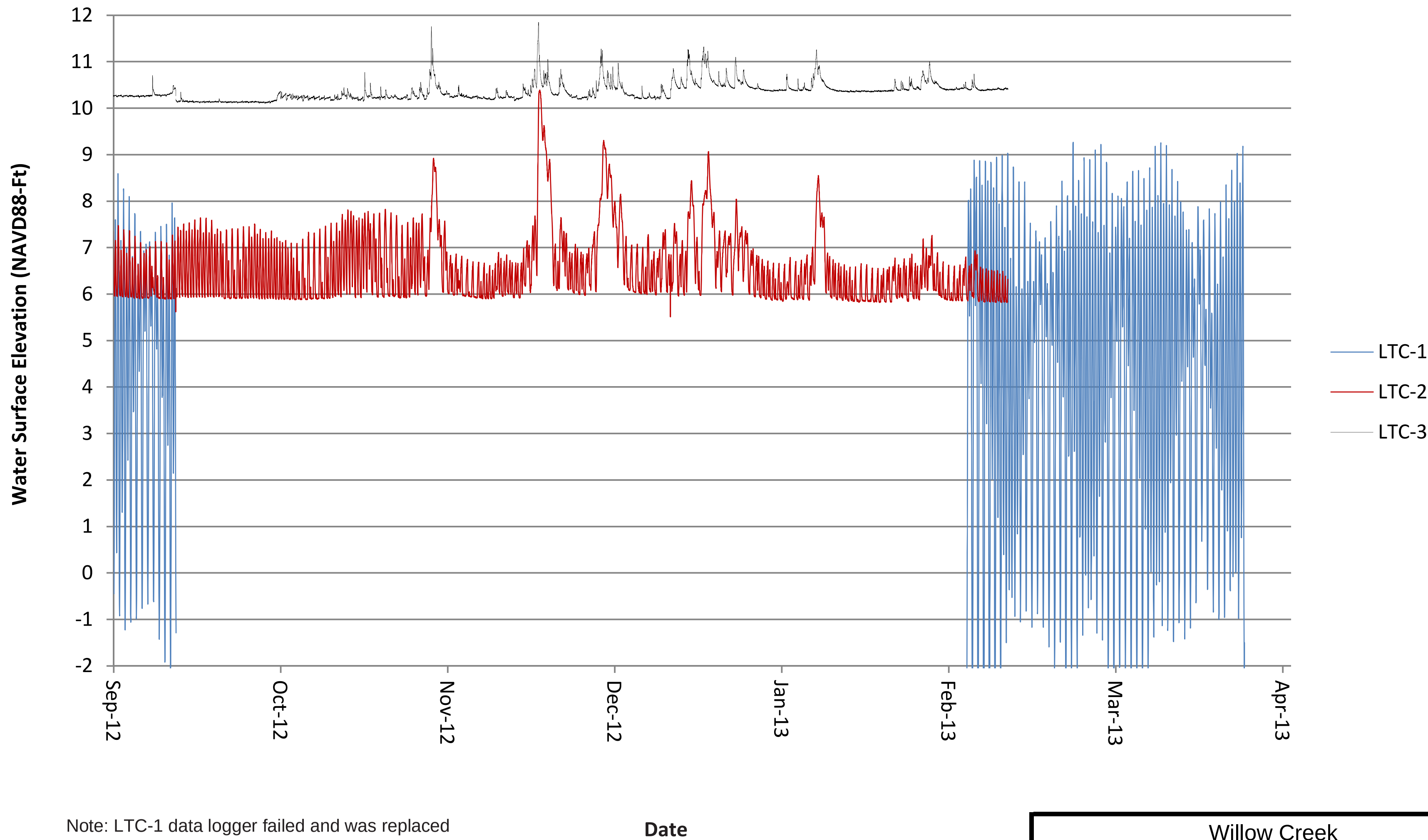
Edmonds, WA

1964 Marsh and Unocal Site

October 2012 21-1-12393-003

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG 5.

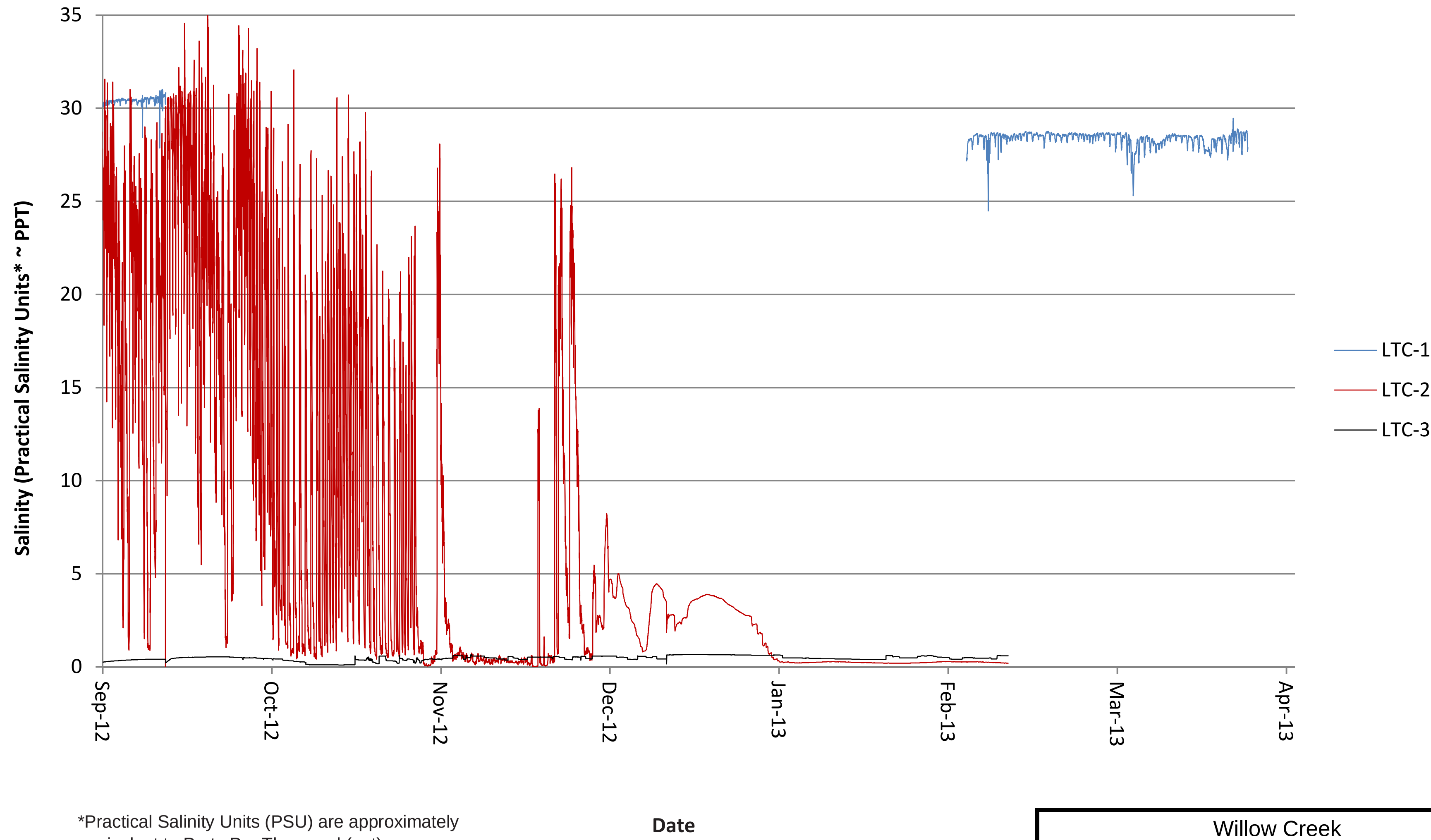


Note: LTC-1 data logger failed and was replaced February 5, 2013. NOAA Elliott Bay station 9447130 is acceptable replacement for missing data.

Willow Creek Edmonds, WA	
WATER LEVELS SEPT.2012 - MAR.2013	
April 2013	21-1-12393-102
SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS	**FIG. 6**

FIG. 6

I:\WIP\21-1\12393 Willow Creek Daylight\REPORTS\FIGURES\FIGS.6-8_TIDAL_DATA.xlsx <FIG.6_ELEVATIONS>



*Practical Salinity Units (PSU) are approximately equivalent to Parts Per Thousand (ppt)

Note: LTC-1 data logger failed and was replaced February 5, 2013. NOAA Elliott Bay station 9447130 is acceptable replacement for missing data.

FIG. 7

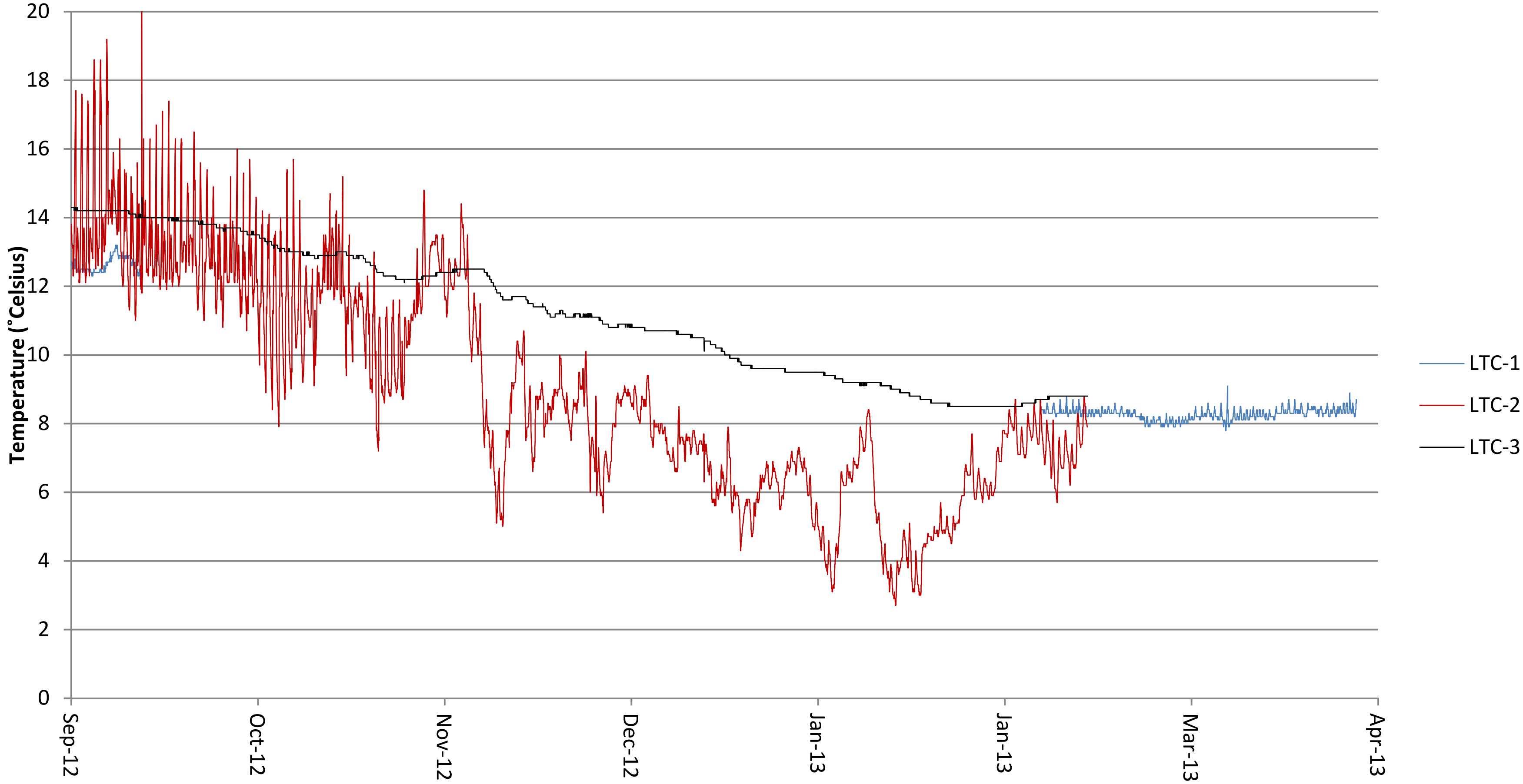
Willow Creek
Edmonds, WA

SALINITY
SEPT.2012 - MAR.2013

April 2013 | 21-1-12393-102

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 7



Note: LTC-1 data logger failed and was replaced February 5, 2013. NOAA Elliott Bay station 9447130 is acceptable replacement for missing data.

FIG. 8

Willow Creek
Edmonds, WA

TEMPERATURE
SEPT.2012 - MAR.2013

April 2013 | 21-1-12393-102

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FIG. 8

Legend
Proposed Daylight Channel
Existing Channel
Existing Stormline
Macroalgae Bed
Sediment Drift Zone
Proposed Areas
Dredge Channel
New Beach Channel
New Daylight Channel
Existing Channel, Marsh, and Upland Areas
Existing Daylight Channel
Mudflat and Salt Marsh
Freshwater Emergent
Forested Wetland
Forested Upland
Proposed Tidal Inundation
0 150 300
Feet
Fish Migration Pathway
Sediment Drift
Macroalgae Beds
Beach Outfall Area
Off-Leash Dog Park Area
New Beach Channel (Approx. 0.6 Acres)
Pedestrian Bridge and (SRT) Tidegate
Existing BNSF / ST Crossing
Marina Beach Park
Abandon Existing Willow Creek Outfall
Remove Existing Outfall Inlet
Protect/Relocate Existing Stormwater Pipes
Existing Daylight Channel (Approx. 0.55 Acres)
Daylight Channel Excavation (Approx. 0.88 Acres)
Chevron / Unocal Property
MUDLINE
Existing Tidal Marsh (Approx. 26.6 Acres)
Cattail Removal
Cattail Removal
Shellabarger Creek
Willow Creek
Shellabarger Marsh (Approx. 4.7 Acres)
Harbor Square
W Dayton St
2nd Ave S
4th Ave
104
Unoco Rd
Point Edwards
Pine St
216th St SW
Point Edwards Pl
Erben Dr
Edmonds City Park
PROJECT LOCATION
Edmonds
Lynnwood
Mountlake Terrace
Shoreline
Kenmore
Lake Forest Park
KITSAP PENINSULA
Indianola
Suquamish
Bainbridge Island
Seattle
National Geographic, Esri, DeLorme, NAVTEQ, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, iPC
Note: Marsh areas calculated from [Mudflat and Salt Marsh] + [Freshwater Emergent] + [Forested Wetland].
Willow Creek Daylighting
Edmonds Marsh
Edmonds, Washington
CONCEPTUAL DESIGN PLAN
PREFERRED DAYLIGHT ALIGNMENT
April 2013
21-1-12393-206
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 9
Filename: T:\Project\21-1\12393 Edmonds Marsh\AV mxd\ProposedConditions.mxd Date: 4/12/2013 beo

APPENDIX A

PHOTOGRAPHS

APPENDIX A

PHOTOGRAPHS

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Photograph 1 – Looking at Willow Creek entering Edmonds Marsh.

Photograph 2 – Looking upstream at Shellabarger Creek Marsh upstream (east) of SR 104

Photograph 3 – Looking downstream Shellabarger Creek (west) of SR 104.

