Willow Creek Daylight Project
Expanded Marsh Concept Design
And Hydraulic Modeling Report
Edmonds, Washington

Revised November 7, 2017

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GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Excellence. Innovation. Service. Value.

Since 1954.

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WILLOW CREEK DAYLIGHT PROJECT DRAFT EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING REPORT EDMONDS, WASHINGTON

1.0 INTRODUCTION

This report presents the hydraulic assessment of the Willow Creek daylight channel alternatives. We have provided our services in general accordance with the Supplemental Contract Agreement #5940 Supplemental Agreement No. 2, signed November 1, 2016.

2.0 SITE AND PROJECT DESCRIPTION

Willow Creek and Shellabarger Creek flow from the south and east to the west through residential Edmonds, Washington (the City) (Figure 1). The two streams reach a confluence at the Edmonds Marsh (the marsh) and are joined by local stormwater system outfalls from State Route (SR-) 104, the Harbor Square commercial development, and the Point Edwards residential development to the south. The marsh historically connected to the Puget Sound through an open channel near Brackets Landing and later near the location of the Marina. As the surrounding area has developed, the channel was piped along Admiral Way and the Port of Edmonds Marina, to an outfall at Marina Beach Park (Figure 2).

The City has completed a feasibility study concerning the daylighting of Willow Creek downstream of the marsh through land owned by Union Oil Company of California (UNOCAL) with plans to transfer the property to the Washington State Department of Transportation (WSDOT) for the Edmonds Crossing project (Shannon & Wilson, Inc. [S&W], 2015). The feasibility study's preliminary daylight alignment is a continuation of the straight portion of the existing channel to a crossing beneath the BNSF Railway Company (BNSF) tracks at a bridge, then through the Marina Beach Park (Figure 3). These daylighting efforts will re-introduce tidal flows to the marsh, increasing beneficial flushing and promoting connectivity for non-natal juvenile salmon habitat, among others.

The City and grant agencies are exploring an expanded restoration footprint. The original feasibility study concept design daylight channel was constricted by the BNSF right-of-way (ROW) to the west and the future Edmonds Crossing WSDOT ferry crossing to the east on the UNOCAL property. The City has contracted S&W to evaluate a more sinuous daylight channel alignment through the WSDOT Edmonds Crossing ferry parking area to analyze available increases in habitat restoration area and effects of a more sinuous channel on velocity, depth, and inundation areas within the marsh. This analysis of a larger restoration footprint also involves a fish habitat study, quarterly water and annual soil and sediment sampling in the potential expanded area, and sampling of the existing channel for benthic macro-invertebrates to inform the design phase. This draft report concerns the extended daylight grading, wetland habitat increases, cost estimate, and hydraulic analysis only, and will be updated to include these additional tasks for its final submittal.

3.0 SCOPE OF SERVICES

Our scope of services includes performing a hydrologic and hydraulic (drainage) study to evaluate the potential effects from daylighting Willow Creek via an expanded restoration alternative. The draft drainage study tasks include:

- Develop a conceptual expanded restoration plan (Selected Alternative) with input from the City Public Works and Parks department and the project team hydraulic engineer, wetland scientist, and fish biologist.
- Develop an alternative description, grading plan, cost estimate, and calculation of habitat area increase for the Selected Alternative compared to the alternative described in the feasibility study.
- Perform hydraulic modeling of the Selected Alternative and provide depth, velocity, and inundation information.
- Provide a fish habitat summary of the Expanded Marsh Restoration Alternatives using the hydraulic modeling results (memo to be provided at a later date).

4.0 EXPANDED CHANNEL DESIGN

S&W developed four alternatives for review by the City and WSDOT. We present the alignment options and selection rational of two for hydraulic modeling and analysis below.

4.1 Feasibility Study Alternate – Alternative 1

The feasibility study alignment utilizes the original daylight alignment with a straight channel from the edge of the marsh to the BNSF railroad bridge (Figure 3). The channel side slopes through the area are 2:1 with a channel bottom width of 10 feet. Downstream of the BNSF bridge, through the Marina Beach Park, the channel widens to a 3:1 side slope and adds sinuosity. Downstream of the marsh, this option produces restoration of 0.31 acres of created wetland and an average wetland buffer width of 97 feet along the southeast edge of the daylight, but no buffer between the railroad ROW and the channel. The total new riparian buffer area downstream of the existing marsh is 2.45 acres.

We note that other channel side slopes, low flow channels, and large woody debris features will be evaluated further as part of Task 5, additional hydraulic modeling, which follows the scope of this report.

4.2 Alternative 2 – Sinuous Channel With 166-Foot Total Buffer Width

Alternative 2 has a sinuous channel with a total average buffer width of 166 feet (Figure 4). This alternative would connect with the stormwater pond as new wetland on the UNOCAL property and reduce the parking area of the WSDOT Edmonds Crossing plan. Downstream of the marsh, the Alternative 2 alignment provides 2.11 acres of created wetland restoration along the channel and pond and a total riparian buffer area of 5.02 acres.

4.3 Alternative 3 – Sinuous Channel, 275-Foot Total Buffer Width

Alternative 3 has a sinuous channel with an average buffer width of 75 feet between the railroad ROW and the channel and 200 feet to the southeast for a total average buffer width of 275 feet (Figure 5). Downstream of the marsh, this option results in 1.71 acres of new wetland restoration and 8.33 acres of new riparian forest buffer areas.

4.4 Alternative 4 – Sinuous Channel, 135-Foot Total Buffer Width

Alternatives 1 through 3 were reviewed by the City and presented to WSDOT ferries on December 20, 2016. Alternative 4 was developed as a hybrid based on feedback from WSDOT to limit the daylight footprint on the ferry Edmonds crossing plan and considering riparian buffer width targets. Once these three options were considered, the City agreed to evaluate Alternative 4 with an average buffer width of 110 feet to the southeast of the channel and a buffer width of 25 feet to the north along the BNSF ROW for a total average buffer of 135 feet (Figure 6). Downstream of the marsh, Alternative 4 restores 2.33 acres of new created wetland and 4.31 acres of new riparian forest buffer along the channel and UNOCAL pond.

5.0 HYDRAULIC MODELING

The feasibility study utilized one-dimensional hydraulic modeling in the U.S. Army Corps of Engineers Hydrologic Engineering Center River Analysis System (HEC-RAS) 4.0 program (Anchor QEA, 2015). Since the completion of the feasibility study, the newest release of HEC-RAS (5.0.3) has added the ability to model streamflow in two dimensions (2D), increasing accuracy and improving visualization of the movement of water through the site. S&W developed HEC-RAS2D (U.S. Army Corps of Engineers, 2016) models for Alternatives 1 and 4 described above.

5.1 Geometry

Grading for each of the two alternatives was developed using AutoCAD Civil3D and then the surfaces were exported to GIS shapefiles. These surfaces were imported into the HEC-RAS Rasmapper application where they were combined with LIDAR survey data from 2004, 2008, and 2012. The 2D modeling grid area was expanded from the feasibility study limits to include the Marina Beach Park, the UNOCAL property, and the entire Edmonds Marsh and Shellabarger Creek Marsh (Stellas Marsh) west of SR-104. Grid cells for calculations and visualization were spaced evenly through the 2D modeling area at a 10-foot by 10-foot resolution.

The system of stormwater culverts and tidegates downstream of the existing Willow Creek channel were modeled using survey and as-built data provided by the City and as described in the feasibility study (S&W, 2015). The tidegate is located in the Marina Beach Park parking lot. The tidegate is allowed to operate (opening/closing with the tide) from November through March. From April through October, the tidegate is chained open.

The following is a list of culvert sizes and locations used in the existing conditions geometry.

- One 48-inch corrugated metal pipe beneath SR-104 (also in proposed alternatives).
- One 24-inch reinforced concrete pipe (RCP) beneath berm upstream of BNSF railway (Note: the 36-inch culvert at this location is gated shut year-round.)
- Two 42-inch RCP beneath BNSF railway.
- One 42-inch composite culvert from Admiral Way to the tidal outlet, with a tidegate.

5.2 Hydrology

The hydrology developed in the feasibility study combined the flow in upper Willow Creek and Shellabarger Creek into a single point-hydrograph midway through the marsh. This hydrograph reaches a peak flow of 91 cubic feet per second (cfs) followed by a 12-hour period of varying flow near 72 cfs before tailing off down to a constant low flow. This peak of 91 cfs was estimated to be near the 100-year storm and 72 cfs was estimated to be an average storm (Anchor QEA, 2015). Low flows were estimated at 0.8 cfs (0.5 cfs Shellabarger Creek and 0.3 cfs Willow Creek). These design events were based on previous modeling by Anchor QEA in 2007 and information in the SAIC stormwater modeling report (Anchor QEA, 2013; SAIC, 2013). Both events are modeled with a two-week tidal period including a High Astronomical Tide (HAT).

The low flow event will be almost entirely driven by tidal inflows and represents tidal inundation and wetland functions in existing and proposed conditions during late spring and early summer when non-natal juvenile salmon would be present in the system. To model flood conditions, the 100-year event inflows are conservatively aligned with the HAT to evaluate changes in flooding at adjacent properties.

SAIC developed a watershed scale model of the marsh, stream and stormwater system using Hydrologic Simulation Program – FORTRAN for the City's improvements at Dayton Street to the north (SAIC, 2013). This analysis provides 100-year peak flow estimates for Willow and Shellabarger Creeks as well as inflows from stormwater systems in the Harbor Square development and the Point Edwards residential development to the south. The inflow peaks from the SAIC report were applied to an SCS Type IA distribution and the resultant hydrographs were applied at their respective inflow locations (i.e., Shellabarger Creek, Willow Creek, Harbor Square, and Point Edwards) on the edge of the HEC-RAS 2D modeling grid for both the 100-year flow and for the low flow conditions. Downstream tidal water surface boundary conditions and local inflow hydrographs were applied for unsteady conditions (Figure 7).

The downstream tidal boundary condition was replicated from the feasibility study as the same two-week period of tidal activity including a king tide (HAT) of 10.7 feet NAV88 (SAIC, 2013). It was also noted in the feasibility study that this king tide aligns with the initial peak of the 100-year storm. We evaluated the timing of the stormwater inflow hydrograph to the timing of the crest of the HAT and the resulting tidegate closures to identify a worse case timing condition. Flood models were run for a peak 100-year storm occurring at and 12 hours before the crest of the HAT. These shifted boundary conditions showed minor increases in flood elevations.

5.3 Results

Two-dimensional (2D) unsteady state modeling runs were created representing existing conditions and proposed conditions for Alternatives 1 and 4 for each of the 100-year storm and low flow tidal habitat events. The models predict velocity, depth, and water surface elevations across the site. Specific output nodes listed below were used to frame the analyses (Figure 8).

1. Downstream tidal boundary
2. Upstream of BNSF bridge
3. Upstream of daylight channel
4. Center of marsh
5. Willow Creek, downstream of the hatchery
6. Shellabarger Creek, downstream of the culvert crossing SR 104

Comparisons of the results for each geometry at the 100-year storm and low flow tidal habitat event are provided in Figures 9 through 18. Comparison maps of depths and velocities for the existing and selected alternative are provided in Figures 19 through 26 and Tables 1 through 6.

TABLE 1
LOW (TIDAL) FLOW EXISTING CONDITIONS

Node	Velocity (ft/s)		Depth (ft)			Maximum Inundation (Acres)
	Average	Maximum	Minimum	Average	Maximum	
1	0.00	0.02	2.45	7.55	13.13	20.8
2						
3	0.21	0.50	0.00	2.58	3.22	
4	0.00	0.02	0.00	0.00	0.06	
5	0.07	0.08	0.00	0.20	0.22	
6	0.01	0.31	0.00	2.98	3.52	

Notes: Existing Node 1 is north of Node 1 for both proposed conditions. Node 2 in proposed grading area only.
ft/s = foot per second

TABLE 2
LOW (TIDAL) FLOW ALTERNATIVE 1

Node	Velocity (ft/s)		Depth (ft)			Maximum Inundation (Acres)
	Average	Maximum	Minimum	Average	Maximum	
1	0.21	1.42	0.09	2.20	6.78	27.4
2	0.53	1.97	0.45	2.36	6.42	
3	1.10	2.83	0.00	0.90	3.80	
4	0.03	0.13	3.06	3.37	5.19	
5	0.01	0.26	0.00	0.00	0.31	
6	0.03	0.69	1.06	1.51	3.30	

Notes:
Existing Node 1 is north of Node 1 for both proposed conditions.
ft/s = foot per second

TABLE 3
LOW (TIDAL) FLOW ALTERNATIVE 4

Node	Velocity (ft/s)		Depth (ft)			Maximum Inundation (Acres)
	Average	Maximum	Minimum	Average	Maximum	
1	0.24	1.50	0.09	2.21	6.78	30.1
2	0.58	1.99	0.44	2.34	6.31	
3	0.20	1.26	0.00	0.93	3.77	
4	0.03	0.14	2.72	3.13	5.15	
5	0.01	0.22	0.00	0.00	0.28	
6	0.02	0.40	0.85	1.28	3.28	

Notes:
Existing Node 1 existing is north of Node 1 for both proposed conditions.
ft/s = foot per second

TABLE 4
100-YEAR FLOW EXISTING CONDITIONS

Node	Velocity (ft/s)		Depth (ft)			Maximum Inundation (Acres)
	Average	Maximum	Minimum	Average	Maximum	
1	0.00	0.00	2.51	7.62	13.19	26.6
2						
3	0.07	0.33	0.00	1.84	4.26	
4	0.00	0.15	0.00	0.08	1.24	
5	0.06	0.66	0.00	0.18	1.24	
6	0.02	0.53	0.00	3.53	4.87	

Notes: Existing Node 1 is north of Node 1 for both proposed conditions. Node 2 in proposed grading area only.
ft/s = foot per second

TABLE 5
100-YEAR FLOW ALTERNATIVE 1

Node	Velocity (ft/s)		Depth (ft)			Maximum Inundation (Acres)
	Average	Maximum	Minimum	Average	Maximum	
1	0.23	1.57	0.08	2.20	6.78	29.3
2	0.53	2.01	0.42	2.38	6.43	
3	0.65	2.27	0.06	1.16	4.13	
4	0.05	0.90	2.93	3.26	5.19	
5	0.04	1.70	0.00	0.01	0.42	
6	0.05	1.20	1.06	1.60	3.44	

Notes: Existing Node 1 is north of Node 1 for both proposed conditions.
ft/s = foot per second

TABLE 6
100-YEAR FLOW ALTERNATIVE 4

Node	Velocity (ft/s)		Depth (ft)			Maximum Inundation (Acres)
	Average	Maximum	Minimum	Average	Maximum	
1	0.23	1.56	0.08	2.20	6.78	31.1
2	0.60	2.08	0.38	2.33	6.33	
3	0.17	1.05	0.00	1.09	4.12	
4	0.06	0.96	2.62	3.06	5.18	
5	0.03	1.72	0.00	0.01	0.41	
6	0.05	1.20	1.02	1.43	3.44	

Notes: Existing Node 1 is north of Node 1 for both proposed conditions.
ft/s = foot per second

6.0 COST ESTIMATES

The cost estimate for Alternative 1 provided in the feasibility study (S&W 2015) (Table 7) has been updated to reflect the grading in Alternative 4 (Table 8) along the daylight channel and through the Marina Beach Park. Cost line items have also been added for the removal and disposal of the liner, sediment, and pumps within the UNOCAL pond, and decommissioning of 5 groundwater wells.

Excavation and haul costs were developed from recommendations in the RS Means construction estimating manual. Disposal of clean and hazardous waste costs were developed from WSDOT bid prices on local projects. All other costs were developed by averaging recent bid amounts on local restoration projects.

The cost of the expanded restoration footprint is roughly 10% larger due to additional contaminated soil removal, and grading. An assumption for both estimates was that 50% of the soil volume removed would need to be handled as hazardous waste, and the remaining 50% would be general waste.

The expanded restoration estimate also contained volume assumptions for disposal of the liner in the UNOCAL treatment pond, and the estimated 1 foot of sediment above it. During S&W's Fall water sampling event, staff encountered additional remediation activities in the pond, including some observed demolition. This activity could reduce the amount of hazardous waste onsite needing disposal and should be investigated with UNOCAL/Arcadis in additional phases.

TABLE 7
ALTERNATIVE 1
COST ESTIMATE

Item	Description	Quantity	Units	Unit Cost	Item Cost[1]	Subtotal
1.0	Mobilization and Demobilization	1	LS	$ 50,000.00	$ 50,000	
1.1	Contract Administration, Submittals, Closeout	1	LS	$ 100,000.00	$ 100,000	**$ 150,000**
2.0	**Marina Beach Park (Channel and Habitat Features)**					
2.1	Temporary Erosion and Sediment Control	1	LS	$ 50,000.00	$ 50,000	
2.2	Demolition and Removal (existing tidegate and water main)	1	LS	$ 50,000.00	$ 50,000	
2.3	Dewatering	1	LS	$ 100,000.00	$ 100,000	
2.4	Channel Excavation	8,000	CY	$ 10.00	$ 80,000	
2.4.1	Haul and Dispose Excavated Material (uncontaminated)	3,900	CY	$ 10.00	$ 39,000	
2.4.2	Haul and Dispose Excavated Material (50 percent contaminated)	3,900	CY	$ 95.35	$ 372,000	
2.5	Vegetated Reinforced Soil Slope	1,000	VSF	$ 81.50	$ 82,000	
2.6	Channel and Shoreline Habitat Features	1	LS	$ 50,000.00	$ 50,000	
2.7	Revegetation	1	LS	$ 50,000.00	$ 50,000	**$ 873,000**
3.0	**Daylight Channel Construction**					
3.1	Temporary Erosion and Sediment Control	1	LS	$ 50,000.00	$ 50,000	
3.2	Dewatering	1	LS	$ 250,000.00	$ 250,000	
3.3	Dewatering (Contaminated GW Treatment)	1	LS	$ 50,000.00	$ 50,000	
3.4	Channel Excavation	16,900	CY	$ 7.00	$ 118,000	
3.5.1	Haul and Dispose Excavated Material (uncontaminated)	13,520	CY	$ 10.00	$ 676,000	
3.5.2	Haul and Dispose Excavated Material (50 percent contaminated)	13,520	CY	$ 95.35	$ 1,082,000	
3.6	Demolition, Protection, Modification of Stormwater Structures	1	LS	$ 250,000.00	$ 250,000	
3.7	HDPE Channel Liner for Contaminant Protection	84,600	SF	$ 2.50	$ 212,000	
3.8	Self-regulating Tidegate	1	LS	$ 400,000.00	$ 400,000	
3.9	Import Clean Liner Backfill	9,400	CY	$ 16.20	$ 152,000	
3.10	Utility Relocations	1	LS	$ 25,000.00	$ 25,000	
3.11	BNSF Railroad ROW Work					
3.11.1	BNSF Permits and Construction Maintenance Agreement	1	LS	$ 50,000.00	$ 50,000	
3.11.2	BNSF Railroad Crossing Special Insurance	1	LS	$ 100,000.00	$ 100,000	
3.11.3	BNSF Railroad Flagger	30	EA	$ 2,000.00	$ 60,000	
3.11.4	Erosion Protection Rock Bedding Material	250	CY	$ 60.00	$ 15,000	
3.11.5	Erosion Protection Rock (12-inch Riprap)	500	CY	$ 60.00	$ 30,000	
3.14	Soldier Pile Wall	150	LF	$ 2,500.00	$ 375,000	
3.15	MSE Wall Facing	750	SF	$ 50.00	$ 38,000	
3.16	Daylight Channel Revegetation	1	LS	$ 50,000.00	$ 50,000	**$ 3,983,000**
4.0	**Marsh Improvements**					
4.1	Clearing and Grubbing (remove cattails)	1.4	AC	$ 10,000.00	$ 14,000	
4.2	Channel Excavation/Dredging	970	CY	$ 50.00	$ 49,000	
4.3	Haul and Dispose Excavated Material (uncontaminated)	485	CY	$ 10.00	$ 5,000	
4.4	Haul and Dispose Excavated Material (contaminated)	485	CY	$ 95.35	$ 46,000	
4.5	Marsh Habitat Features	1	LS	$ 25,000.00	$ 25,000	
4.6	Revegetation	1	LS	$ 50,000.00	$ 50,000	**$ 189,000**
	Equipment, Labor, and Material Costs				**$ 5,195,000**	**$ 5,195,000**
	Taxes (10.3%)				$ 535,000	
	Bonding & Insurance (5%)				$ 260,000	
	Contingency (25%)				$ 1,487,000	
	Construction Cost				**$ 7,477,000**	**$ 7,477,000**
	Real Estate Agreements, Easements, Real Property (TBD)				$ -	
	Engineering, Permits (15%)				$ 1,122,000	
	Project Costs				**$ 8,599,000**	**$ 8,599,000**

