APPENDIX A

## PHOTOGRAPHS

### **APPENDIX A**

## PHOTOGRAPHS

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Photograph 1 – Looking downstream Willow Creek outlet to vault underneath Admiral Way with 48-inch concrete pipe.



Photograph 2 – Willow Creek stormwater vault and tidegate.



Photograph 3 – Looking at pre-constructed BNSF railroad bridge.



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## **APPENDIX B**

### HYDROLOGIC MONITORING

## SHANNON & WILSON, INC.

### **APPENDIX B**

### HYDROLOGIC MONITORING

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## **APPENDIX B**

## HYDROLOGIC MONITORING

## **B.1 INTRODUCTION**

Shannon & Wilson, Inc. installed surface water hydrologic data loggers for the Willow Creek Daylight project site (Figure B-1 of main report). The purpose of the monitoring network is to document baseline conditions for use in engineering design and model calibrations.

## **B.2 DATA LOGGER INSTALLATIONS**

A total of six locations had data loggers installed for surface water monitoring (Figure B-1). Data loggers were used at multiple locations over varying periods of time to collect the data. Table B-1 is a summary of data logger information and data collection periods.

Stand pipes were installed with polyvinyl chloride pipes and secured to adjacent structures, or driven into the stream bed sediments. Data loggers were then deployed into the stand pipes with secure locking caps. The top of cap was then surveyed to facilitate calculation of water surface elevations from the data logger output.

## **B.2.1** Surface Water Level, Salinity, and Temperature Measurements

Water level, temperature, and salinity were collected at each of the data logger locations, except for LTC-3b and LTC-4 in Shellabarger and Willow Creek, respectively, which only collected water level and temperature. Salinity was not collected as these are known freshwater sections of the streams. Water level, temperature, and salinity were recorded early in the study at the Port of Edmonds Marina (LTC-1A), the Lower Willow Creek channel (LTC-2), and the Shellabarger Creek Marsh (LTC-3A). Water level and salinity were recorded and reported in the WSDOT manhole data logger LTC-1B. Water level and temperature were recorded for the upstream tributaries Shellabarger Creek and Willow Creek, LTC-3B and LTC-4, respectively.

## **B.2.2** Data Observations and Interpretations

LTC-1A was the tidal data logger located in the Port of Edmonds Marina. This data logger recorded tidal water levels, conductivity (salinity), and temperature (Figures B-2 through B-4). The water level data collected confirmed that the Seattle, Elliott Bay National Oceanic and Atmospheric Administration Gauge 9441370 was very similar in tidal elevations and timing, and could be used as a reference and data source for tidal data. Observed salinities and temperatures were typical of Puget Sound seawater conditions.

LTC-2 was the data logger located in Lower Willow Creek channel near the Union Oil Company of California stormwater pond (Figures B-2 through B-4). This data logger recorded water surface elevations that fluctuated between elevation 6 feet (North American Vertical Datum of 1988 (NAVD88), which is roughly the bottom of the channel, and elevation 8 to 9 feet on average. The data indicate muted tidal inflows. A maximum observed water surface elevation of 10.4 feet on November 19, 2012. For reference, the Dayton Street catch basin low point is approximately elevation 10.1 feet. Salinities for the Lower Willow Creek channel LTC-2 range from 0 to 35 parts per thousand. Temperatures ranged from 0 degrees Celsius (°C) to 24°C for LTC-2. The higher temperatures near 24°C are above the lethal limits for fish (16°C). The likely source of high water temperatures is the shallow nature of flows in the Lower Willow Creek channel, which has little shading.

LTC-3A was the data logger located in lower Shellabarger Creek Marsh (Figures B-2 through B-4). The water levels recorded in Shellabarger Creek marsh lie around elevation 10 feet (NAVD88) and are on average about 4 feet higher than in the Lower Willow Creek and Edmonds Marsh. This is likely due to clogged or blocked WSDOT culverts beneath State Route 104. The peak observed water surface elevation was 11.84 feet (NAVD88), which is above the Dayton Street catch-basin inlet, and near the top of curb along the WSDOT cueing lane of 11.53 feet.

LTC-1B was the data logger located in the WSDOT manhole at the downstream end of the existing Lower Willow Creek channel (Figures B-5 and B-6). The water levels recorded in the WSDOT manhole show tidal flows, with a peak tidal water elevation of 12.67 feet on November 28, 2014. The top of the manhole elevation is 11.83 feet and is evidently overtopped. A riser could be added to the manhole to reduce the potential for overtopping and flowing into Willow Creek. The overflows appear to be associated with high tides, and not necessarily stormwater runoff flows alone. Storm flows occurring at high tide would undoubtedly overtop the manhole. We note salinity levels fluctuate with the tide at this gage. The fluctuations are likely related to the drying out of the data logger on each cycle, and not upstream freshwater inflows to the pipe system.

LTC-3B and 4 are the data loggers installed in upper Shellabarger and Willow Creeks that are recording water level and temperatures (Figures B-7 and B-8). The water levels recorded in the streams are fairly consistent between the two stream systems with Shellabarger

Creek being more "flashy" due to the confined nature of the channel where the gauge is located, and in a more urbanized watershed. The peak observed water surface elevation for LTC-3B Shellabarger Creek was 18.9 feet on October 11, 2014. The peak observed water surface elevation for LTC-4 Willow Creek was 18 feet on December 11, 2014. Water temperatures ranged between 4°C and 18°C for both creeks, with Shellabarger Creek exhibiting about a 2°C higher water temperatures during the summer months compared to Willow Creek.

### **B.3 DATA QUALITY ASSURANCE**

Quality control activities involves comparisons of onsite measurements of water surface elevations of wells against the compensated water surface elevation time-series. These differences vary from 0.0 to 0.3 foot and can be attributed to slight adjustments in data logger cable lengths during data download and redeployment and accuracy of measuring water surface depth in wells.

We note several data logger failures during the data collection period, for which new equipment was installed and replaced when the failures occurred.

### **B.4 FUTURE DATA COLLECTION SCHEDULE**

The end of the data collection monitoring period is July 2015.

ID	Туре	Serial Number	Date of Deployment	Date of Removal	Top of Casing Elevation (ft) (NAVD88)	Description
LTC-1a	Level, Temp., Conductivity	0121068287, 0121068547	8/30/2012	7/30/2013	2.67	Located Edmonds Marina near J-Dock, on pile underneath weather station.
LTC-1b	Level, Temp., Conductivity	1069279	12/18/2013	N/A	11.83	Located in WSDOT Manhole.
LTC-2	Level, Temp., Conductivity	121068297	8/31/2012	7/25/2014	10.10	Located in Lower Willow Creek just upstream of Unocal Stormwater Pond Outlet.
LTC-3a	Level, Temp., Conductivity	121068299	8/31/2012	7/18/2013	14.48	Located in Shellabarger Creek Marsh northeast of SR-104 near WSDOT culverts.
LTC-Barrow	Barometric Pressure	12013265	8/31/2012	N/A	N/A	Originally located in Lower Shellabarger Creek Marsh. Now located in Upper Shellabarger Creek.
LTC-3b	Level, Temp.	121068299	12/18/2013	N/A	22.12	Located in Upper Shellabarger Creek. Access from 3 <sup>rd</sup> Avenue Condominiums parking lot.
LTC-4	Level, Temp.	2025122	12/18/2013	N/A	22.34	Located in Upper Willow Creek, upstream from Trout Unlimited Hatchery footbridge.

### TABLE B-1 DATA LOGGER SUMMARY

Notes:

Ft = feet

ID = identification

N/A = not applicable

NADV88 = North American Vertical Datum of 1988

SR = State Route

Unocal = Union Oil Company of California

WSDOT = Washington State Department of Transportation





I:\WIP\21-1\12393 Willow Creek Daylight\409. FINAL FEASIBILITY STUDY\Appendix B\_Hydrologic Monitoring\WILLOW\_CRK\_MASTER\_20150416 <FIG\_B2\_LTC-1A,2,3A\_WSE>



I:\WIP\21-1\12393 Willow Creek Daylight\409. FINAL FEASIBILITY STUDY\Appendix B\_Hydrologic Monitoring\WILLOW\_CRK\_MASTER\_20150416 <FIG\_B3\_LTC-1A,2,3A\_SALINITY>



I:\WIP\21-1\12393 Willow Creek Daylight\409. FINAL FEASIBILITY STUDY\Appendix B\_Hydrologic Monitoring\WILLOW\_CRK\_MASTER\_20150416 <FIG\_B4\_LTC-1A,2,3A\_TEMP>



I:\WIP\21-1\12393 Willow Creek Daylight\409. FINAL FEASIBILITY STUDY\Appendix B\_Hydrologic Monitoring\WILLOW\_CRK\_MASTER\_20150416 <FIG\_B5\_LTC-1B\_WSE>



I:\WIP\21-1\12393 Willow Creek Daylight\409. FINAL FEASIBILITY STUDY\Appendix B\_Hydrologic Monitoring\WILLOW\_CRK\_MASTER\_20150416 <FIG\_B6\_LTC-1B\_SALINITY>



I:\WIP\21-1\12393 Willow Creek Daylight\409. FINAL FEASIBILITY STUDY\Appendix B\_Hydrologic Monitoring\WILLOW\_CRK\_MASTER\_20150416 <FIG\_B7\_LTC-3B,4\_WSE>



I:\WIP\21-1\12393 Willow Creek Daylight\409. FINAL FEASIBILITY STUDY\Appendix B\_Hydrologic Monitoring\WILLOW\_CRK\_MASTER\_20150416 <FIG\_B8\_LTC\_3B,4\_TEMP>



Photograph B-1 – LTC-1 Data Logger in Edmonds Marina Near J Dock.



Photograph B-2 – LTC-1B Data Logger in WSDOT Manhole.



Photograph B-3 – LTC-2 Data Logger in Lower Willow Creek.



Photograph B-4 – LTC-3A Data Logger in Lower Shellabarger Creek Marsh.



Photograph B-5 – LTC-3B Data Logger in Upper Shellabarger Creek.



Photograph B-6 – LTC-4 Data Logger in Upper Willow Creek.