Photograph 4 – Looking downstream Willow Creek confined channel. Note: S&W LTC-2 Gage location on left. Chevron / Unocal Stormwater Pond Gate in background on left side of channel.

Photograph 5 – Chevron / Unocal Stormwater Pond Overflows

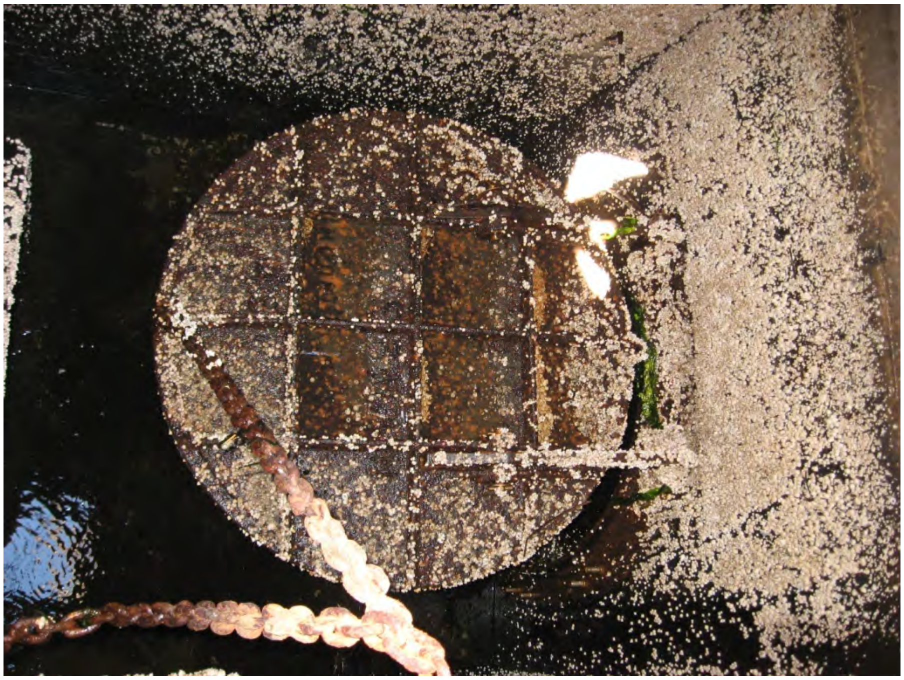
Photograph 6 – Looking towards WSDOT "Overflow" Manhole in Willow Creek.

Photograph 7 – Looking towards Edmonds Point stormwater detention pond.

Photograph 8 – Looking at low marsh vegetation Edmonds Marsh.

Photograph 9 – Looking upstream at Willow Creek crossing underneath BNSF Railway.

Photograph 10 – Looking downstream Willow Creek outlet to vault underneath Admiral with 48-inch concrete pipe.



Photograph 11 – Willow Creek Stormwater Vault and Tide Gate.

Photograph 12 – Looking towards shoreline area with stormwater outfall pipe submerged to west (left).

Photograph 13 – Marina Beach park northern beach area.

Photograph 14 – Looking at pre-constructed BNSF Railway bridge.

Photograph 15 – Marina Beach dog park area.

Photograph 16 – Marina Beach south parking lot.

Photograph 17 – Marina Beach north parking lot and grassy knoll.

Photograph 18 – Marina dock pier LTC-1 gage near Docks “F” and “G”.

APPENDIX B

TIDAL HYDRAULICS REPORT

DRAFT TIDAL MARSH HYDRODYNAMICS REPORT

WILLOW CREEK DAYLIGHT EARLY FEASIBILITY STUDY

Prepared for

Shannon and Wilson, Inc.

400 North 34th Street, Suite 100

Seattle, Washington 98103

Prepared by

Anchor QEA, LLC

720 Olive Way, Suite 100

Seattle, Washington 98101

March 2013

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LIST OF ACRONYMS AND ABBREVIATIONS

City	City of Edmonds
Confluence	Confluence Environmental
ft/s	feet per second
HEC-RAS	Hydrologic Engineering Center River Analysis System
LiDAR	Light Detection and Ranging
Marsh	Edmonds Marsh
MLLW	mean lower low water
NAVD 88	North American Vertical Datum of 1988
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
psu	practical salinity unit
S&W	Shannon and Wilson, Inc.
SR	State Route
WSDOT	Washington State Department of Transportation

1 INTRODUCTION

Anchor QEA, LLC, was retained by Shannon and Wilson, Inc. (S&W) to complete a preliminary evaluation of existing tidal hydrodynamics within Edmonds Marsh (Marsh), as well as predicted future tidal hydrodynamics in the Marsh based on a proposed new entrance channel to the project site (preferred alternative). This work was completed to support the Willow Creek Daylight Early Feasibility Study being conducted by S&W, Confluence Environmental (Confluence), and Anchor QEA for the City of Edmonds (City) (S&W 2012).

2 PURPOSE OF HYDRODYNAMIC EVALUATION

The purpose of the early feasibility hydrodynamic evaluation was to evaluate, assess, and compare tidal hydrodynamics in the Marsh for existing and proposed conditions (preferred alternative for new entrance channel) for typical low flow and approximate 100-year flow conditions in the basin. The results of this study were used to assess the potential to maintain a permanent connection between the Marsh and Puget Sound, inform an evaluation of potential fish passage and use of the restored Marsh (described in X report completed by Confluence 2013), and evaluate potential for upland flood impacts due to construction of the new entrance channel.

3 SITE DESCRIPTION

Edmonds Marsh is an approximate 23-acre estuarine marsh located within the City of Edmonds (Figure 1). It is bordered by State Route 104 to the east; Harbor Square to the north; the BNSF Railroad tracks to the west; and the Chevron/Unocal property (and 216th Street SW) to the south. The Marsh is tidally influenced by Puget Sound; the current connection between the Sound and the Marsh is a complex system of culverts, gates, and storage ponds (SAIC 2012; S&W 2012). The Marsh also receives freshwater runoff from approximately 900 acres, including two creeks and run-off from surrounding properties (Sea-Run Consulting 2007). Elevations within the Marsh (based on the digital elevation model developed by S&W; see Table 2) range from approximately 4 feet North American Vertical Datum of 1988 (NAVD 88) (6.2 feet mean lower low water [MLLW]) to 13 feet NAVD 88 (15.2 feet MLLW). Detailed information regarding existing and historical site conditions of the Marsh can be found in the *Alignment Alternatives Screening Analysis Report* (S&W 2012).

4 EVALUATION OF TIDAL HYDRODYNAMICS

Existing and future tidal hydrodynamics (post-restoration) within the Marsh were evaluated using a combination of site specific data collection and numerical modeling. Data collection included targeted site survey (conducted by Perteet in June 2012) and water level loggers installed in the Marsh and in Puget Sound within the Port of Edmonds Marina (by Shannon and Wilson from September 2012 to present). These data were used to evaluate tidal attenuation through the current connection of the marsh with Puget Sound (tide gage system) and the corresponding tidal inundation of the marsh.

Modeling efforts included development of a one –dimensional hydraulic model for both existing and proposed conditions (preferred new channel alternative). The models were used to evaluate tidal inundation, water depths, and in-channel velocities in the marsh for both and existing and future proposed conditions based on typical low flow and approximate 100-yr flood flow conditions. The model used for the evaluation was HEC-RAS, a one dimensional hydraulic model developed by the U.S. Army Corps of Engineers Hydrologic Engineering Center River Analysis System (HEC-RAS).

4.1 Tidal Information and Water Level Data

Tidal elevations for the project site was taken from the National Oceanic and Atmospheric Administration (NOAA) National Ocean Service (NOS) tidal benchmark in Elliott Bay, Seattle Washington (gage #9447130). Tidal heights at Elliott Bay were compared to water level data measured in Port of Edmonds Marina (see Section Appendix A) for the same time period; and the data were found to be in phase and have the same magnitude (within a few tenths of a foot). Therefore, tidal data at Elliott Bay was determined to be representative of tidal heights in the Sound at the project location. Conversion between MLLW and NAVD 88 was taken from NOAA's VDATUM software. This information is provided in Table 1.

Table 1
Tidal Elevations at the Project Site (based on NOAA Gage #9447130)

Tidal Elevation (feet)	Based on MLLW Datum (feet)	Based on NAVD 88 Datum (feet)
Mean higher high water	11.3	9.3
Mean high water	10.4	8.4
Mean tide level	6.6	4.4
Mean low water	2.8	0.6
NAVD 88 (feet)	2.2	0.0
Mean lower low water	0.0	-2.2

Notes:
NAVD 88 = North American Vertical Datum of 1988
MLLW = mean lower low water

Extreme high tide at the project site is approximately 12 feet NAVD 88 (14 feet MLLW), but occurs only a few times per year based on hourly water level data at Elliott Bay (Appendix A).

Water level data was collected synoptically in the Marsh, above SR 104 in Shellabarger Creek and in Puget Sound (Port of Edmonds Marina) from September 2012 through the present. The loggers measured water level, salinity, and temperature over the deployment time period.

A map showing the locations of the data loggers and water level, salinity, and temperature data from September 1 to September 14, 2012, is provided in Appendix A.

- Water surface elevations in the Marsh (Location LTC-2) oscillate between 6 feet NAVD 88 (8.2 feet MLLW) and approximately 7.5 feet NAVD 88 (9.7 feet MLLW).
- The highest water level in the Marsh (over the tidal cycle) lags behind the high tide elevation in Puget Sound (Location LTC-1). Also, water surface elevations in the Marsh drop more slowly than those in Puget Sound. This is typical of systems where the tidal incursion is limited by control structures (i.e., tide gages and weirs).
- Water levels in Shellabarger Creek remain relatively constant over the tidal cycle (at just higher than 10 feet NAVD 88 (12.2 feet MLLW).

- Salinity in Shellabarger Creek is quite low (less than 1 practical salinity unit [psu]) and remains relatively constant over the tidal cycle.
- Salinity in the marsh tends to oscillate between 30 psu (the salinity measured in Puget Sound) and approximately 20 psu. However, there are times when the salinity drops significantly to below 5 psu, likely due to freshwater inflows from Shellabarger or Willow creeks or other upland stormwater flows that drain into the Marsh.
- Temperature in the Marsh (over the period of record shown in Appendix A) appears to be relatively constant in Puget Sound and in Shellabarger Creek, but oscillates between 12 degrees Celsius and 18 degrees Celsius.
  - The increase with temperature on incoming tide (above the water temperature in Puget Sound) is not unusual. However, it may be due to water that was previously held downstream within stormwater pipes and storage ponds now being transported upstream into the Marsh during incoming tide. The water temperatures in the Marsh decrease after September 9 or 10, which may be a result of a higher flow event in Shellabarger Creek during that time.

4.2 Existing Conditions HEC-RAS Model

An existing conditions HEC-RAS model of the project area was developed using topography, water level, and flow data from several sources, as listed in Table 2.

Table 2
Data Sources Utilized in Existing Conditions HEC-RAS Model

Date Type	Source	Spatial Extent	Temporal Extent
Topography/Stream Geometry	Shannon & Wilson; Digital Terrain Model	Project Area	N/A
Culvert Geometry	Shannon & Wilson; Survey Data	Project Area	N/A
Spring Tidal Data	NOAA	Lower Willow Creek	May 1-15, 2008
High Flow Tidal Data	NOAA	Lower Willow Creek	Dec 17-31, 2007
Spring Flow Conditions	Provided by Shannon & Wilson; taken from SR-104 HSPF Model (SAIC 2012)	Shellabarger Creek & Upper Willow Creek	May 1-15, 2008
High Flow Conditions	Provided by Shannon &	Shellabarger Creek &	Dec 1-14, 2007

	Wilson; taken from SR-104 HSPF Model (SAIC 2012)	Willow Creek	
Predicted Water Surface Elevation Data in the Marsh (High Flows)	Provided by Shannon & Wilson; taken from SR-104 HSPF Model (SAIC, 2012)	Willow Creek (at Section 1285 as shown in Figure 2)	Dec 1-14, 2007

Note:
NOAA = National Oceanic and Atmospheric Administration

Surface data from S&W were processed using HEC-GeoRAS, a tool developed for ArcGIS to process geospatial data for use in the HEC-RAS model. HEC-RAS geometry data were developed from HEC-GeoRAS at cross-sections within the project area. The cross-sections and existing surface data are shown in Figure 2.

Cross-sections were adjusted and culverts were added as necessary using survey data provided by S&W. Manning's roughness coefficients were estimated using professional judgment and available literature.

The HEC-RAS model was run as an unsteady flow model to simulate tidal cycles during a typical spring period (see Figure 4) and a typical low-flow and high-flow event. Low flows were provided by S&W and represent average flows during May in Shellabarger and Upper Willow creeks (0.5 cfs and 0.3 cfs, respectively). The high-flow event was provided by S&W and taken from flood modeling work completed by SAIC (SAIC 2012) and represents a flow event in December 2007 (see Figure 5). To improve the stability of the model, the model was split into three reaches (Upper Willow Creek, Shellabarger Creek, and Lower Willow Creek). To further improve stability, the downstream boundary location was set at the storm vault entrance upstream of the tide gate. Downstream boundary conditions for Lower Willow Creek were set to the higher of the bottom of the storm vault entrance or NOAA tidal data (spring)/SAIC water surface elevations (high flow). Downstream boundary conditions for Upper Willow Creek and Shellabarger Creek were set to the water surface elevation at the uppermost cross-section of Lower Willow Creek. Flow conditions were assumed to be concurrent such that the Lower Willow Creek flow was equal to the sum of the Upper Willow Creek and Shellabarger Creek flows. Simulation time periods were set for 2 weeks.

4.3 Proposed Conditions Model

The proposed conditions model was developed based on the existing conditions model and geometry for the preferred alternative for the proposed new channel developed by S&W (S&W 2012). Data sources used to develop the proposed conditions model are the same as those provided in Table 2. However, a new digital terrain model was provided by S&W that included the preferred alternative design for the new entrance channel in the topography. The thalweg of the new entrance channel just above the railroad bride is similar to existing conditions—approximately 4 feet NAVD 88 (6.2 feet MLLW).

Cross-section locations were kept the same as the existing model, where possible. In new channel areas, cross-sections were moved to capture likely flow paths. Figure 3 shows the proposed model cross-section locations and proposed surface. The downstream boundary location for Lower Willow Creek in the proposed conditions is at the channel outlet to Puget Sound. All other conditions remained the same as those described in the existing conditions model.

4.4 Model Results

Four model simulations were completed: one low-flow and one high-flow simulation for both existing and proposed conditions. Each simulation was run for a 2-week timeframe with a tidal downstream boundary condition (see Figure 4). Results for the low- and high-flow simulations are described in detail below.

4.4.1 Low-flow Model Runs

The purpose of the low-flow model runs was to evaluate tidal inundation based on existing and proposed conditions and to provide predictions of in-channel flow velocities in the Marsh to assess fish access.

