To: Jennifer Vanderhoof, King County Water and Land Resources Division

From: Shane Cherry   Christina Merten, PE

Date: November 5, 2015

Re: McSorley Creek Sediment Trend Analysis – DRAFT Technical Memorandum

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INTRODUCTION

Confluence Environmental Company (Confluence) evaluated sediment trends in the McSorley basin using field observations, surveyed channel dimensions, historical aerial photos, and landscape data. The sediment trend analysis informs the initial conceptual design development for the proposed channel modifications at the mouth of McSorley Creek. Understanding and accounting for existing and potential sediment delivery to the relocated channel will ensure that the new channel is designed to receive and route the sediment to the marine environment while maintaining the desired channel form and function.

FIELD OBSERVATIONS

Confluence conducted field reconnaissance on August 11, 2015, to observe and evaluate creek conditions in McSorley Creek and its tributaries in Saltwater State Park. The reconnaissance focused on evaluating channel substrate size, channel geometry, and slope to inform a qualitative assessment of sediment supply and transport trends in the drainage basin. Confluence walked the stream for its entire length within the park (530 feet) from the mouth upstream to the eastern park boundary at 16th Avenue S. Confluence also walked the trail system on the hillsides above the creek and its tributaries to observe landscape conditions within the park and identify potential sediment sources.

Estimated dimensions for the bank full channel changed progressively upstream with decreasing drainage area and increasing slope. Near the mouth of the stream, the unconfined portion of the channel with natural banks had a top width approximately 18 feet with some variations along the channel. Average width decreased progressively upstream to approximately 12 feet near the upstream boundary of the park.

Stream banks were predominantly vegetated by English ivy, shrubs, and trees within the park with a few locations vegetated with grass or other low vegetation at campsites located adjacent to the stream (see Appendix A for photos). The channel contained little woody debris with a few occasional small

accumulations of wood. Channel morphology was most commonly plane bed configuration with few pools. Occasional pools were noted at sharp bends and other places where wood accumulations or large bank vegetation promoted scour to form pools.

The stream bed was composed of gravel and sand with some small cobbles (see Appendix A for photos). The maximum observed sediment diameter in the stream bed was approximately 8-inch cobble. Typical streambed and gravel bar surface composition was dominated by gravel ranging in size from 1 to 4 inches in diameter. In the vicinity of bank armoring, larger angular rock cobbles were observed in the stream bed presumably mobilized from nearby armored banks.

Overall, the stream channel within the park included frequent gravel bars where wider channel width accommodated bar formation. The channel appeared to have a substantial volume of sediment available for transport stored within gravel bars. There appeared to be sufficient channel volume to handle the sediment load in the system and although gravel bars were observed, they were not large enough or frequent enough to impede flow; therefore, the system did not appear to be overwhelmed by the current sediment load. Evidence of bank erosion was localized in a few places that were not otherwise prevented by channel stabilization measures, and there was no indication of system-wide bank erosion or channel migration. Evidence of past channel modification including wooden weirs, bank armoring and channel re-alignment was observed.

DRAINAGE BASIN CONDITIONS

The McSorley Creek drainage basin receives runoff from a mostly developed landscape within incorporated Cities of Des Moines, Federal Way, and Kent, Washington. Based on the USGS StreamStat analysis of McSorley Creek (USGS 2015) the total drainage basin area is 2.96 square miles (Figure 1). King County GIS mapping shows that the headwaters of McSorley Creek originate near South 272nd Street and State Route 509 (Pacific Highway South) in Federal Way. From the headwaters, the stream flows through a forested wetland complex and then in an open channel through a forested ravine approximately 2.25 miles to its mouth. The lower portion of the drainage basin is located within Saltwater State Park, which hosts a campground, day use area, and affiliated access roads, parking lots, trails, and buildings. Potential landscape development within the basin is largely fulfilled, and substantial future changes in land use and associated impervious area are not anticipated.

Prior to park development McSorley Creek would have had the entire valley bottom to move within. This would have allowed for a much larger area sediment deposition and marsh development than what is currently available at the park. Historical aerial photos were reviewed to determine historic sediment input into the system. These same photos were reviewed and summarized in the Coast and Harbor Engineering Analysis of Shoreline Geomorphic Processes report (CHE 2015). Based on this review, a large delta was present in the location of the original creek mouth in 1936, which would indicate a sediment source feeding the system. The creek system was re-routed and further channelized in 1952 and the delta has shifted north with the new outlet of the creek showing that

sediment is still being supplied to the system. The source of the sediment could not be determined based on the extent of the historical aerial photos.