Notes:
[1] Costs are rounded to nearest thousand.
% = percent
AC = asphalt concrete; CY = cubic yards; EA = each; GW = groundwater; LS = lump sum; TBD= to be determined; VSF = volume scattering function

TABLE 8
ALTERNATIVE 4
COST ESTIMATE

Item	Description	Quantity	Units	Unit Cost	Item Cost[1]	Subtotal
1.0	Mobilization and Demobilization	1	LS	$ 50,000.00	$ 50,000	
1.1	Contract Administration, Submittals, Closeout	1	LS	$ 100,000.00	$ 100,000	**$ 150,000**
2.0	**Marina Beach Park (Channel and Habitat Features)**					
2.1	Temporary Erosion and Sediment Control	1	LS	$ 50,000.00	$ 50,000	
2.2	Demolition and Removal (existing tidegate and water main)	1	LS	$ 50,000.00	$ 50,000	
2.3	Dewatering	1	LS	$ 100,000.00	$ 100,000	
2.4	Channel Excavation	12,200	CY	$ 10.00	$ 122,000	
2.4.1	Haul and Dispose Excavated Material (uncontaminated)	6,100	CY	$ 10.00	$ 61,000	
2.4.2	Haul and Dispose Excavated Material (50 percent contaminated)	6,100	CY	$ 95.35	$ 582,000	
2.5	Vegetated Reinforced Soil Slope	1,000	VSF	$ 81.50	$ 82,000	
2.6	Channel and Shoreline Habitat Features	1	LS	$ 50,000.00	$ 50,000	
2.7	Revegetation	1	LS	$ 50,000.00	$ 50,000	**$ 1,147,000**
3.0	**Daylight Channel Construction**					
3.1	Temporary Erosion and Sediment Control	1	LS	$ 50,000.00	$ 50,000	
3.2	Dewatering	1	LS	$ 250,000.00	$ 250,000	
3.3	Dewatering (Contaminated GW Treatment)	1	LS	$ 50,000.00	$ 50,000	
3.4	Channel Excavation	17,400	CY	$ 7.00	$ 122,000	
3.5.1	Haul and Dispose Excavated Material (uncontaminated)	8,700	CY	$ 10.00	$ 87,000	
3.5.2	Haul and Dispose Excavated Material (50 percent contaminated)	8,700	CY	$ 95.35	$ 830,000	
3.6	Demolition, Protection, Modification of Stormwater Structures	1	LS	$ 250,000.00	$ 250,000	
3.7	HDPE Channel Liner for Contaminant Protection	90,000	SF	$ 2.50	$ 225,000	
3.8	Self-regulating Tidegate	1	LS	$ 400,000.00	$ 400,000	
3.9	Import Clean Liner Backfill	10,000	CY	$ 16.20	$ 162,000	
3.10	Utility Relocations	1	LS	$ 25,000.00	$ 25,000	
3.11	BNSF Railroad ROW Work					
3.11.1	BNSF Permits and Construction Maintenance Agreement	1	LS	$ 50,000.00	$ 50,000	
3.11.2	BNSF Railroad Crossing Special Insurance	1	LS	$ 100,000.00	$ 100,000	
3.11.3	BNSF Railroad Flagger	30	EA	$ 2,000.00	$ 60,000	
3.11.4	Erosion Protection Rock Bedding Material	250	CY	$ 60.00	$ 15,000	
3.11.5	Erosion Protection Rock (12-inch Riprap)	500	CY	$ 60.00	$ 30,000	
3.14	Soldier Pile Wall	150	LF	$ 2,500.00	$ 375,000	
3.15	MSE Wall Facing	750	SF	$ 50.00	$ 38,000	
3.16	Daylight Channel Revegetation	1	LS	$ 50,000.00	$ 50,000	**$ 3,169,000**
4.0	**Marsh Improvements**					
4.1	Clearing and Grubbing (remove cattails)	1.4	AC	$ 10,000.00	$ 14,000	
4.2	Channel Excavation/Dredging	9,028	CY	$ 50.00	$ 451,000	
4.3	Haul and Dispose Excavated Material (uncontaminated)	2,853	CY	$ 10.00	$ 29,000	
4.4	Haul and Dispose Excavated Material (contaminated)	6,175	CY	$ 95.35	$ 589,000	
4.5	Marsh Habitat Features	1	LS	$ 25,000.00	$ 25,000	
4.6	Demo and Dispose of Pond Pump Station	1	LS	$ 50,000.00	$ 50,000	
4.7	Decomission wells	5	EA	$ 5,000.00	$ 25,000	
4.8	Revegetation	1	LS	$ 50,000.00	$ 50,000	**$ 1,233,000**
				Equipment, Labor, and Material Costs	**$ 5,699,000**	**$ 5,699,000**
				Taxes (10.3%)	$ 587,000	
				Bonding & Insurance (5%)	$ 285,000	
				Contingency (25%)	$ 1,643,000	
				Construction Cost	**$ 8,214,000**	**$ 8,214,000**
				Real Estate Agreements, Easements, Real Property (TBD)	$ -	
				Engineering, Permits (15%)	$ 1,232,000	
				Project Costs	**$ 9,446,000**	**$ 9,446,000**

Notes:

[1] Costs are rounded to nearest thousand.

% = percent

AC = asphalt concrete; CY = cubic yards; EA = each; GW = groundwater; LS = lump sum; TBD= to be determined; VSF = volume scattering function

Liner and contaminated sediment depth inside existing treatment pond assumed to total 1 ft.

7.0 CONCLUSIONS AND RECOMMENDATIONS

The comparison of existing conditions and the Alternative 1 alignment reflects the increase in inundated area discussed in the feasibility study report. The flooding of the site in Alternative 1 and Alternative 4 is, however, better visualized with the 2D model. The modeled maximum water surface flood elevation along SR-104 for the 100-year flood event and downstream tidal HAT is 12.0. The elevation of SR-104 at this culvert crossing is 14.0 and is not overtopped. The elevation at the intersection with Dayton Street is 12.0. Flooding is observed at the northern end of Shellabarger Creek (Stellas Marsh) area, which drains north to the Dayton Street intersection. This may be a result of low sidewalk and curb areas towards the north end of SR-104, or possibly reduced conveyance of the SR-104 culvert due to freshwater cattails in the marsh. Similarly, flood flows do not overtop the berm south of Harbor Square at elevation 12.1. It is more likely that the flooding seen in these locations is caused by an increased tailwater on storm sewer outfalls, or caused by capacity issues with the inlet from Shellabarger Creek to the Dayton Street Stormwater System.

Water surface elevations within the marsh at nodes 3 and 4 will increase as a result of increases in the tidal prism. Increases in water surface elevations are only minimally affected by stormwater flood flows. The new daylight channel has the capacity to drain stormwater flood flows with each tidal cycle. At the three upstream nodes 4 through 6, flood water surface elevations decrease from existing conditions to the proposed alternatives. This is because the daylight channel fully drains the marsh on each tidal cycle, thereby increasing flood storage areas and lowering flood water surface elevations. These decreases in flood water surface elevations reduce flooding at SR-104 and Harbor Square. We note that sections of the daylight channel lower in the system have velocities greater than 2 feet per second and could pose risks to the public at Marina Beach Park, and we recommend further study as part of Task 5 of our scope of services.

These results are provided for review by the City, our fishery biologist, and the project partners for feedback to decide next steps and future recommendations.

8.0 LIMITATIONS

S&W prepared this report for the exclusive use of the City and their representatives for specific application to the Willow Creek Daylight. Our judgments, conclusions, and interpretations presented in the report should not be construed as a warranty of existing site conditions or future estimated conditions. It is in no way guaranteed that any regulatory agency will reach the same conclusions as S&W.

Our assessment, conclusions, recommendations, etc., are based on the limitations of our approved scope, schedule, and budget described in our contract dated November 1, 2016. If a service is not specifically indicated in this letter, do not assume that it was performed.

Stream and wetland systems function as a collection of integrated system components. It is not practical or possible to completely know all of the geomorphic, hydrologic, and hydraulic properties of a stream and wetland system. Consequently, uncertainty exists as to actual stream and wetland behavior, performance and function. Regular inspections of the stream and storm drainage systems should be performed. Risks should be managed as appropriate based on observed conditions, uncertainty, and potential consequences. If conditions different from those described herein are encountered during later phases of work on this project, we should review our description of the stream and wetland conditions and reconsider our conclusions and recommendations. Potential variation includes, but is not limited to:

- The conditions between and beyond study areas may be different.
- The passage of time or intervening causes (natural and manmade) may result in changes to site and stream conditions.
- Changes in land uses in the watershed beyond the site area.

We have prepared our recommendations for daylight alignment selection considering the information available at the time of this report. If additional information becomes available, the recommendations presented herein may need to be revised. S&W should be made aware of the revised or additional information so we can evaluate our recommendations for applicability.

S&W has prepared an Appendix, "Important Information About Your Geotechnical/ Environmental Report," to assist you and others in understanding the use and limitations of our reports.

We are pleased to have the opportunity to assist you with this project. If you have questions about the contents of this letter, please contact myself at (206) 695-6706 or Dave Cline at (206) 695-6885.

SHANNON & WILSON, INC.

11/7/2017

Christopher M. Helland, PE, CFM
Hydraulic Engineer

CMH:DRC/cmh

9.0 REFERENCES

Anchor QEA, LLC, 2013, Tidal marsh hydrodynamics report, Willow Creek daylight early feasibility study: Report prepared by Anchor QEA, LLC, Seattle, Wash., Project Number 120017-01.01, for Shannon & Wilson, Inc., Seattle, Wash., May.

Anchor QEA, LLC, 2015, Beach outlet and hydrodynamic evaluation report, Willow Creek daylight final feasibility study: Report prepared by Anchor QEA, LLC, Seattle, Wash., Project Number 140017-01.01, for Shannon & Wilson, Inc., Seattle, Wash., January.

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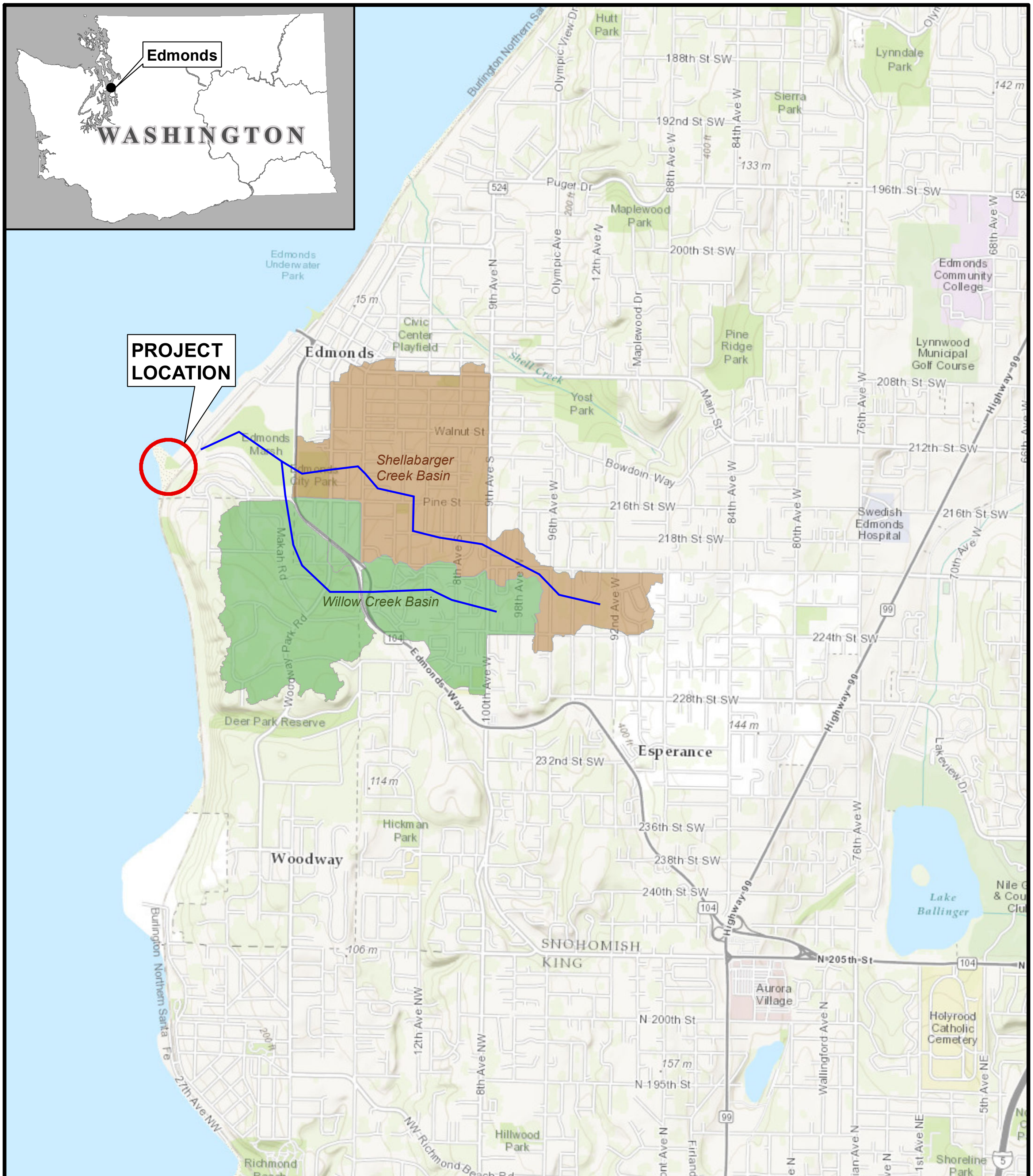

0 ½ 1

Scale in Miles

N E S W

Willow Creek Daylight Project
Expanded Marsh Concept Design and Hydraulic Modeling
Edmonds, Washington

VICINITY MAP

November 2017 21-1-12588-020

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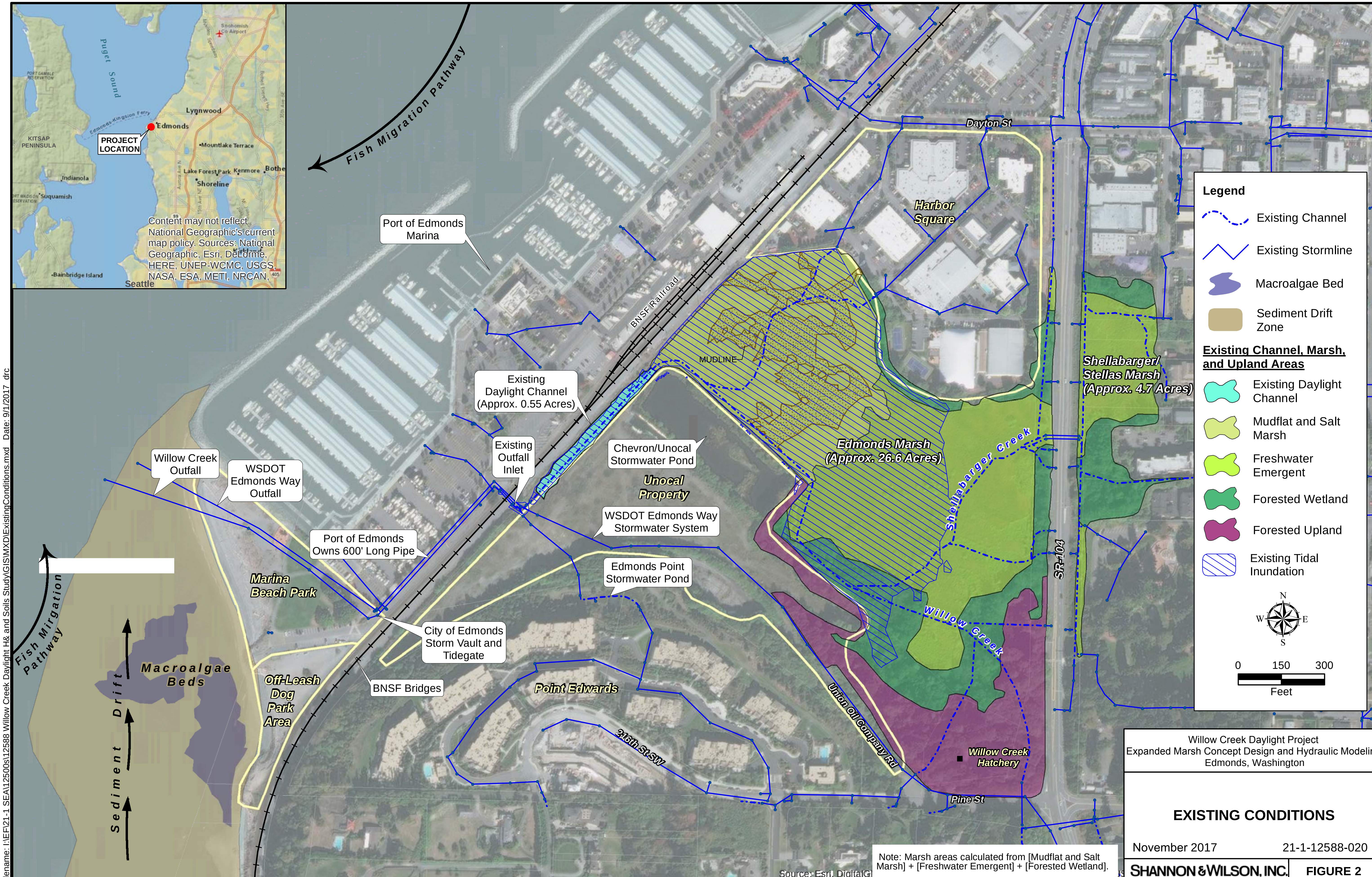
FIG. 1

Filename: I:\WIP\21-1\12393 Willow Creek Daylight\406. GEOTECH\Report\Figures\old\VicinityMap.mxd Date: 9/28/2015 beo



Willow Creek Daylight Project
Expanded Marsh Concept Design and Hydraulic Modeling
Edmonds, Washington

EXISTING CONDITIONS

November 2017 21-1-12588-020

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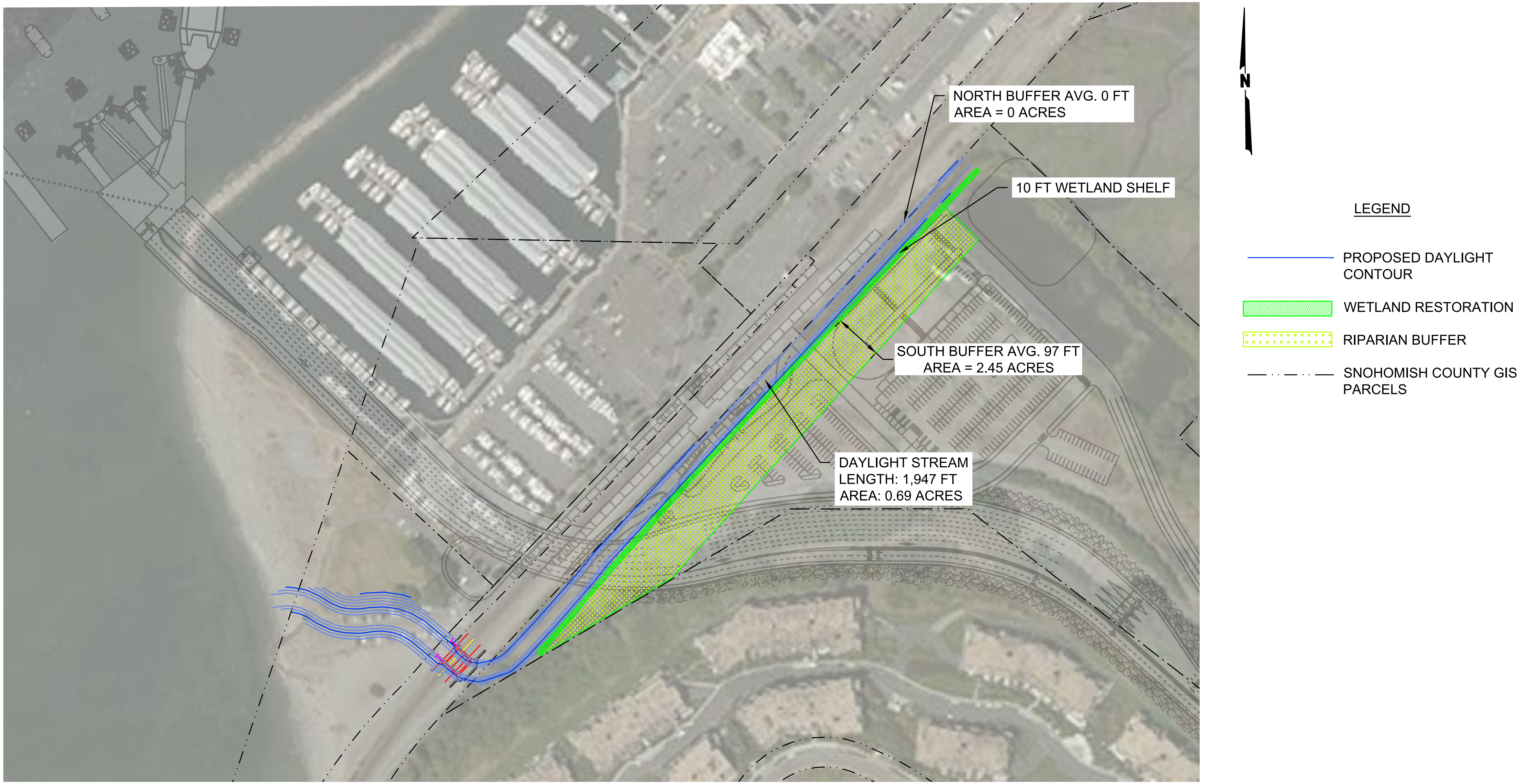
FIGURE 2

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\GIS\MXD\ExistingConditions.mxd Date: 9/1/2017 drc



NOTE

Figure adapted from electronic files, *2004_Willow_Cr_Survey.dwg*, 2008_Marsh_Survey.dwg, *20120049 TOPO.dwg* and Basemap.dwg received 08-04-2014. Also aerial.jpg received 08-11-2014.