Figures 6, 7, and 8 show predicted inundation areas for existing and proposed condition, and a comparison of these inundation areas, based on results of the low-flow HEC-RAS model runs. Figures 10 to 17 provide average in-channel velocities for existing and proposed conditions at various locations (see Figure 9) within the project area as predicted by the

HEC-RAS model. Following is a summary of model results for the low-flow HEC-RAS simulations:

- Predicted Inundation at low flows is not *significantly* different between existing and proposed conditions (16.8 acres compared to 19.2 acres, respectively). However, the proposed conditions do show a slightly larger inundation area (based on available topography and hydrodynamic conditions modeled).
- Predicted Maximum velocities in Willow Creek in the salt marsh area would increase because of proposed conditions from 0.2 feet per second (ft/s) to 0.6 ft/s, because of an increase in the tidal prism once the new channel is constructed.
- Predicted Maximum velocities in Willow Creek in the channelized section parallel to the railroad would increase because of proposed conditions from 1 ft/s to 3ft/s.
- Predicted Maximum velocities in the proposed new outlet channel would 1.8 ft/s upstream of the railroad bridge and could get as high as 5 ft/s in the channel outlet on the beach (at low tide).
- Predicted velocities in Shellabarger Creek and Upper Willow Creek are higher with existing conditions than with proposed conditions. This is due to an increase in channel cross-section in this area due to excavation proposed as part of the preferred alternative.

4.4.2 High-flow Model Runs

Figures 18 and 19 provide flow and velocity information, respectively, predicted by the HEC-RAS model for existing and proposed conditions in the Marsh. A summary of model results for the high flow HEC-RAS simulations is provided below:

- Low tide water surface elevations just upstream of the railroad bridge (in the proposed new channel) are increased during the flood event, but high tide water surface elevations are not noticeably higher than normal high tide conditions during the flood event.
- Water surface elevations just downstream of the confluence of Shellabarger and Willow creeks increase to just below 13 feet NAVD 88 (15.2 feet MLLW) for existing conditions. This elevation compares well with the reported 100-year flood elevation for the Marsh provided in SAIC 2012.

- Water surface elevations just downstream of the confluence of Shellabarger and Willow creeks for proposed conditions do not get above 11 feet NAVD 88 (13.2 feet MLLW) during the flood event.

5 PRELIMINARY CONCLUSIONS AND NEXT STEPS

Based on the review of site-specific data (Section 4.1) and results of the modeling effort (Section 4.2), several preliminary conclusions can be made regarding the performance of the preferred alternative (new channel) compared to existing conditions in the Marsh:

- The increase in conveyance in the channel due to proposed conditions does not appear to significantly increase water surface elevations in the Marsh during the approximate 100-year flood event (compared to published flood elevations in the marsh for existing conditions).
- The thalweg of the proposed new entrance channel (approximately 4 feet NAVD 88, 6.2 feet MLLW) will control the low tide elevation of water in the Marsh at low tide; it will equal the thalweg elevation. It will also control the frequency of tidal inundation into the Marsh for proposed conditions. Based on tidal elevations in Puget Sound at Elliot Bay (Appendix A), tides are higher than 6.2 feet MLLW approximately 60% of the time on an annual basis.
- Water surface elevations in the Marsh are currently controlled by the existing tide gate system and are lower than high tide elevations in Puget Sound during the portions of the year that the existing tide gate is closed (October through March). If the gate is removed (and not replaced), the Marsh site and adjacent streams will see water surface elevations up to high tide elevations (see Table 1) on an almost daily basis.
- A tide gate could be installed on the outflow channel to the Marsh (at the bridge) to limit water surface elevations in the Marsh, as is done currently. However, this will also limit conveyance through the bridge opening and the amount of time that fish will be able to enter or exit the marsh. Since fish access to the marsh is a primary goal of the project, a separate alternatives analysis of with and without tidegate is recommended for the feasibility phase of study.
- There needs to be additional hydraulic study to quantify other stormwater flows into the Marsh that are not captured in the current run-off model. These sources include the Washington State Department of Transportation (WSDOT) Edmonds Way manhole overflow and any additional back flooding from the Dayton stormwater system.

- There needs to be additional survey in the Marsh to increase data coverage (in areas where Light Detection and Ranging (LiDAR) could be impacted by vegetation) and decrease uncertainty in the inundation maps developed as part of this phase of work.
- There needs to be additional alternatives analysis and subsequent design refinement to the outflow channel on the beach to account for impacts of wind-waves, littoral drift (in-filling), and planned park and public uses.

6 UNCERTAINTY DISCUSSION

The results of the preliminary tidal hydrodynamic evaluation for this project were based on the best available data at the time and targeted to meet the specific needs of the early feasibility evaluation. Uncertainties in the model are due to limitations of the input data to the model (i.e., topography, flows, and water levels) and assumptions made by the model itself. Specific potential sources of uncertainty with this study include:

- Multiple sources of topography information, with different spatial resolutions, coverage areas, and collection times, were used to create the digital elevation models used to develop both existing and proposed conditions hydrodynamic (HEC-RAS) models.
- Flow data was provided by a run-off model completed by SAIC (SAIC, 2012); there are no stream gage data available for project area.
- The existing conditions model was not calibrated based on synoptic measured flow and water level data in the Marsh, due to lack of data.
- Some stormwater inflows to the marsh are not currently quantified.

7 REFERENCES

SAIC, 2012. *Dayton Street and SR 104 Storm Drainage Alternatives Study (DRAFT).* Prepared for the City of Edmonds. November 2012.

Sea-Run Consulting, TetraTech, Inc., Reid Middleton, Inc., and Pentec, 2007. *City of Edmonds; Shoreline Master Program Update; Shoreline Inventory & Characterization*. SMA Grant Agreement No. 60600108. Prepared for City of Edmonds. November 2007.

Shannon and Wilson, Inc., 2012. *Alignment Alternatives Screening Analysis; Willow Creek Daylight Early Feasibility Study*. Prepared for People for Puget Sound. September 2012.

FIGURES

NOTES:
Base Map: ESRI Data and Maps [DVD]. (2009). Redlands, CA: Environmental Systems Research Institute
Aerial: Bing Maps

I:\Users\ahill\Public\Willow Creek\GIS\Site_Map.mxd ahill 3/22/2013 1:02:04 PM

ANCHOR QEA

Feet
0 300 600

Figure 1
Site Location Map
Tidal Marsh Hydrodynamics Report (DRAFT)
Willow Creek Daylight Early Feasibility Study

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ANCHOR QEA

NOTES:
Existing surface source: Shannon & Wilson
Aerial source: Bing

Feet
0 100 200 300 400

Figure 2
Existing Marsh Topography and HEC-RAS Model Cross-Section Locations
Tidal Marsh Hydrodynamics Report (DRAFT)
Willow Creek Daylight Early Feasibility Study

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ANCHOR QEA

NOTES:
Proposed surface source: Shannon & Wilson
Aerial source: Bing

Feet
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Figure 3
Proposed Marsh Topography and HEC-RAS Model Cross-Section Locations
Tidal Marsh Hydrodynamics Report (DRAFT)
Willow Creek Daylight Early Feasibility Study

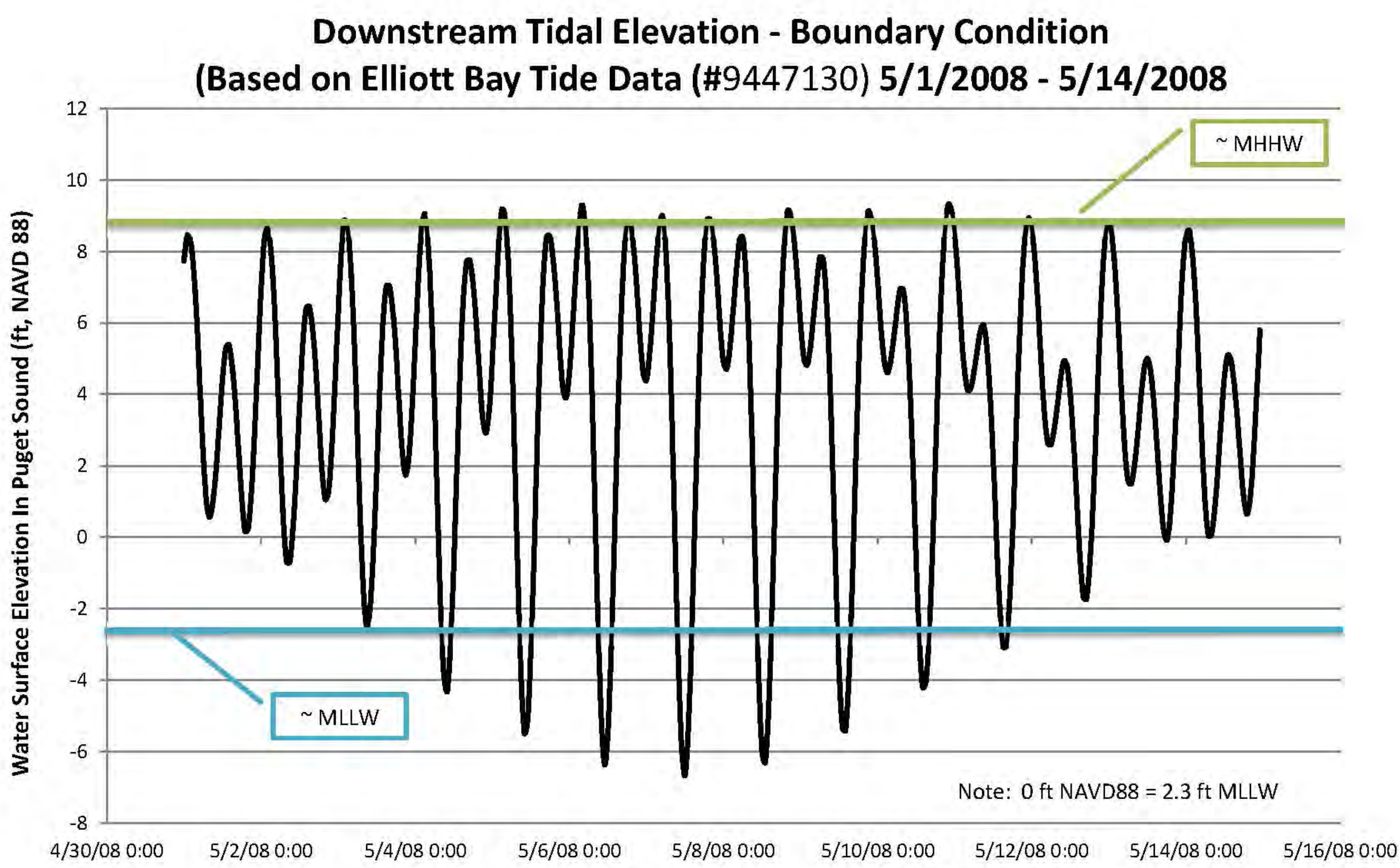
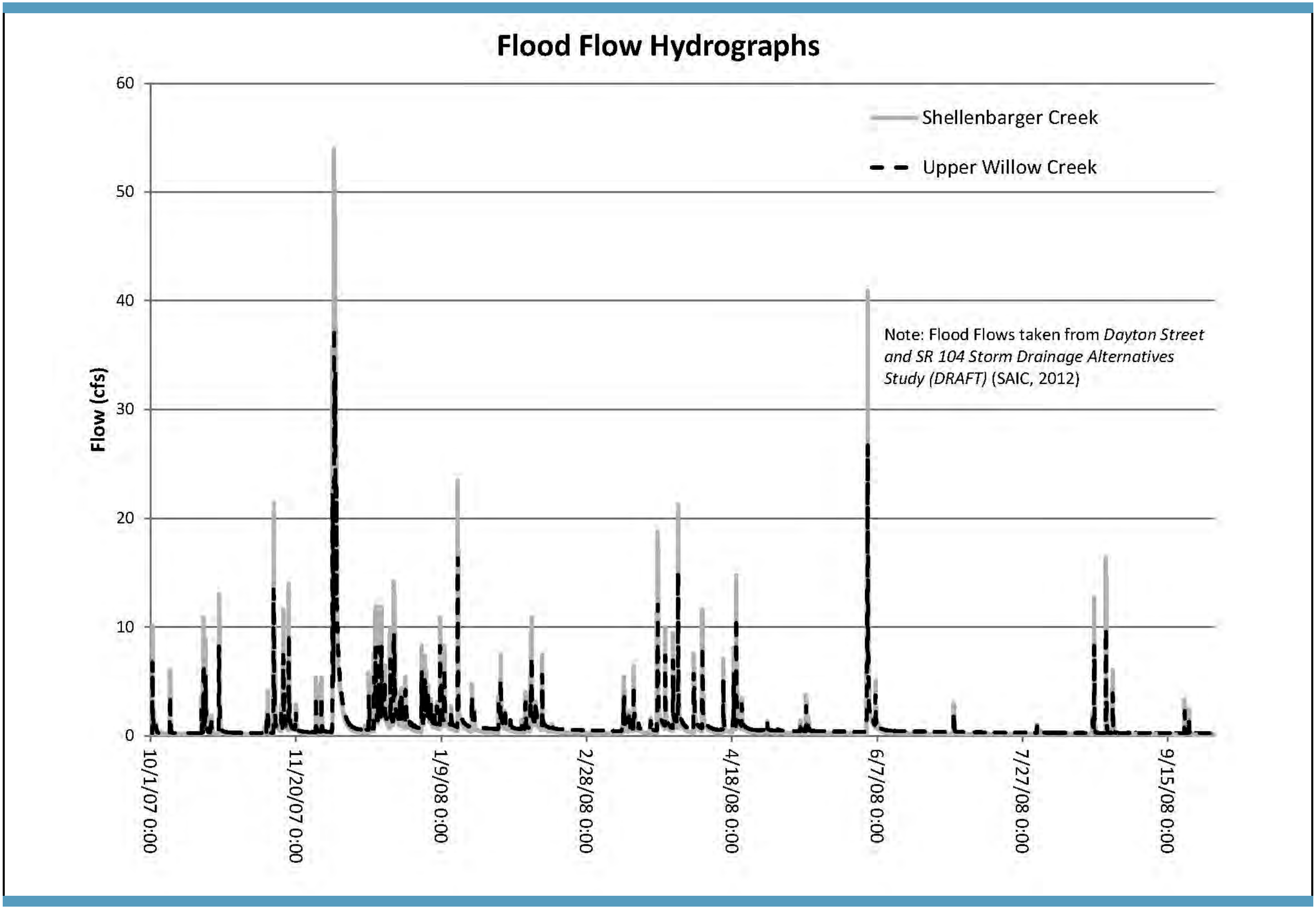


Figure 4
Tidal Boundary Conditions
Tidal Marsh Hydrodynamic Report (DRAFT)
Willow Creek Daylight Early Feasibility Study