SEDIMENT MOBILITY AND TRANSPORT

Confluence evaluated sediment mobility and transport using channel and sediment characteristics observed in the field along with channel gradient determined based on 2015 topographic survey (see the attached Sheet 1: McSorley Creek Profile). .

Confluence used two sediment transport characteristics to evaluate sediment dynamics in the McSorley Creek channel within the park. The first characteristic is sediment transport competence. The second characteristic is sediment transport capacity. These characteristics were determined for the estimated bank full condition based on field observations made on August 11, 2015. Field depth observations are course (to the nearest 0.5 ft). The flow calculations discussed below are based on these one-time field measurements.

In sediment transport analysis, "competence" is a technical term that describes the ability of a stream to mobilize a particular size of sediment. Sediment transport competence is typically stated as a maximum grain size (e.g., the channel is competent to mobilize all sediment up to 6 inch diameter cobbles). Competence usually varies along the channel with changes in channel geometry, gradient, and flow. When a stream channel traverses a geomorphic transition and becomes flatter or less confined, the competence of the channel is reduced and may result in sediment deposition if the appropriate larger sediment sizes are presently in transport. Sediment transport competence analysis relies on the Shields diagram to identify the critical shear stress associated with particular size sediment (Shields 1936, Vanoni 1975, Yalin 1977).

Sediment transport capacity describes the rate of sediment transport usually as a volume or mass of sediment per unit time (e.g., tons per year). Sediment transport capacity is determined by the hydraulic characteristics of the channel and the nature of the sediment supplied by and transported by the stream system. There are multiple empirically derived sediment transport equations each with its limitations and optimal application. All sediment transport formulas and predictions include uncertainty. This uncertainty is due to the highly variable nature of sediment supply processes and basin hydrology. In addition, a system's sediment transport capacity is different from the actual sediment supply most of the time. Much of the natural variation in sediment loading results in variations in sediment delivery and stream flow, which are unpredictable. The Meyer-Peter and Muller formula was selected for the present analysis based on its ability to represent sediment transport including gravel and sand mixtures.

$$q_{S*} = 8(\tau_* - \tau_{C*})^{3/2}$$

Where:

q_{S*} = dimensionless sediment transport rate,

τ^* = dimensionless shear stress

τ_c^* = dimensionless critical shear stress

Sediment transport calculation results are summarized in Table 1. Competence decreases slightly from approximately 8 inch diameter cobbles in the steeper reaches upstream to approximately 5 inch diameter cobbles in the relatively flatter reaches downstream near the mouth. For all reaches, the bank full condition has sufficient energy to mobilize the gravel and small cobble material observed composing the streambed (typical size range 1 to 4 inch diameter gravel and small cobbles). Bed load sediment discharge for the bank full flow condition was estimated at about 0.01 to 0.88 tons per hour. This result is the steady-state transport capacity of the channel as determined using the Meyer-Peter and Muller formula. As discussed previously there are uncertainties associated with this range of sediment delivery rate. Margin of error for these types of models can be anywhere from a factor of two to an order of magnitude. Actual transport is highly variable and typically less than the channel's total capacity in situations where the supply of mobile sediment to the drainage network is limited or flows are reduced. Field observations indicated substantial sediment is available in gravel bars deposited within the stream bed suggesting that this estimate is a realistic representation of anticipated load during a bank full flow event. The loading is also assumed to be less than the full capacity for this system due to the armoring that exists along the lower reaches within the park.