WSDOT Ferry preferred alternative location is approximate.

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN
AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

ALTERNATIVE 1
ALIGNMENT AND BUFFERS

November 2017 21-1-12588-020

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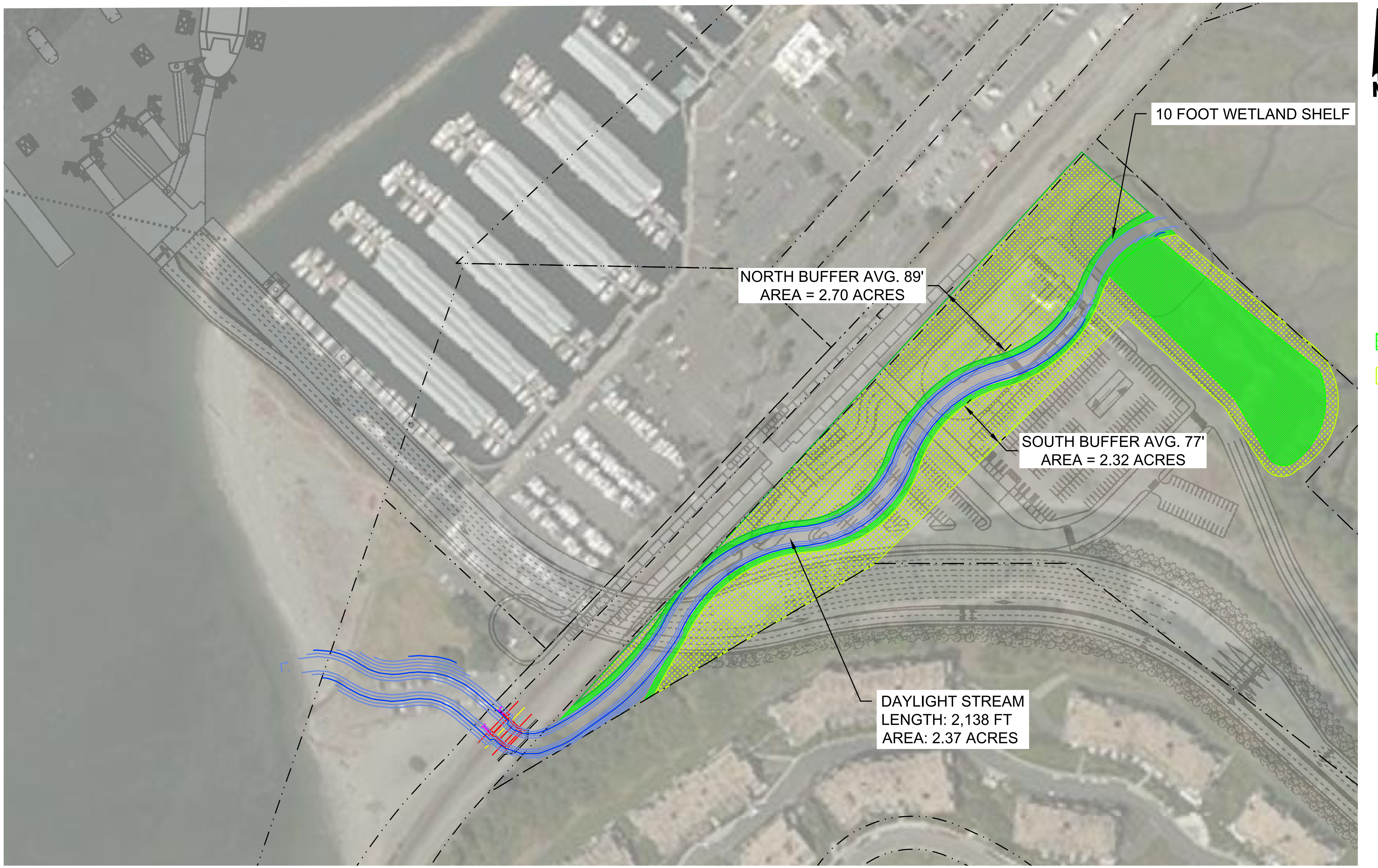
FIG. 3

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\CAD\Figure\21-1-12588 Buffer Options.dwg Date: 11-07-2017 Login: CMH



LEGEND

- PROPOSED DAYLIGHT CONTOUR
- WETLAND RESTORATION
- RIPARIAN BUFFER
- SNOHOMISH COUNTY GIS PARCELS

NOTE

Figure adapted from electronic files, *2004_Willow_Cr_Survey.dwg*, 2008_Marsh_Survey.dwg, *20120049 TOPO.dwg* and Basemap.dwg received 08-04-2014. Also aerial.jpg received 08-11-2014.

WSDOT Ferry preferred alternative location is approximate.

0 200 400

Scale in Feet

Contour Interval = 1 Foot

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN
AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

ALTERNATIVE 2
ALIGNMENT AND BUFFERS

November 2017 21-1-12588-020

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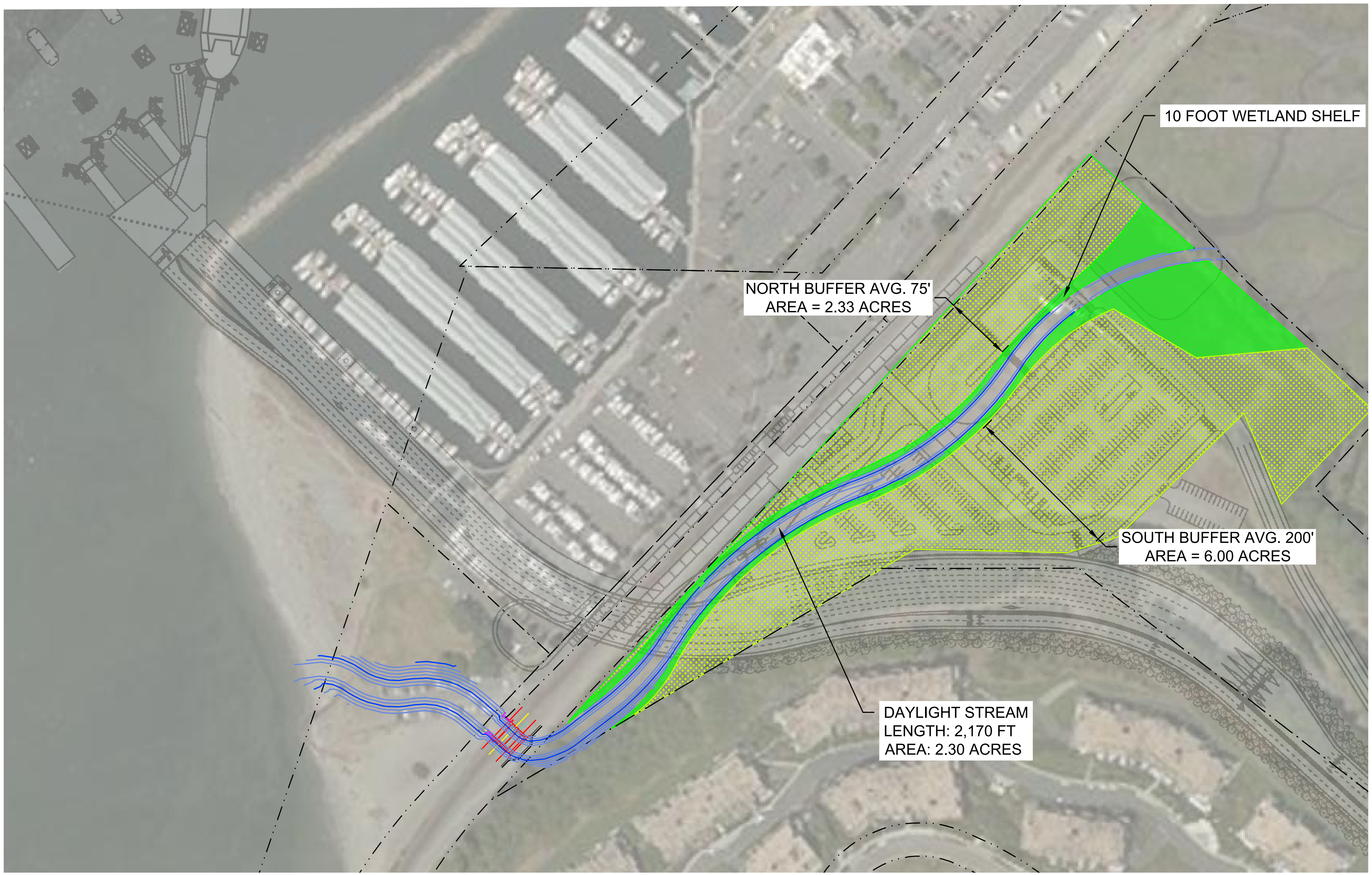
FIG. 4

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\CAD\Figure\21-12588 Buffer Options.dwg Date: 11-07-2017 Login: CMH



N

LEGEND

- PROPOSED DAYLIGHT CONTOUR
- WETLAND RESTORATION
- RIPARIAN BUFFER
- SNOHOMISH COUNTY GIS PARCELS

NOTE

Figure adapted from electronic files, *2004_Willow_Cr_Survey.dwg*, 2008_Marsh_Survey.dwg, *20120049 TOPO.dwg* and Basemap.dwg received 08-04-2014. Also aerial.jpg received 08-11-2014.

WSDOT Ferry preferred alternative location is approximate.

0 200 400

Scale in Feet
Contour Interval = 1 Foot

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN
AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

ALTERNATIVE 3
ALIGNMENT AND BUFFERS

November 2017 21-1-12588-020

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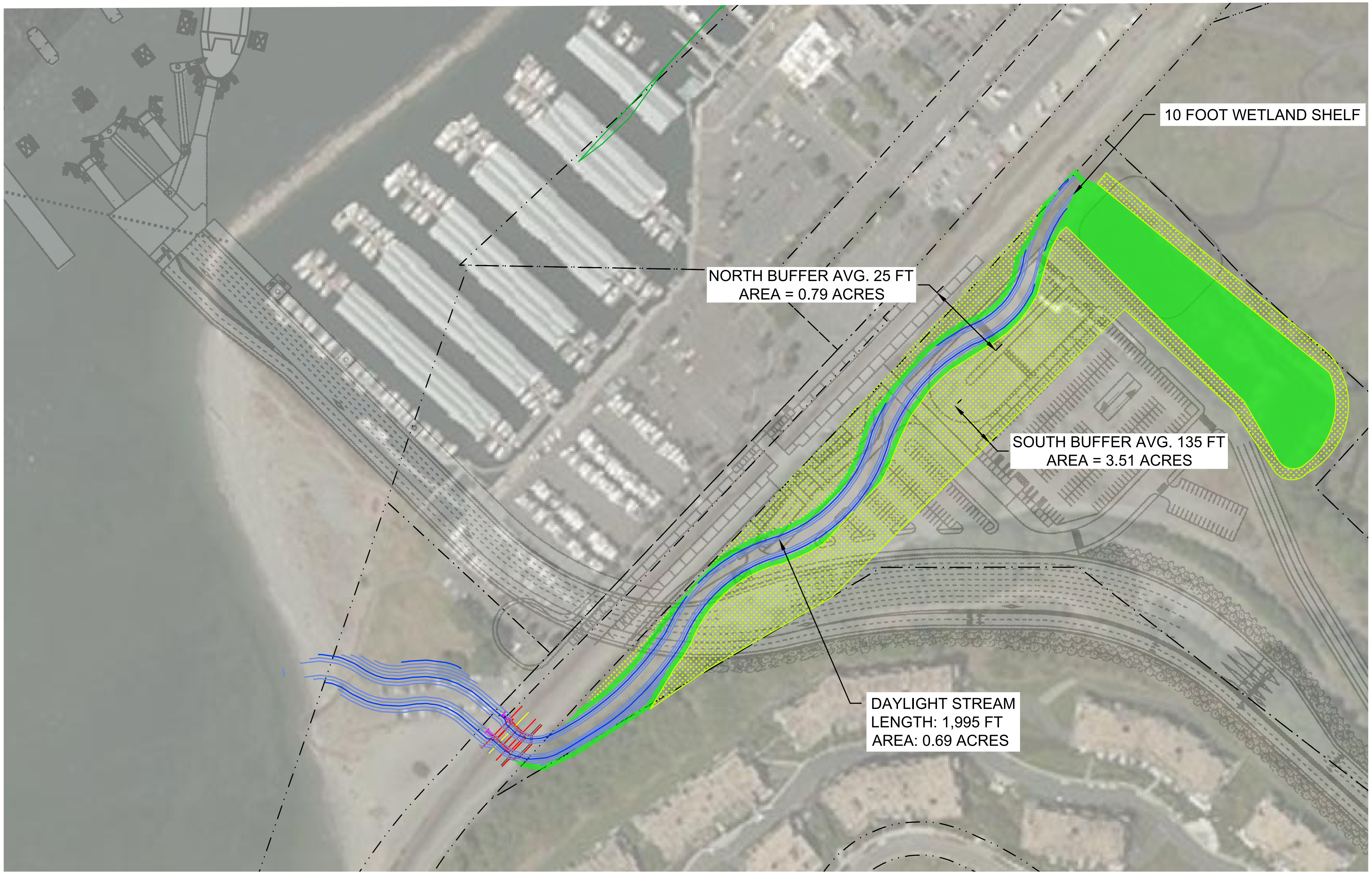
FIG. 5

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\CAD\Figure\21-12588 Buffer Options.dwg Date: 11-07-2017 Login: CMH



N

LEGEND

- PROPOSED DAYLIGHT CONTOUR
- WETLAND RESTORATION
- RIPARIAN BUFFER
- SNOHOMISH COUNTY GIS PARCELS

NOTE

Figure adapted from electronic files, *2004_Willow_Cr_Survey.dwg*, 2008_Marsh_Survey.dwg, *20120049 TOPO.dwg* and Basemap.dwg received 08-04-2014. Also aerial.jpg received 08-11-2014.

WSDOT Ferry preferred alternative location is approximate.

0 200 400

Scale in Feet
Contour Interval = 1 Foot

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN
AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

ALTERNATIVE 4
ALIGNMENT AND BUFFERS

November 2017 21-1-12588-020

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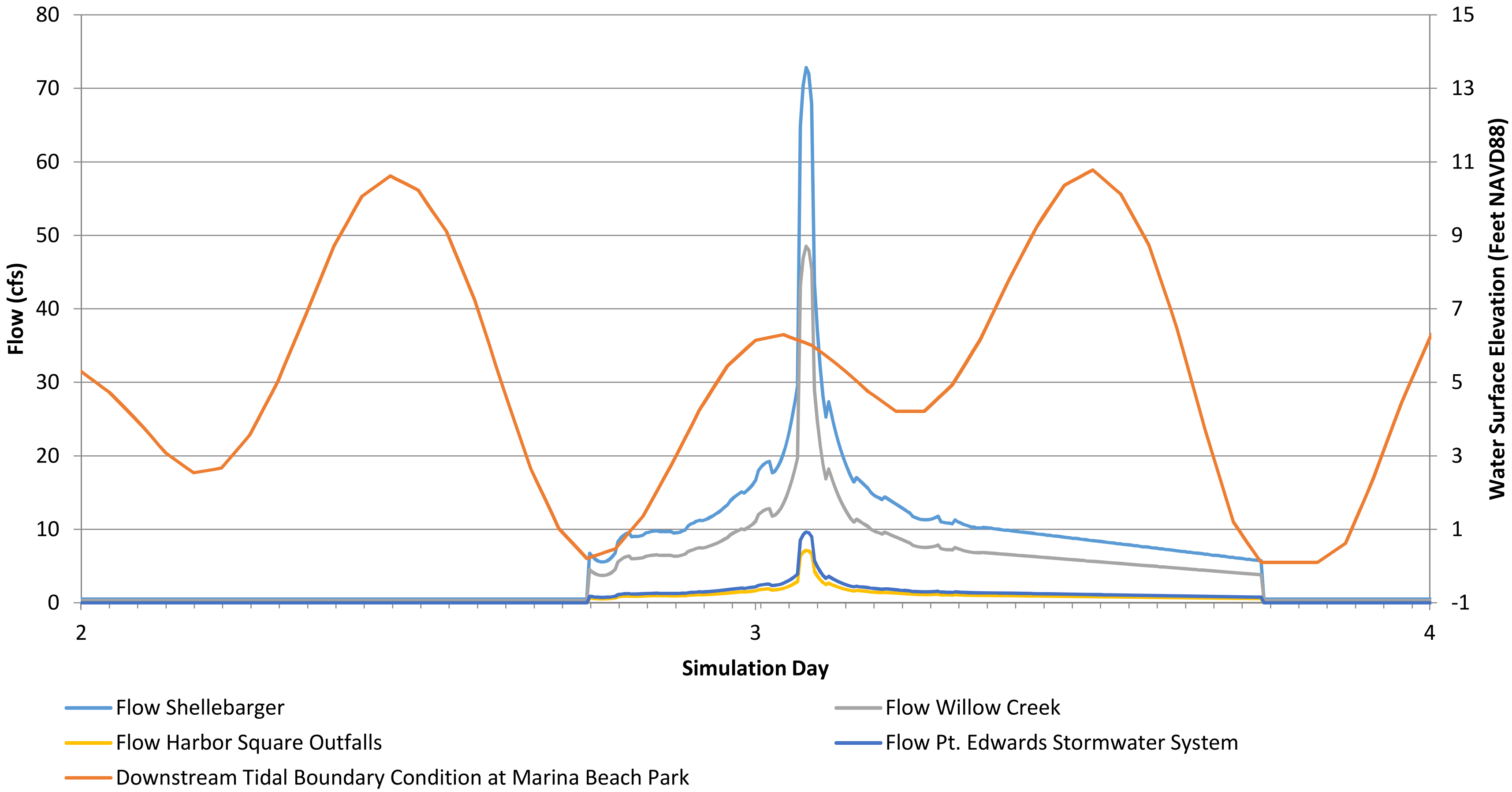
FIG. 6

Filename: I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\CAD\Figure\21-12588 Buffer Options.dwg Date: 11-07-2017 Login: CMH