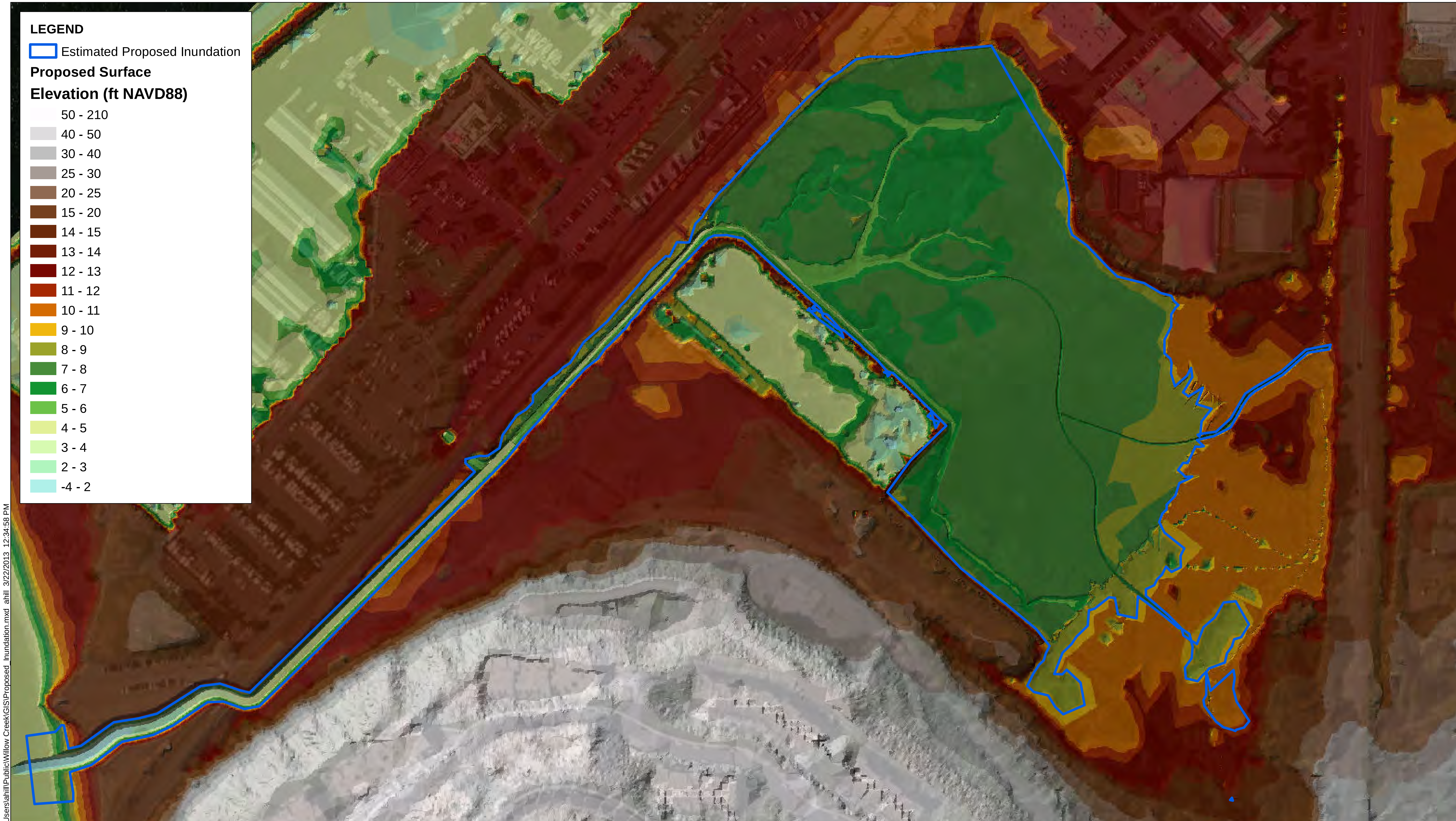
ANCHOR QEA

Figure 5
Flood Flow Hydrographs
Tidal Marsh Hydrodynamic Report (DRAFT)
Willow Creek Daylight Early Feasibility Study

NOTES:
Inundation areas based on HEC-RAS maximum water surface model outputs.
Existing surface source: Shannon & Wilson
Aerial source: Bing

Feet
0 100 200 300 400

Figure 6
Estimated Inundation Areas - Existing Spring Conditions
Tidal Marsh Hydrodynamics Report (DRAFT)
Willow Creek Daylight Early Feasibility Study



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NOTES:
Inundation areas based on HEC-RAS maximum water surface model outputs.
Proposed surface source: Shannon & Wilson
Aerial source: Bing

Feet
0 100 200 300 400

Figure 7
Estimated Inundation Areas - Proposed Spring Conditions
Tidal Marsh Hydrodynamics Report (DRAFT)
Willow Creek Daylight Early Feasibility Study

NOTES:
Inundation areas based on HEC-RAS maximum water surface model outputs.
Aerial source: Bing

ANCHOR QEA

Figure 8
Comparison of Estimated Inundation Areas - Spring Conditions
Tidal Marsh Hydrodynamics Report (DRAFT)
Willow Creek Daylight Early Feasibility Study

ANCHOR QEA

NOTES:
Aerial source: Bing

Feet
0 100 200 300 400

Figure 9
Approximate Locations of Plotted Velocities
Tidal Marsh Hydrodynamics Report (DRAFT)
Willow Creek Daylight Early Feasibility Study

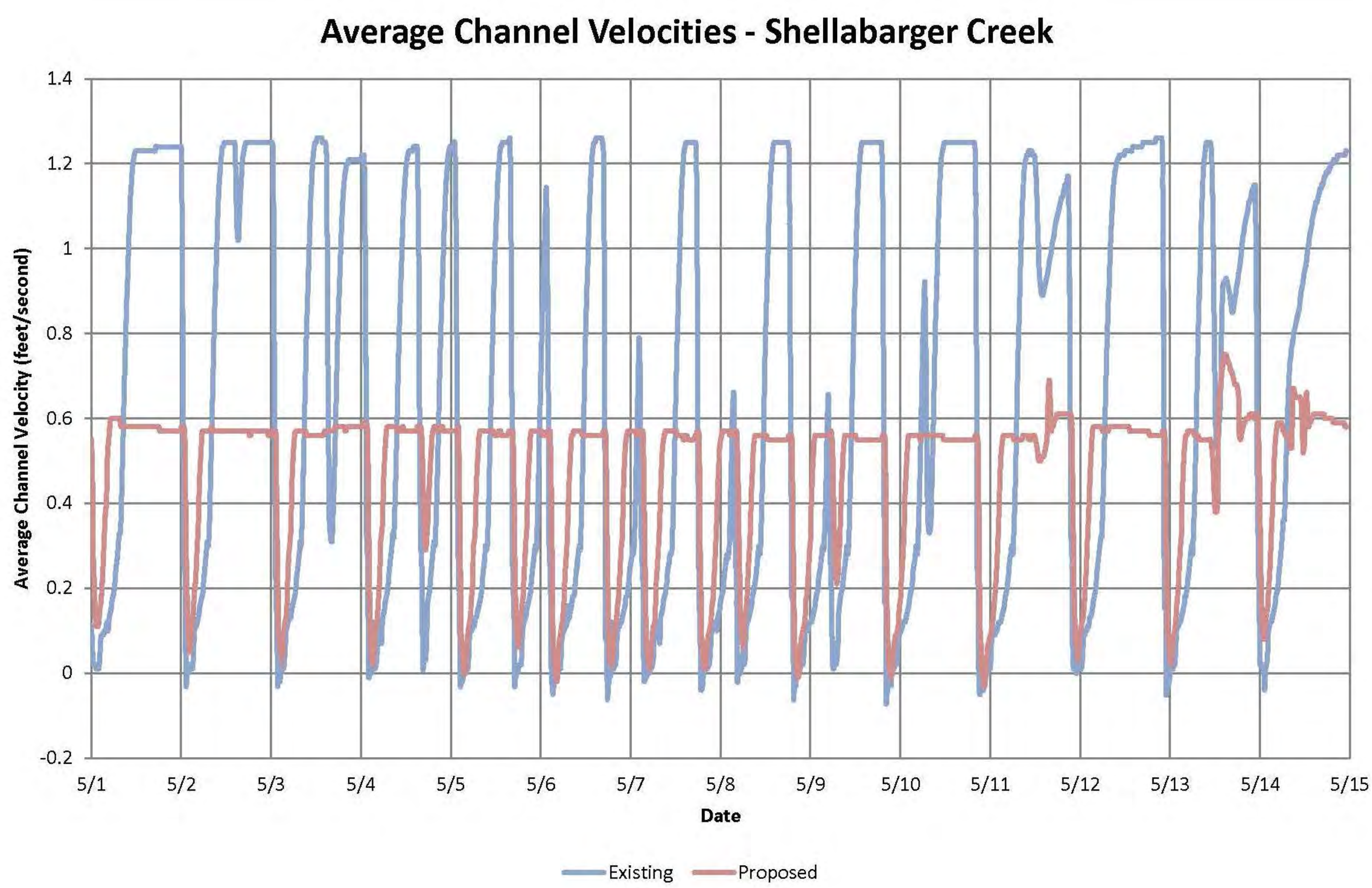


Figure 10
Comparison of Average Channel Velocities: Existing and Proposed Conditions—Shellabarger Creek
Tidal Marsh Hydrodynamic Report (DRAFT)
Willow Creek Daylight Early Feasibility Study

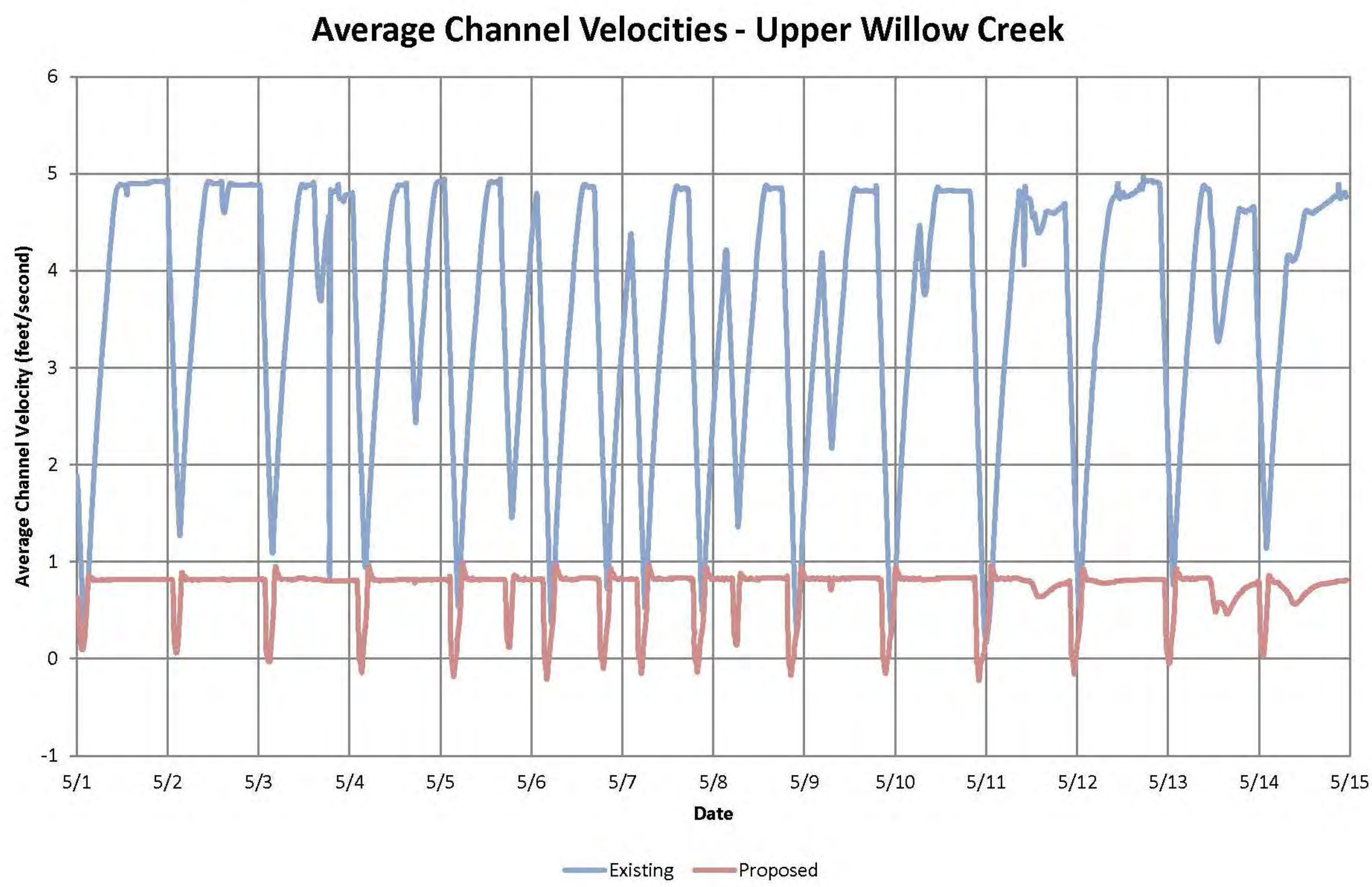


Figure 11
Comparison of Average Channel Velocities: Existing and Proposed Conditions—Upper Willow Creek
Tidal Marsh Hydrodynamic Report (DRAFT)
Willow Creek Daylight Early Feasibility Study

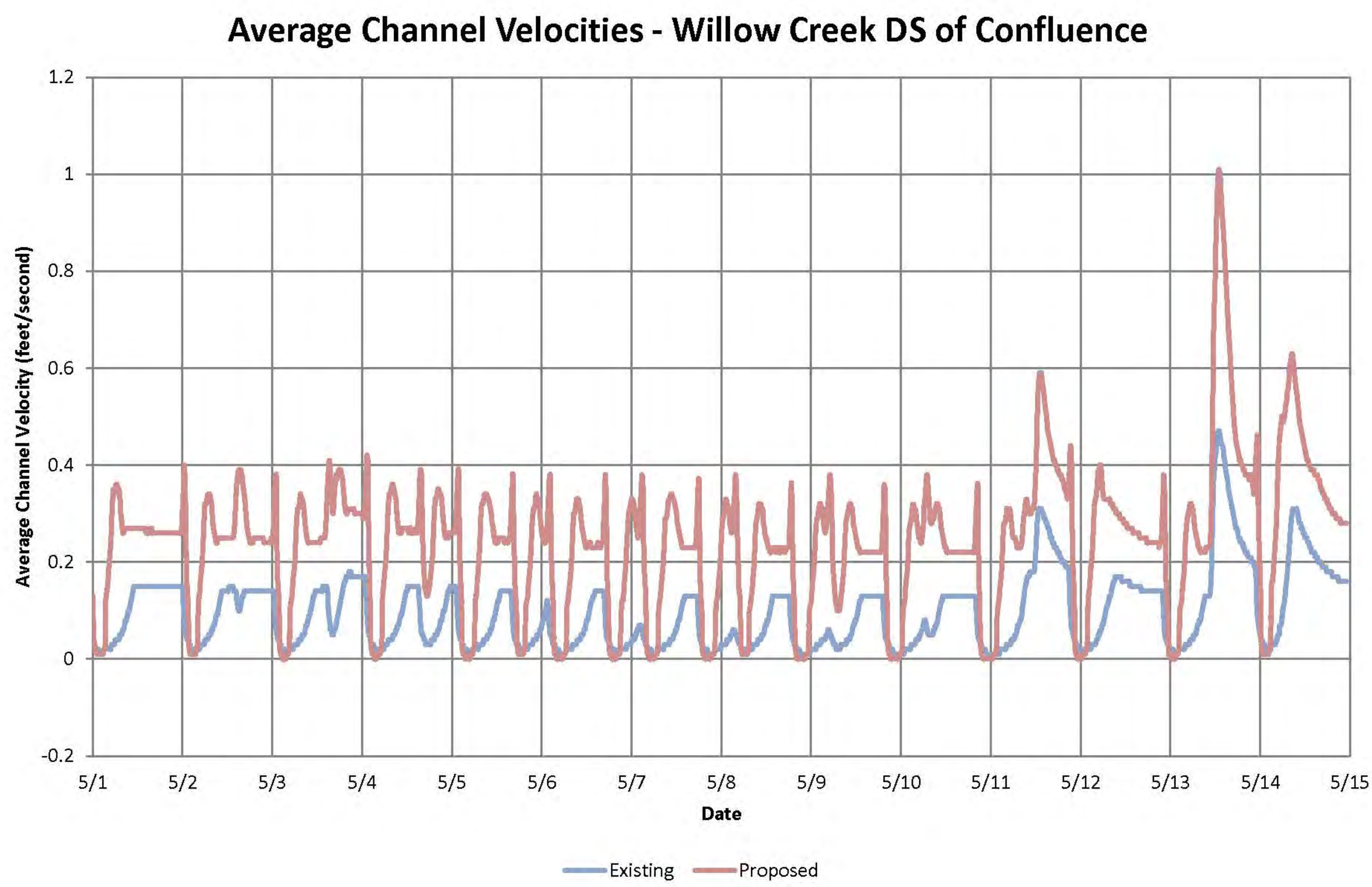


Figure 12
Comparison of Average Channel Velocities: Existing and Proposed Conditions—Willow Creek DS of Confluence
Tidal Marsh Hydrodynamic Report (DRAFT)
Willow Creek Daylight Early Feasibility Study