Table 1: Summary of Sediment Transport Calculations

Station Range (ft upstream of mouth)	Slope	Width (ft)	Depth (ft)	Shear Stress (lb/ft^2)	Mobile Sediment Diam. (in)	Estimated Flow (cfs)	Qs (ton/hr)
0 - 126	0.9%	18	1.5	0.84	1.64	143	0.03
126-160	2.9%	18	1.5	2.71	5.27	256	0.88
160-239	1.3%	18	1.5	1.22	2.36	172	0.13
239-275	2.8%	18	1.5	2.62	5.09	252	0.82
275-320	2.2%	18	1.5	2.06	4.00	223	0.50
320-445	0.8%	18	1.5	0.75	1.45	135	0.01
445-480	2.9%	18	1.5	2.71	5.27	256	0.88
480-530	1.0%	18	1.5	0.94	1.82	151	0.05
530-1485	2.8%	18	1.5	2.62	5.09	252	0.82

The sediment transport analysis focused on bed load transport of gravel and small cobbles. Similar Puget Sound Lowland streams discharging to Puget Sound and Lake Washington through ravines can deliver suspended sediment (sand and silt) at a rate as much as 4 times the bed load transport rate depending on availability of fine sediment sources. Studies within the Taylor Creek system, which is

similar in nature to the McSorley Creek, support this estimate (Perkins 2007). Fine sediments were not explicitly evaluated in this analysis because the channel slope and dimensions ensure that the channel has more than enough capacity to transport material finer than small gravel out of the stream channel. Based on field observations the lower reaches are able to transport the finer material during low tides due to confinement of the channel.

Review of stream gage information shows that a USGS stream gage existed on McSorley creek from 1986 to 1988. Measured daily flows during this time period ranged from 0.16 cfs to 65 cfs. USGS StreamStats analysis of the McSorley system estimates that flows would be 60.7 cfs for the 2 year peak and 108 cfs for the 10 year peak (see Appendix B). These estimates are based on only a single year of record and with an urban drainage basin are likely underestimating the flow in the system.

The sediment transport analysis did not evaluate sediment transport conditions at extreme flow events greater than the observed bank full flow condition, which typically coincides with a recurrence interval of 1 to 5 years. Sediment delivery would presumably be greater for larger flow events in a way that is proportional to flow depth and the associated increase in bed shear stress. Additional gaging or field measurements to confirm bank full width and depth used above to calculate flows compared to those calculated using StreamStats are recommended prior to the 90% design effort for this project. In lieu of collecting additional measurements a search of data on similar stream systems in the Puget Sound region with longer gage record could be conducted. This analog system information could then be used to better estimate the hydrology in the McSorley Creek system.

SEDIMENT DELIVERY RATE BASED ON SHORELINE PROCESSES

Coast and Harbor Engineering analyzed the shoreline geomorphic processes at work for the site (CHE 2015). As part of this analysis, they estimate that the long-term sediment transport will be northward, but that it may vary annually based on storm and wave activity. The largest amount of sediment delivery into the shoreline area would be during or shortly after a large storm event due to increased flow in the system and the potential for landslides contributing sediment. These factors should be considered during the design.

The natural analog for the McSorley system is an estuary system that transitions from freshwater wetland to high marsh to delta over a larger area than what is currently available to the creek. The high marsh habitat is most constrained when it is pinched between a high energy wave zone and a high delivery rate of coarse sediment within a narrow valley. For McSorley Creek we have a relatively wide valley, but it is effectively narrowed by the constraints of the park. With the high energy wave zone and gravel/sand sediment delivery that exist here we do not believe this site would naturally produce an extensive high marsh zone except when the wide valley mouth is available.

IMPLICATIONS FOR STREAM CHANNEL DESIGN

The sediment transport analysis provides useful insights about the delivery and transport of sediment to and through the future reconfigured McSorley Creek channel. At its current slope and shape, the channel has sufficient energy to mobilize and transport sand, gravel, and small cobbles typical of the stream bed all the way to the mouth of the creek and the interface with salt water. This was confirmed in the field based on visual observations. The altered condition of the watershed and shoreline have likely changed the streamflow and sediment regime compared to historic conditions, and the existing channel in the transition zone is armored, straightened, and constrained by surrounding park infrastructure.

The habitat restoration concept for the lower portion of the creek would establish a wetland/marsh typical of a small estuary within the transition zone between the stream valley and the delta, where waves and currents drive sediment transport. The fate of sediment delivered from upstream is an essential consideration in selecting a viable restoration concept and developing a design that will restore natural processes. Three generalized approaches to sediment may be considered in developing the restoration concept and design:

1. Account for and provide adequate capacity for long-term sediment deposition within the footprint of the habitat restoration area.

2. Convey sediment through or around the marsh in a channel into the intertidal zone where waves and currents can distribute and deposit material delivered from upstream.

3. Trap and remove sediment from the stream system if it cannot be conveyed through or around the low-gradient wetland/marsh and if sediment deposition would overly impair the desired functions of the restored wetland/marsh.

The approach that would most closely replicate historical naturally functioning conditions at this site would be a transitional wetland/marsh that is large enough to accommodate episodic sediment deposition and channel migration. Aerial photographs show the delta below the water surface extending across the entire width of the stream valley mouth. The restored marsh does not necessarily have to be that large to be functional. For this approach to succeed, the critical factor would be to establish a transitional zone large enough to accommodate episodic deposition at a scale that matches the sediment load. The geomorphic analysis included in this technical memo includes a basic analysis of sediment transport capacity based on channel dimensions and bed composition. The actual sediment load is typically less than the transport capacity and limited by sediment delivery to the channel network by slope processes and bank erosion. If this option is selected, we recommend that design development phase include additional sediment source investigation work to develop a more precise estimate of actual sediment load rather than relying on an estimate based on transport capacity alone. In the absence of additional analysis, the risk of lost habitat function resulting from sediment deposition can be mitigated by including the largest possible area to establish more capacity for sediment accumulation.

The second approach may be preferable in the event that the available area is too limited to accommodate sediment accumulation without impairing habitat objectives. A sustainable wetland/marsh would likely be feasible with a flow-through channel to convey sediment to the intertidal zone during high flow events, but the challenge would be ensuring wetland hydrology during low flow conditions if water from the stream is a significant driver for soil saturation. If this approach is selected, the channel dimensions may be determined by matching the minimum transport capacity and competence observed in the existing channel.

The third approach would entail significant costs associated with ongoing sediment management. As a general rule, such an approach in restoration is a kind of last resort when a natural system is so altered and impaired that continual maintenance is required to support the desired functions. The preliminary geomorphic analysis suggests that such a sediment management approach would not be necessary, but it is mentioned here as an option for consideration.

REFERENCES

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Yalin, M.S. 1977. The Mechanics of Sediment transport, second edition. Pergamon Press, Oxford United Kingdom. xiv + 298pp.

1121.001_McSorley Creek Shoreline Armoring\Reports\Sediment Transport Memo\

FIGURES

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CONFLUENCE
ENVIRONMENTAL COMPANY

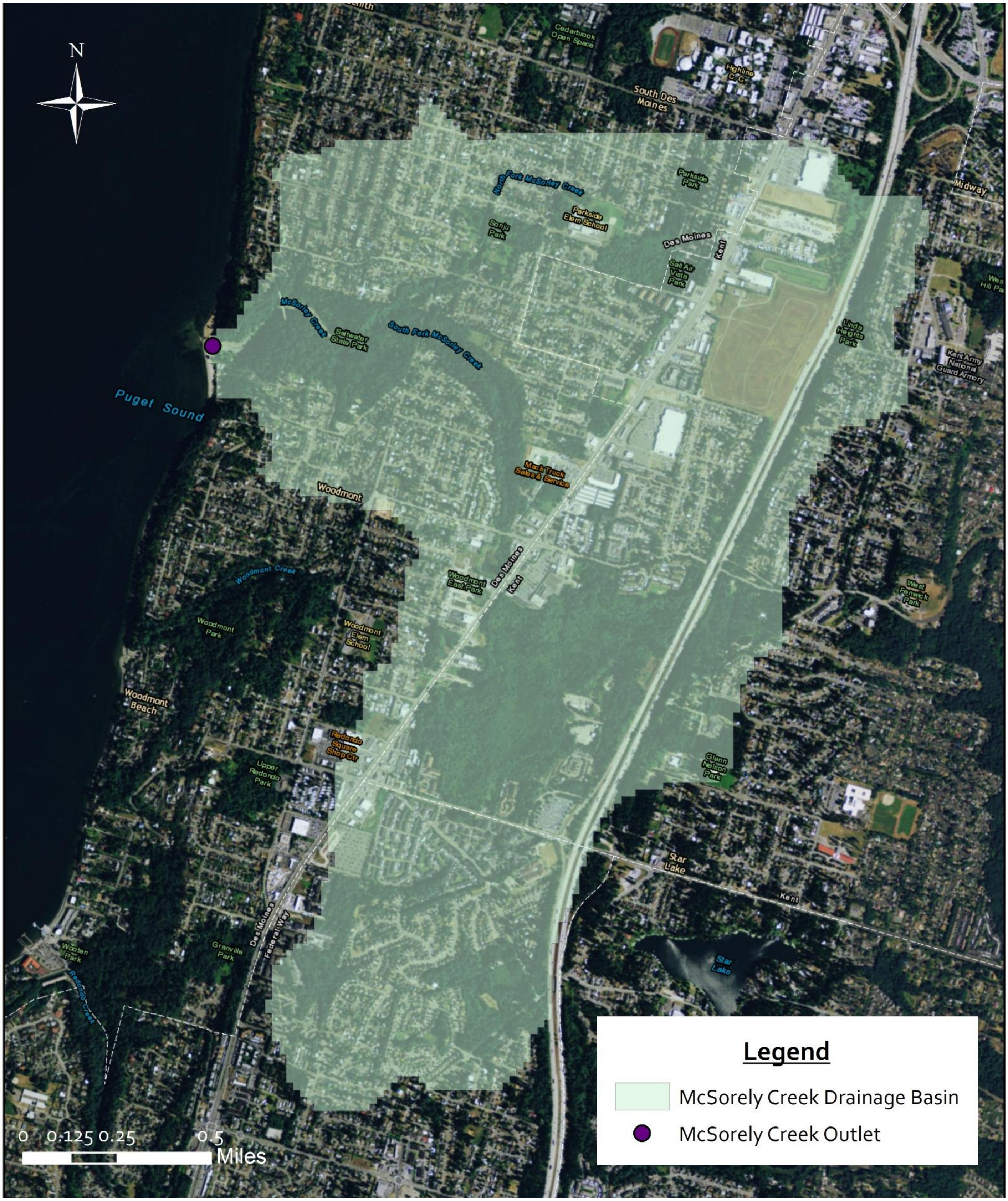


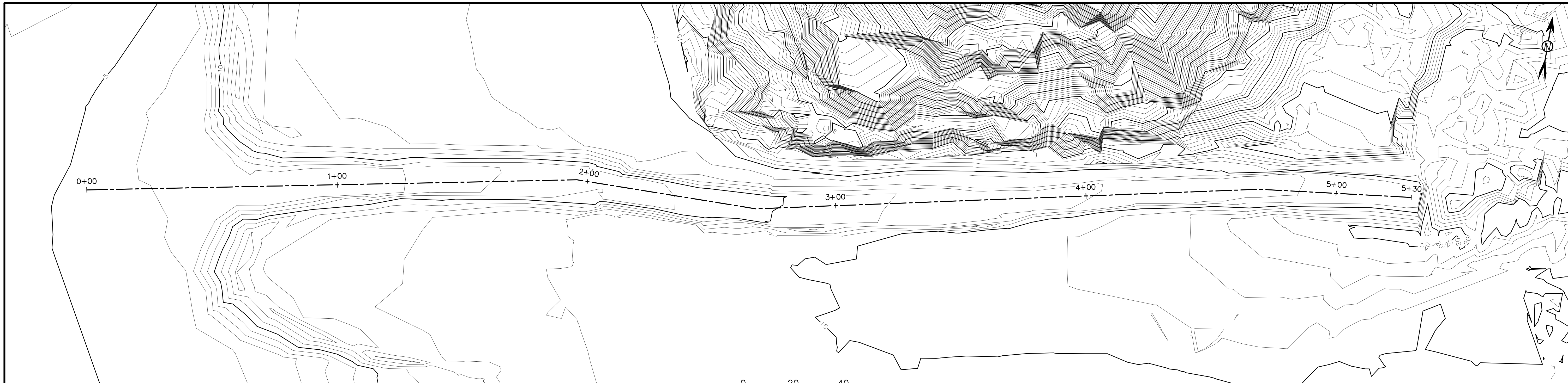
FIGURE 1

McSorely Creek Drainage Basin

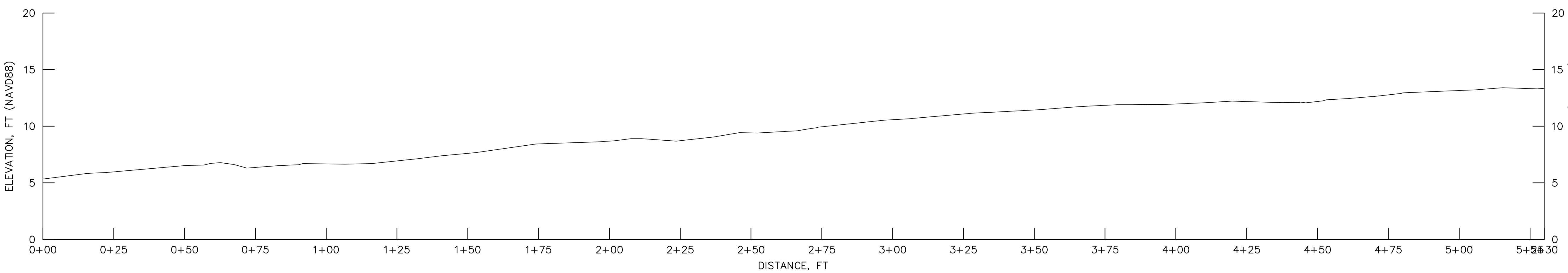
MCSORELY CREEK SHORELINE ARMORING

Des Moines, WA
for King County DNRP

Prepared on:10/15/2015
Prepared by: Christina Merten
Map/Data Source: ESRI, USGS StreamStats Version 3



0 20 40
SCALE IN FEET



HORIZ. 0 20 40
VERT. 0 5 10
SCALE IN FEET

DRAFT

NOTE: ELEVATION DATA SOURCE IS FROM PROJECT BASEMAP
PROVIDED BY CONFLUENCE (10-8-2015)

DESIGNED BY				
ENTERED BY				
CHECKED BY				JOB NUMBER
PROJECT ENGINEER				351681
PROJECT MANAGER				CONTRACT NO.
	DATE	REVISION	BY	

SCALE
HORIZ.: AS NOTED
VERT.: AS NOTED

VERIFY SCALE
BAR IS ONE INCH ON 22x36 DRAWINGS AND HALF INCH ON 11x17 DRAWINGS, IF NOT, ADJUST SCALES ACCORDINGLY
0 1"

COAST & HARBOR ENGINEERING
A Division of Hatch Mott MacDonald
110 JAMES ST, STE 101 EDMONDS, WA 98020
PH 425-778-2542 • FAX 425-778-6883

McSORLEY CREEK POCKET ESTUARY RESTORATION PROJECT AT SALTWATER STATE PARK

McSORLEY CREEK PROFILE

REFERENCE SHEET NUMBER

SHEET 1 OF 1 SHEETS

FILE: Z:\351681 McSorely Creek SP\7 - Design\Working\351681-McSorely Creek rev12 Base.dwg PLOT DATE: 2015-10-14

Appendix A
Photos

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APPENDIX A – PHOTOS

Photo 1 — McSorley Creek stream and banks within the park at campsite.

Photo 2 — McSorley Creek typical stream bank within park.

Photo 3 — McSorley Creek streambed.

Photo 4 — McSorley Creek streambed material.

Appendix B
USGS
StreamStats

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StreamStats Version 3 Beta

Flow Statistics Ungaged Site Report

Date: Thurs Oct 15, 2015 3:26:45 PM GMT-7
Site Location: Washington
NAD 1983 Latitude: 47.3726 (47 22 21)
NAD 1983 Longitude: -122.3242 (-122 19 27)
Drainage Area: 2.96 mi2

Peak-Flow Basin Characteristics			
100% Region 2 (2.96 mi2)			
Parameter	**Value**	**Regression Equation Valid Range**	
		Min	**Max**
Drainage Area (square miles)	2.96	0.08	3020
Mean Annual Precipitation (inches)	39.8	23	170

Peak-Flow Statistics						
Statistic	**Value**	**Unit**	**Prediction Error (percent)**	**Equivalent years of record**	**90-Percent Prediction Interval**	
					Min	**Max**
PK2	60.7	cfs	56	1		
PK10	108	cfs	53	1		
PK25	132	cfs	53	2		
PK50	154	cfs	53	2		
PK100	173	cfs	54	3		
PK500	225	cfs				

http://pubs.er.usgs.gov/usgspubs/wri/wri974277 (http://pubs.er.usgs.gov/usgspubs/wri/wri974277)
Sumioka_ S.S._ Kresch_ D.L._ and Kasnick_ K.D._ 1998_ Magnitude and Frequency of Floods in Washington: U.S. Geological Survey Water-Resources Investigations Report 97-4277_ 91 p.