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

100 Year Flood Hydrographs and Tidal Water Surface Elevation Boundary Condition

November 2017 21-1-12588-020

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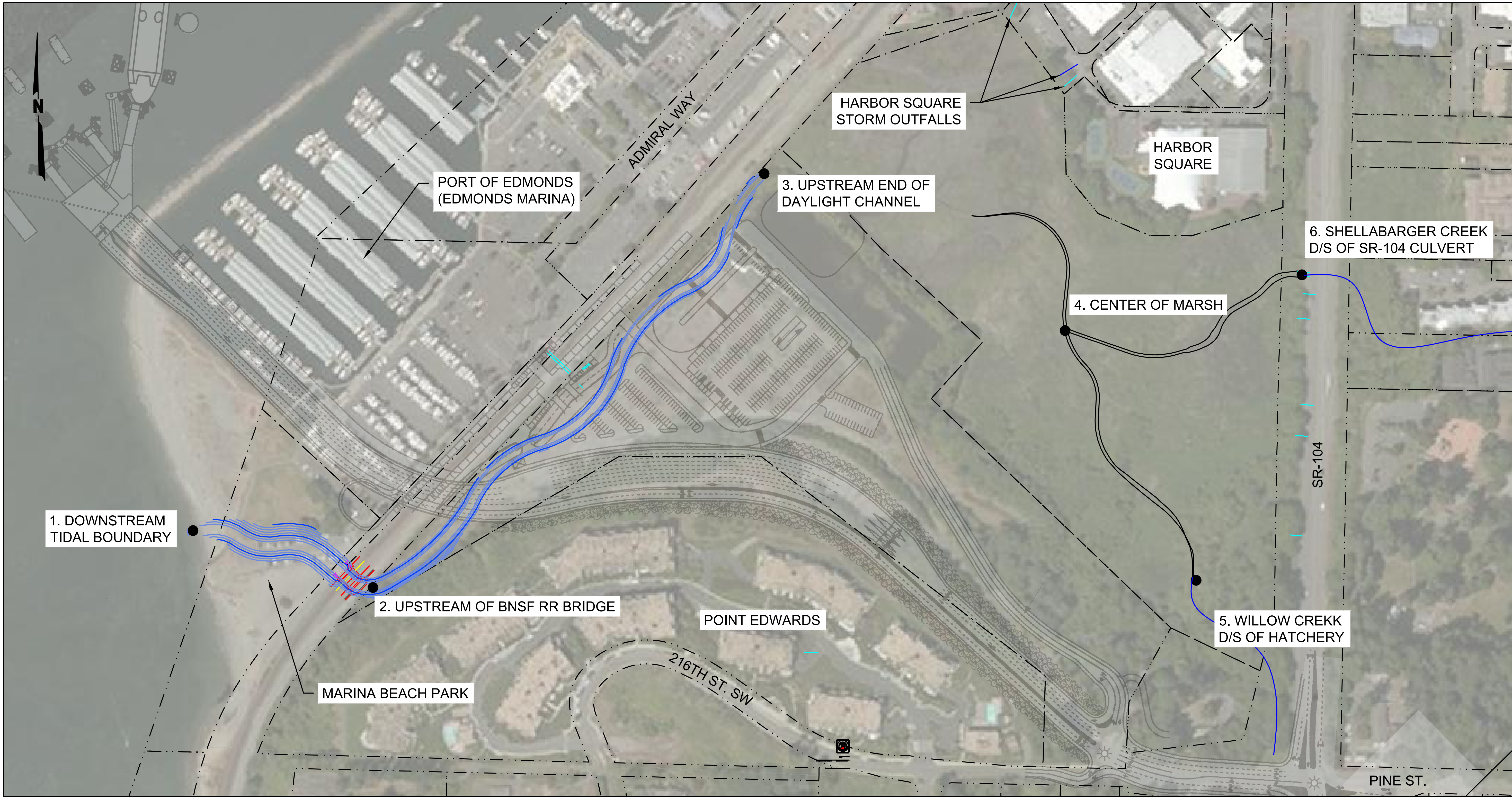
FIG. 7

FIG. 7

I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\020 H&H ALTS\Report\21-1-12588-020_Tables_ Figures 7-18.xlsx <Hydrographs>



LEGEND

PROPOSED DAYLIGHT CONTOUR

SNOHOMISH COUNTY GIS PARCELS

MODELING NODE

0 250 500

Scale in Feet

Contour Interval = 1 Foot

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN
AND HYDRAULIC MODELING
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MODELING NODES

November 2017 21-1-12588-020

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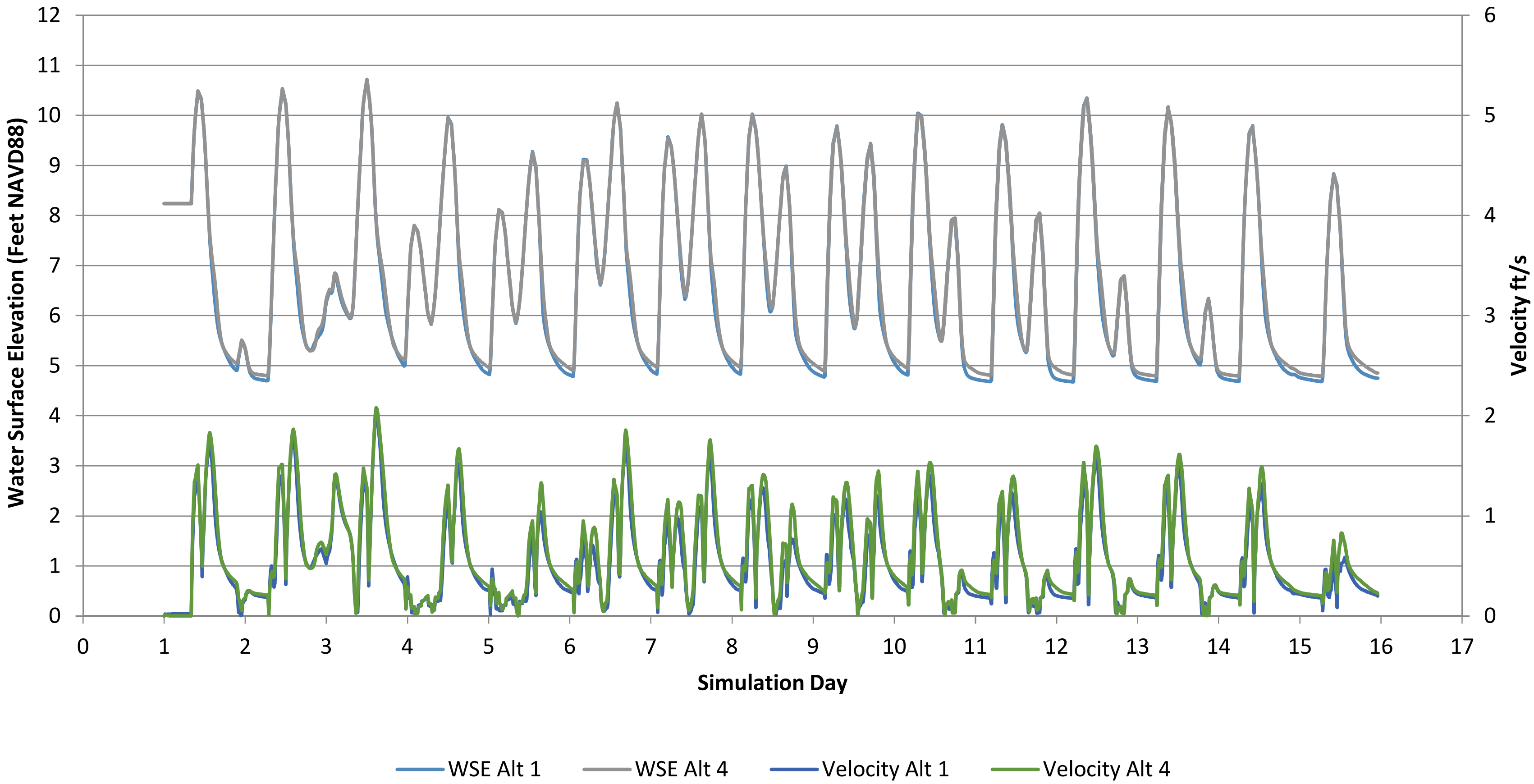
FIG. 8



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

100 Year Flood Water Surface Elevation and Velocity
Node 2 - Upstream of BNSF Bridge

November 2017 21-1-12588-020

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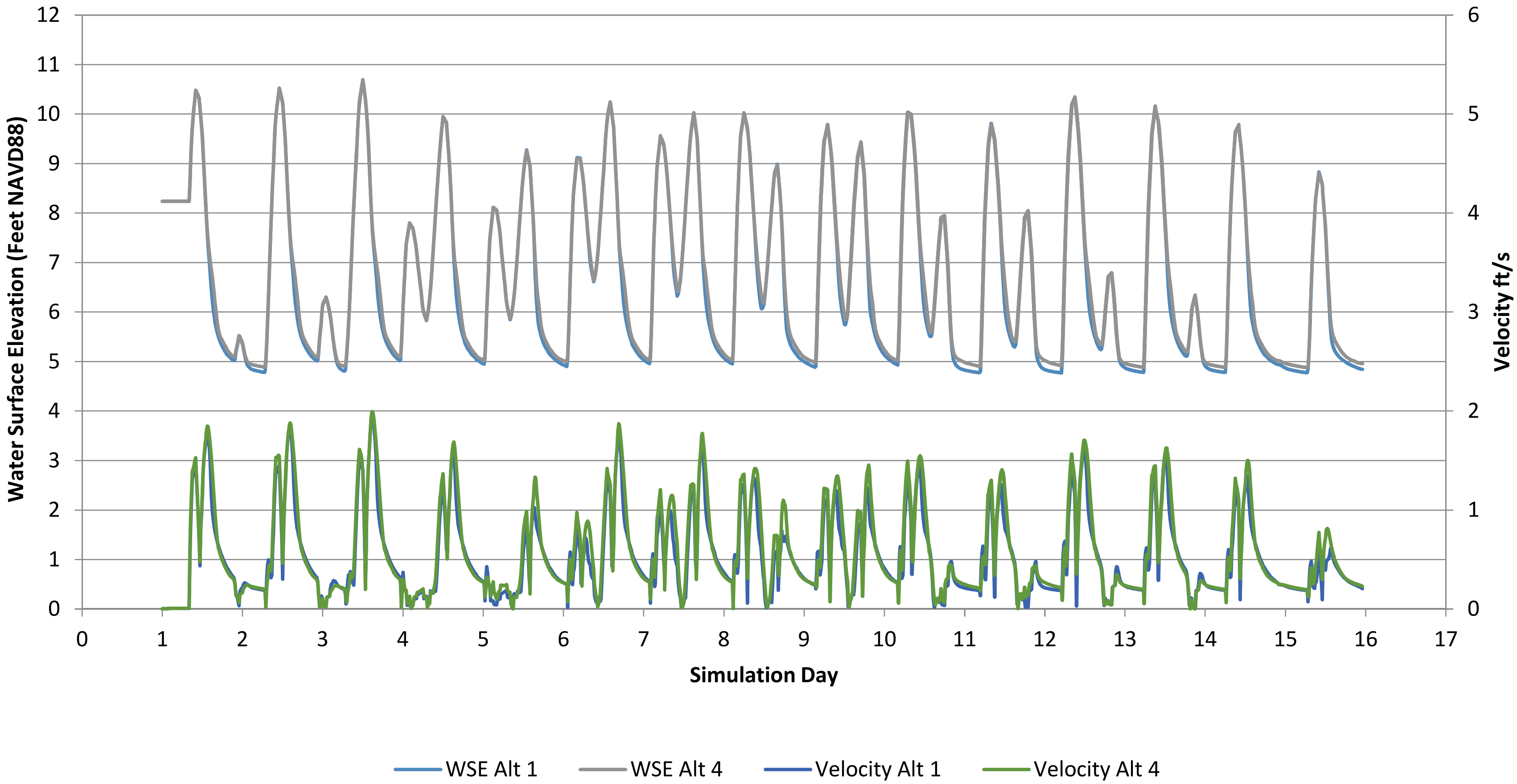
FIG. 9

FIG. 9

I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\020 H&H ALTS\Report\21-1-12588-020_Tables_ Figures 7-18.xlsx <Node 2 100 Year>



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

Late Spring Fish Habitat Water Surface Elevation and Velocity Node 2 - Upstream of BNSF Bridge

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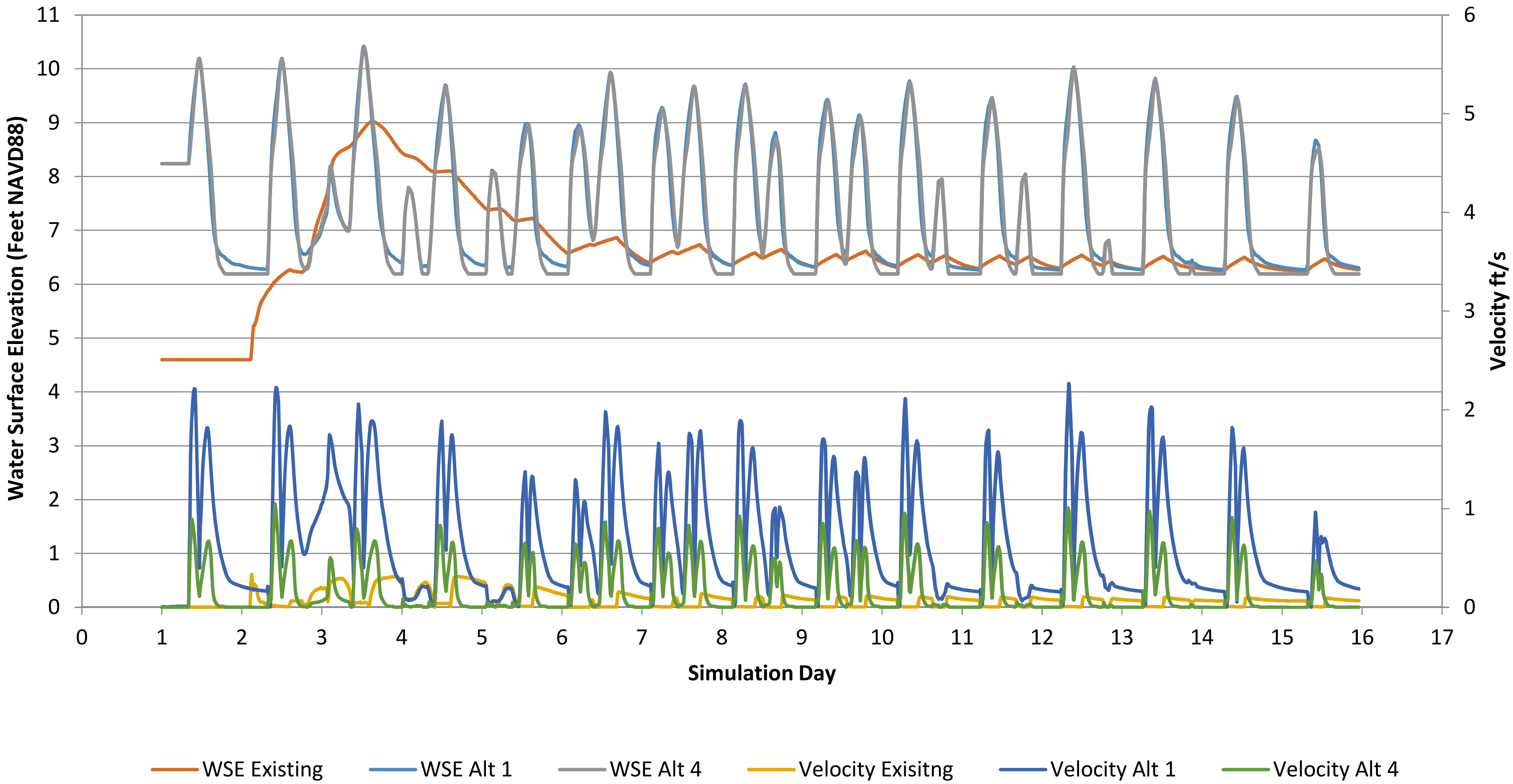
FIG. 10

FIG. 10

I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\020 H&H ALTS\Report\21-1-12588-020_Tables_ Figures 7-18.xlsx <Node 2 Low Flow>



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING
EDMONDS, WASHINGTON

100 Year Flood Water Surface Elevation and Velocity
Node 3 - Upstream of Daylight Channel

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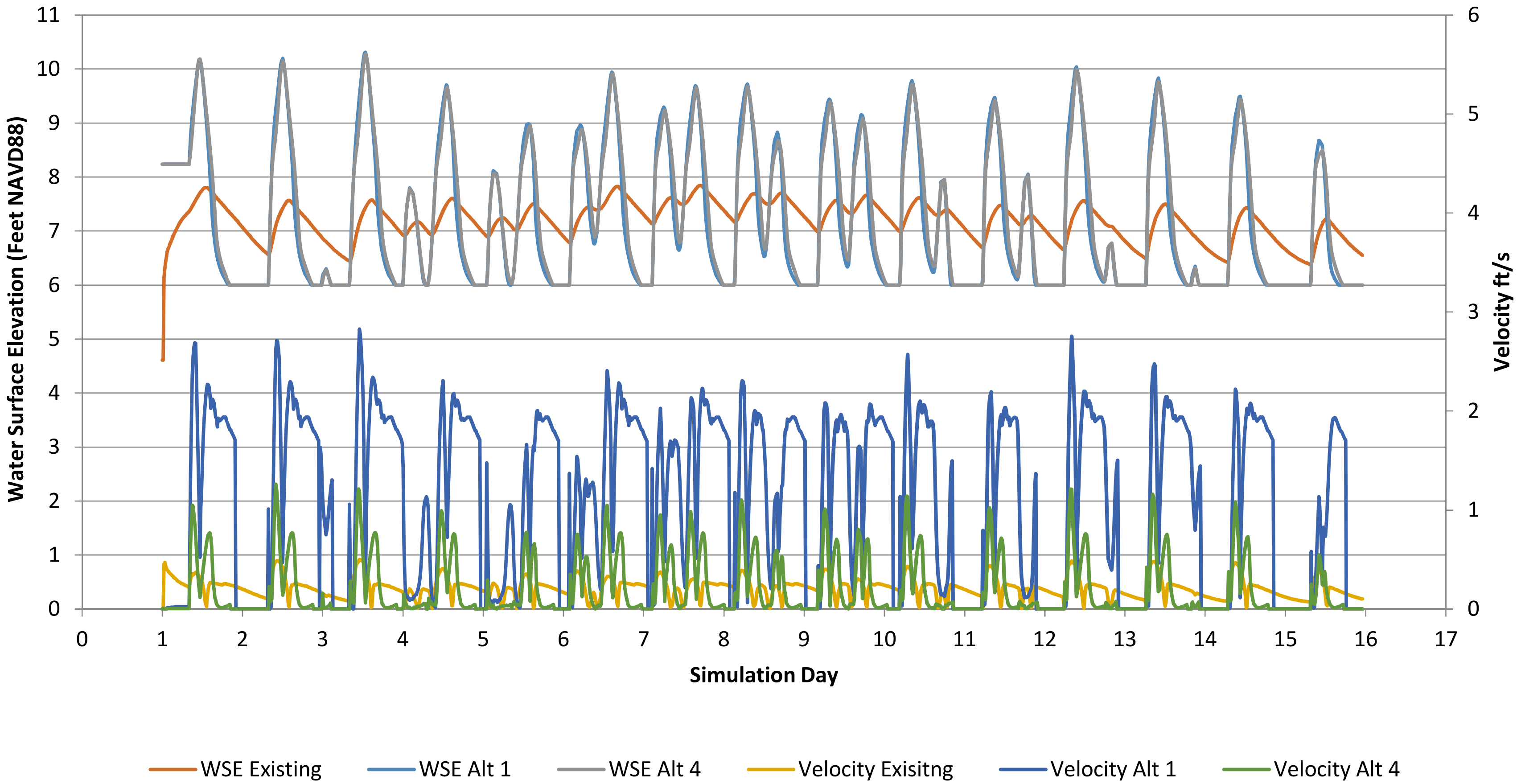
FIG. 11

FIG. 11

I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\020 H&H ALTS\Report\21-1-12588-020_Tables_ Figures 7-18.xlsx <Node 3 100 Year >



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING
EDMONDS, WASHINGTON

Late Spring Habitat Water Surface Elevation and Velocity
Node 3 - Upstream of Daylight Channel