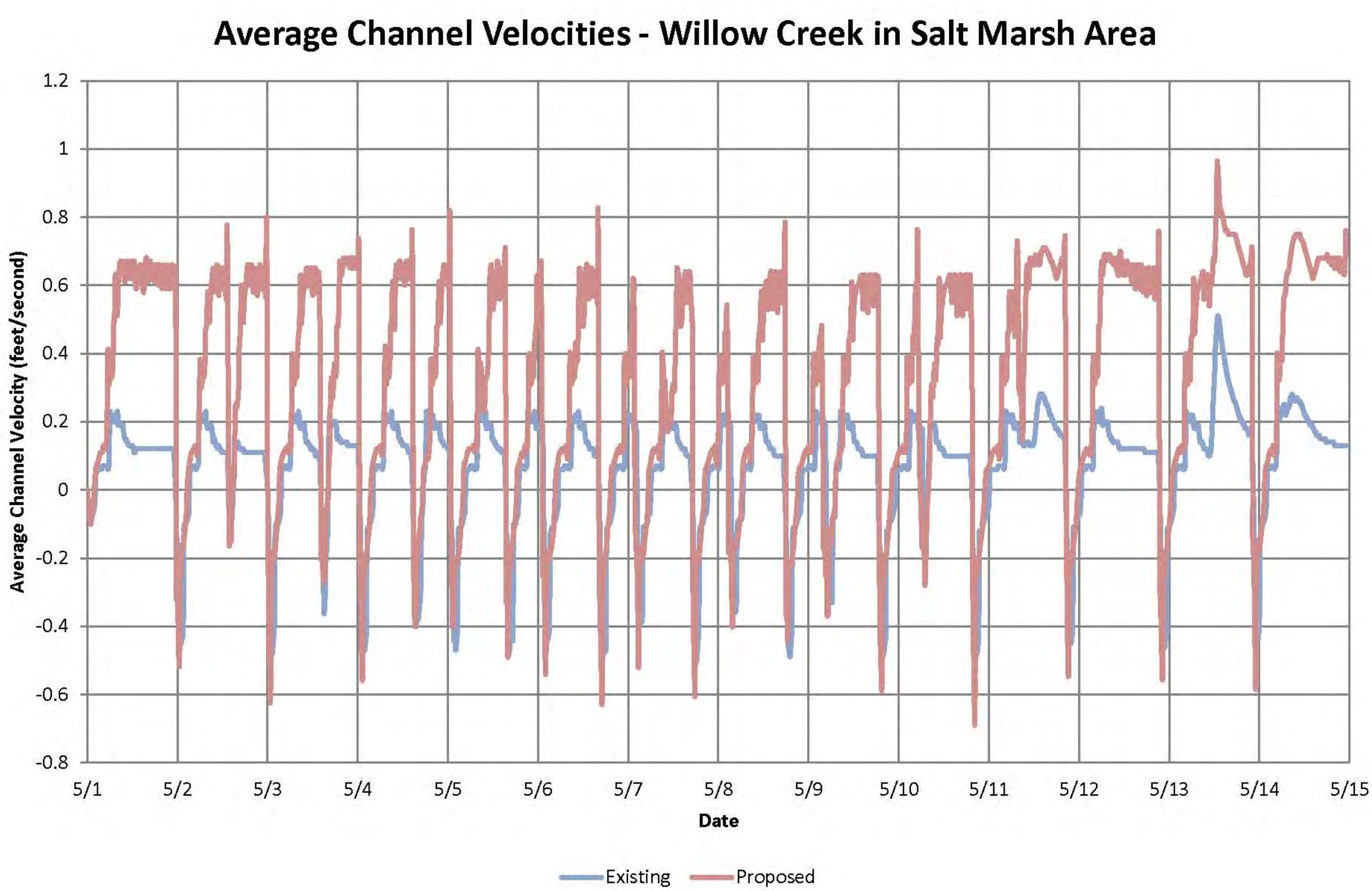


Figure 13
Comparison of Average Channel Velocities: Existing and Proposed Conditions—Willow Creek in Salt Marsh Area
Tidal Marsh Hydrodynamic Report (DRAFT)
Willow Creek Daylight Early Feasibility Study

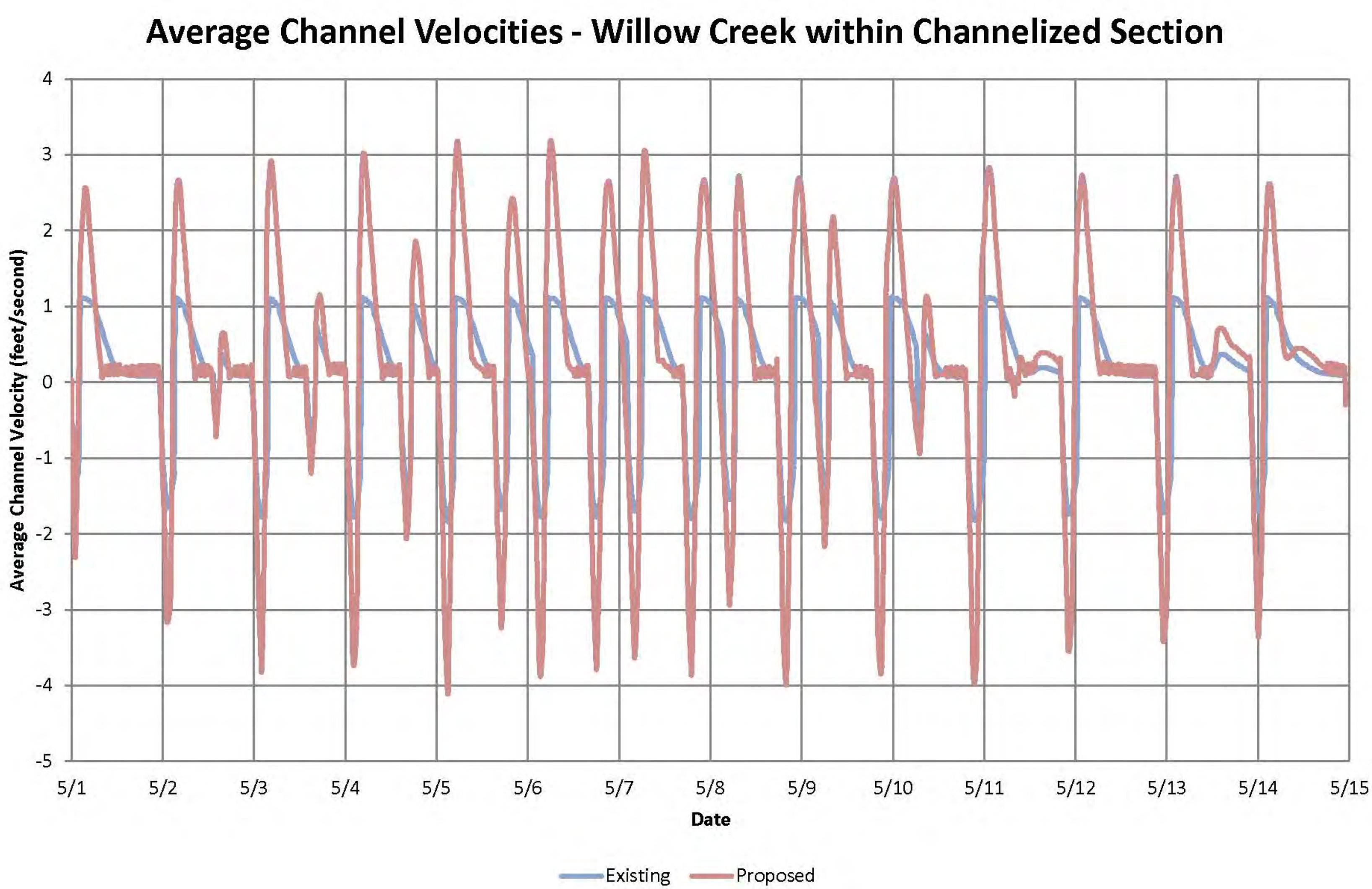
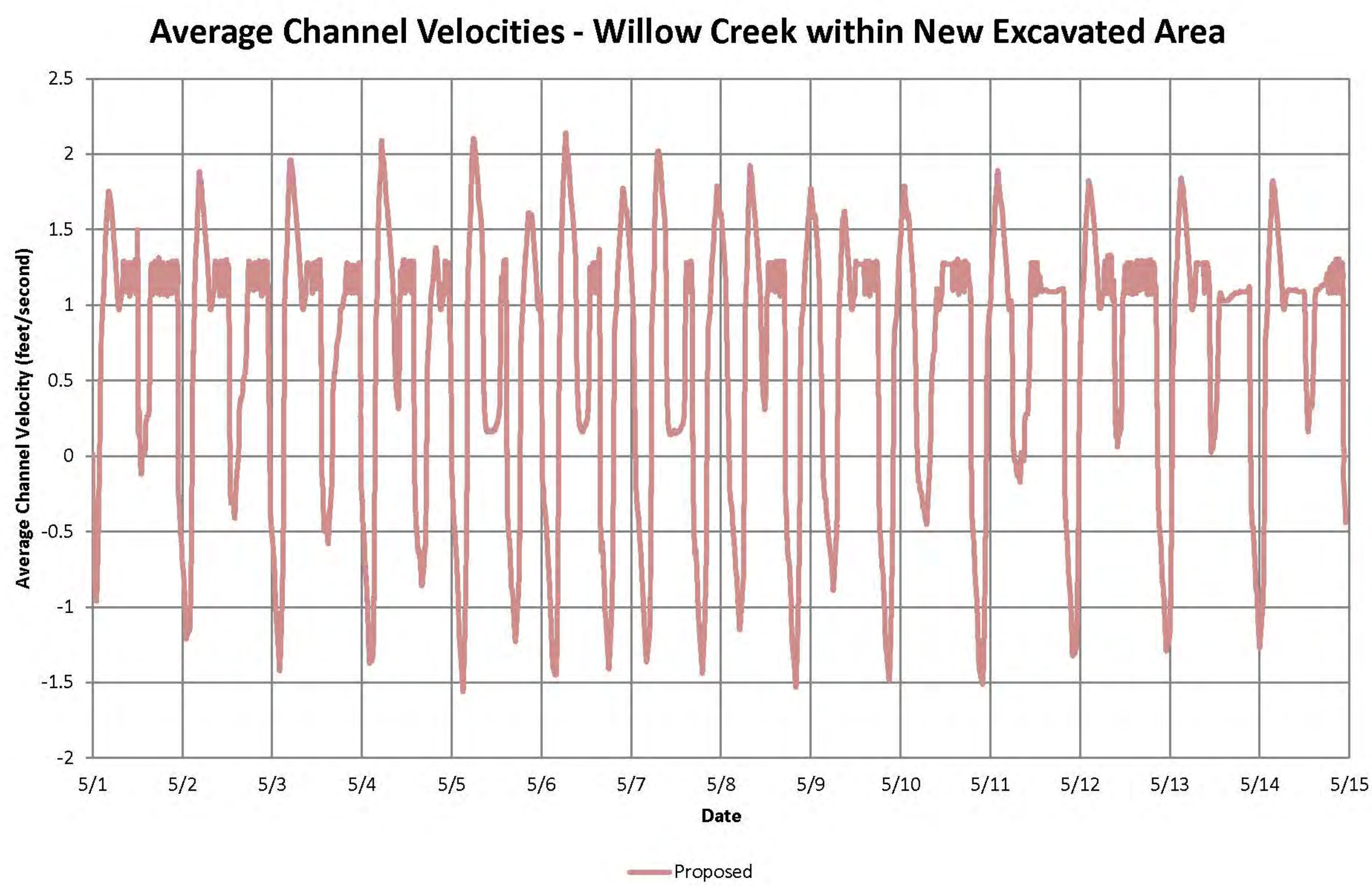


Figure 14
Comparison of Average Channel Velocities: Existing and Proposed Conditions—Willow Creek within Channelized Section
Tidal Marsh Hydrodynamic Report (DRAFT)
Willow Creek Daylight Early Feasibility Study



ANCHOR QEA

Figure 15
Comparison of Average Channel Velocities: Existing and Proposed Conditions—Willow Creek within New Excavated Area
Tidal Marsh Hydrodynamic Report (DRAFT)
Willow Creek Daylight Early Feasibility Study

