CENWS-OD-TS-DMMO

MEMORANDUM FOR: RECORD January 30, 2012

SUBJECT: DMMP SUITABILITY DETERMINATION FOR PROPOSED MAINTENANCE DREDGED MATERIAL FROM THE SNOHOMISH RIVER, EVERETT, SNOHOMISH COUNTY, EVERETT (CENWS-OD-TS-NS-35, DATED JULY 20, 2011) FOR UNCONFINED OPEN-WATER DISPOSAL AT THE PORT GARDNER NONDISPERSIVE SITE OR AT AN APPROVED BENEFICIAL USE OR UPLAND SITE.

1. Introduction. This memorandum reflects the consensus determination of the Dredged Material Management Program (DMMP) agencies (U.S. Army Corps of Engineers, Washington Departments of Ecology and Natural Resources, and the Environmental Protection Agency) regarding the suitability of approximately 651,571 cubic yards (cy) of dredged material from the Snohomish River federal navigation channel and settling basins for beneficial use or for disposal at the Port Gardner nondispersive open-water site.

2. Project. The Snohomish River project consists of deep and shallow-draft navigation channels and two settling basins to serve Everett Harbor and the Snohomish River (Figure 1). The Corps routinely maintains the lower 6.5 miles of the river channel and settling basins with dredging to authorized depths and placement of the dredged material at approved upland, beneficial use or open-water disposal sites. The Snohomish River project is characterized by rapid and routine shoaling that requires frequent dredging to maintain safe navigation, and its sediment is thus considered "homogenous" for DMMP purposes.

The Corps proposes to dredge portions of the authorized project between stations 46+00 and 375+00. Details of the dredging project and associated characterizations are detailed in Table 1.

Table 1. Snohomish Navigation Channel project summary

Project rankings: 1. downstream settling basin and approach channel 2. navigation channel and upstream settling basin 3. shoals upstream of upstream settling basin	 1. Low 2. Confirmatory 3. Tier 1 Suitability (no testing required)
Proposed dredging volume	651,571 cubic yards
Draft SAP received	September 22, 2011
SAP approved	September 23, 2011
Sampling dates	September 26-29, 2011
Data report received	December 13, 2011
DAIS Tracking number	EVEOM-1-A-F-312
USACE Public Notice Number	CENWS-OD-TS-NS-35
Recency Determination (5-7 years)	September 2016-2018

3. Background. The Everett Harbor and Snohomish River Project and maintenance dredging by the Department of the Army was adopted June 25, 1910 and modified by subsequent acts. The project was last fully characterized in 2003 (downstream) and 2004 (upstream) (DMMP 2004a; DMMP 2004b). There were no DMMP screening level exceedances in either full characterization and all material was found

suitable for open-water disposal. In 2010 a supplemental dioxin characterization was completed due to increasing concerns about dioxin in the region (DMMP 2010). Dioxin levels were low throughout the project with toxicity equivalents (TEQs, with undetects = ½ detection limit) ranging from 0.16 to 1.06 parts per trillion (pptr), well below concern levels.

4. Project Ranking and Sampling Requirements. The Snohomish navigation channel is divided into five parts, with separate characteristics, per federal authorization. The DMMP modified ranking for this characterization based on past results as summarized in Table 2 and detailed below.

Table 2. Summary of channel segments, DMMP rank and sampling scheme.

	Location and Station	Authorized Depth + Overdepth (ft)	Est. Dredge Volume (cy)	Min. # of Grab Samples	# of Analyses	Comments
DMMU 1	Shallow Nav. Channel 46+00 to 55+00	8 + 2	12,484	0	0	Tier 1 suitability (no testing required)[1]
DMMU 2	Upstream Settling Basin 67+88 to 75+10	30 + 2	400,504	5	1	Confirmatory sampling[2]
DMMU 3	US Settling Basin 75+10 to 78+90	30 + 2		5	1	
DMMU 4	Upstream Settling Basin 78+90 to 82+95	30 + 2		5	1	
DMMU 5	Upstream Settling Basin 82+95 to 88+29	30 + 2		5	1	
DMMU 6	Shallow Nav. Channel 88+00 to 333+50	8 + 2	89,321	4	1	Existing shoals, confirmatory sampling[2]
DMMU 7	Downstream Settling Basin 333+50 to 338+34	20 + 2	149,261	8	1	Settling basin[3]
DMMU 8	Downstream Settling Basin 338+34 to 344+12	20 + 2		8	1	Settling basin[3]
DMMU 9	Downstream Settling Basin, Deep-draft Channel & Transition 344+12 to 375+00	15 + 2		3	1	Downstream end of settling basin, shoal downstream of settling basin[3]
Total characterized volume (cy)			651,571			

Results of previous years' testing have demonstrated consistent patterns of grain size and low levels of contaminants throughout the channel. This information was used to modify the testing requirements for this low ranked area as follows:

1 Material is historically gravel/cobble; DMMP agreed no testing is required for this DMMU.
2 Material is historically clean sandy material with low organic matter content; DMMP agreed to reduce the number of required DMMUs and samples.
3 Testing for the downstream settling basin & nav. channel follows standard DMMP sampling guidance for low ranked, homogeneous sediments.

a) The most upstream shoal in the channel is consistently characterized as gravel and cobble. The DMMP used a Tier 1 evaluation (review of site history and data) to conclude that no additional testing was necessary to determine whether this material is suitable for open water disposal and/or beneficial use.
b) All material in the upstream turning basin and shallow navigation channel between settling basins has consistently been found to be primarily coarse sediments with no history of contamination. A confirmatory level of sampling, designated as approximately one sample per 20,000 cy and one analysis per 100,000 cy, was considered sufficient for characterizing these portions of the project.
c) Though no exceedances have previously been observed in the downstream settling basin, the standard level of testing for a low-ranked area is retained because of the fine-grained and organic nature of the sediments that settle out there. For homogenous sediments in a low-ranked area, DMMP calls for one grab sample for each 8,000 cy and one laboratory analysis for each 60,000 cy.

5. Sampling. Field sampling took place from September 26 – 29, 2012. A pneumatically-powered sediment grab sampler was deployed from a private vessel to collect 43 grab samples. Multiple attempts were required to collect acceptable sediment samples at five locations (SR-2, SR-6, SR-12, SR-13, and SR-21). Each subsequent sample attempt to collect an acceptable grab occurred at a new location within the boundaries of the DMMU. Per observations of the sampling crew, several of the grab samples collected in the downstream settling basin had deposits of fibrous wood and plant material, including dark sulfide-stained plant material consisting of twigs, leaves and fir needles. The deposits were covered by a thin (1 to 3 inches) layer of sandy silt or silty sand sediments

6. Conventional & Chemical Analyses. All analyses were performed by Analytical Resources, Inc. (ARI). The approved analysis plan (AMEC & Innovar 2011) was followed and quality control guidelines specified by the PSEP and DMMP programs were generally met. Sediment conventional results (Table 3) indicated that the nature of the material in different segments of the channel was similar to that found previously, with all samples from the Upstream Settling Basin and Navigation Channel averaging over 95% gravel and sand. The Downstream Settling Basin contained a much higher percentage of fines (from about 32% - 52%) than did the rest of the project, as expected. It also contained levels of sulfides two orders of magnitude higher than the upstream portions of the channel, as well as higher total organic carbon (TOC) and total volatile solids (TVS).

The chemical results indicated that there were no detected or undetected exceedances of screening levels for the standard DMMP chemicals of concern in all upstream DMMUs (Table 4). A single COC, benzyl alcohol, was found at levels above the SL in DMMUs 7, 8, and 9, all from the downstream settling basin. Benzyl alcohol and several other semi-volatiles were analyzed by EPA Method 8270D using both a full scan and a SIM methodology using the same sample extract. The laboratory used the SIM methodology to lower reporting limits on these analytes. The concentrations found in Table 4 reflect the results from the SIM methodology in those cases where it was used. No QA/QC problems appeared to exist in the benzyl alcohol data.

In most cases of exceedances of even a single detected or undetected COC, bioassays are used to determine whether the exceedances cause observable toxicity in benthic organisms. In this case, the DMMP agencies determined that bioassay testing was not necessary and instead used several lines of evidence to determine that all material was suitable for open water disposal. These included:

- Several of the grab samples collected in the downstream settling basin had a subsurface lens of sulfide-stained plant and wood material. The sulfide-stained layer was covered by a thin 1- to 3-inch-thick layer of sandy silt or silty sand. The overall depth of the deposits could not be determined from the grab sampling but the sulfide-stained layer appeared to extend deeper than 20 cm below the sediment surface. In addition, some of the samples without discrete layers of plant material had trace amounts of wood and plant material in discrete pockets or distributed throughout the sample. Plant and woody material are known natural sources of benzyl alcohol.
- Anthropogenic sources of benzyl alcohol include pharmaceuticals, soap, perfume and flavor products. However, anthropogenic sources to the Snohomish River have not changed appreciably since previous characterizations. Also, if the benzyl alcohol was from an anthropogenic source, it would most likely be found along with exceedances, or at least detections, of other compounds. There were very low detections of PAHs in the downstream turning basin but those were orders of magnitude below the SL and consistent with past data.
- The Portland District, USACE also used best professional judgment (BPJ) in a similar circumstance in the Umpqua River basin (Abney 2006). In this case as well, this was an isolated exceedance in an area removed from other sources.