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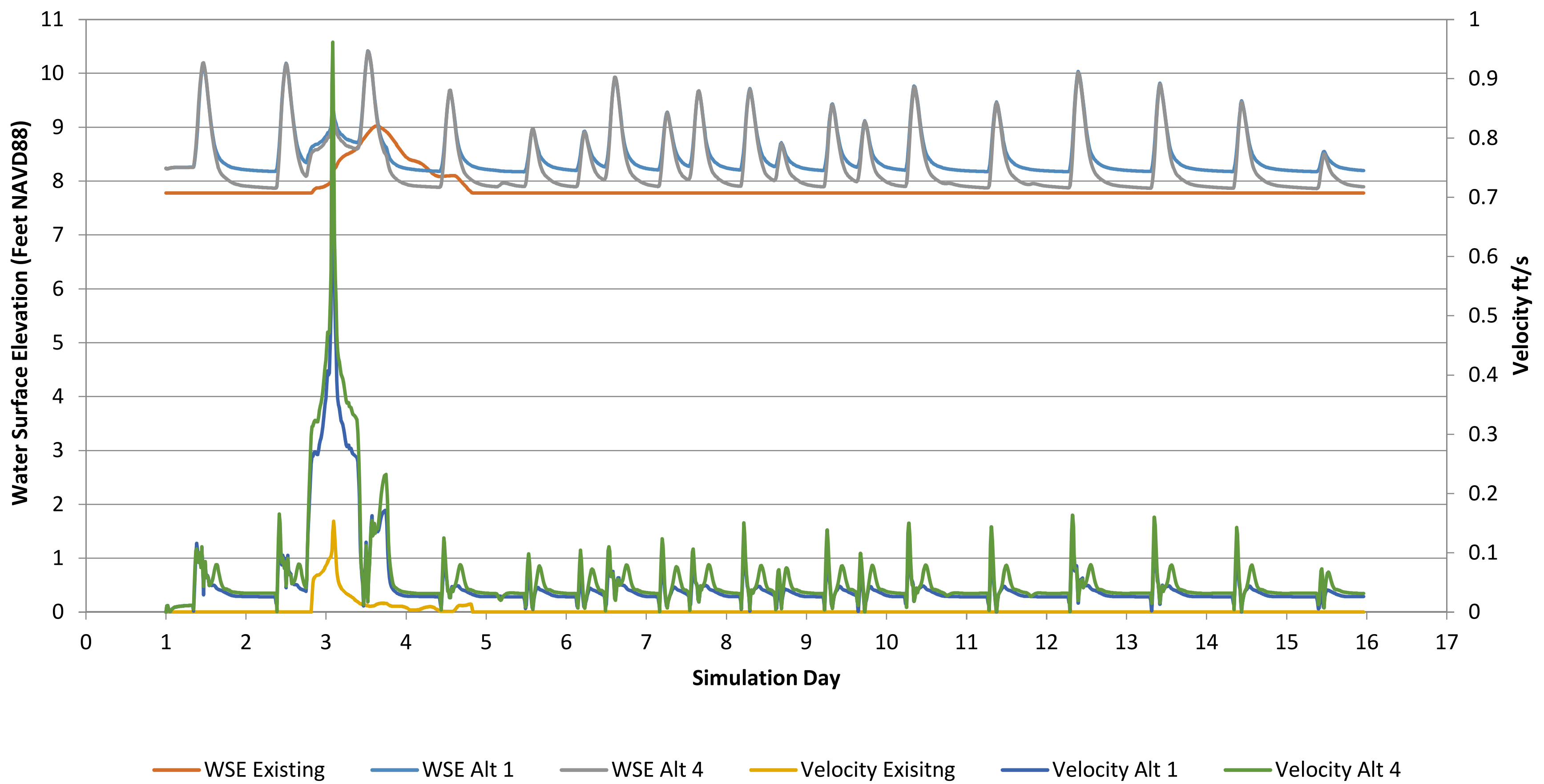
FIG. 12

FIG. 12



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

100 Year Flood Water Surface Elevation and Velocity Node 4 - Center of Marsh

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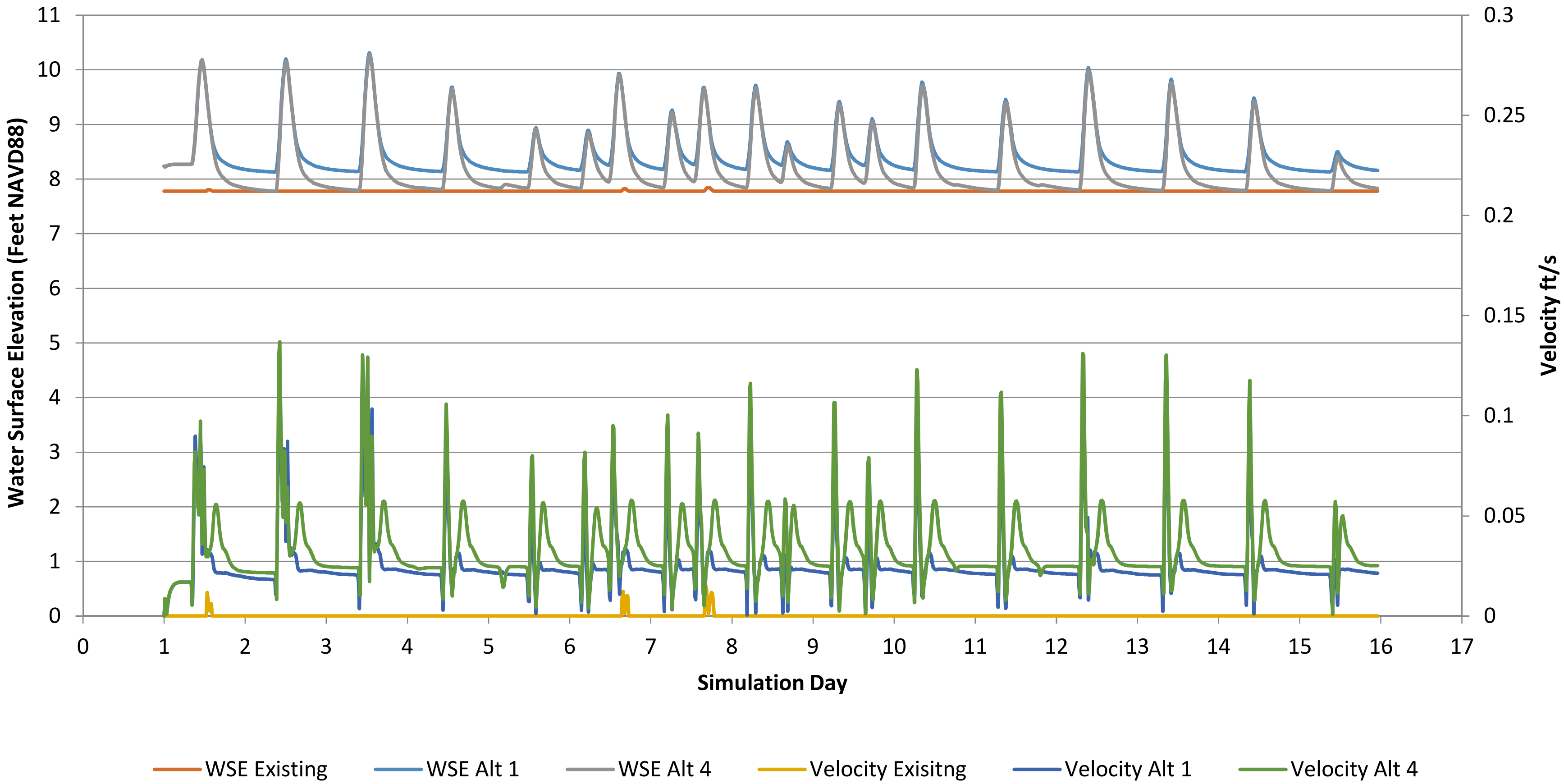
FIG. 13

FIG. 13

I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\020 H&H ALTS\Report\21-1-12588-020_Tables_ Figures 7-18.xlsx <Node 4 100 Year>



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

Late Spring Fish Habitat Water Surface Elevation and Velocity Node 4 - Center of Marsh

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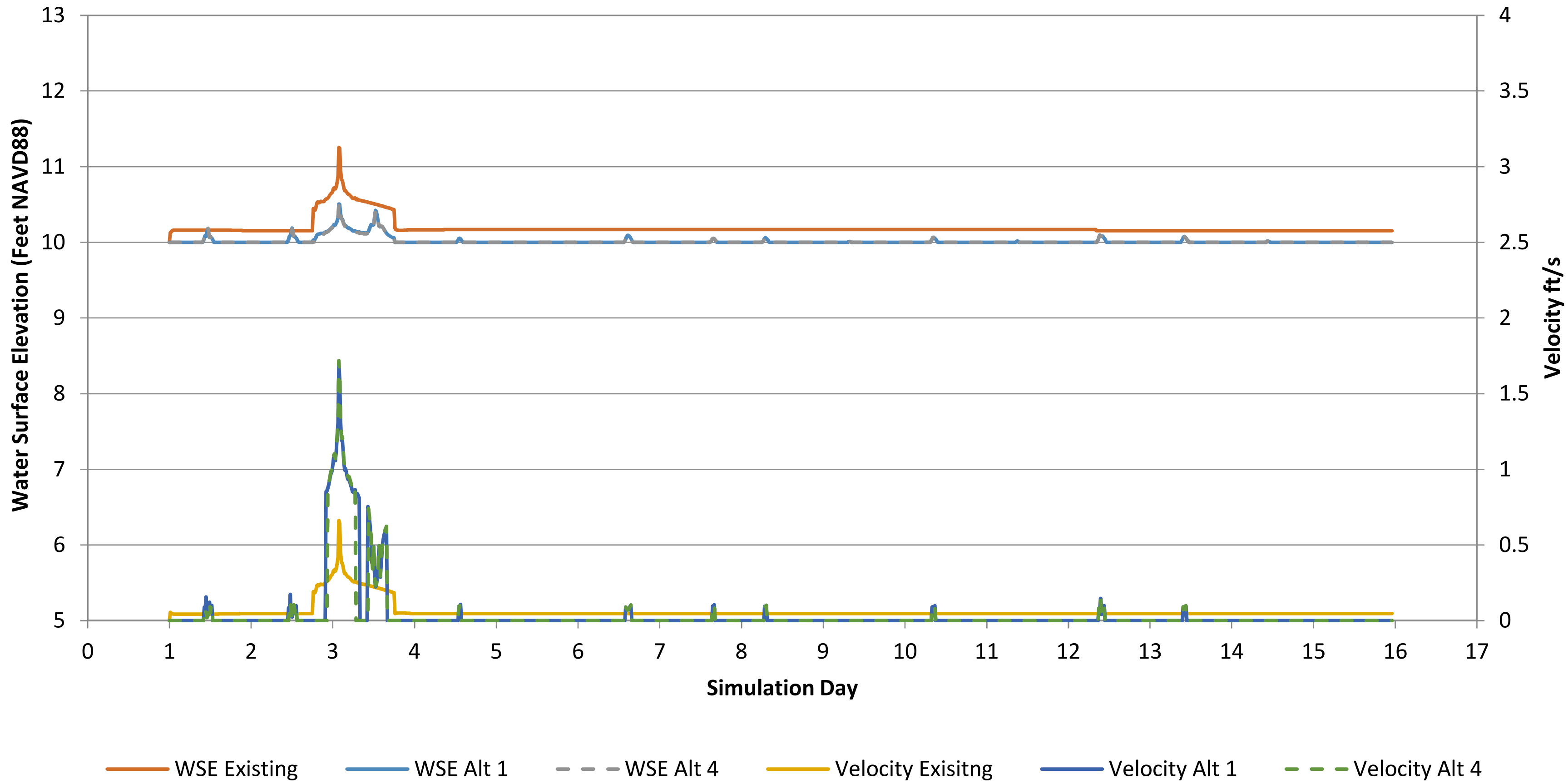
FIG. 14

FIG. 14

I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\020 H&H ALTS\Report\21-1-12588-020_Tables_ Figures 7-18.xlsx <Node 4 Low Flow>



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING
EDMONDS, WASHINGTON

100 Year Flood Water Surface Elevation and Velocity
Node 5 - Willow Creek Downstream of Hatchery

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FIG. 15

FIG. 15

I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\020 H&H ALTS\Report\21-1-12588-020_Tables_ Figures 7-18.xlsx <Node 5 100 Year>

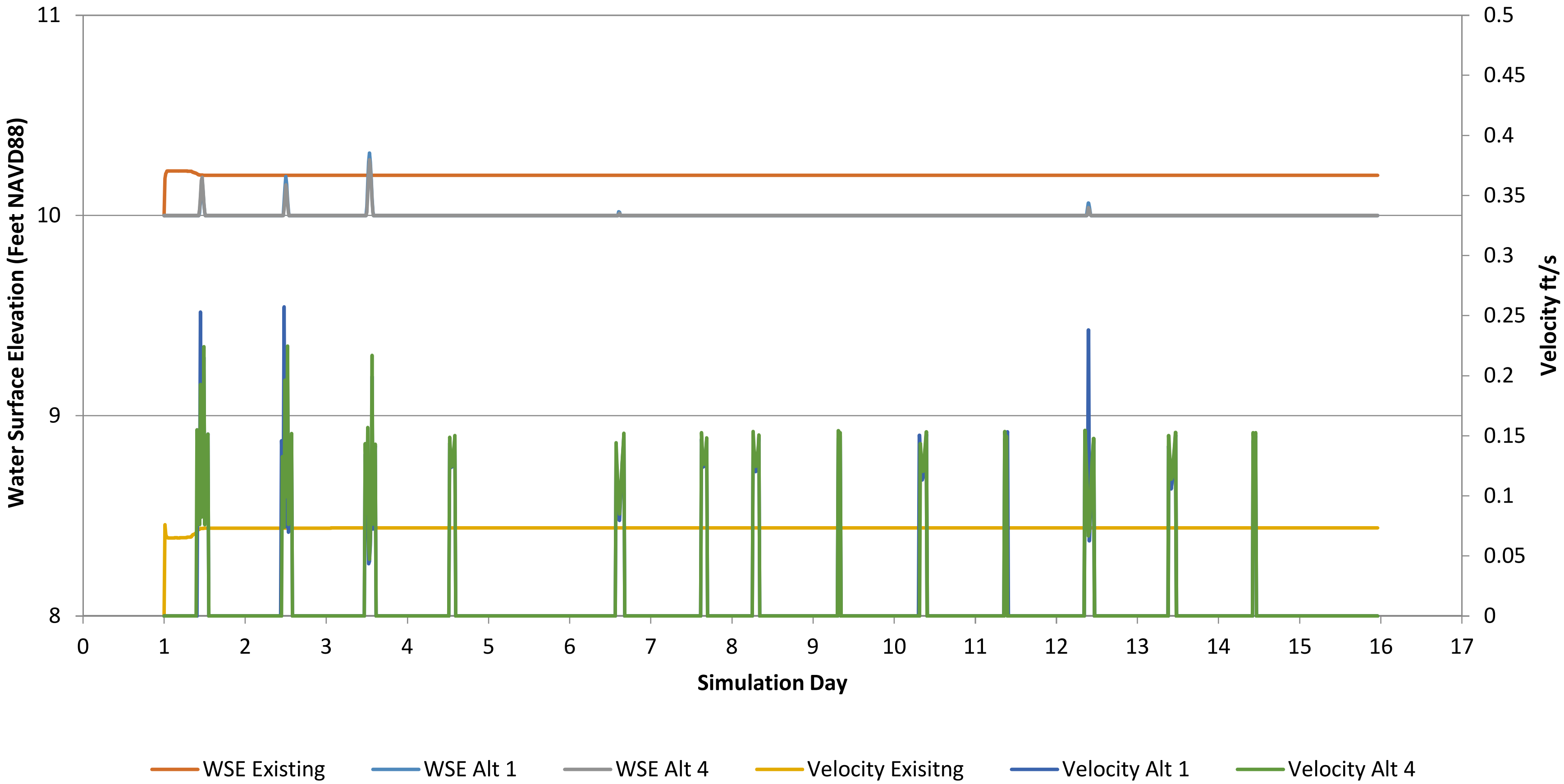

FIG. 16

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING
EDMONDS, WASHINGTON

Late Spring Fish Habitat Water Surface Elevation and Velocity
Node 5 - Willow Creek Downstream of Hatchery

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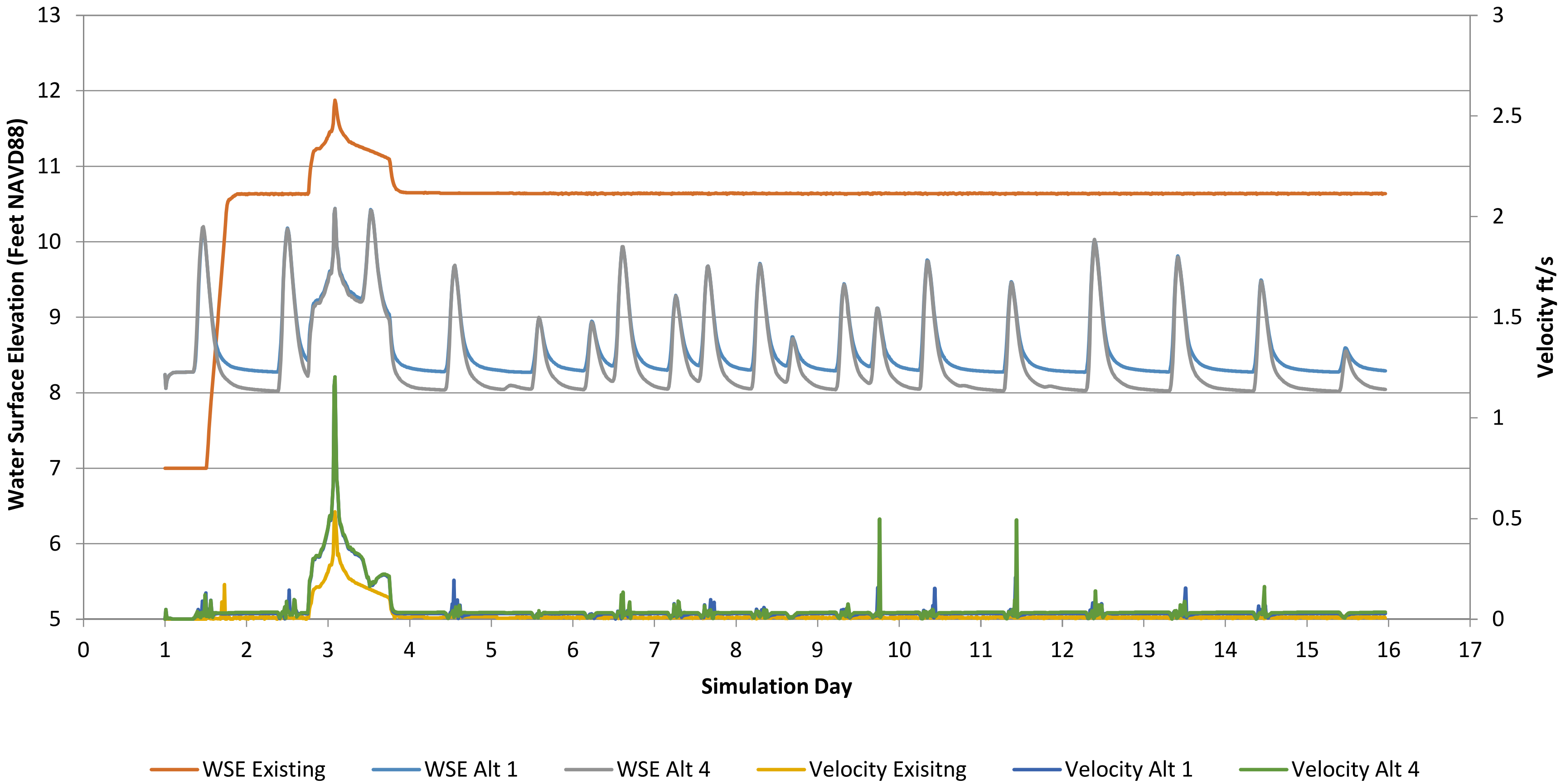
FIG. 16

I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\020 H&H ALTS\Report\21-1-12588-020_Tables_ Figures 7-18.xlsx <Node 5 Low Flow>



WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING
EDMONDS, WASHINGTON

100 Year Flood Water Surface Elevation and Velocity
Node 6 - Shellabarger Creek Downstream of SR 104

November 2017 21-1-12588-020

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FIG. 17

FIG. 17

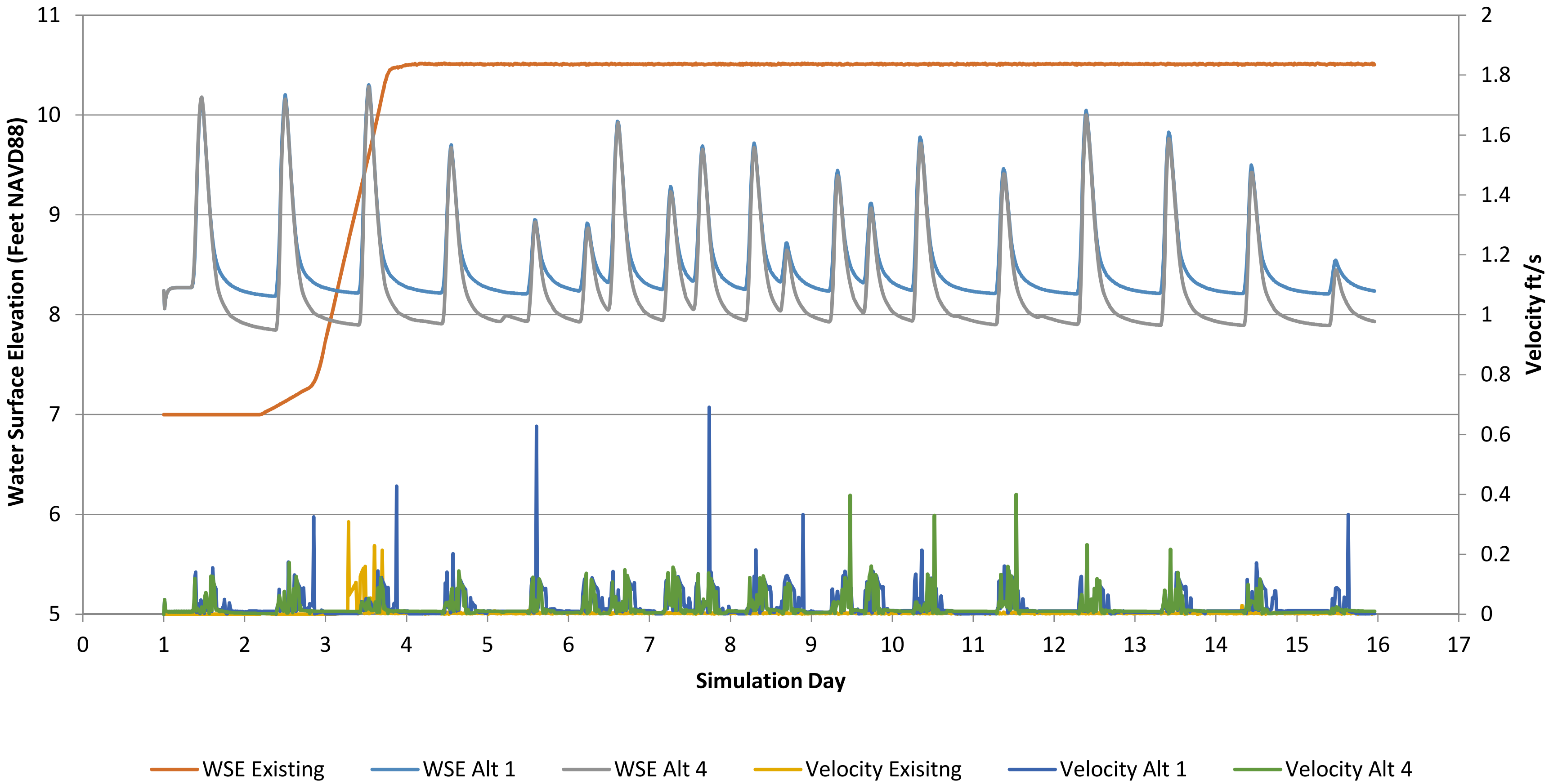

FIG. 18

WILLOW CREEK DAYLIGHT PROJECT
EXPANDED MARSH CONCEPT DESIGN AND
HYDRAULIC MODELING
EDMONDS, WASHINGTON

Late Spring Habitat Water Surface Elevation and Velocity
Node 6 - Shellabarger Creek Downstream of SR 104