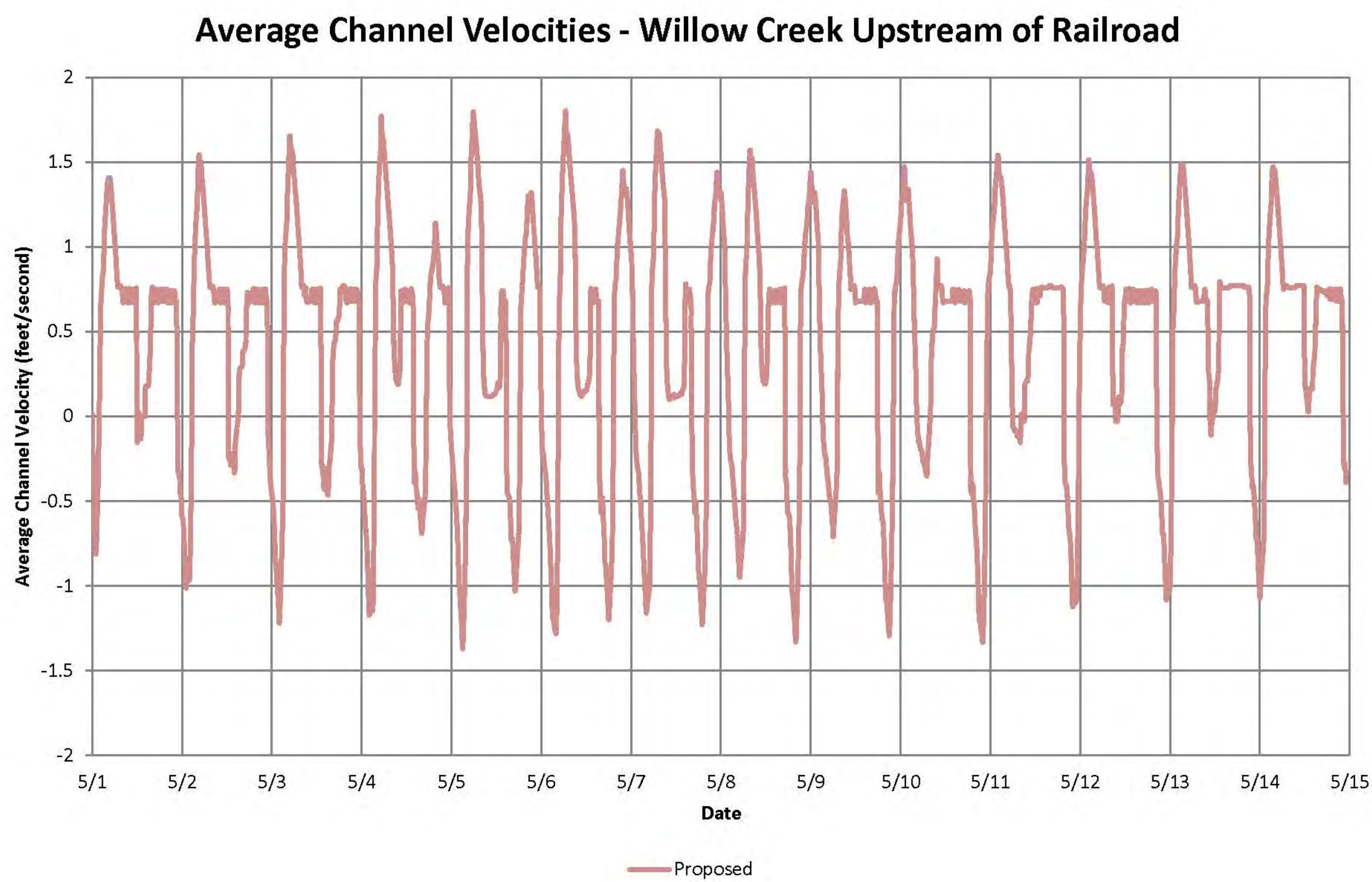


Figure 16
Comparison of Average Channel Velocities: Existing and Proposed Conditions—Willow Creek Upstream of Railroad
Tidal Marsh Hydrodynamic Report (DRAFT)
Willow Creek Daylight Early Feasibility Study

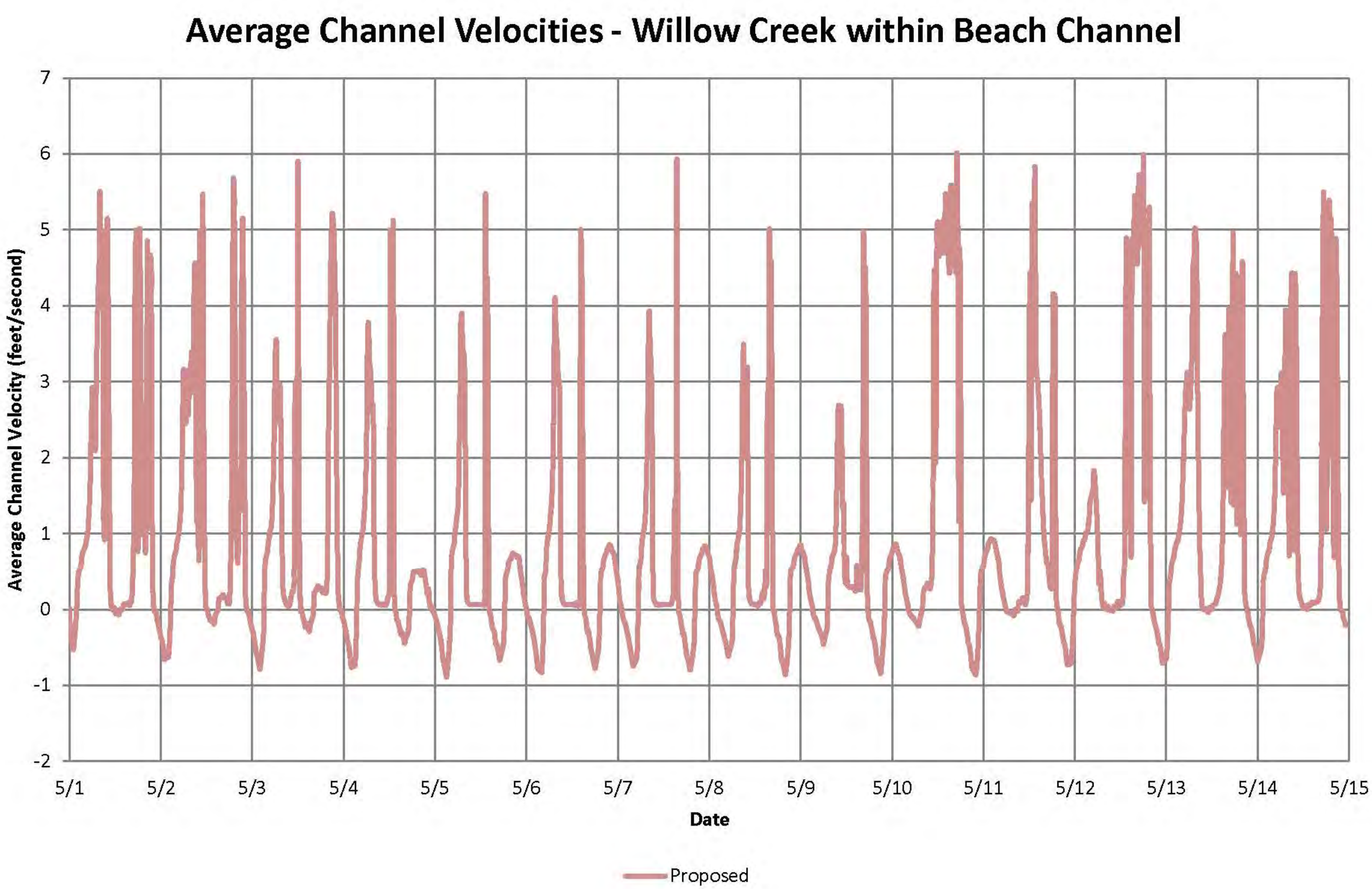


Figure 17
Comparison of Average Channel Velocities: Existing and Proposed Conditions—Willow Creek within Beach Channel
Tidal Marsh Hydrodynamic Report (DRAFT)
Willow Creek Daylight Early Feasibility Study

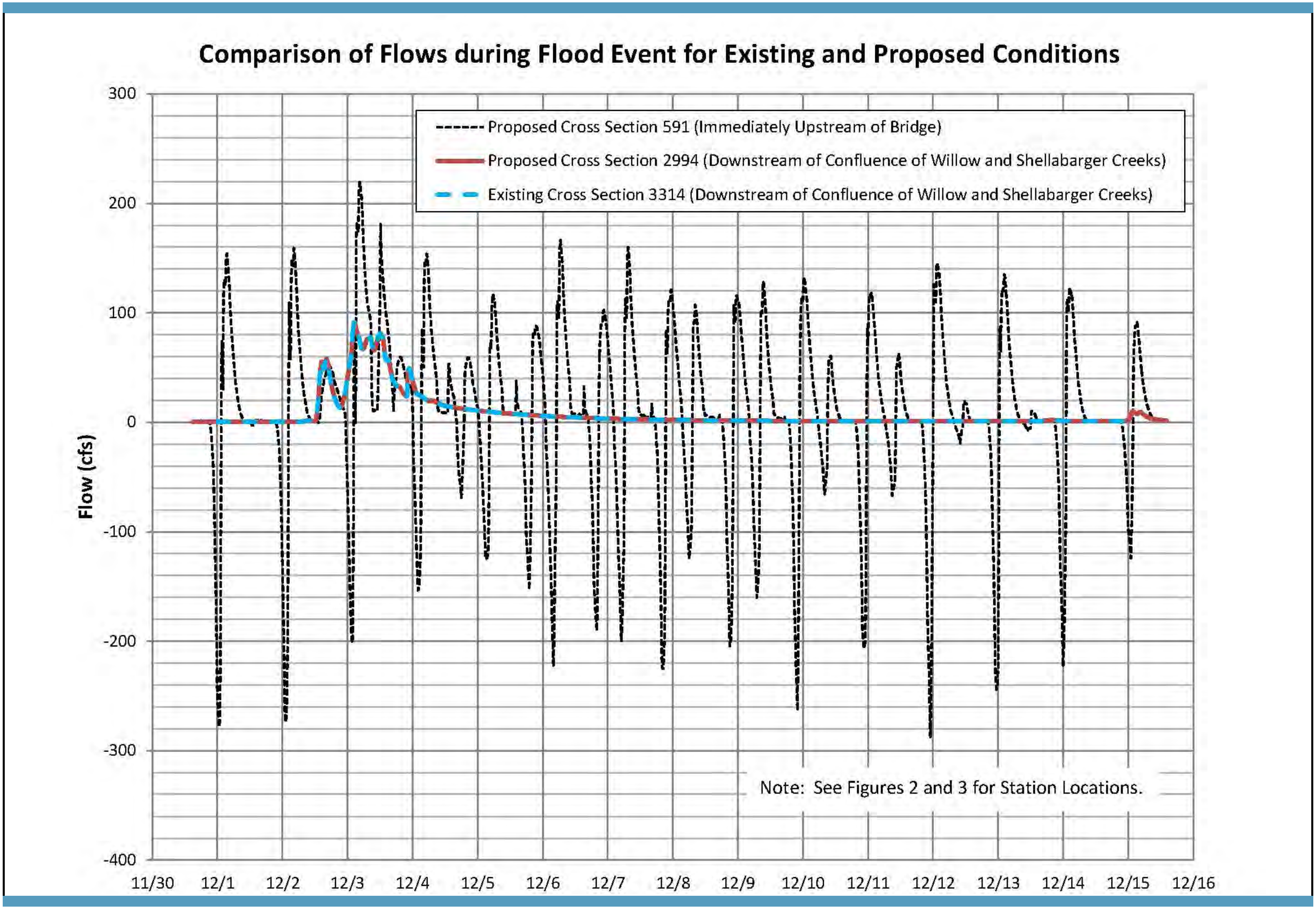


Figure 18
Comparison of Flows during Flood Event for Existing and Proposed Conditions
Tidal Marsh Hydrodynamic Report (DRAFT)
Willow Creek Daylight Early Feasibility Study

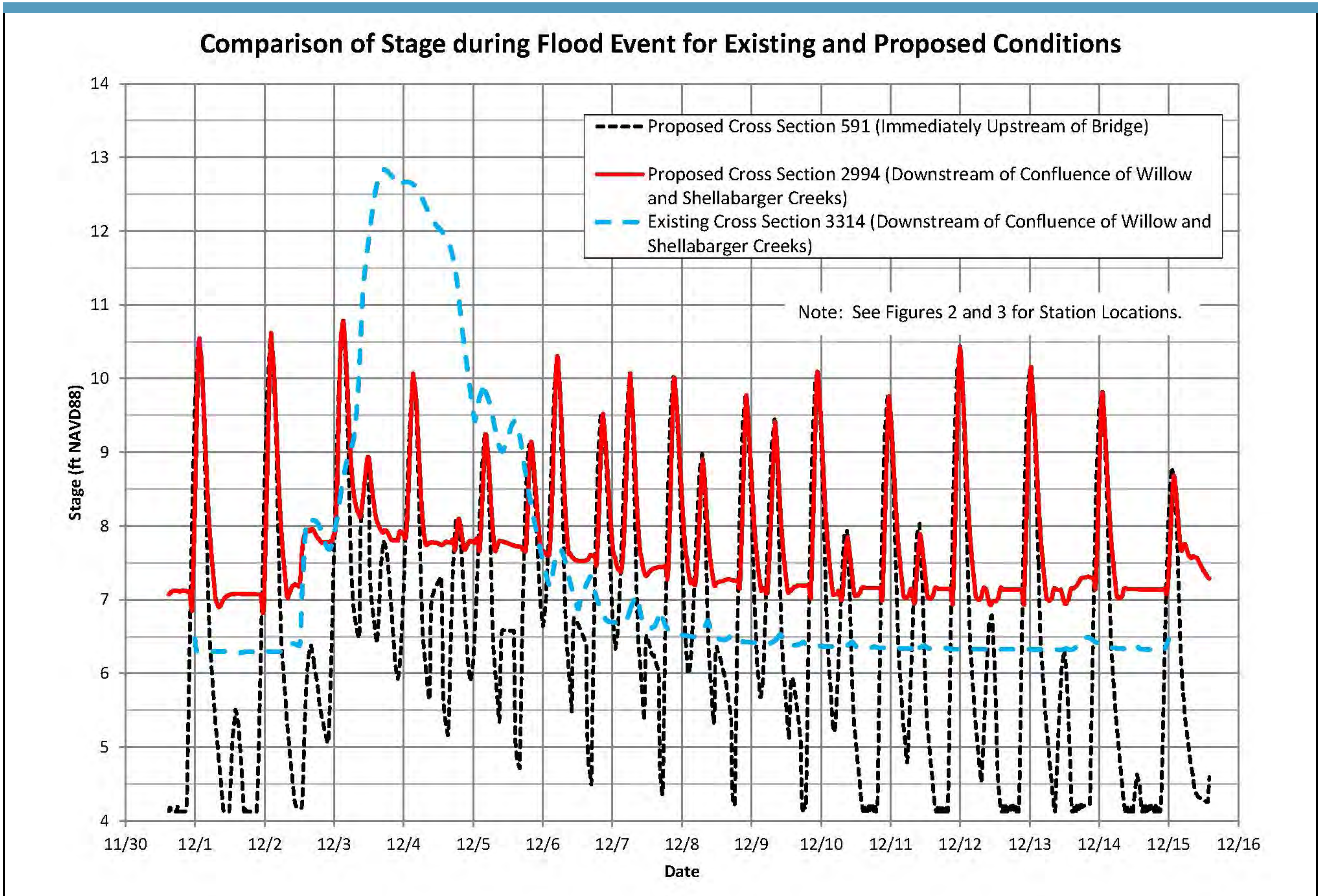
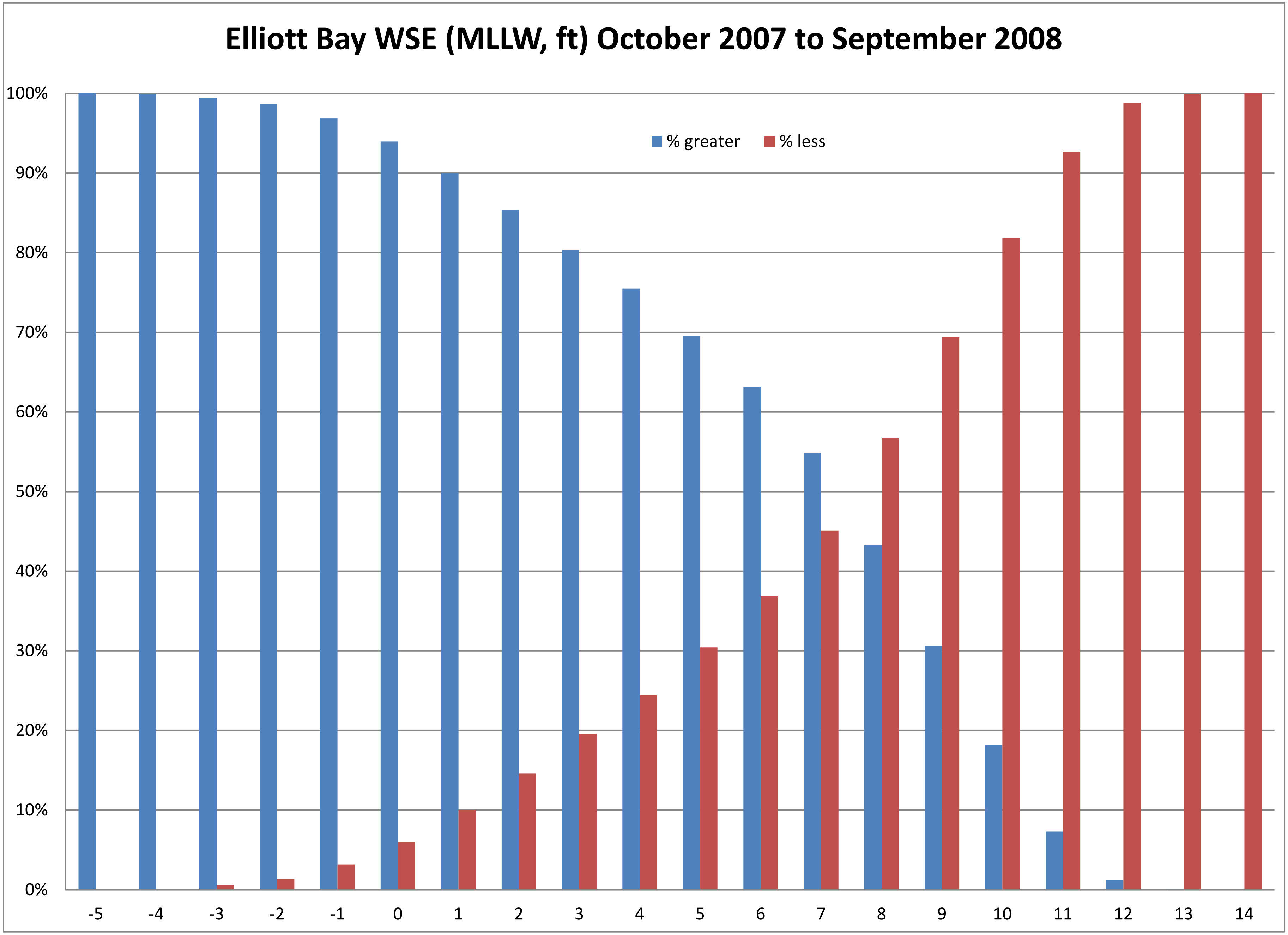