Sayler Data Solutions, Inc. performed a Stage 4 data review of the conventionals, metals, semivolatile organic analytes (SVOAs), pesticides, and PCB data. Only minor QA/QC issues were reported. Data qualifiers assigned by Saylor can be found in the column labeled "Q2" in Table 4. All data were considered acceptable for use.

Table 3. Conventional results for Snohomish 2012.

		US Shoal	Upstream Settling Basin				Nav. Channel	Downstream Settling Basin & Approach Channel		
DMMU		1	2	3	4	5	6	7	8	9
Composite		--	C1	C2	C3	C4	C5	C6	C7	C8
# samples		0	5	5	5	5	4	8	8	3
Volume		12,484	100,000	100,000	100,000	101,504	89,321	60,000	60,000	29,281
Ammonia (mg/kg)		--	0.11 J	0.1 J	0.11 U	0.1 U	1.68	17.4	23.8	20.1
Total Solids (%)		--	86.4	88.8	92.3	89.8	77.9	61.5	55.9	58.9
TOC (%)		--	0.853	0.37	0.345	0.166	0.471	1.17	0.999	0.855
TVS (%)		--	1.53	1.14	0.96	0.97	1.37	3.92	5.96	5.32
Sulfides (mg/kg)		--	1.2 U	1.14 U	1.32	1.13 U	1.44	595	503	609
Grain Size	% Gravel	--	5	5.5	3.8	2.2	0.4	0.2	0.4	0.1 U
	% Sand	--	93.6	92.7	96	96.7	95.6	67.6	55.7	47.3
	% Silt	--	NA	NA	NA	NA	NA	25	33.7	41.8
	% Clay	--	NA	NA	NA	NA	NA	7.2	10.1	10.8
	% Total Fines (Silt + Clay)	--	1.6	1.9	0.3	0.8	4	32.2	43.8	52.6

7. Beneficial Use Analysis. All dredged material was evaluated for beneficial use. Material from the Snohomish River has historically been used for both in-water beneficial use (Jetty Island) and upland disposal and beneficial re-use. All dry weight data was carbon normalized, if necessary, and compared to SMS regulatory guidelines (Table 5). Detected concentrations of benzyl alcohol also exceeded the SMS guidelines in the downstream turning basin but do not cause concern for beneficial reuse, using the lines of evidence cited above for finding the material suitable for open water disposal. Thus this evaluation showed that all material suitable for open water disposal is also suitable for approved, in-water beneficial uses under Washington State Sediment Management Standards and DMMP guidelines. As always, actual beneficial uses must be approved in other applicable permits and/or authorizations.

8. Recommendations for Future Characterization. The DMMP makes the following recommendations based on lessons learned during this characterization. These recommendations apply only to the Snohomish River federal navigation project.

- Adjustments made to the testing required for individual reaches of this project were effective in characterizing the material to be dredged. The same approach should be applied in future testing unless conditions and/or sources within the channel are altered.
- Because the Snohomish is dredged regularly, and is in an area where large amounts of material are deposited over a short time frame, the DMMP program considers material in the navigation channel to fit the definition of "homogenous sediments." In general, a dredge prism made up of homogenous sediment can be well represented with surface (grab) samples. However, material sampled in the downstream settling basin contained distinct layers of sediment and organic material that may not have been well represented with grab samples. It is thus recommended that the material in the downstream settling basin be sampled with vertical cores throughout the depth of the dredge prism. This approach could potentially alter the portion of organic material in the analyzed sample to more adequately reproduce the proportions in the entire dredge prism.

9. Suitability Determination. This memorandum documents the evaluation of the suitability of sediment proposed for dredging from the federal navigation project in the Snohomish River for in-water beneficial use or open-water disposal. The approved sampling and analysis plan was followed and the data gathered were deemed sufficient and acceptable for regulatory decision-making under the DMMP program.

Based on the results of the previously described testing, the DMMP agencies concluded that all 651,571 cubic yards of sediment are suitable for open-water disposal at the Port Gardner non-dispersive site. All material is also suitable, from a chemical and toxicity standpoint, for beneficial use in a marine environment. Upland beneficial use would require consultation with the local health department.

This suitability determination does *not* constitute final agency approval of the project. A final decision will be made after full consideration of agency input, and after an alternatives analysis is done under section 404(b)(1) of the Clean Water Act.

10. References.

Abney 2006. *Umpqua Federal Channel, Winchester Bay and Gardiner Channel Sediment Quality Evaluation Report.* Prepared by Ruth Abney, US Army Corps of Engineers, Portland District. August 2006.

AMEC & Innovar 2011. *Data Report: DMMP Full Characterization for Maintenance Dredging, Snohomish River, Everett, WA.* Prepared by AMEC and Innovar Enivironmental, Inc. for the US Army Corps of Engineers. December 2011.

DMMP 2008. *Dredged Material Evaluation and Disposal Procedures (Users Manual)*. Prepared by the Seattle District Dredged Material Management Office for the Dredged Material Management Program, July 2008.

DMMP 2011. *Marine Sediment Quality Screening Levels: Adopting RSET Marine SLs for Use in DMMP.* A Clarification Paper prepared by Laura Inouye (Ecology) and David Fox (USACE) for the Dredged Material Management Program, June 2011.

Ecology 1995. *Sediment Management Standards – Chapter 173-204 WAC*. Washington State Department of Ecology, December 1995.

12. Agency Signatures.

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Concur:

2/2/12 _____
Date — Lauran Cole Warner - Seattle District Corps of Engineers

2/2/12 _____
Date — Erika Hoffman - Environmental Protection Agency

02/02/12 _____
Date — Laura Inouye, Ph.D. - Washington Department of Ecology

02/02/12 _____
Date — Celia Barton - Washington Department of Natural Resources

Copies furnished:

DMMP signatories
John Pell, CENWS-OD-TS-NV
Graham Anderson, Port of Everett

Table 4. Results of chemical analysis for DY12 Snohomish O&M compared to DMMP guidelines.

CHEMICAL	SL	BT	ML	DMMU 2 (C1)			DMMU 3 (C2)			DMMU 4 (C3)			DMMU 5 (C4)			DMMU 6 (C5)			DMMU 7 (C6)			DMMU 8 (C7)			DMMU 9 (C8)		
					Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2
METALS (mg/kg)																											
Antimony	150	---	200	6	U	UJ	6	U	UJ	5	U	UJ	5	U	UJ	6	U	UJ	8	U	UJ	9	U	UJ	8	U	UJ
Arsenic	57	507.1	700	9			9			8			8			8			14			15			15		
Cadmium	5.1	11.3	14	0.2	U		0.2	U		0.2	U		0.2	U		0.2	U		0.3	U		0.4	U		0.3	U	
Chromium	260	260	---	25			24.2			21.9			23.9			25.1			43.1			48.7			48.9		
Copper	390	1,027	1,300	21			21.9			18			19.7			18.5			38.1			44.8			45.1		
Lead	450	975	1,200	3			3			2			3			3			6			7			7		
Mercury	0.41	1.5	2.3	0.02	U		0.02	U		0.02	U		0.02	U		0.03	U		0.04			0.07			0.08		
Selenium	---	3	---	0.6	U		0.6	U		0.5	U		0.5	U		0.6	U		0.8	U		0.9	U		0.8	U	
Silver	6.1	6.1	8.4	0.4	U		0.4	U		0.3	U		0.3	U		0.4	U		0.5	U		0.5	U		0.5	U	
Zinc	410	2,783	3,800	42			43			37			42			42			61			68			66		
ORGANICS (µg/kg)																											
PAHs																											
Total LPAH	5,200	---	29,000	14	J		18	U		19	U		20	U		19	U		111	J		179	J		109	J	
Naphthalene	2,100	---	2,400	14	J		18	U		19	U		20	U		19	U		29			70			43		
Acenaphthylene	560	---	1,300	18	U		18	U		19	U		20	U		19	U		19	U		20	U		19	U	
Acenaphthene	500	---	2,000	18	U		18	U		19	U		20	U		19	U		16	J		19	J		10	J	
Fluorene	540	---	3,600	18	U		18	U		19	U		20	U		19	U		14	J		17	J		13	J	
Phenanthrene	1,500	---	21,000	18	U		18	U		19	U		20	U		19	U		52			58			43		
Anthracene	960	---	13,000	18	U		18	U		19	U		20	U		19	U		19	U		15	J		19	U	
2-Methylnaphthalene[1]	670	---	1,900	18	U		18	U		19	U		20	U		19	U		14	J		27			14	J	
Total HPAH	12,000	---	69,000	18	U		18	U		19	U		20	U		19	U		90	J		154	J		110	J	
Fluoranthene	1,700	4,600	30,000	18	U		18	U		19	U		20	U		19	U		35			42			33		
Pyrene	2,600	11,980	16,000	18	U		18	U		19	U		20	U		19	U		30			35			33		
Benz(a)anthracene	1,300	---	5,100	18	U		18	U		19	U		20	U		19	U		19	U		16	J		10	J	
Chrysene	1,400	---	21,000	18	U		18	U		19	U		20	U		19	U		12	J		22			17	J	
Benzofluoranthenes (b, j ,k)	3,200	---	9,900	18	U		18	U		19	U		20	U		19	U		13	J		25			17	J	
Benzo(a)pyrene	1,600	---	3,600	18	U		18	U		19	U		20	U		19	U		19	U		14	J		19	U	
Indeno(1,2,3-c,d)pyrene	600	---	4,400	18	U		18	U		19	U		20	U		19	U		19	U		20	U		19	U	