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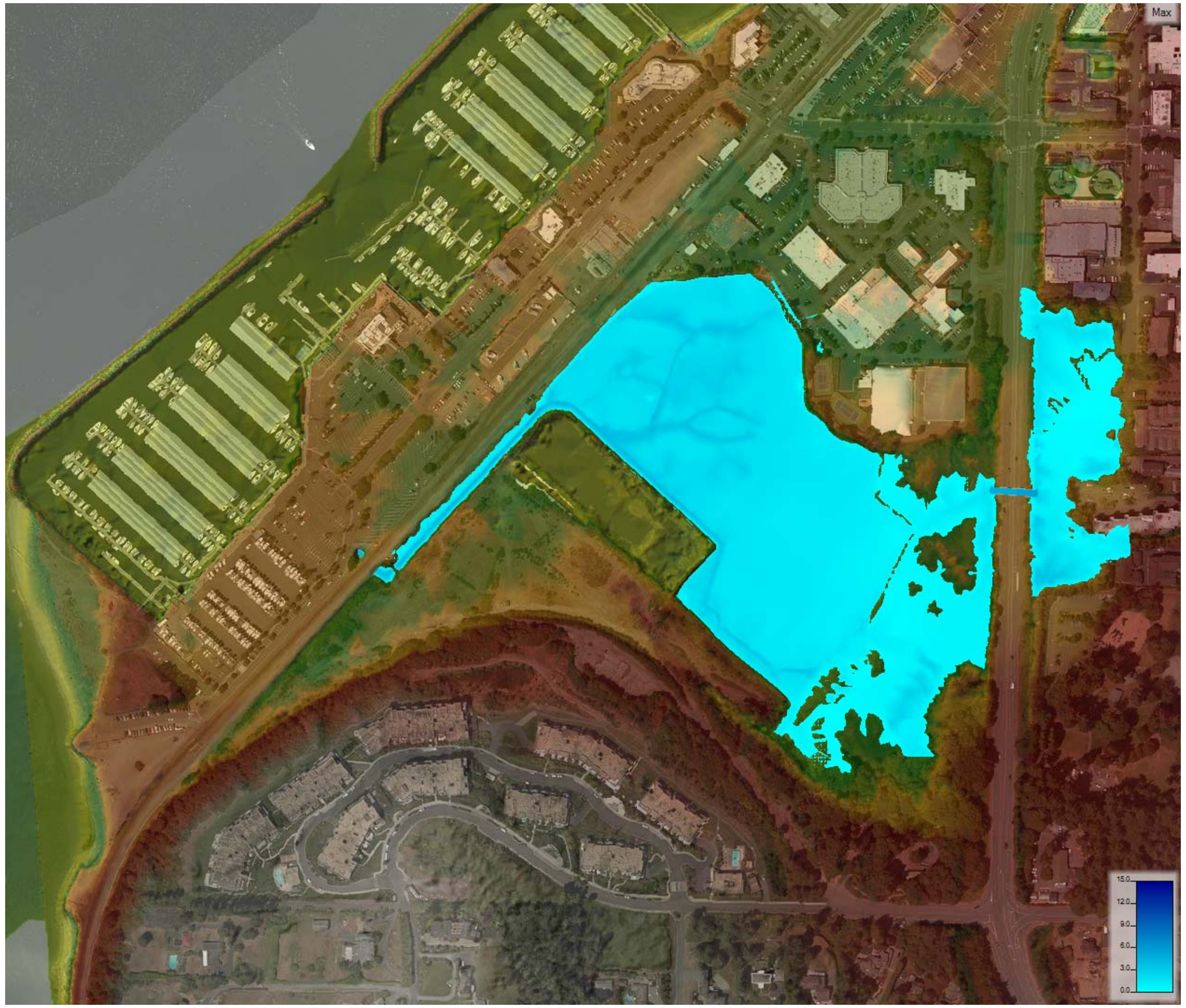
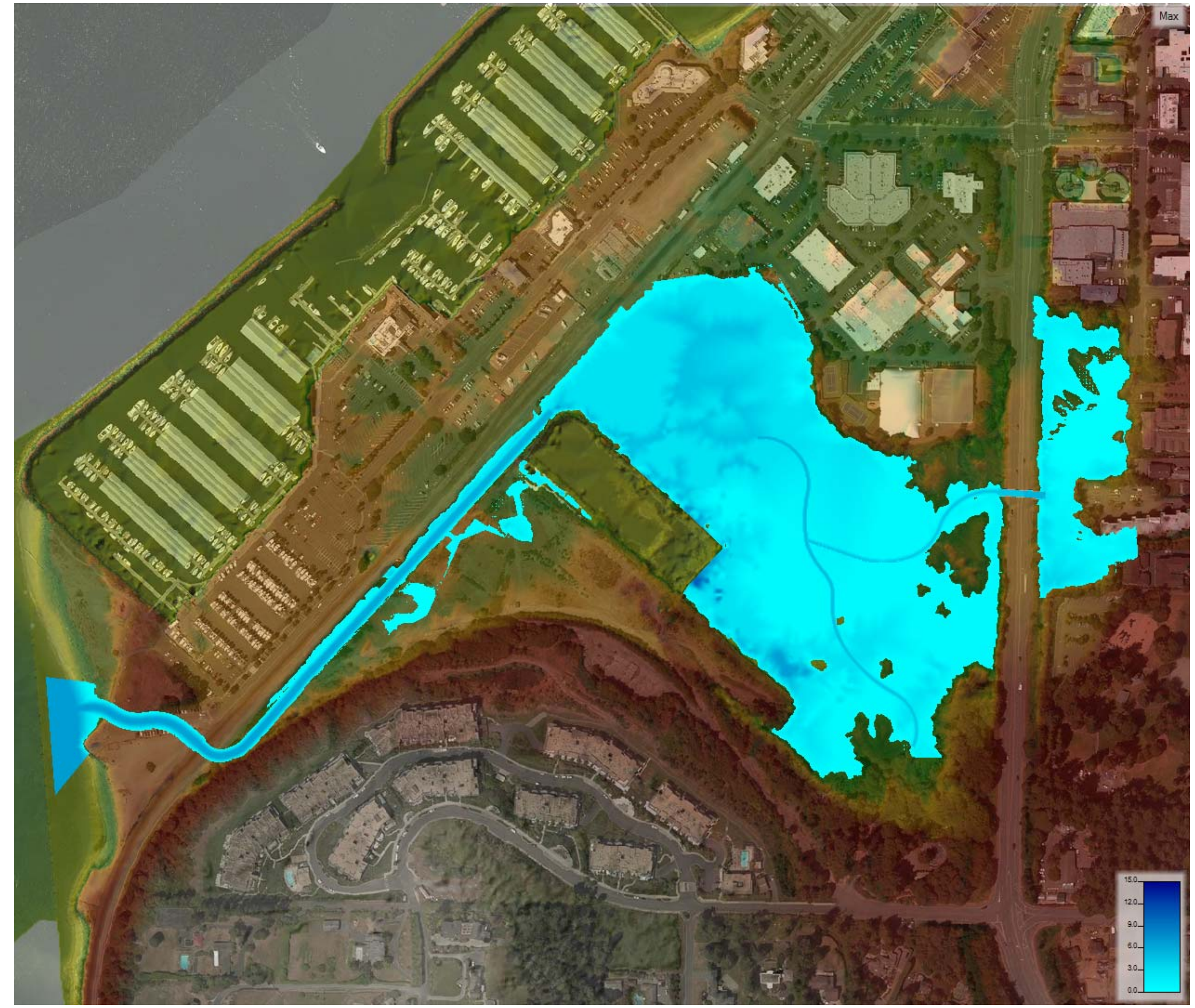
FIG. 18

I:\EF\21-1 SEA\12500s\12588 Willow Creek Daylight H& and Soils Study\020 H&H ALTS\Report\21-1-12588-020_Tables_ Figures 7-18.xlsx <Node 6 Low Flow>

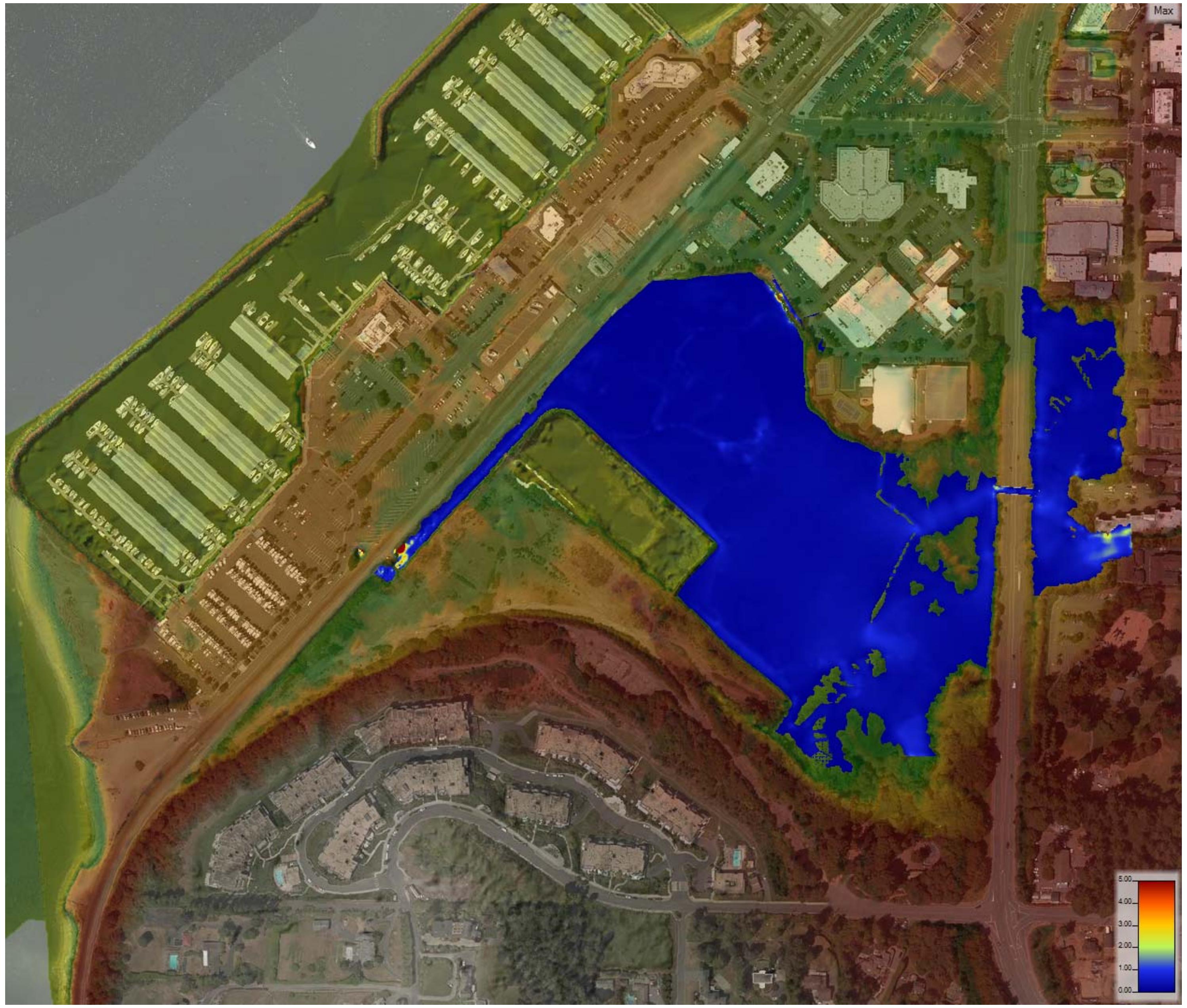


EXISTING CONDITIONS 100 YEAR INUNDATION DEPTH (FT)

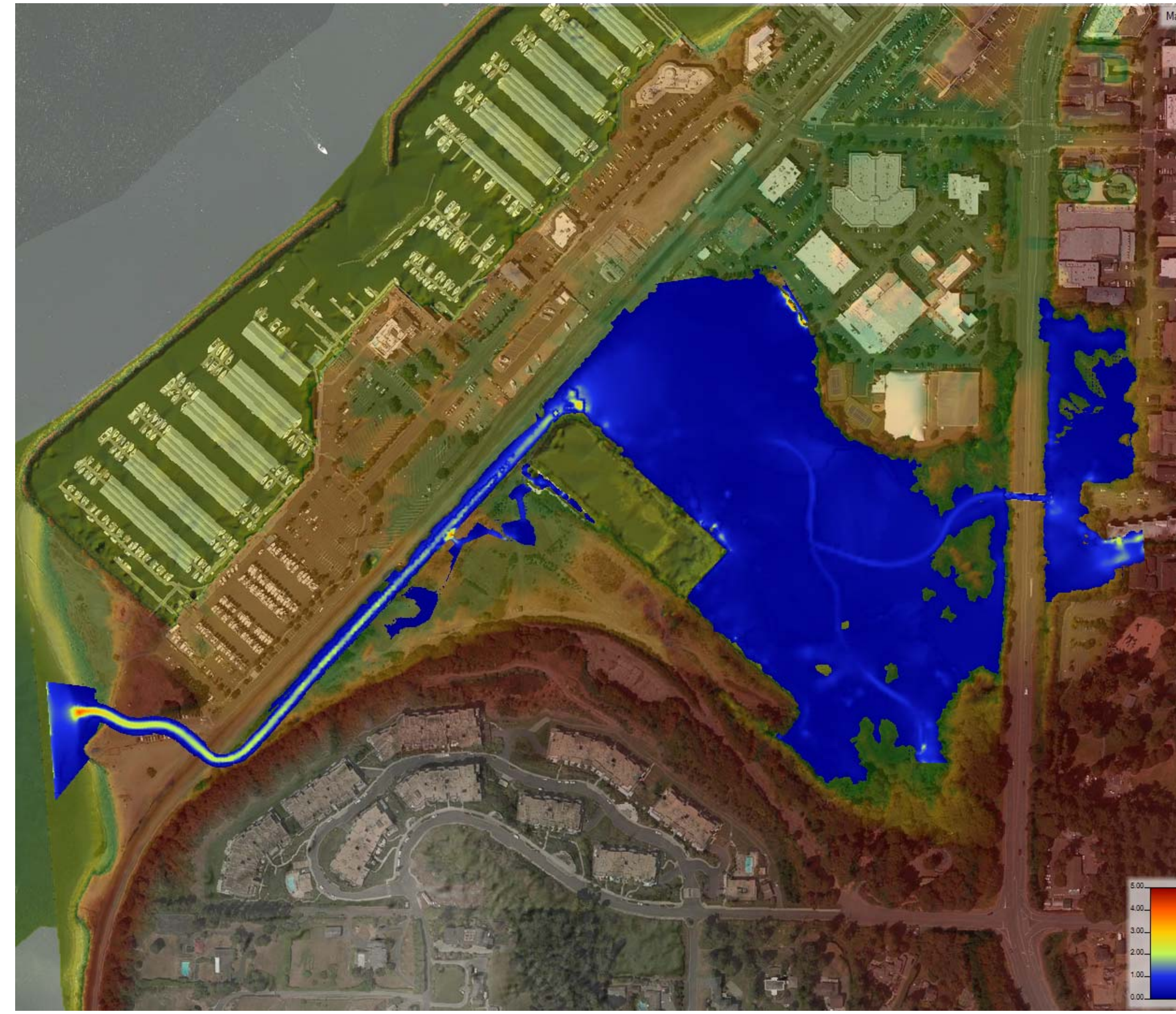


ALTERNATIVE 1 100 YEAR INUNDATION DEPTH (FT)

WILLOW CREEK DAYLIGHT PROJECT EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING	
EXISTING AND ALTERNATIVE 1 100 YEAR MAXIMUM INUNDATION DEPTHS	
November 2017	21-1-12588-020
SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS	FIG. 19

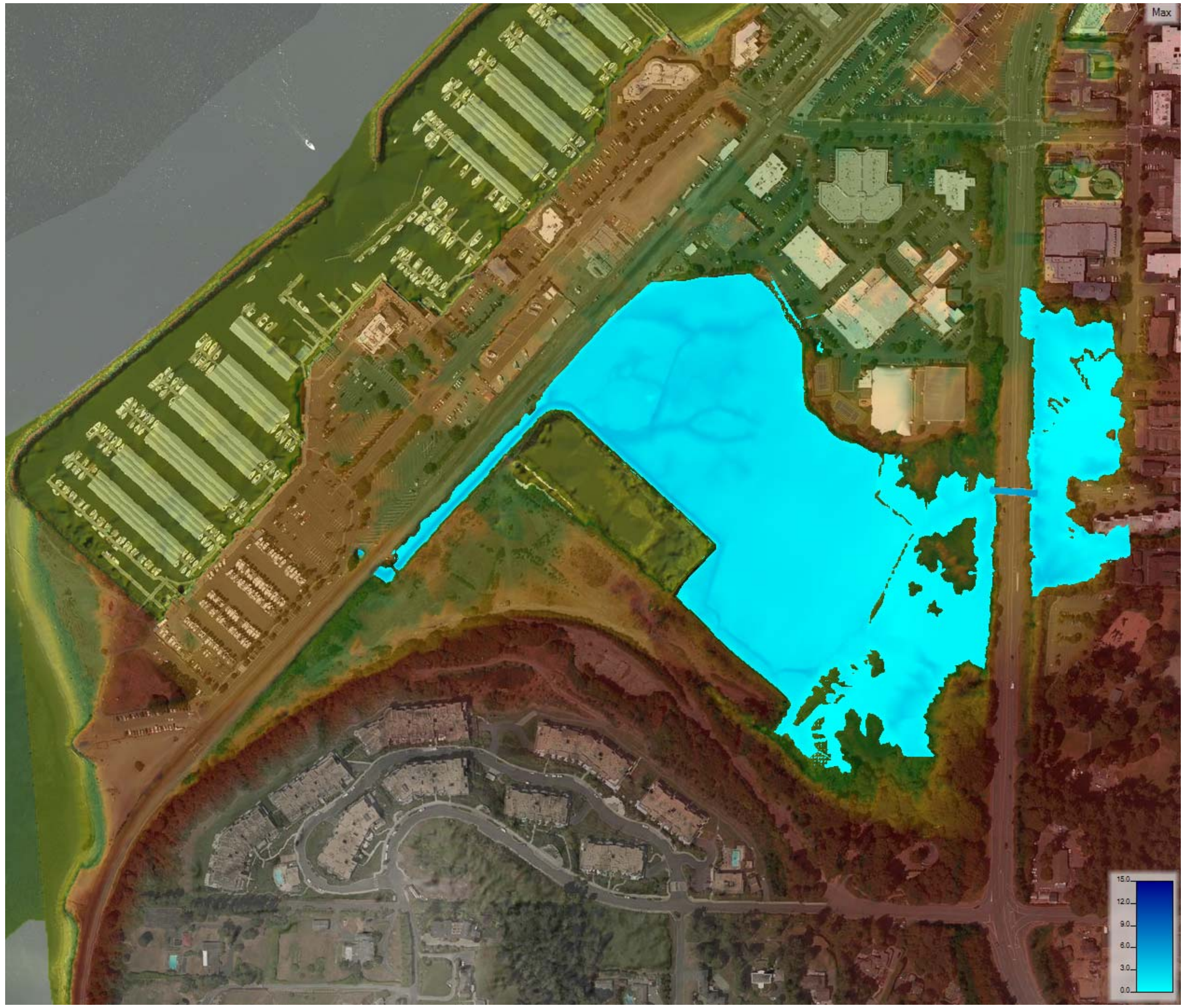


EXISTING CONDITIONS 100 YEAR MAX VELOCITY (FT/S)

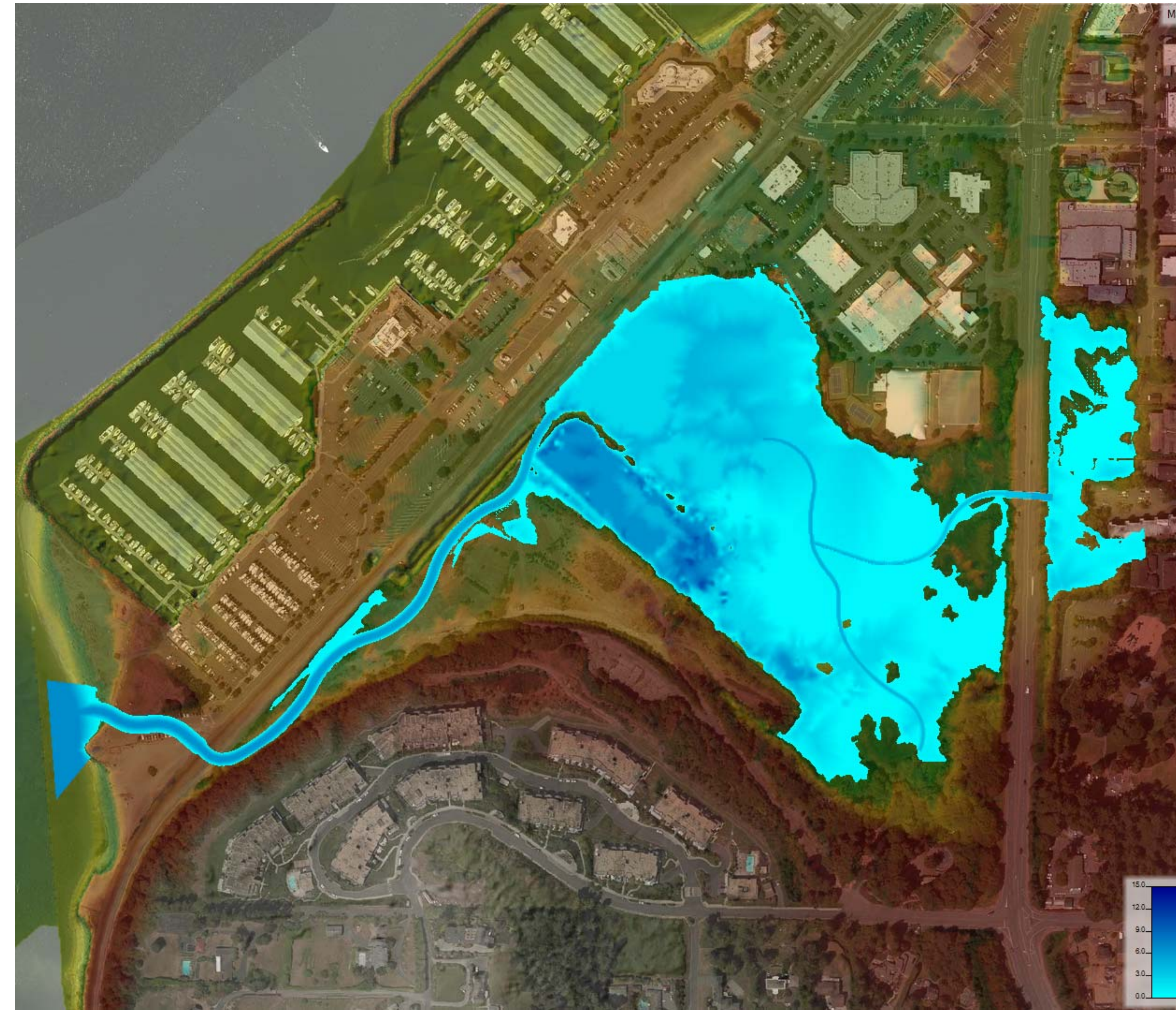


ALTERNATIVE 1 100 MAX VELOCITY (FT/S)

WILLOW CREEK DAYLIGHT PROJECT EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING	
EXISTING AND ALTERNATIVE 1 100 YEAR MAXIMUM VELOCITIES	
November 2017	21-1-12588-020
SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS	FIG. 20

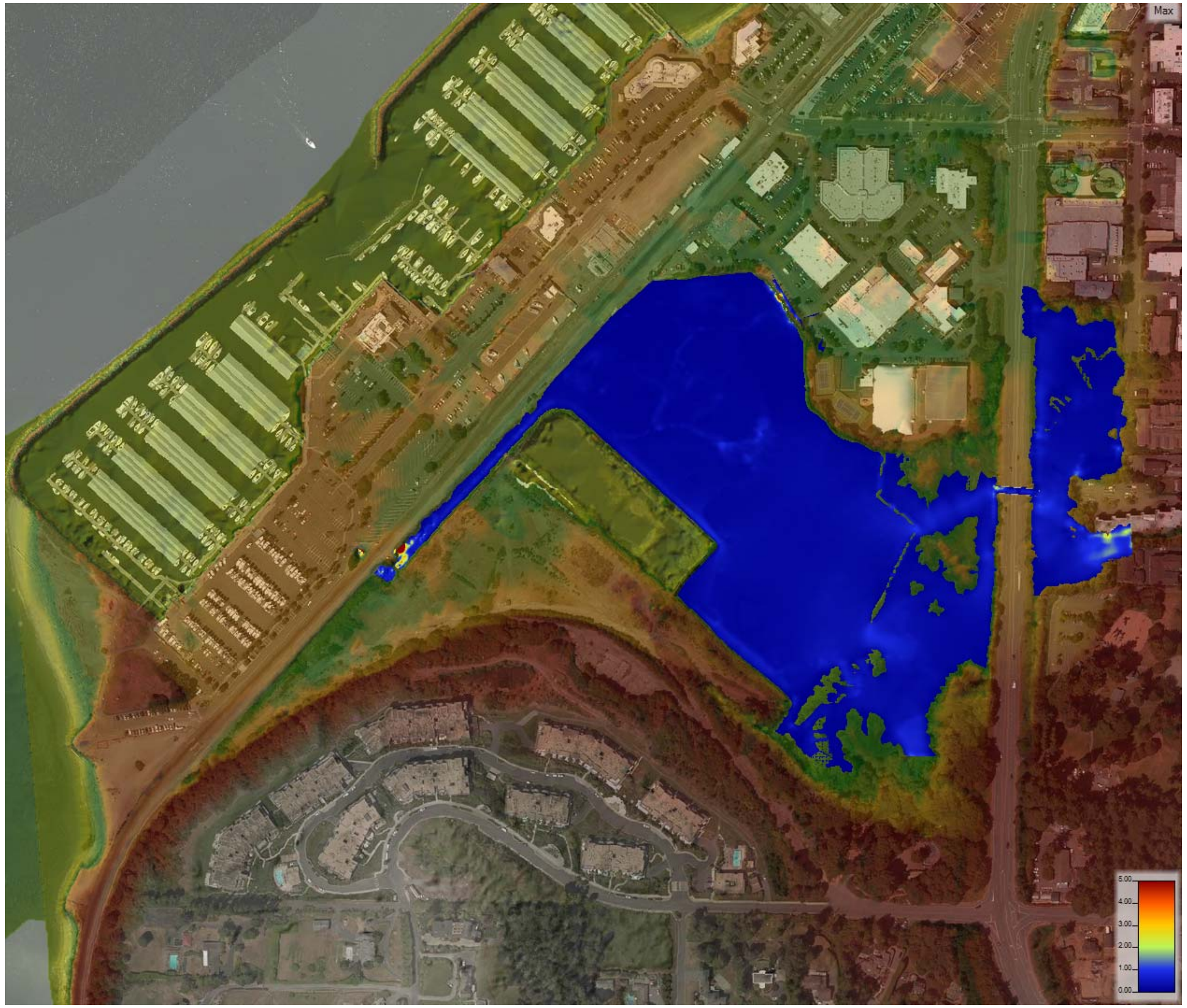


<u>**EXISTING CONDITIONS 100 YEAR INUNDATION DEPTH (FT)**</u>

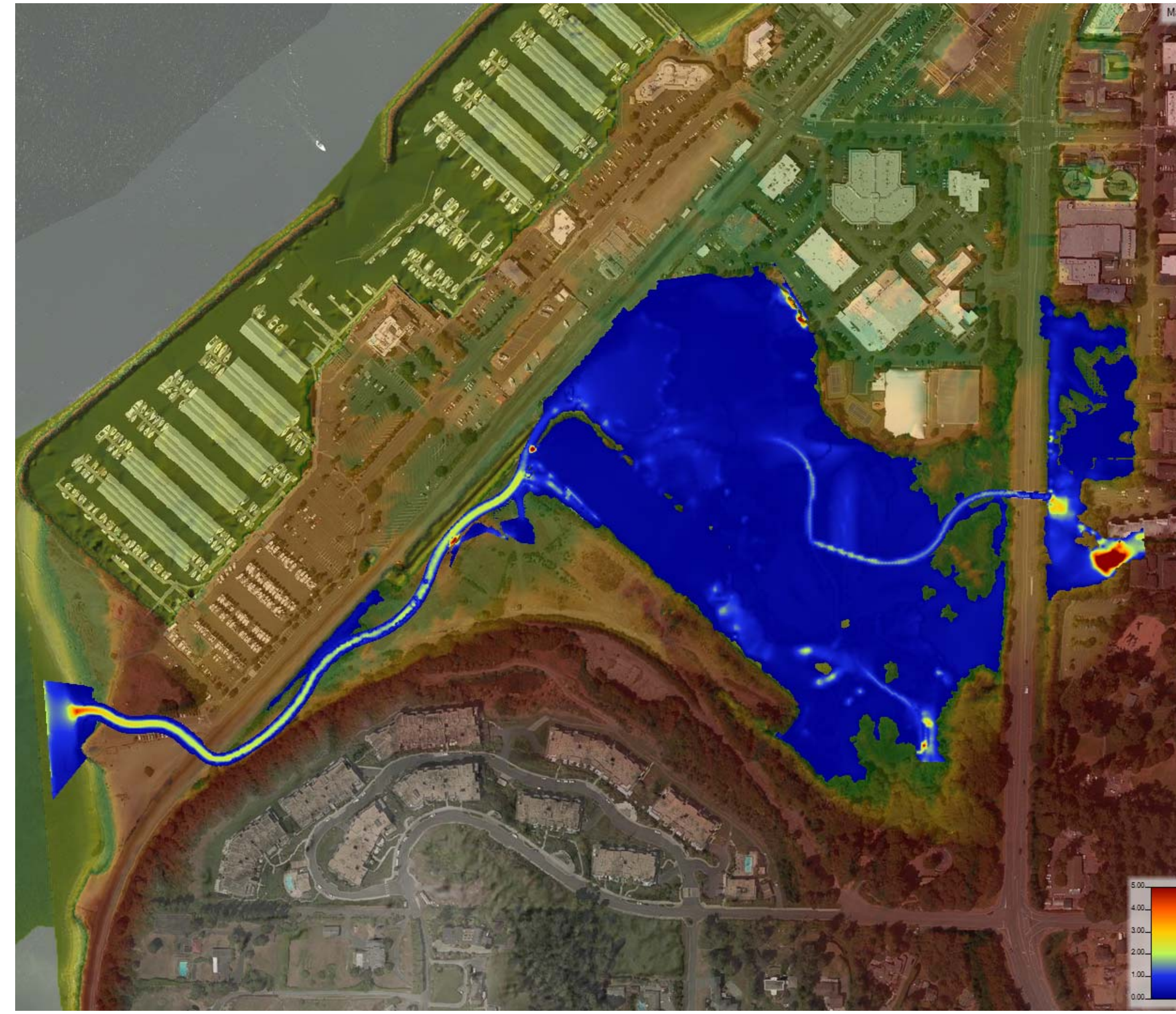


<u>**ALTERNATIVE 4 100 YEAR INUNDATION DEPTH (FT)**</u>

WILLOW CREEK DAYLIGHT PROJECT EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING	
EXISTING AND ALTERNATIVE 4 100 YEAR MAXIMUM INUNDATION DEPTHS	
November 2017	21-1-12588-020
SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS	**FIG. 21**

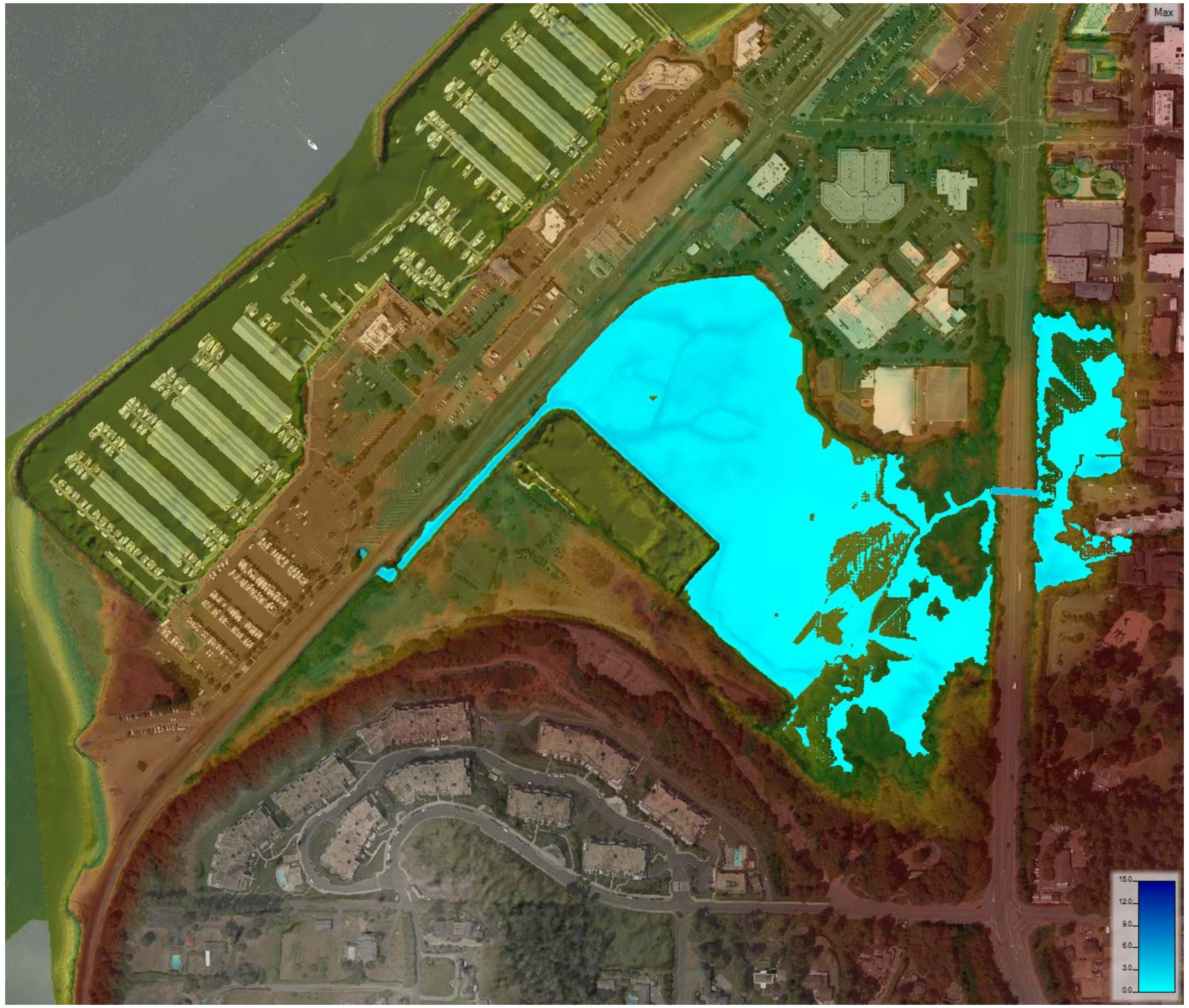


EXISTING CONDITIONS 100 YEAR MAX VELOCITY (FT/S)

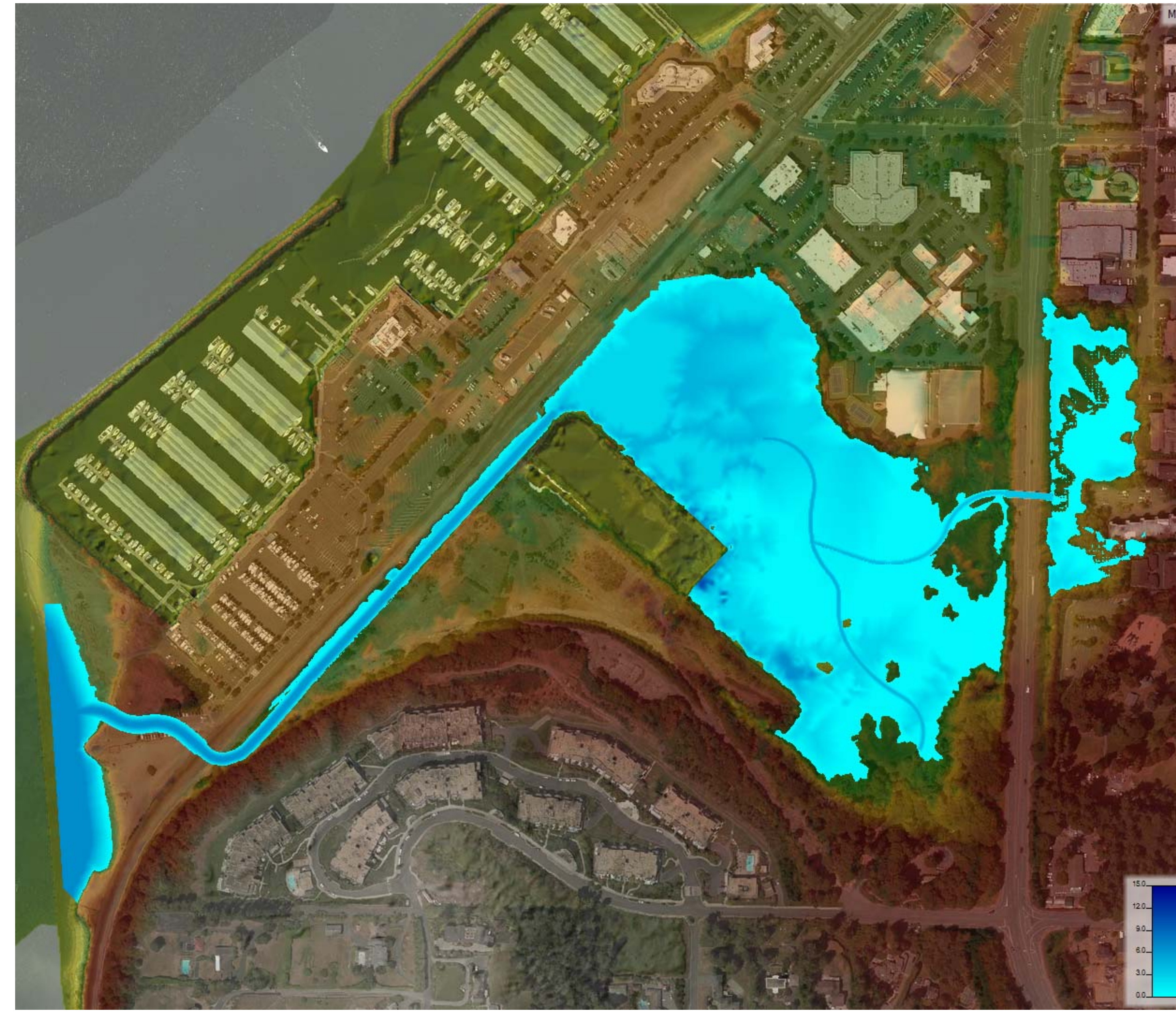


ALTERNATIVE 4 100 MAX VELOCITY (FT/S)

WILLOW CREEK DAYLIGHT PROJECT **EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING**
EXISTING AND ALTERNATIVE 4 **100 YEAR MAXIMUM VELOCITIES**
November 2017 — 21-1-12588-020
SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS — **FIG. 22**

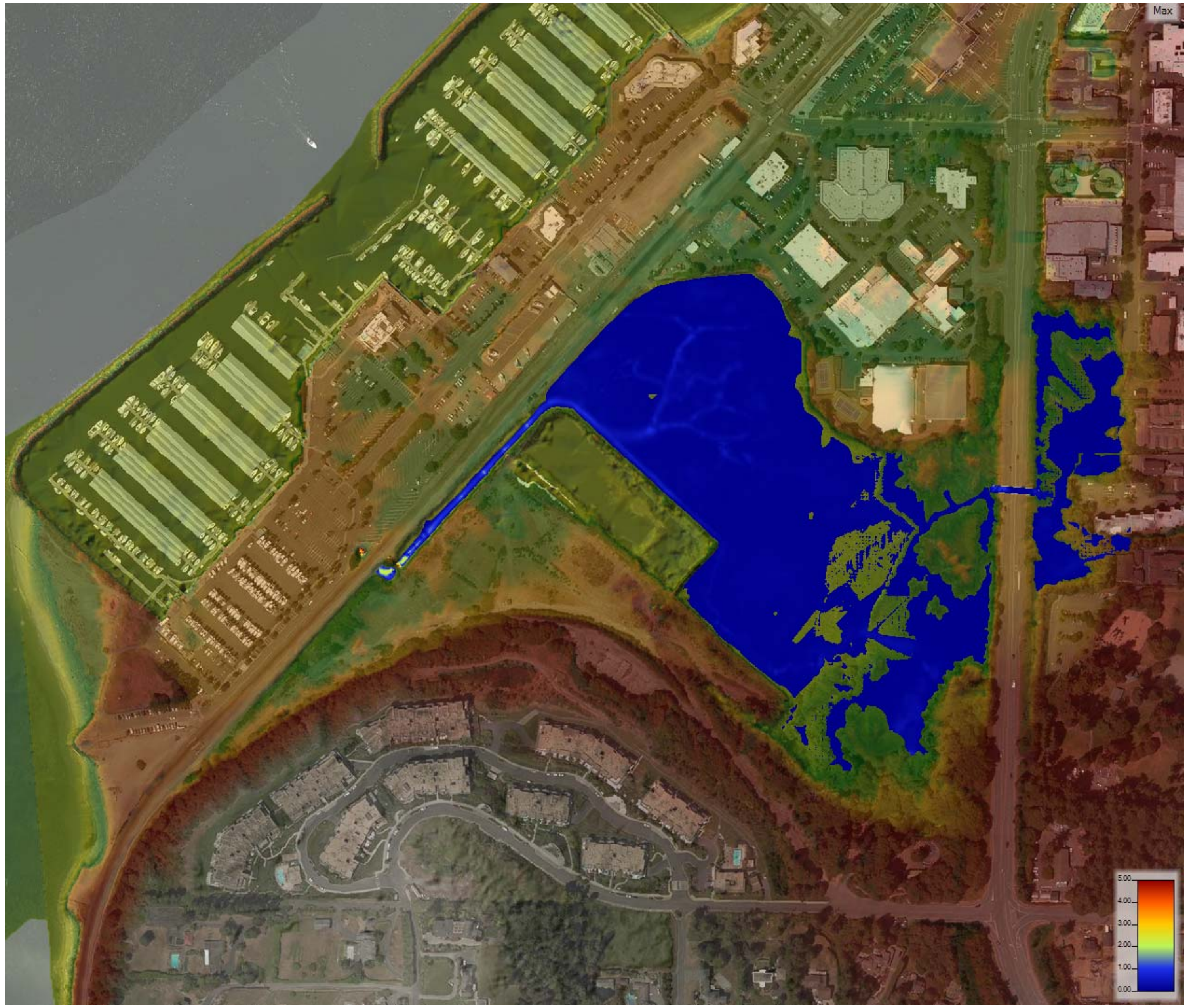


EXISTING CONDITIONS TIDAL INUNDATION DEPTH (FT)



ALTERNATIVE 1 TIDAL INUNDATION DEPTH (FT)

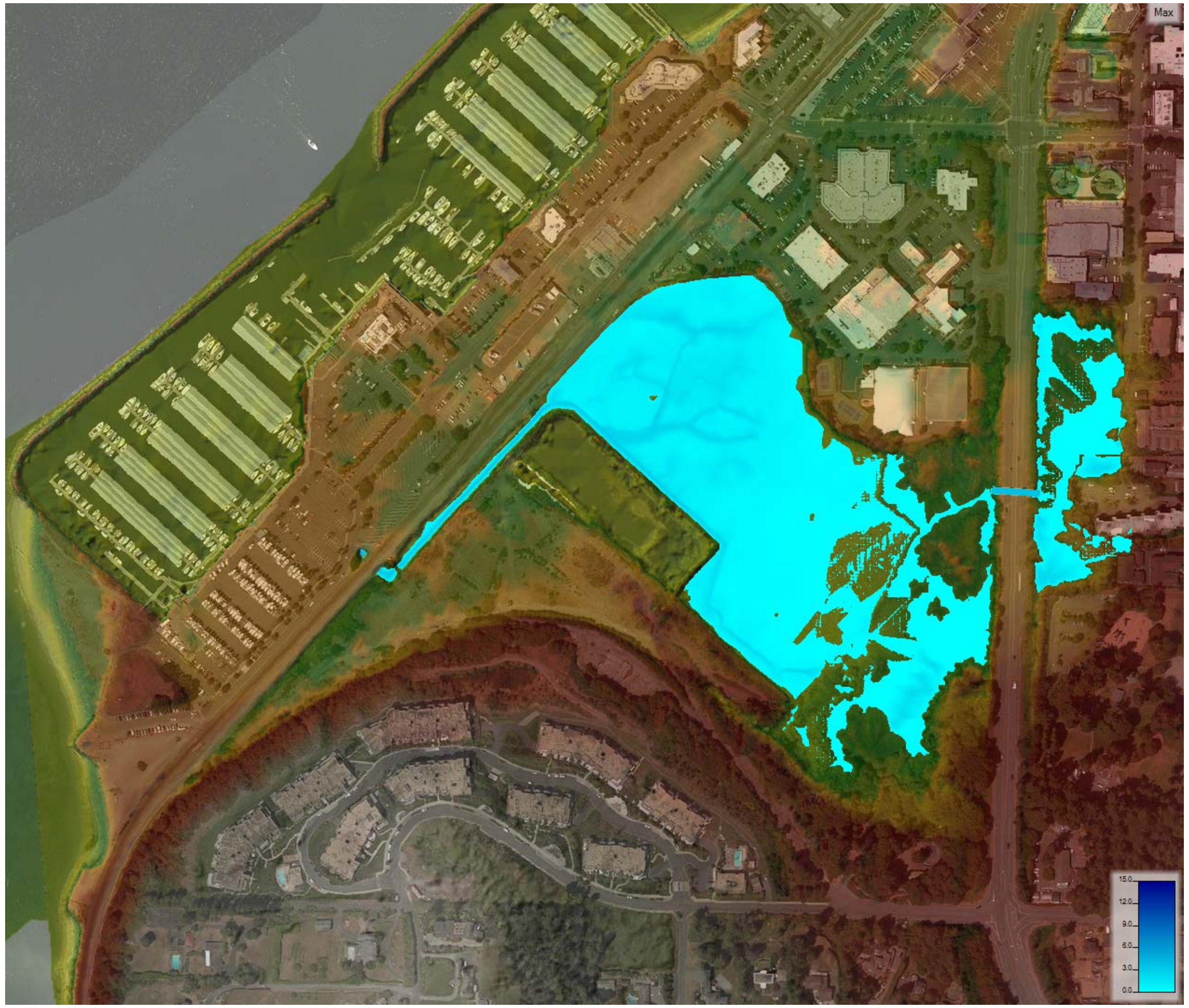
WILLOW CREEK DAYLIGHT PROJECT EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING	
EXISTING AND ALTERNATIVE 1 LATE SPRING FISH HABITAT INUNDATION DEPTHS	
November 2017	21-1-12588-020
SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS	FIG. 23



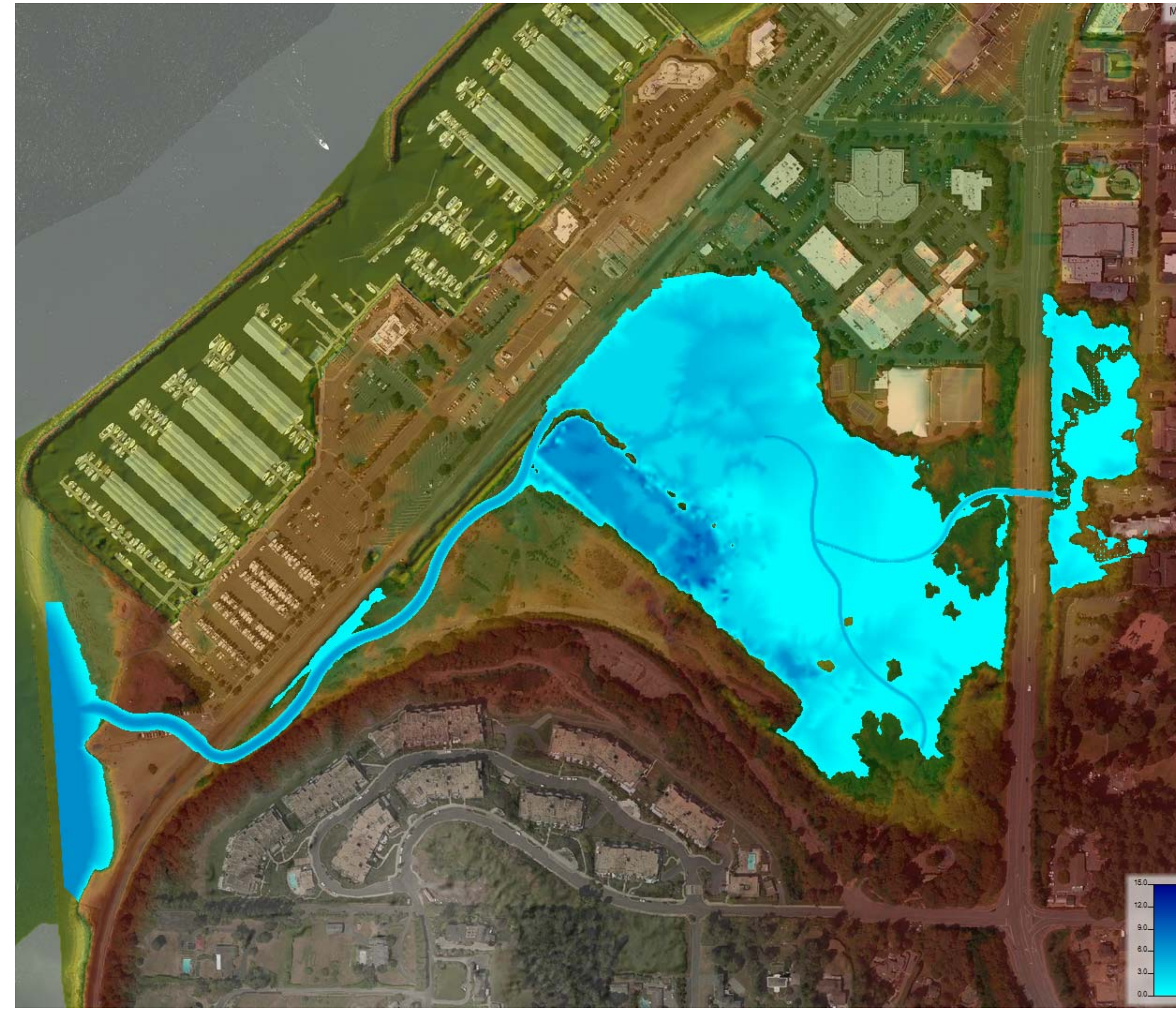
EXISTING CONDITIONS TIDAL MAX VELOCITIES (FT/S)

ALTERNATIVE 1 TIDAL MAX VELOCITIES (FT/S)

WILLOW CREEK DAYLIGHT PROJECT EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING
EXISTING AND ALTERNATIVE 1 LATESPRING FISH HABITAT MAXIMUM VELOCITIES
November 2017 21-1-12588-020
SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS — **FIG. 24**

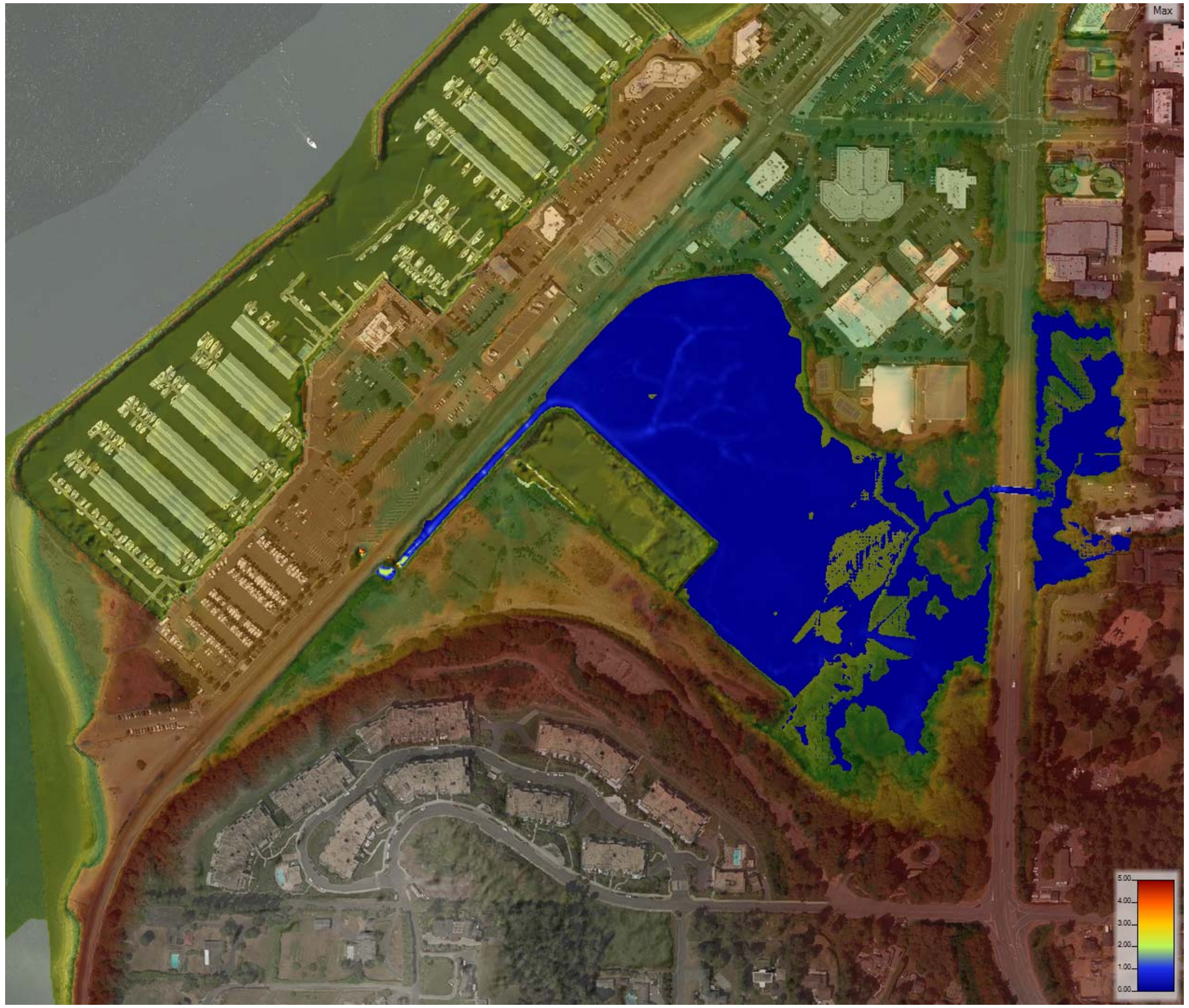


EXISTING CONDITIONS TIDAL INUNDATION DEPTH (FT)

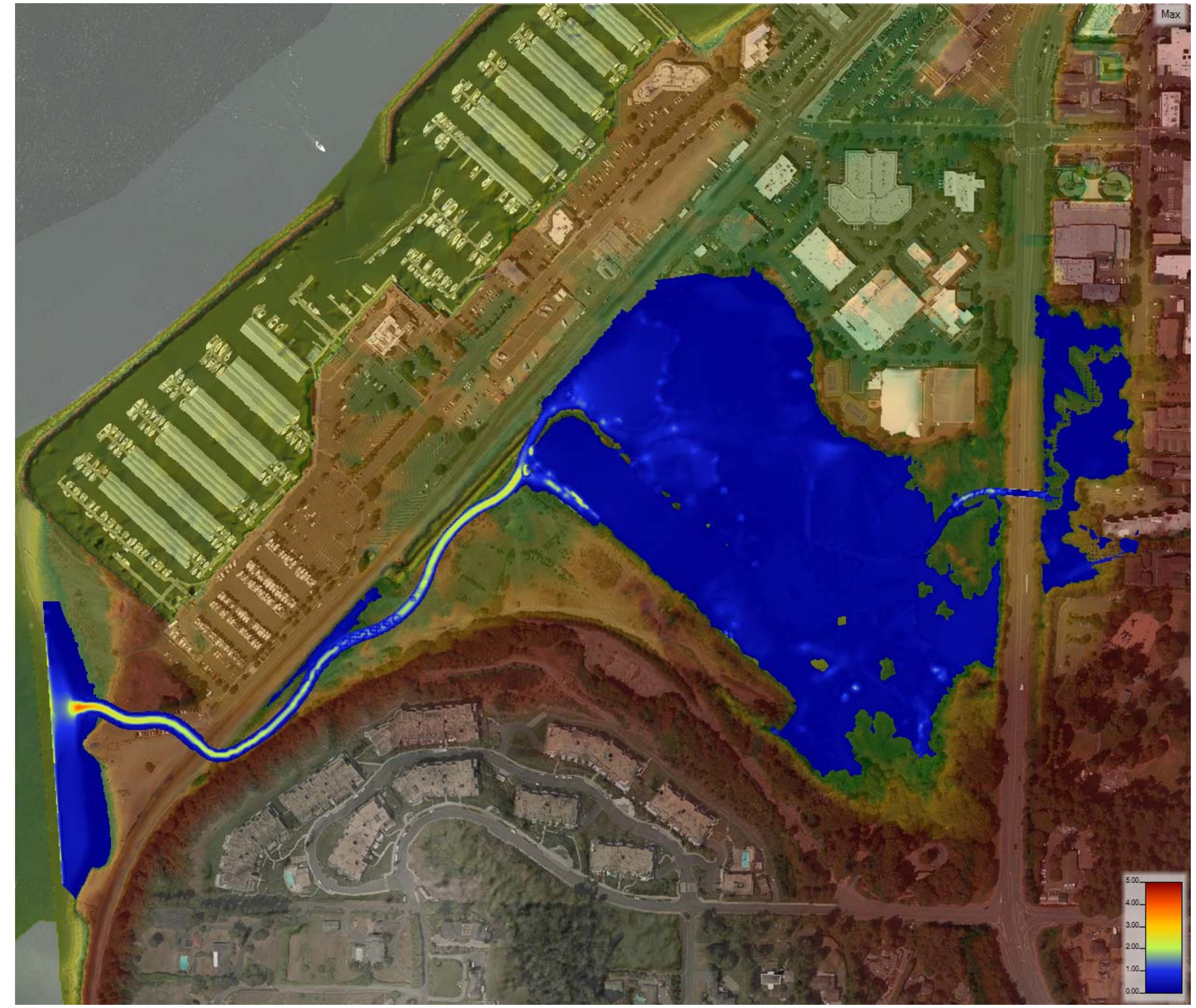


ALTERNATIVE 4 TIDAL INUNDATION DEPTH (FT)

WILLOW CREEK DAYLIGHT PROJECT EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING	
EXISTING AND ALTERNATIVE 4 LATE SPRING FISH HABITAT INUNDATION DEPTHS	
November 2017	21-1-12588-020
SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS	FIG. 25



EXISTING CONDITIONS TIDAL MAX VELOCITIES (FT/S)



ALTERNATIVE 4 TIDAL MAX VELOCITIES (FT/S)

WILLOW CREEK DAYLIGHT PROJECT EXPANDED MARSH CONCEPT DESIGN AND HYDRAULIC MODELING	
EXISTING AND ALTERNATIVE 4 LATE SPRING FISH HABITAT MAXIMUM VELOCITIES	
November 2017	21-1-12588-020
SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS	FIG. 26

APPENDIX

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

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