Figure 19
Comparison of Flows during Flood Event for Existing and Proposed Conditions
Tidal Marsh Hydrodynamic Report (DRAFT)
Willow Creek Daylight Early Feasibility Study

APPENDIX A
WATER LEVEL, SALINITY AND TEMPERATURE DATA PLOTS


Elliott Bay WSE (MLLW, ft) October 2007 to September 2008
% greater
% less
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
-5
-4
-3
-2
-1
0
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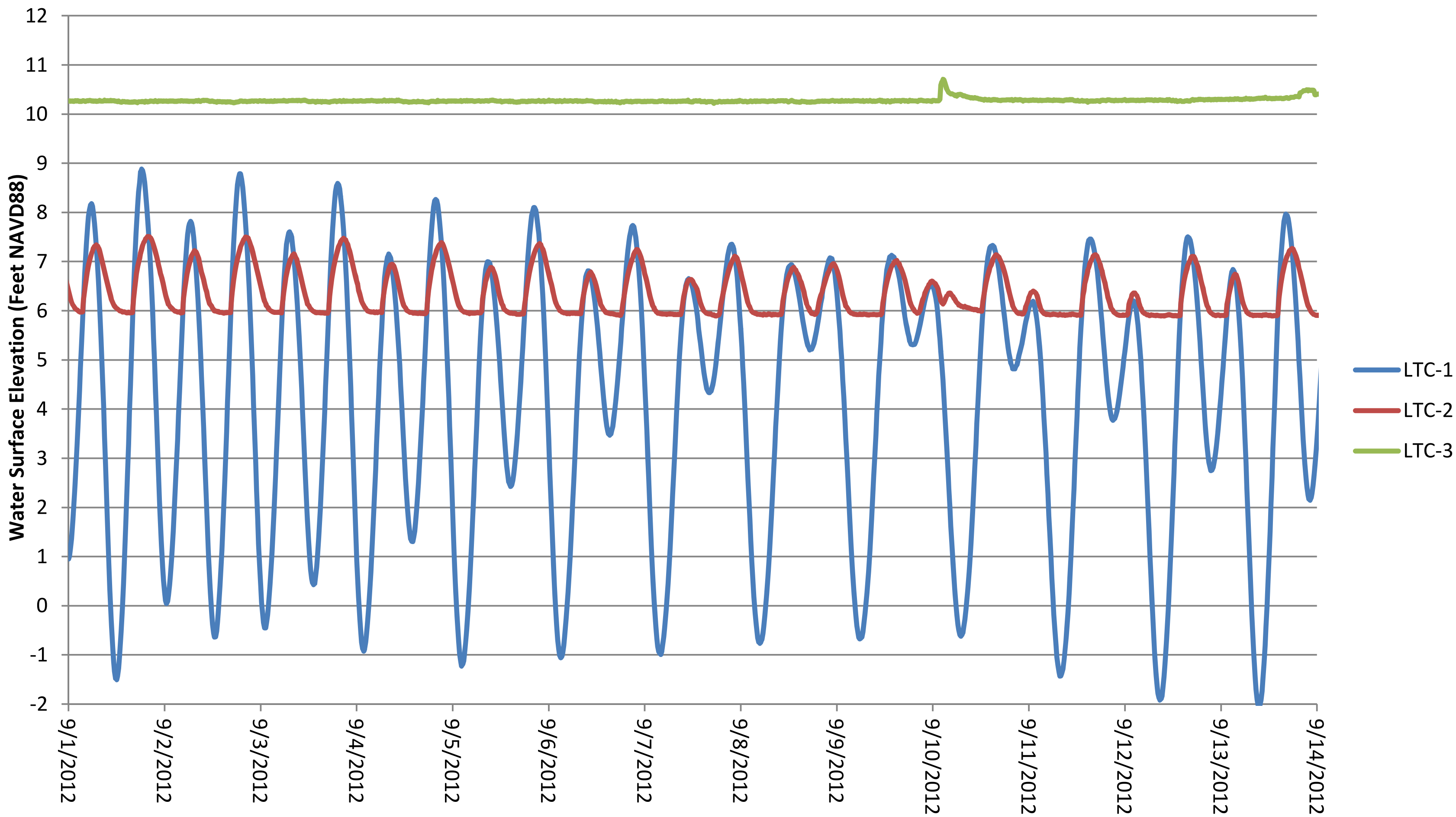

Willow Creek Edmonds, WA	
WATER LEVELS **SEPTEMBER 2012**	
September 2012	21-1-12393-102
SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS	**FIG. 2**

FIG. 2

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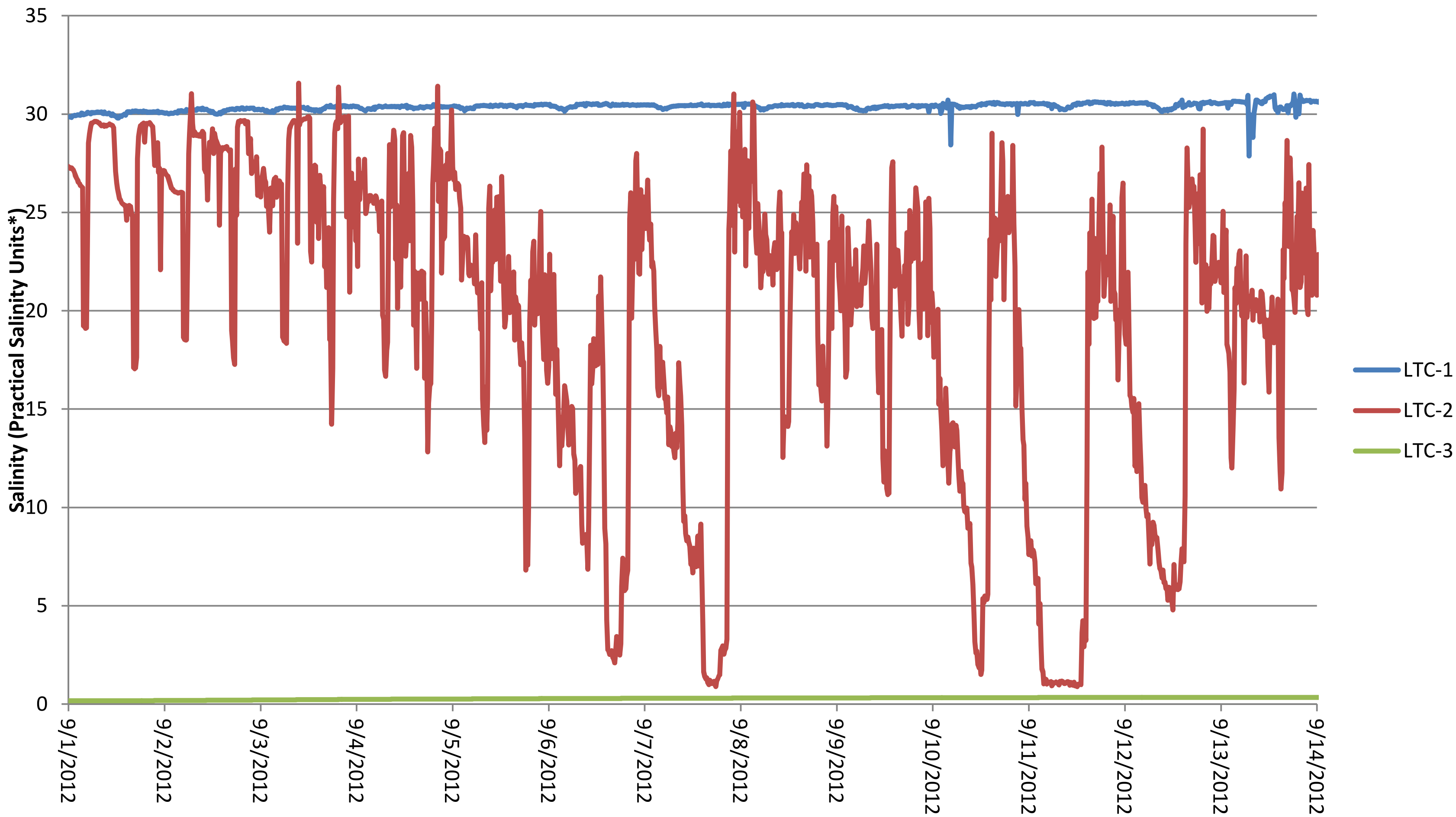

*Practical Salinity Units (PSU) are approximately equivalent to Parts Per Thousand (ppt)

Willow Creek

Edmonds, WA

SALINITY
SEPTEMBER 2012

September 2012 | 21-1-12393-102

SHANNON & WILSON, INC.

FIG. 3

FIG. 3

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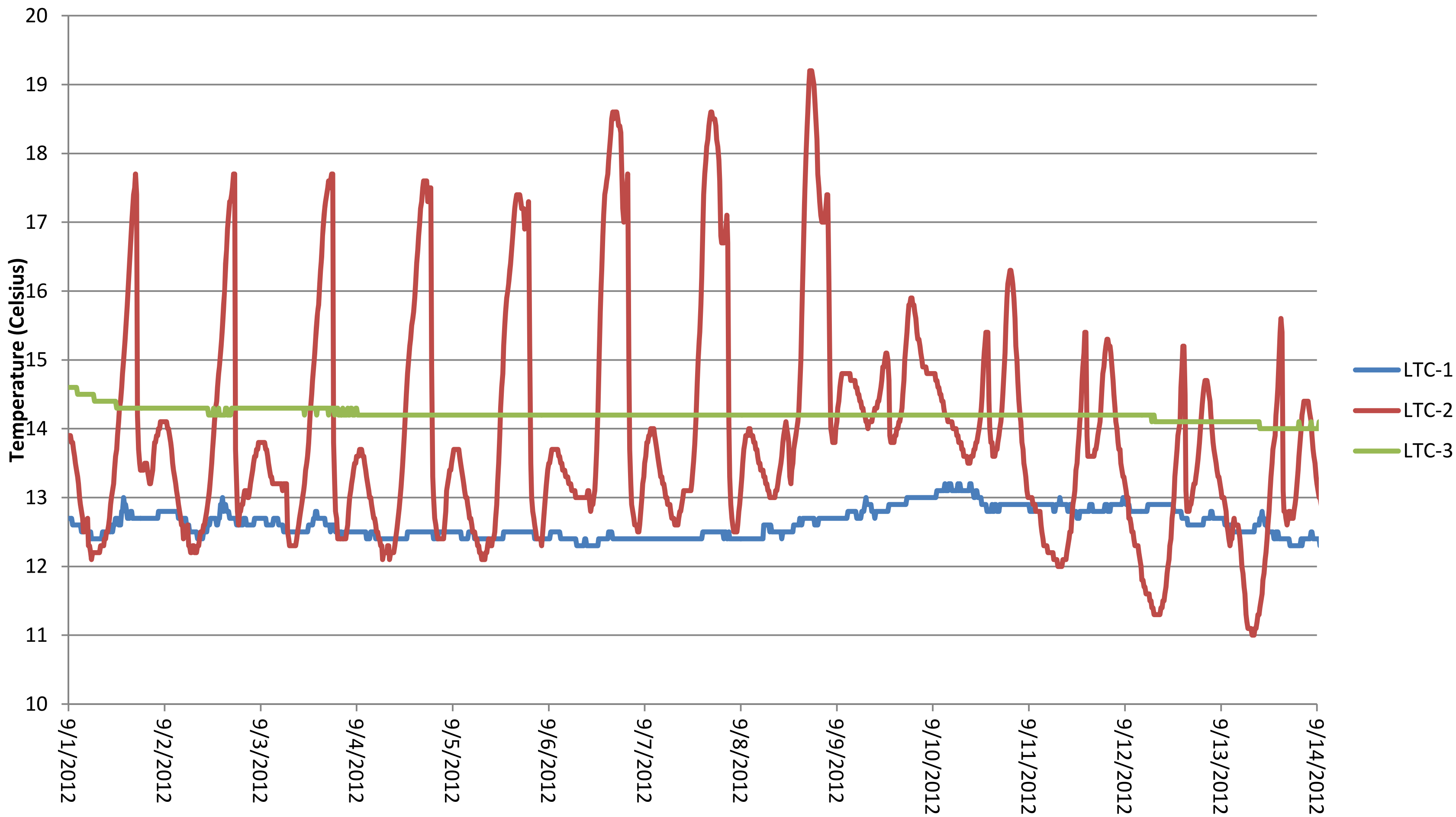