CHEMICAL	SL	BT	ML	DMMU 2 (C1)			DMMU 3 (C2)			DMMU 4 (C3)			DMMU 5 (C4)			DMMU 6 (C5)			DMMU 7 (C6)			DMMU 8 (C7)			DMMU 9 (C8)		
					Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2
Dibenz(a,h)anthracene	230	---	1,900	4.6	U		4.3	U		4.8	U		5	U		4.7	U		4.7	U		5	U		4.7	U	
Benzo(g,h,i)perylene	670	---	3,200	18	U		18	U		19	U		20	U		19	U		19	U		20	U		19	U	
CHLORINATED HYDROCARBONS																											
1,4-Dichlorobenzene	110	---	120	4.6	U		4.3	U		4.8	U		5	U		4.7	U		4.7	U		5	U		4.7	U	
1,2-Dichlorobenzene	35	---	110	4.6	U		4.3	U		4.8	U		5	U		4.7	U		4.7	U		5	U		4.7	U	
1,2,4-Trichlorobenzene	31	---	64	4.6	U		4.3	U		4.8	U		5	U		4.7	U		4.7	U		5	U		4.7	U	
Hexachlorobenzene (HCB)	22	168	230	4.6	U		4.3	U		4.8	U		5	U		4.7	U		4.7	U		5	U		4.7	U	
PHTHALATES																											
Dimethyl phthalate	71	---	1,400	4.6	U		4.3	U		4.8	U		5	U		4.7	U		4.7	U		5	U		4.7	U	
Diethyl phthalate	200	---	1,200	46	U		45	U		48	U		50	U		47	U		47	U		50	U		47	U	
Di-n-butyl phthalate	1,400	---	5,100	18	U		18	U		19	U		20	U		19	U		19	U		20	U		19	U	
Butyl benzyl phthalate	63	---	970	4.6	U		4.3	U		4.8	U		5	U		4.7	U		26	Y		6.8			4.7		
Bis(2-ethylhexyl) phthalate	1,300	---	8,300	18	J		19	J		24	U		15	J		24	U		32	B		30			31		
Di-n-octyl phthalate	6,200	---	6,200	18	U		18	U		19	U		20	U		19	U		19	U		20	U		19	U	
PHENOLS																											
Phenol	420	---	1,200	18	U		18	U		19	U		20	U		19	U		13	J		20	U		27		
2-Methylphenol	63	---	77	4.6	U		4.3	U		4.8	U		5	U		4.7	U		4.7	U		5	U		4.7	U	
4-Methylphenol	670	---	3,600	37	U		36	U		39	U		40	U		38	U		30	J		160			48		
2,4-Dimethylphenol	29	---	210	4.6	U		4.3	U		4.8	U		5	U		4.7	U		4.7	U		5	U		4.7	U	
Pentachlorophenol	400	504	690	23	U		22	U		24	U		25	U		24	U		24	U		25	U		24	U	
MISCELLANEOUS EXTRACTABLES																											
Benzyl alcohol	57	---	870	4.6	U		4.3	U		4.8	U		5	U		4.7	U		59			200			160		
Benzoic acid	650	---	760	370	U		360	U		390	U		400	U		380	U		380	U		360	J		310	J	
Dibenzofuran	540	---	1,700	18	U		18	U		19	U		20	U		19	U		13	J		18	J		15	J	
Hexachlorobutadiene	11	---	270	4.6	U		4.3	U		4.8	U		5	U		4.7	U		4.7	U		5	U		4.7	U	
N-Nitrosodiphenylamine	28	---	130	4.6	U		4.3	U		4.8	U		5	U		4.7	U		4.7	U		5	U		4.7	U	
PESTICIDES & PCBs																											
4,4'-DDD	16	---	---	0.93	U		0.92	U		0.95	U		0.97	U		0.96	U		0.96	U		0.96	U		0.97	U	
4,4'-DDE	9	---	---	0.93	U		0.92	U		0.95	U		0.97	U		0.96	U		0.96	U		0.96	U		0.97	U	
4,4'-DDT	12	---	---	0.93	U		0.92	U		0.95	U		0.97	U		0.96	U		0.96	U		0.96	U		0.97	U	
sum of 4,4'-DDD, 4,4'-DDE and 4,4'-DDT)	---	50	69	0.93	U		0.92	U		0.95	U		0.97	U		0.96	U		0.96	U		0.96	U		0.97	U	

CHEMICAL	SL	BT	ML	DMMU 2 (C1)			DMMU 3 (C2)			DMMU 4 (C3)			DMMU 5 (C4)			DMMU 6 (C5)			DMMU 7 (C6)			DMMU 8 (C7)			DMMU 9 (C8)		
					Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2		Q1	Q2
Aldrin	9.5	---	---	0.47	U		0.46	U		0.48	U		0.49	U		0.48	U		0.48	U		0.48	U		0.49	U	
Total Chlordane (sum of cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, oxychlordane)	2.8	37	---	1.9	U		1.8	U		1.9	U		2	U		1.9	U		1.9	U		1.9	U		1.9	U	
Dieldrin	1.9	---	---	0.93	U		0.92	U		0.95	U		0.97	U		0.96	U		0.96	U		0.96	U		0.97	U	
Heptachlor	1.5	---	---	0.47	U		0.46	U		0.48	U		0.49	U		0.48	U		0.48	U		0.48	U		0.49	U	
Total PCBs	130	38 (2)	3,100	3.7	U		3.6	U		3.8	U		3.8	U		3.8	U		3.8	U		3.8	U		3.9	U	

Notes:
(1) 2-Methylnaphthalene is not included in the summation for total LPAH.
(2) This value is normalized to total organic carbon, and is expressed in mg/kg carbon.
Shaded values indicate SL exceedances.

Table 5. Results of chemical analysis for DY12 Snohomish O&M compared to SMS guidelines.

CHEMICAL	SQS	CSL	DMMU 2 (C1)		DMMU 3 (C2)		DMMU 4 (C3)		DMMU 5 (C4)		DMMU 6 (C5)		DMMU 7 (C6)		DMMU 8 (C7)		DMMU 9 (C8)	
TOTAL ORGANIC CARBON (decimal)			0.8530		0.3700		0.3450		0.1660		0.4710		1.1700		0.9990		0.8550	
METALS (mg/kg dry)			conc	Q	conc	Q	conc	Q	conc	Q	conc	Q	conc	Q	conc	Q	conc	Q
Arsenic	57	93	9		9		8		8		8		14		15		15	
Cadmium	5.1	6.7	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.3	U	0.4	U	0.3	U
Chromium	260	270	25		24.2		21.9		23.9		25.1		43.1		48.7		48.9	
Copper	390	390	21		21.9		18		19.7		18.5		38.1		44.8		45.1	
Lead	450	530	3		3		2		3		3		6		7		7	
Mercury	0.41	0.59	0.02	U	0.02	U	0.02	U	0.02	U	0.03	U	0.04		0.07		0.08	
Silver	6.1	6.1	0.4	U	0.4	U	0.3	U	0.3	U	0.4	U	0.5	U	0.5	U	0.5	U
Zinc	410	960	42		43		37		42		42		61		68		66	
LPAH (mg/kg OC)																		
2-Methylnaphthalene	38	64	0.02	U	0.05	U	0.06	U	0.12	U	0.04	U	0.01	J	0.03		0.02	J
Acenaphthene	16	57	0.02	U	0.05	U	0.06	U	0.12	U	0.04	U	0.01	J	0.02	J	0.01	J
Acenaphthylene	66	66	0.02	U	0.05	U	0.06	U	0.12	U	0.04	U	0.02	U	0.02	U	0.02	U
Anthracene	220	1200	0.02	U	0.05	U	0.06	U	0.12	U	0.04	U	0.02	U	0.02	J	0.02	U
Fluorene	23	79	0.02	U	0.05	U	0.06	U	0.12	U	0.04	U	0.01	J	0.02	J	0.02	J
Naphthalene	99	170	0.02	J	0.05	U	0.06	U	0.12	U	0.04	U	0.02		0.07		0.05	
Phenanthrene	100	480	0.02	U	0.05	U	0.06	U	0.12	U	0.04	U	0.04		0.06		0.05	
Total LPAH	370	780	0.02	J	0.05	U	0.06	U	0.12	U	0.04	U	0.09	J	0.18	J	0.13	J
HPAH (mg/kg OC)																		
Benzo(a)anthracene	110	270	0.02	U	0.05	U	0.06	U	0.12	U	0.04	U	0.02	U	0.02	J	0.01	J
Benzo(a)pyrene	99	210	0.02	U	0.05	U	0.06	U	0.12	U	0.04	U	0.02	U	0.01	J	0.02	U
Benzo(g,h,i)perylene	34	88	0.02	U	0.05	U	0.06	U	0.12	U	0.04	U	0.02	U	0.02	U	0.02	U
Benzofluoranthenes	230	450	0.02	U	0.05	U	0.06	U	0.12	U	0.04	U	0.01	J	0.03		0.02	J
Chrysene	110	460	0.02	U	0.05	U	0.06	U	0.12	U	0.04	U	0.01	J	0.02		0.02	J
Dibenzo(a,h)anthracene	12	33	0.01	U	0.01	U	0.01	U	0.03	U	0.01	U	0.004	U	0.01	U	0.01	U
Fluoranthene	160	1200	0.02	U	0.05	U	0.06	U	0.12	U	0.04	U	0.03		0.04		0.04	
Indeno(1,2,3-c,d)pyrene	34	88	0.02	U	0.05	U	0.06	U	0.12	U	0.04	U	0.02	U	0.02	U	0.02	U
Pyrene	1000	1400	0.02	U	0.05	U	0.06	U	0.12	U	0.04	U	0.03		0.04		0.04	
Total HPAH	960	5300	0.02	U	0.05	U	0.06	U	0.12	U	0.04	U	0.08	J	0.15	J	0.13	J

CHEMICAL	SQS	CSL	DMMU 2 (C1)		DMMU 3 (C2)		DMMU 4 (C3)		DMMU 5 (C4)		DMMU 6 (C5)		DMMU 7 (C6)		DMMU 8 (C7)		DMMU 9 (C8)	
TOTAL ORGANIC CARBON (decimal)			0.8530		0.3700		0.3450		0.1660		0.4710		1.1700		0.9990		0.8550	
CHLORINATED HYDROCARBONS (mg/kg OC)																		
1,2,4-Trichlorobenzene	0.81	1.8	0.01	U	0.01	U	0.01	U	0.03	U	0.01	U	0.004	U	0.01	U	0.01	U
1,2-Dichlorobenzene	2.3	2.3	0.01	U	0.01	U	0.01	U	0.03	U	0.01	U	0.004	U	0.01	U	0.01	U
1,4-Dichlorobenzene	3.1	9	0.01	U	0.01	U	0.01	U	0.03	U	0.01	U	0.004	U	0.01	U	0.01	U
Hexachlorobenzene	0.38	2.3	0.01	U	0.01	U	0.01	U	0.03	U	0.01	U	0.004	U	0.01	U	0.01	U
PHTHALATES (mg/kg OC)																		
Bis(2-ethylhexyl)phthalate	47	78	0.02	J	0.05	J	0.07	U	0.09	J	0.05	U	0.03	B	0.03		0.04	
Butyl benzyl phthalate	4.9	64	0.01	U	0.01	U	0.01	U	0.03	U	0.01	U	0.02	Y	0.01		0.01	
Di-n-butyl phthalate	220	1700	0.02	U	0.05	U	0.06	U	0.12	U	0.04	U	0.02	U	0.02	U	0.02	U
Di-n-octyl phthalate	58	4500	0.02	U	0.05	U	0.06	U	0.12	U	0.04	U	0.02	U	0.02	U	0.02	U
Diethyl phthalate	61	110	0.05	U	0.12	U	0.14	U	0.30	U	0.10	U	0.04	U	0.05	U	0.05	U
Dimethyl phthalate	53	53	0.01	U	0.01	U	0.01	U	0.03	U	0.01	U	0.00	U	0.01	U	0.01	U
PHENOLS (ug/kg dry)																		
2 Methylphenol	63	63	4.6	U	4.3	U	4.8	U	5.0	U	4.7	U	4.7	U	5.0	U	4.7	U
2,4-Dimethylphenol	29	29	4.6	U	4.3	U	4.8	U	5.0	U	4.7	U	4.7	U	5.0	U	4.7	U
4 Methylphenol	670	670	37	U	36	U	39	U	40	U	38	U	30	J	160		48	
Pentachlorophenol	360	690	23	U	22	U	24	U	25	U	24	U	24	U	25	U	24	U
Phenol	420	1200	18	U	18	U	19	U	20	U	19	U	13	J	20	U	27	
MISCELLANEOUS EXTRACTABLES																		
Benzoic acid (ug/kg dry)	650	650	370	U	0.97	U	1.13	U	2.41	U	0.81	U	0.32	U	0.36	J	0.36	J
Benzyl alcohol (ug/kg dry)	57	73	5	U	4	U	5	U	5	U	5	U	59		200		160	
Dibenzofuran (mg/kg OC)	15	58	0.02	U	0.05	U	0.06	U	0.12	U	0.04	U	0.01	J	0.02	J	0.02	J
Hexachlorobutadiene (mg/kg OC)	3.9	6.2	0.01	U	0.01	U	0.01	U	0.03	U	0.01	U	0.00	U	0.01	U	0.01	U
N-Nitrosodiphenylamine (mg/kg OC)	11	11	0.01	U	0.01	U	0.01	U	0.03	U	0.01	U	0.00	U	0.01	U	0.01	U
PCBs (mg/kg OC)	12	65	0.004	U	0.01	U	0.01	U	0.02	U	0.008	U	0.003	U	0.004	U	0.005	U

Note: Shaded values indicate SQS exceedance. See text for details.

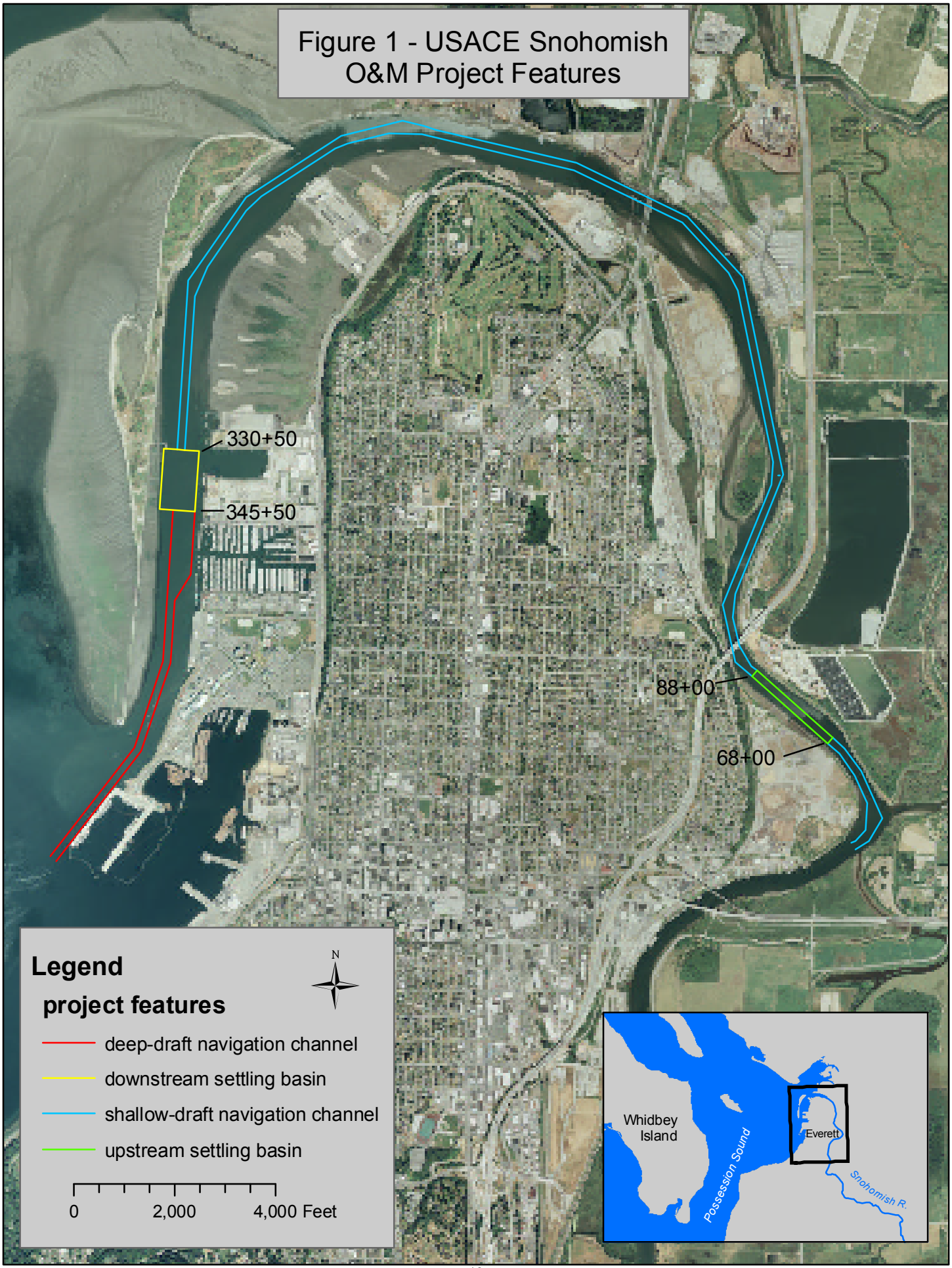
Figure 1 - USACE Snohomish O&M Project Features
330+50
345+50
88+00
68+00
Legend
project features
deep-draft navigation channel
downstream settling basin
shallow-draft navigation channel
upstream settling basin
N
0
2,000
4,000 Feet
Whidbey Island
Possession Sound
Everett
Snohomish R.

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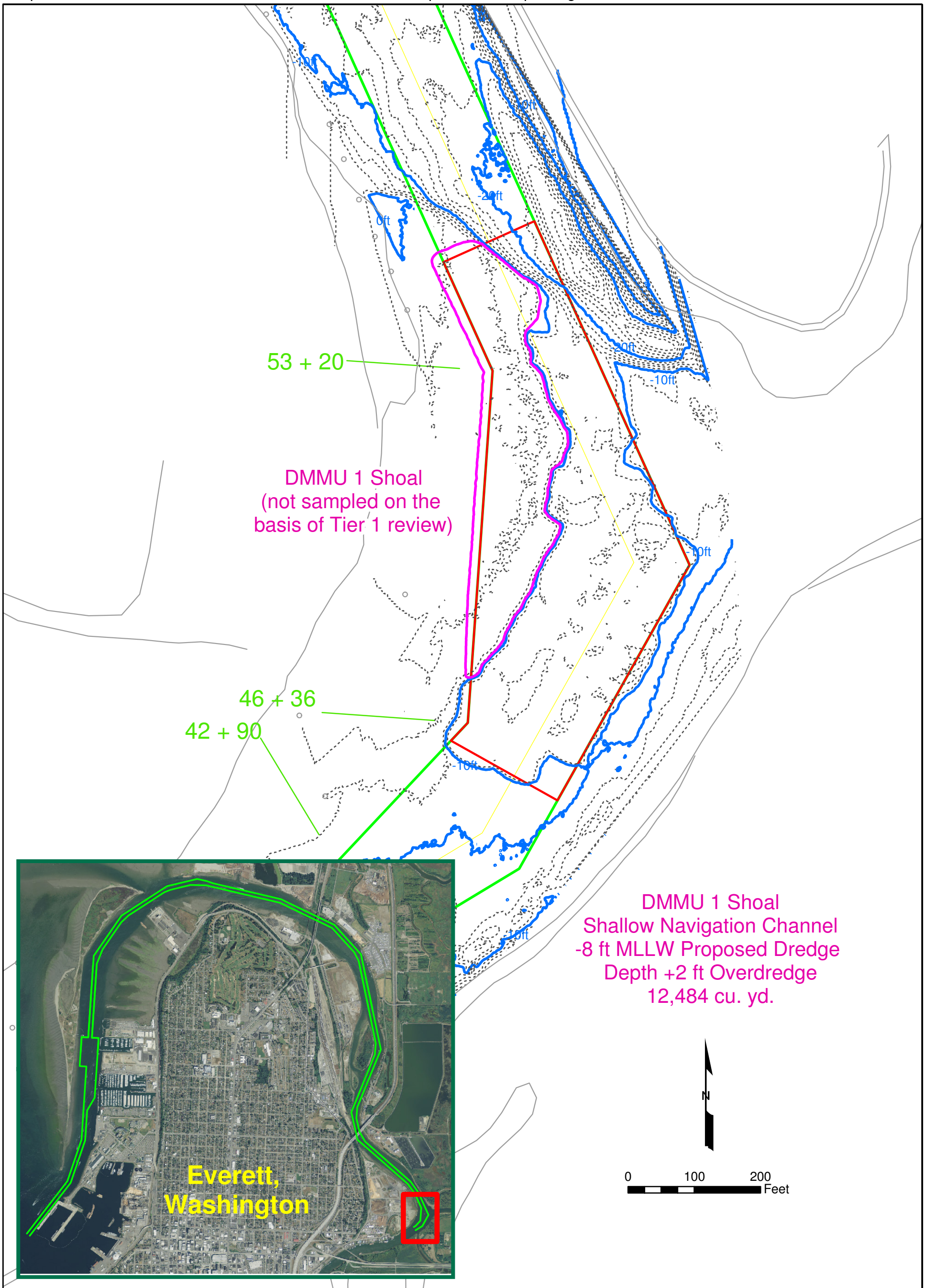


Legend

- Channel Centerline
- Navigation Channel
- Project Reaches
- Limits of Dredging (DMMUs)

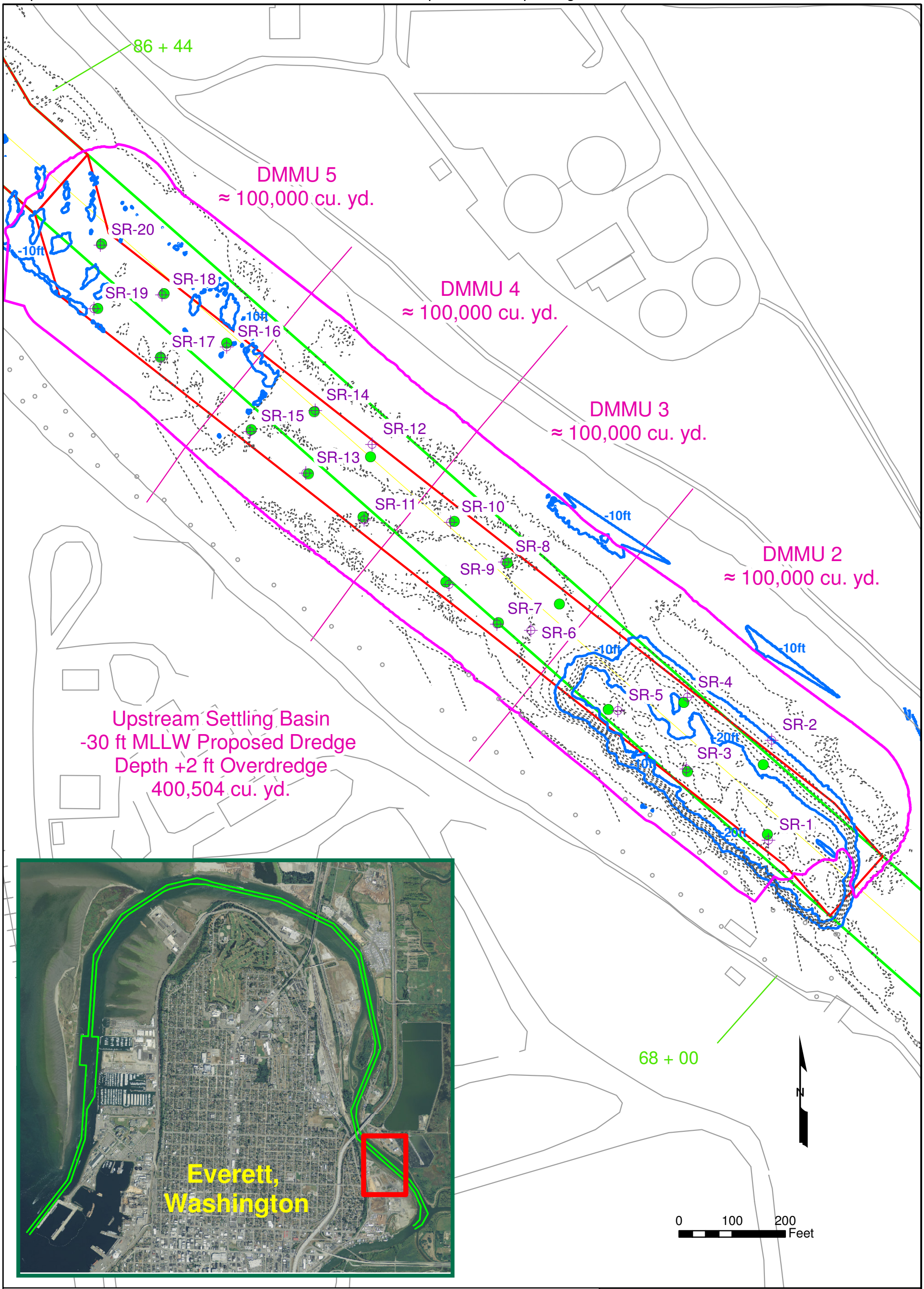
Bathymetric Contours

- Minor 2 ft interval
- Major (0 ft, -10 ft, -20 ft MLLW, etc.)

PROPOSED AND ACTUAL
SAMPLING LOCATIONS
DMMP Full Characterization for Maintenance
Dredging Snohomish River

By: rhg	Date: 11/11/2011	Project No. LY11160120
amec		Figure **2a**

File path: P:\Innovar\LY11160120 SnohoRvr Sediment\3000 Reports\Final Report\Figure 2b.mxd



Legend

- Channel Centerline
- Navigation Channel
- Project Reaches
- Limits of Dredging (DMMUs)

Bathymetric Contours

- Minor 2 ft interval
- Major (0 ft, -10 ft, -20 ft MLLW, etc.)

Sampling Station

- Proposed Station
- Actual Station

PROPOSED AND ACTUAL
SAMPLING LOCATIONS
DMMP Full Characterization for Maintenance
Dredging Snohomish River

By: rhg	Date: 11/11/2011	Project No. LY11160120
amec		Figure **2b**

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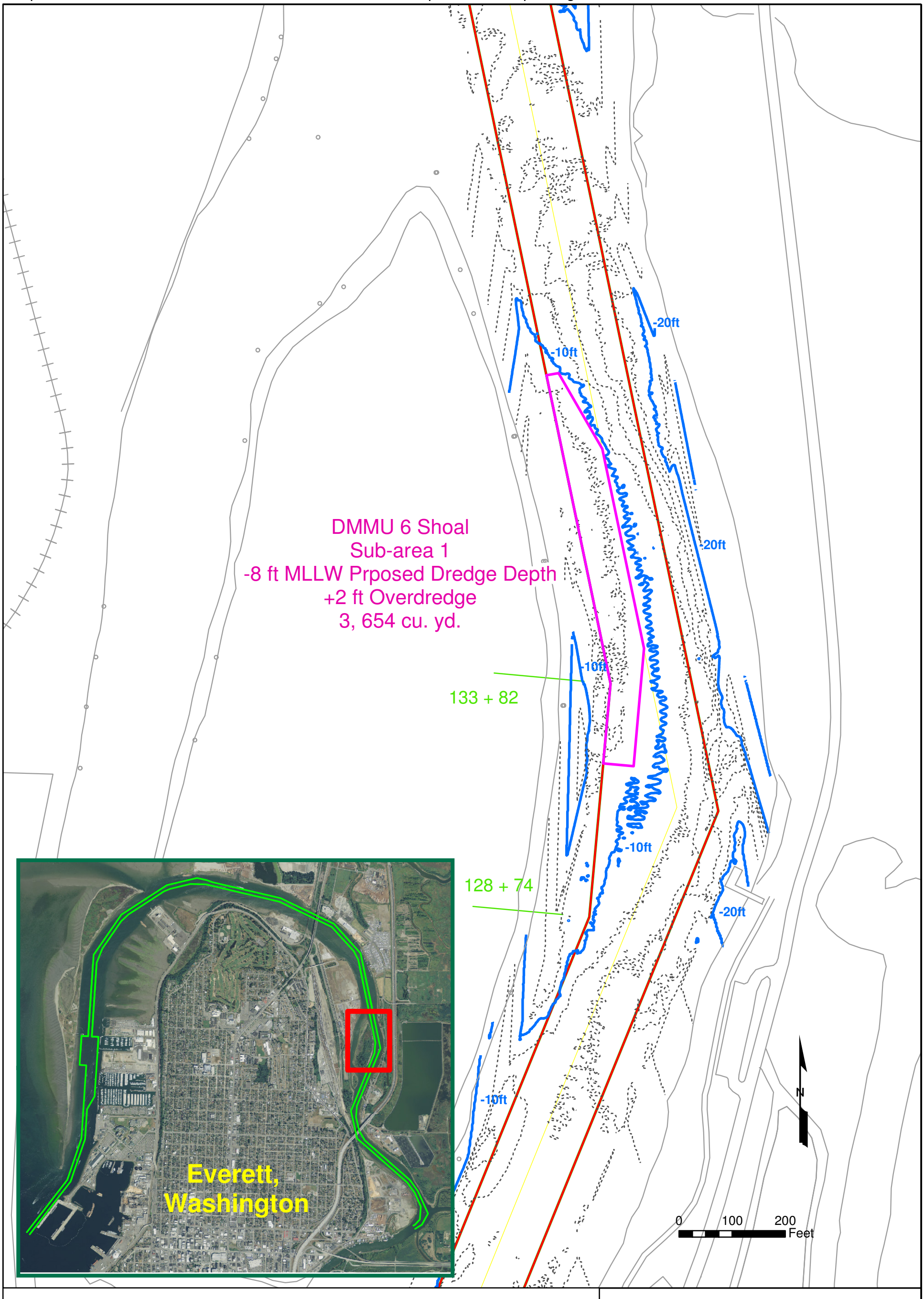

Legend

- Channel Centerline
- Navigation Channel
- Project Reaches
- Limits of Dredging (DMMUs)

Bathymetric Contours

- Minor 2 ft interval
- Major (0 ft, -10 ft, -20 ft MLLW, etc.)

PROPOSED AND ACTUAL
SAMPLING LOCATIONS
DMMP Full Characterization for Maintenance
Dredging Snohomish River

By: rhg	Date: 11/11/2011	Project No. LY11160120
amec		Figure 2c

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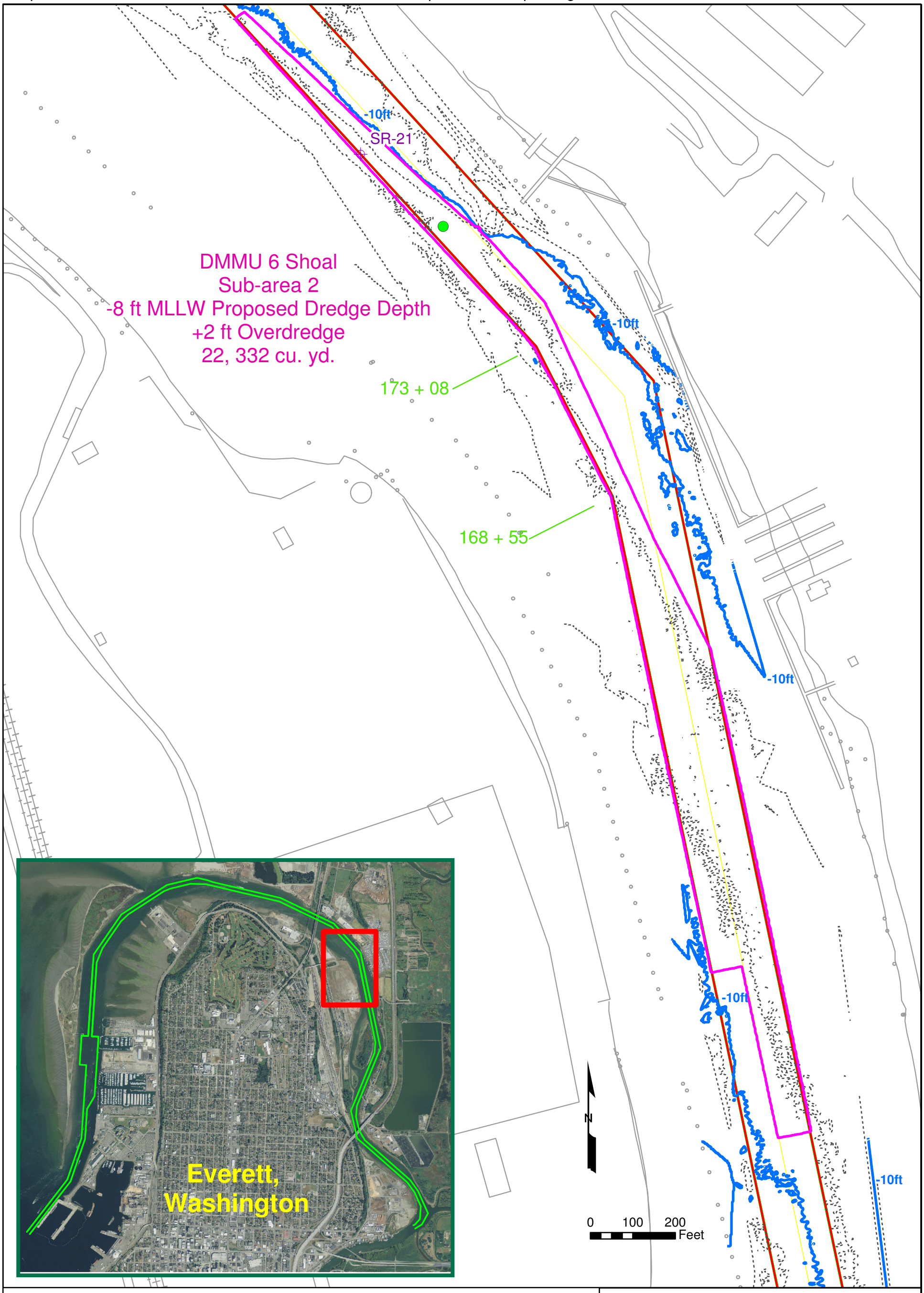

Legend

- Channel Centerline
- Navigation Channel
- Project Reaches
- Limits of Dredging (DMMUs)

Bathymetric Contours

- Minor 2 ft interval
- Major (0 ft, -10 ft, -20 ft MLLW, etc.)

Sampling Station

- Proposed Station
- Actual Station

PROPOSED AND ACTUAL
SAMPLING LOCATIONS
DMMP Full Characterization for Maintenance
Dredging Snohomish River

By: rhg	Date: 11/11/2011	Project No. LY11160120
amec		Figure **2d**

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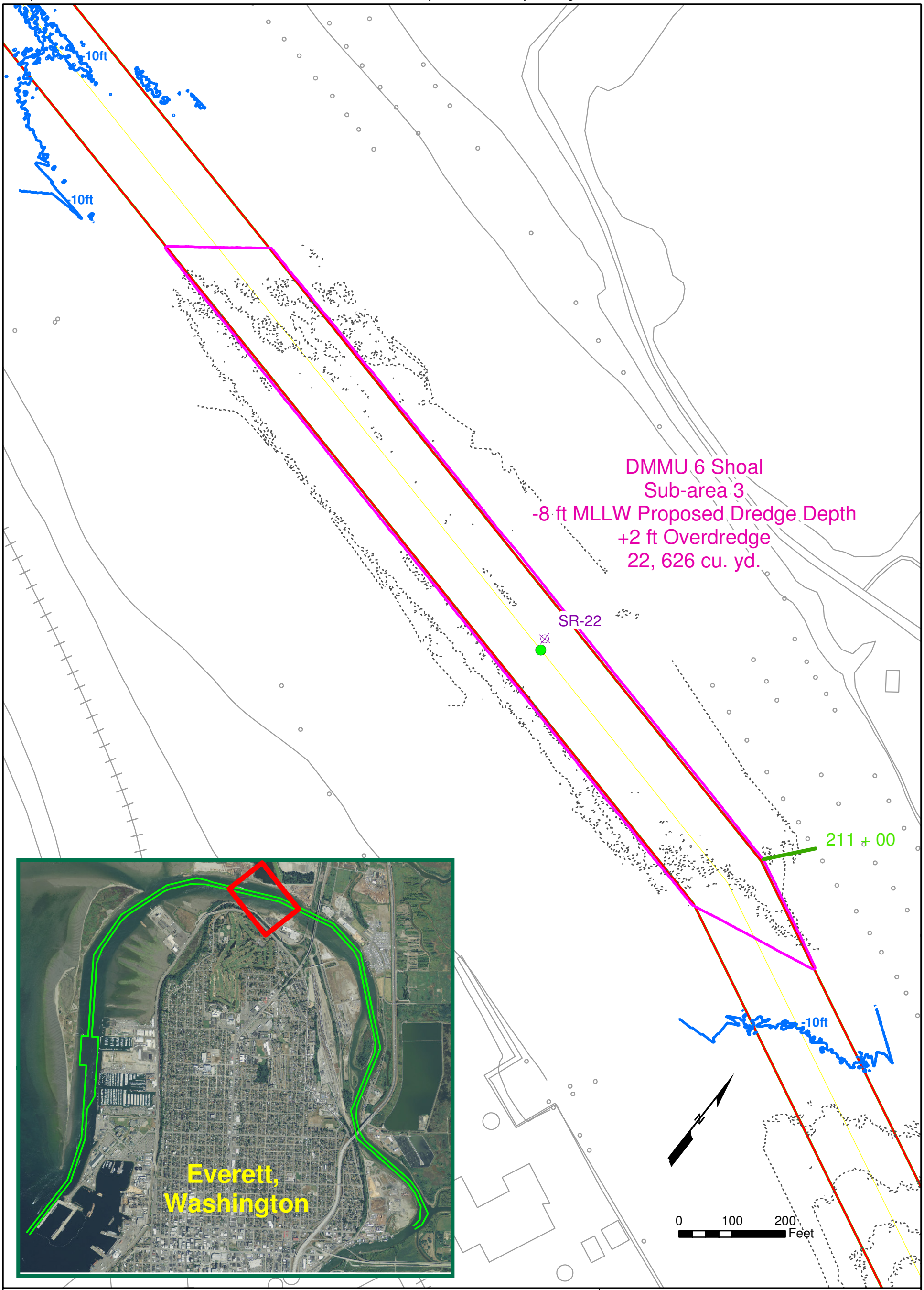

Legend

- Channel Centerline
- Navigation Channel
- Project Reaches
- Limits of Dredging (DMMUs)

Bathymetric Contours

- Minor 2 ft interval
- Major (0 ft, -10 ft, -20 ft MLLW, etc.)

Sampling Station

- Proposed Station
- Actual Station

PROPOSED AND ACTUAL
SAMPLING LOCATIONS
DMMP Full Characterization for Maintenance
Dredging Snohomish River

By: rhg	Date: 11/11/2011	Project No. LY11160120
amec		Figure **2e**

File path: P:\Innovar\LY11160120 SnohoRvr Sediment\3000 Reports\Final Report\Figure 2f.mxd

-10ft

282 + 50

-10ft

DMMU 6 Shoal
Sub-area 4
-8 ft MLLW Proposed Dredge Depth
+2 ft Overdredge
17,082 cu. yd.

SR-23

296 + 00

-10ft

303 + 00

N

0 100 200 Feet

Legend

- Channel Centerline
- Navigation Channel
- Project Reaches
- Limits of Dredging (DMMUs)

Bathymetric Contours

- Minor 2 ft interval
- Major (0 ft, -10 ft, -20 ft MLLW, etc.)

Sampling Station

- Proposed Station
- Actual Station

PROPOSED AND ACTUAL
SAMPLING LOCATIONS
DMMP Full Characterization for Maintenance
Dredging Snohomish River

By: rhg	Date: 11/11/2011	Project No. LY11160120
amec		Figure **2f**

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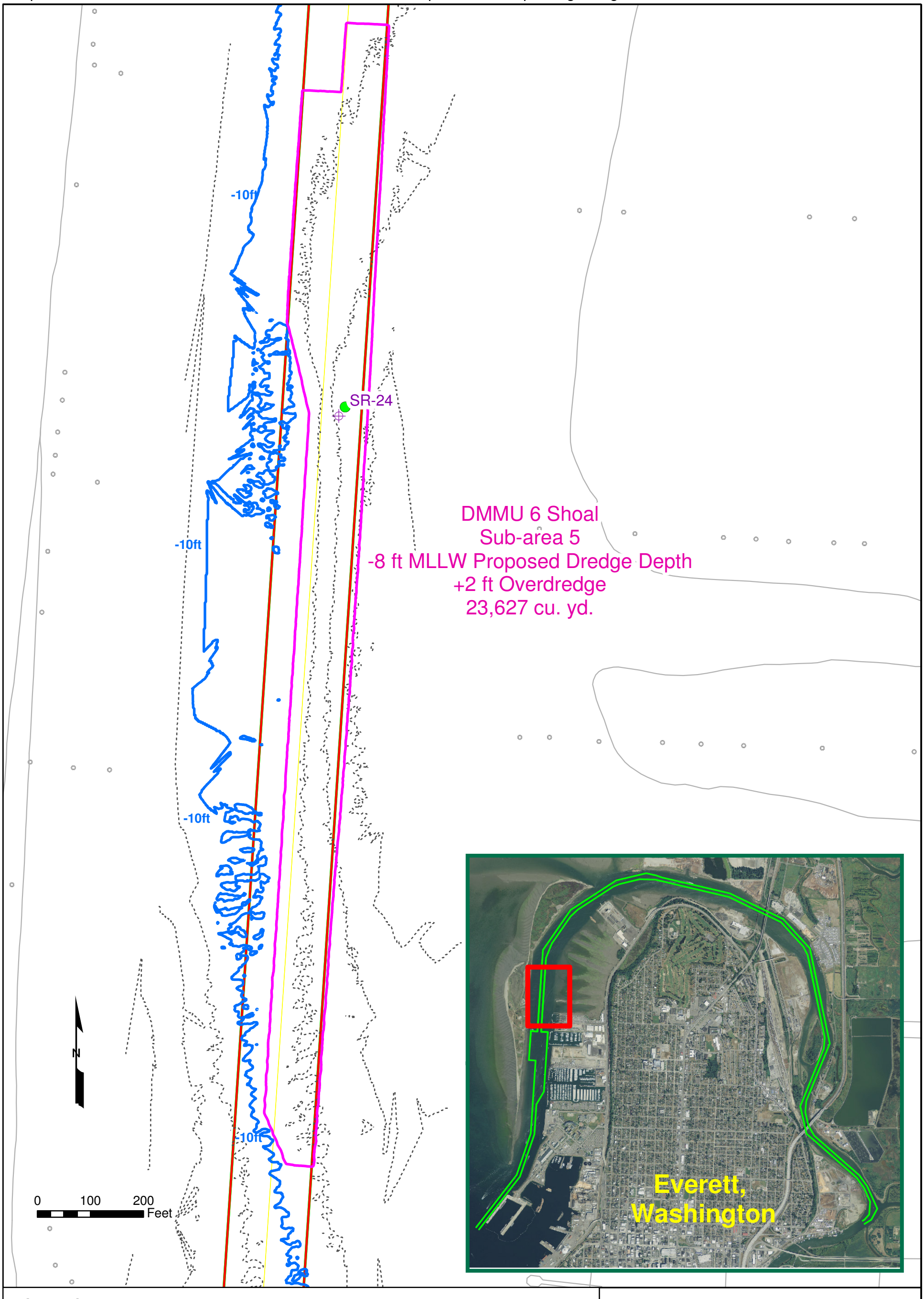


Legend

- Channel Centerline
- Navigation Channel
- Project Reaches
- Limits of Dredging (DMMUs)

Bathymetric Contours

- Minor 2 ft interval
- Major (0 ft, -10 ft, -20 ft MLLW, etc.)

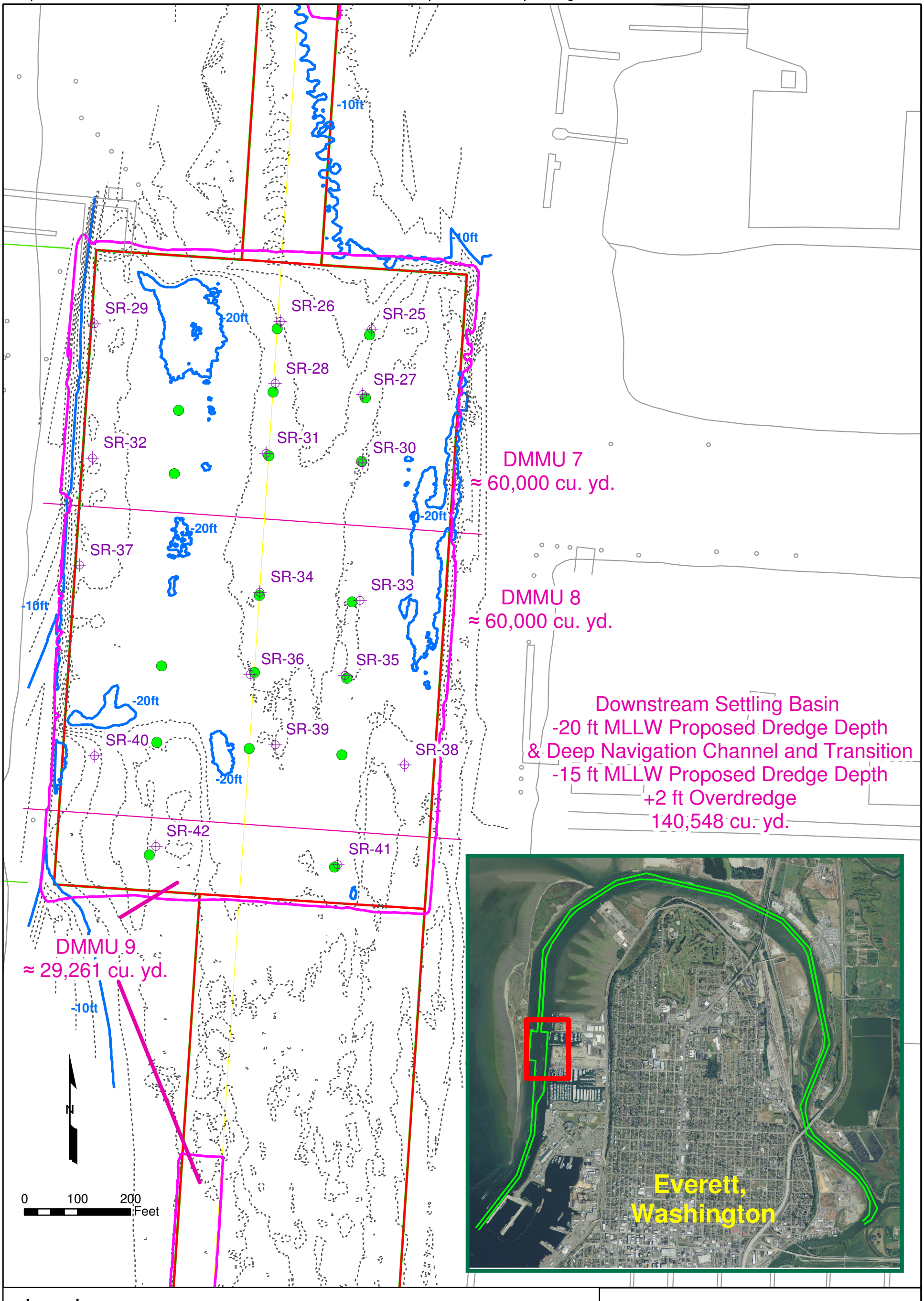
Sampling Station

- Proposed Station
- Actual Station

PROPOSED AND ACTUAL
SAMPLING LOCATIONS
DMMP Full Characterization for Maintenance
Dredging Snohomish River

By: rhg	Date: 11/11/2011	Project No. LY11160120
amec		Figure 2g

File path: P:\Innovar\LY11160120 SnohoRvr Sediment\3000 Reports\Final Report\Figure 2h.mxd



Legend

- Channel Centerline
- Navigation Channel
- Project Reaches
- Limits of Dredging (DMMUs)

Bathymetric Contours

- Minor 2 ft interval
- Major (0 ft, -10 ft, -20 ft MLLW, etc.)

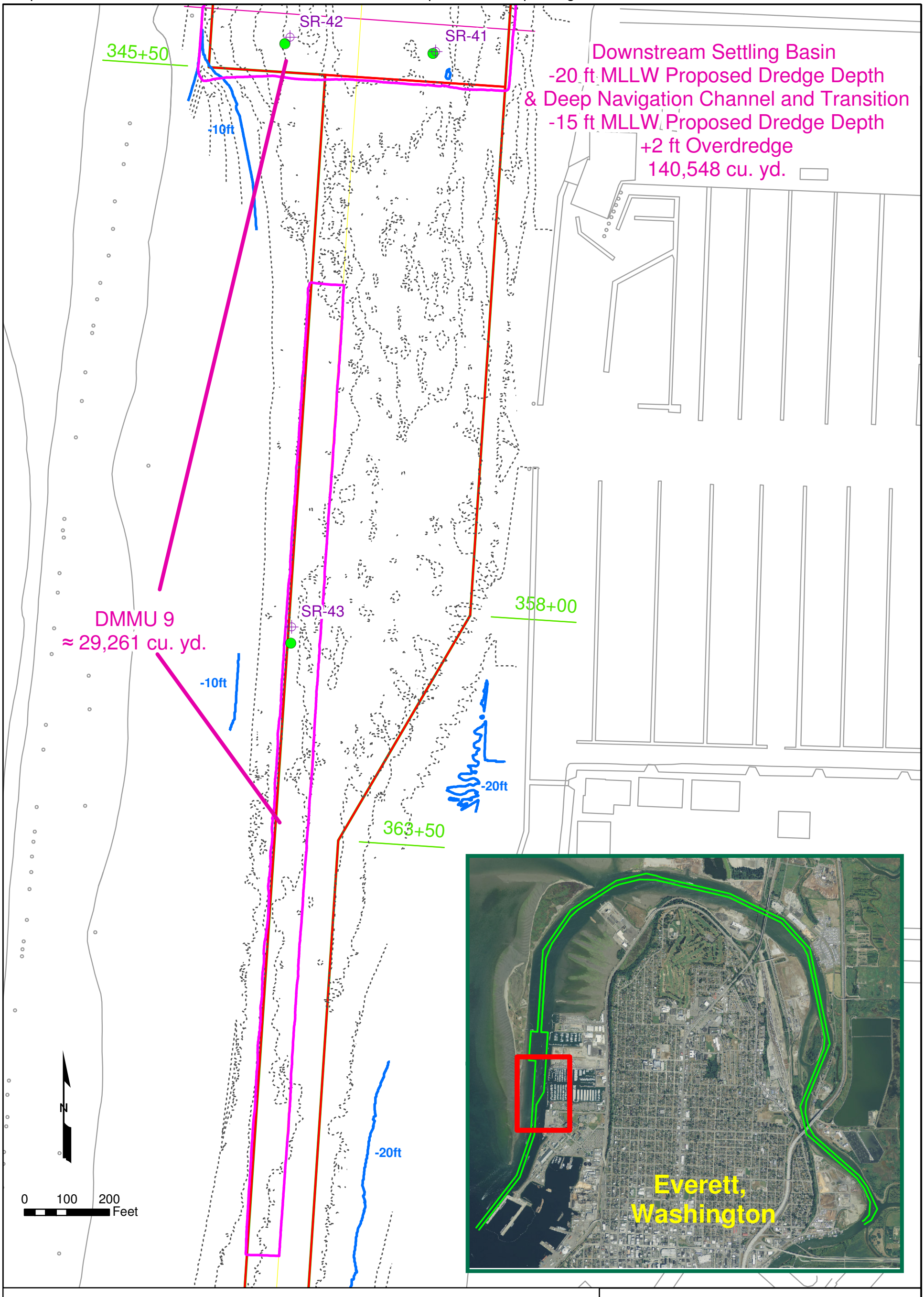
Sampling Station

- Proposed Station
- Actual Station

PROPOSED AND ACTUAL
SAMPLING LOCATIONS
DMMP Full Characterization for Maintenance
Dredging Snohomish River

By: rhg	Date: 11/11/2011	Project No. LY11160120
amec		Figure 2h

File path: P:\Innovar\LY11160120 SnohoRvr Sediment\3000 Reports\Final Report\Figure 2i.mxd



Legend

- Channel Centerline
- Navigation Channel
- Project Reaches
- Limits of Dredging (DMMUs)

Bathymetric Contours

- Minor 2 ft interval
- Major (0 ft, -10 ft, -20 ft MLLW, etc.)

Sampling Station

- Proposed Station
- Actual Station

PROPOSED AND ACTUAL
SAMPLING LOCATIONS
DMMP Full Characterization for Maintenance
Dredging Snohomish River

By: rhg	Date: 11/11/2011	Project No. LY11160120
amec		Figure 2i