FIG. 4

Willow Creek

Edmonds, WA

TEMPERATURE
SEPTEMBER 2012

September 2012 | 21-1-12393-102

SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 4

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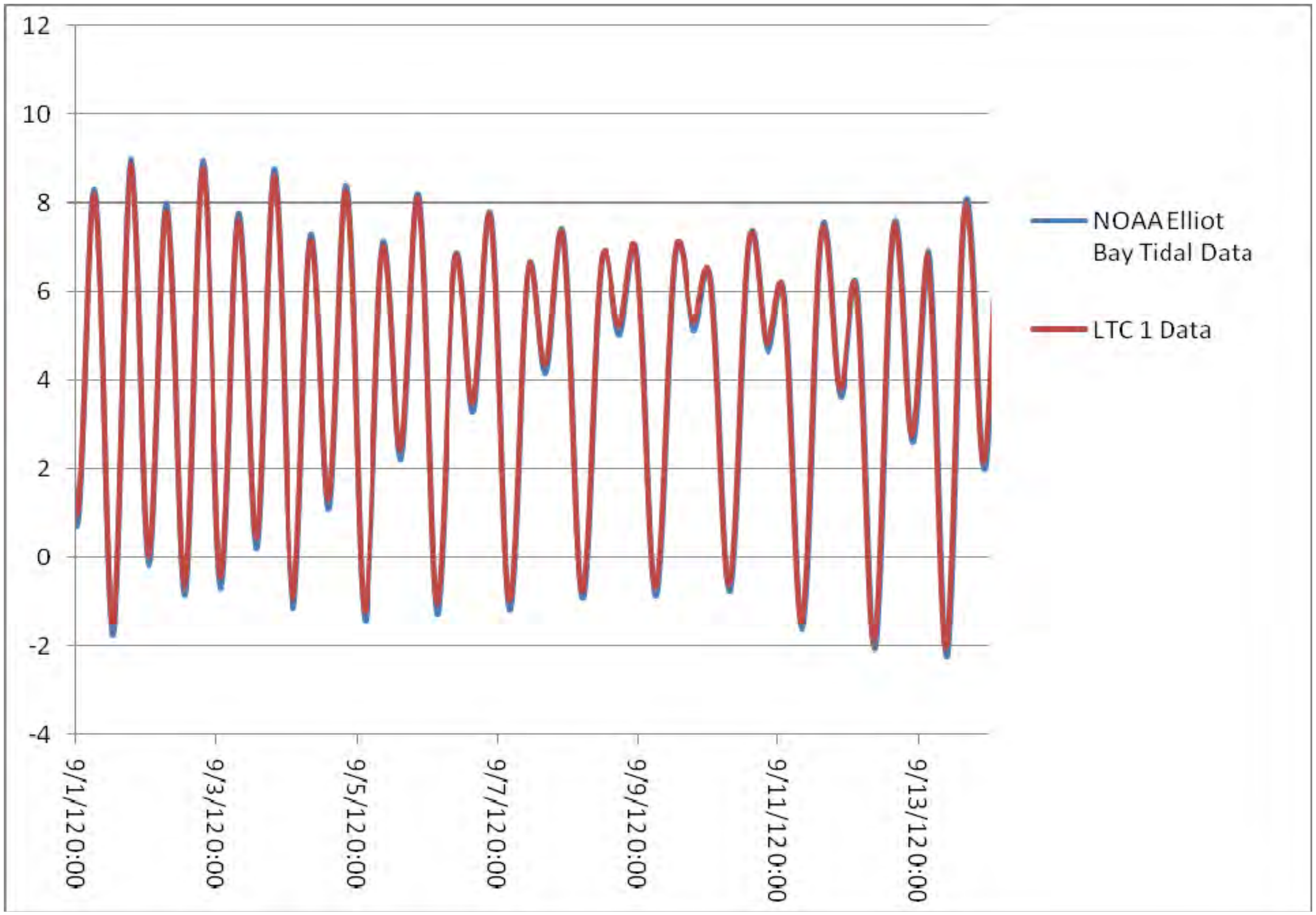

Figure 1. Comparison of tidal gages

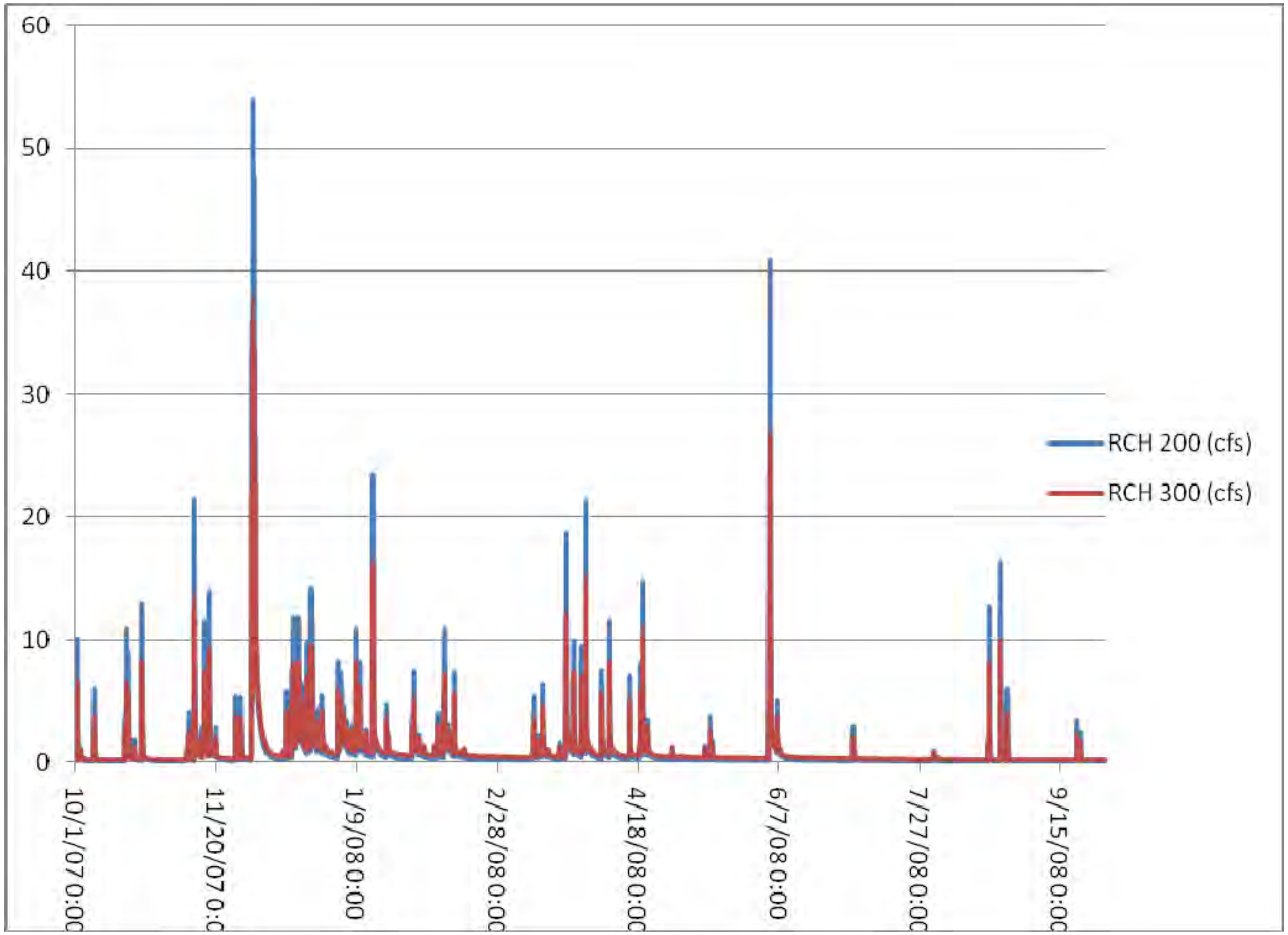

Figure 2. Upstream Inflow Boundary Conditions

APPENDIX C

TECHNICAL MEMORANDA

MEMORANDUM

TO: David Cline, PE (Shannon & Wilson, Inc.)
Kathy Ketteridge, PhD, PE (Anchor QEA LLC)

CC: Jerry Shuster (City of Edmonds)
Keeley O'Connell (EarthCorps)
Paul Schlenger (Confluence Environmental)

FROM: Alex Hallenius, PE

DATE: January 7, 2013

RE: WILLOW CREEK STREAM INFLOW AND TIDAL HYDROLOGY BOUNDARY CONDITIONS

This memo summarizes the Willow Creek stream and tidal inflow hydrology information related to the hydraulic modeling for the Willow Creek Early Feasibility Study.

The project survey vertical datum is the North American Vertical Datum of 1988 (NAVD88). Elevations in tidal environments (and from NOAA tidal gauges) are often reported in Mean Lower Low Water (MLLW) datum. For the project, the NAVD88 elevation can be approximated from the MLLW datum by subtracting 2.09 feet. This transformation was calculated using NOAA's VDatum v3.1 computer program. We recommend a professional surveyor confirm this transformation prior to development of project final design plans.

The tidal data from the NOAA Seattle Elliot Bay gage was compared with the LTC-1 logger installed at the Edmonds Marina for the time period September 1 through 14, 2012. There was little noticeable period (time) shift between the locations. In general, the amplitude of the LTC-1 location was diminished compared to the Seattle Elliot Bay tidal data by -0.2 feet. This may be attributable to the breakwater effect of the Edmonds Marina jetty. Therefore, it appears reasonable to use the Elliot Bay tidal data as a boundary condition for the Edmonds Marsh hydraulic modeling tidal boundary conditions. Figure 1 is a graph of the comparison.

Inflow hydrology modeling results, provided from the Dayton St. / SR-104 stormwater study, were reviewed. Based on our review of the modeling data, and information regarding recent historical flooding in the marsh, we recommend a modeling period of October 1, 2007 through September 30, 2008 for the Willow Creek Early Feasibility Study. This period corresponds to an observed flood event in December 2007 that had documented flooding, including overtopping of the Chevron/Unocal stormwater pond banks (Rasar, 2012).

The estimated 100-year flood event flows are 69cfs for Shellabarger at the SR-104 culvert, and 49cfs for Willow Creek at the 216th St. culvert (Geisburt, 2012). Data provided from the Dayton

St. / SR-104 study for the October 2008 through September 2008 period have peaks inflows of 52cfs and 36cfs, for Shellabarger and Willow Creek respectively, which is on the order of a 25-year flood event. We did not identify inflow peak events on the order of the 100-year flood event. Therefore, we recommend using the large storm event of December 2007, with field documentation for flood overtopping of the Chevron stormwater pond as the project design flood hydrology.

Input files were created for the period October 1, 2007 through September 30, 2008. The data is provided in a file named “Boundary Conditions_20130107.xlsx”. The worksheet “Elliot Bay” contains recorded tidal data from the Seattle Elliot Bay tidal gage for the time period, in one-hour time steps. The worksheet “Upstream” contains modeled flows from the SR-104 HSPF model for the time period, in 15-minute time steps. The designations RCH 200 and RCH 300 represent Shellabarger Creek and Willow Creek, respectively. A graph of the upstream boundary conditions is shown in Figure 2.

MEMORANDUM

TO: file

FROM: Alex Hallenius, Bo Lewis

DATE: September 18, 2012 (revised 3-7-2013)

RE: EDMONDS MARSH COMPOSITE EXISTING GIS SURFACE CREATION EDMONDS, WASHINGTON

This memo describes the process used to create a composite GIS TIN surface of the Edmonds Marsh area. File paths are referenced to the Shannon & Wilson network. Project datum is NAVD88.

The following data sources were used to create the composite surface. Data was provided electronically by the client.

- LIDAR-generated contours for marsh area
  - I:\WIP\21-1\12393 Willow Creek Daylight\02. BACKGROUND_REPORTS\DAYTON_SR-104_DATA\MCD\Site Information\2005 Edmonds Lidar contours
  - ArcGIS shapefile, contains contours with elevations
  - Datum: NAVD88
- 2004 Willow Creek channel survey along BNSF ROW (by CH2M Hill?)
  - I:\WIP\21-1\12393 Willow Creek Daylight\02. BACKGROUND_REPORTS\DAYTON_SR-104_DATA\MCD\2004 CH Willow Creek survey\Edmonds_Willow-Creek SURF.dwg
  - AutoCAD Drawing contains 3d faces and contours
  - Datum: NAVD88
- 2008 Marsh Area survey
  - I:\WIP\21-1\12393 Willow Creek Daylight\02. BACKGROUND_REPORTS\DAYTON_SR-104_DATA\MCD\Site Information\Survey\Marsh Topo\Deliverables\XL1981_Vargot01.dgn
  - Microstation Drawing contains points and breaklines
  - Datum: MLLW
- 2012 Perteet survey
  - I:\WIP\21-1\12393 Willow Creek Daylight\02. BACKGROUND_REPORTS\SURVEY\Perteet Survey 2012-6-6.zip
  - AutoCAD drawing contains points and lines of channels in the marsh

- Datum: NAVD88

The following procedure was used to create the composite surface:

- Create Base surface TIN from LiDAR contours in ArcGIS
- Create AutoCAD Civil3d surface from 2004 data, export in *.xml format
- Import 2008 survey data from Microstation to AutoCAD. Create AutoCAD Civil3d surface from data, adjust surface elevation by -2.28 feet for NAVD88 datum. Export in *.xml format.
- Create 3d polylines from 2012 survey data, save in *.dwg format
- Import *.xml files (2) and *.dwg file (1) into ArcGIS.
- Trim areas of overlap between surfaces
- Create composite surface from data.

The surface was spot-checked to verify the transitions between the inserted surfaces.

The final GIS surface is named "2012_Surface_Combined" and is located in: I:\WIP\21-1\12393 Willow Creek Daylight\GIS\Existing_CombinedSurface

MEMORANDUM

TO: file

FROM: Alex Hallenius, Bo Lewis

DATE: March 7, 2013

RE: EDMONDS MARSH PROPOSED CONDITIONS GIS SURFACE CREATION EDMONDS, WASHINGTON

This memo describes the process used to create a composite GIS TIN surface of the Edmonds Marsh area that includes proposed channel grading. File paths are referenced to the Shannon & Wilson network. Project datum is NAVD88.

The following data sources were used to create the composite surface:

- Composite existing ground surface created by Shannon & Wilson on March 5, 2013, and located at: I:\WIP\21-1\12393 Willow Creek Daylight\GIS\Proposed_Grading
- Proposed channel features created in AutoCAD Civil3d to represent grading for:
    - The beach outfall channel and daylight channel
    - Willow creek marsh dredging
    - Shellabarger creek marsh dredging

  The surfaces are located in: I:\WIP\21-1\12393 Willow Creek Daylight\CAD\Proposed Grading_2013_03_01\Proposed_2013_03_01.dwg

The following procedure was used to create the composite surface:

- Start with composite existing ground TIN surface (Existing_CombinedSurface)
- Import *.xml file into ArcGIS using the AcGIS 3D Analyst Extension.
- Trim areas of overlap between surfaces.
- Create composite surface from data.

The surface was spot-checked to verify the transitions between the inserted surfaces. A few cross-sections were cut to compare the existing and proposed surfaces in the marsh area and verify that the surface was created correctly.

The final GIS surface is named “willowcreek_prop_2013_03_05” and is located in: I:\WIP\21-1\12393 Willow Creek Daylight\GIS\Proposed_Grading

APPENDIX D

IMPORTANT INFORMATION ABOUT YOUR ENVIRONMENTAL SITE ASSESSMENT/EVALUATION REPORT

Date: April 12, 2013
To: Mr. Jerry Shuster
City of Edmonds

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include: the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used: (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors which were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the
ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland