*L*ower *D*uwamish *W*aterway *G*roup

Port of Seattle / City of Seattle / King County / The Boeing Company

Appendix I – Detailed Cost Estimates
Draft Feasibility Study

Lower Duwamish Waterway
Seattle, Washington

For submittal to

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

The Washington State Department of Ecology
Northwest Field Office
Bellevue, WA

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This appendix contains the detailed cost estimates prepared for the remedial alternatives developed in Section 8 of the Lower Duwamish Waterway (LDW) Feasibility Study (FS). The costs are provided in 2008 dollars. This introductory narrative to the appendix provides guidance to the reader regarding: 1) the primary cost assumptions, 2) the interpretation of the spreadsheet workbook used to prepare and assemble the cost estimates (attached as Appendix I tables), and 3) cost uncertainty and sensitivity discussion. The cost estimates were developed in accordance with the EPA guidance document *Guide to Developing and Documenting Cost Estimates during the Feasibility Study, July 2000.*

I.1 Cost Assumptions

Common assumptions to all alternatives regarding work windows, production rates, and other key factors are:

- Dredging production rate 1,000 tons/day is averaged over the dredge season based on existing transloading capacity.
- Operating season of 120 days is based on acceptable fish window of October 1 through February 13. Fish window duration equates to 136 days with allowance for holidays and downtime.
- Work shift is one 12-hour shift per day (about 7 days per week).
- Thin-layer capping (and dredged residuals management) is placement of an average 9-inches of sand for a minimum 6-inch placed thickness in all locations.
- Cap thickness is placement of an average 3.5-ft of sand/gravel/rock material to achieve a minimum 3-ft cap thickness in all locations
- Place backfill material 3.5-ft thick in partial dredge and cap areas to achieve a minimum of 3-ft backfill thickness at these locations.
- Backfill material in partial dredge and cap areas and thin-layer sand placement in residuals management area are not subject to long-term monitoring requirements.
- Dredged areas above -10 feet MLLW backfilled and restored to grade for habitat reasons.
- Off-site landfill is a Subtitle D landfill in Washington that accepts wet dredged materials (Allied Waste Services personal communication 2008).
- Dredged material will be subject to gravity dewatering as practical prior to loading into lined rail containers. The wet bulk unit weight of the dewatered dredged material (as loaded) is assumed to be 1.5 tons/cy.
- Capping material is delivered to the site by barge.

- Standby time (5% of total duration) is included for each alternative to cover items such as tribal fishing, analytical data wait time, water quality exceedances, physical access issues, etc.
- Assume 50% of sediment that is processed through the soil washing unit results in treated sand material. Assume treated sand material will be disposed of at a local source at no cost.
- Overburden material removed from the contained aquatic disposal cells is assumed to be transported by barge and disposed at the DMMP Elliott Bay open-water disposal site.
- For dredging, higher daily rate applied to 10% of the total duration for each alternative to account for additional costs resulting from over-water structures, slope stability, outfall protection, habitat enhancement, etc.
- Assume 5% of the verification monitoring and 10% of MNR areas will require active management after confirmation monitoring.
- Assume 5% of capping and ENR areas will require repair as part of maintenance operations.
- Additional details related to monitoring are provided in Appendix K.

From an implementation perspective, cleanup of the LDW will likely entail multiple independently planned and executed projects sequenced over many years. At the FS level, it is not possible to foresee or predict how projects may be organized under any particular remedial alternative. Therefore, the FS cost estimates make the simplifying assumption that the total number of years (individual projects) required to completely implement any given remedial alternative is indexed to the number of years corresponding to the remedial activity (i.e., dredging or capping) that requires the longest time to implement. Thus, a remedy that requires six years of construction is assumed to be comprised of six individual projects, each spanning the available dredging window within a given year. Each individual project is assumed to have a separate mobilization/demobilization associated with the project (i.e., mobilization/demobilization will be required for each dredging season).

The number of projects per alternative is calculated as follows. The minimum implementation period (in years) is calculated using rolled-up site-wide quantities, assumed production rates, and the annual operating window (i.e., fish window of 120 days). The implementation time frame, in number of days or years, determines the overall site-wide project duration. Activities that take less time are assumed to be evenly distributed over the entire project duration. The following table considers removal and capping and calculates the number of years to implement.

Time to Complete and Production Rate for Example Alternative

Action	Quantity	Unit	Production Rate	Minimum Implementation Time Frame (yrs)
Removal	500,000	cy	1,000 tons/day	6
Capping	50	acre	0.25 ac/day	2
			Total Duration	**6 years**

Operating Season = 120 days
Shift = One 12-hour shift per day
1.5 tons/cubic yard

In this case, the alternative takes six years to implement, and the limiting action is dredging. For this example, the alternative is assumed to consist of six individual projects, each requiring separate mobilization, demobilization and other project specific engineering and administrative components.

Capping, if initiated in one site-wide mobilization and independent of removal, across all sediment management areas (SMAs) designated for capping, could conceivably be completed in two years. Here it is assumed that capping operations occur at any time(s) during the six dredging seasons. The same considerations apply to enhanced natural recovery (ENR).

I.2 Guide to Spreadsheet-Based Cost Estimation Workbook

The contents of the cost estimate workbook for the FS are summarized in the table below. Tables I-1 through I-29 in the workbook describe unit costs common to all or most alternatives. Tables I-30 through I-41 are the cost summaries for each remedial alternative.

Content and Description of Each Cost Estimating Table

Table No.	Description
I-1	**Daily dredging production rate.** Costs are estimated for two dredging and disposal production rates: 1,000 tons/day and 2,000 tons/day. Currently available transloading and rail transportation capacity for dredged material projects in the LDW is approximately 1,000 tons/day. Significant additional transloading infrastructure and transportation planning is required to appreciably increase capacity. Cost analysis assumes a 400-ft by 40-ft lane for debris sweep per day or 0.35 acres/day. Cost includes side-scan survey and debris disposal at a construction debris landfill. Debris sweep costs for capping areas assumed to be lower because only surface debris needs removal.
I-2	**Daily production rate for capping and ENR alternatives.** Production rates are developed based on a range of equipment, operating hours, cycle time, bucket capacity, and total efficiency.
I-3	**Capping material costs.** Material costs for capping assume purchase of cap material from

Content and Description of Each Cost Estimating Table

Table No.	Description
	local or regional quarries.
I-4	**Transloading costs.** Sediment handling costs at the transloading facility assume material transfer from barge onto an offloading area, loading of dewatered sediment onto trucks with a lined 20-ft container and truck transport of the container to an intermodal facility for transfer to rail. The intermodal facility is based locally in the Duwamish Valley.
I-5	**Progress survey costs.** Costs are provided for single beam/multi-beam surveys inclusive of acquisition, processing, and data delivery.
I-6	**Mobilization, Demobilization, Site Restoration and Contractor Project Management Costs.** These costs include all contractor labor for mobilization of equipment and support facilities, land lease for operations and staging, development of construction quality assurance plans, and barge protection.
I-7 to I-16	**Post-remediation monitoring.** Post-remediation monitoring costs, annual operation and maintenance costs, repair costs for capping and ENR, and dredging volume calculations from MNR, and verification monitoring reverting back to active remediation are included. Costs from these tables are rolled into Tables I-18 to I-27 for present value calculations.
I-17	**Long-term monitoring.** It provides the basis for baseline and long-term remedial action objective monitoring costs.
I-18 to I-27	**Present value calculations for annual operations, maintenance, and long-term monitoring.** The present value calculations are based on a discount rate of 3%. Present value calculations are not applied to construction capital costs, although construction costs are spread over several years. All construction capital costs are estimated and presented in 2008 dollars with zero discount rate because construction costs are increasing faster than the rate of return on money invested in the present day. This avoids an unrealistic discount.
I-28	**Sediment volume calculations. These include the estimated in-place volumes of contaminated sediment plus 2.5 ft for overdredge and redredge plus** additional dredging volumes because of MNR and verification monitoring reverting to active remediation. Five percent of verification monitoring area and 10 percent of MNR area are included in the dredging volume calculations. Calculations for capping material volume, backfill material volume for placement in partial dredge and cap areas and thin-layer sand placement volume for placement in residuals management areas are provided.
I-29	**Unit costs, basis, and references**. The cost estimates utilize a wide range of equipment to be used for different capping and dredging conditions. Unit costs and production rates for major components (equipment, material, and labor) were obtained from local marine contractors and material suppliers. The footprint for soil washing operations is approximately 4 to 7 acres with a production rate of 40 to 45 tons per hour. Dredged sediments are assumed to contain 40 percent sand. Treatment cost includes labor, plant operations, maintenance, filter cake disposal, and no assumed disposal cost of treated sand.
I-30 to I-41	**Detailed estimated costs for each remedial alternative.** Costs include thin-layer sand placement over dredged areas as a residuals management practice. Thin-layer sand placement footprint is assumed to be equal to the dredged footprint. Repair costs applied to 5 percent of the total area for capping and ENR with monitoring frequency at Year 5 and Year 10. The residual management layer is on an average 9 inches thick.
I-42	**Summary.** This table provides rolled-up cost estimates for all remedial alternatives.

Please refer to the detailed cost estimate spreadsheets provided in the workbook for further details pertaining to the basis of costs and assumptions.

I.3 Cost Uncertainty and Sensitivity Considerations

This section discusses uncertainty in cost estimates for the remedial alternatives, as presented in the detailed cost estimate workbook.

The costs summarized in this section assumed a limiting production rate (combination of dredging and transloading) of 1,000 tons/day. Sensitivity to production rate was evaluated by also estimating costs at twice this baseline production rate (i.e., 2,000 tons/day). Maintaining higher average production rates over the lifetime of any removal-intensive remedy implemented in the LDW are considered unlikely but should be seriously considered during remedial design for any of the larger volume alternatives. Table I-1 summarizes the effect of production rate on costs. For each alternative, there is approximately a 10% difference in total project costs between the two production rates. A detailed cost estimate workbook for the increased production rate (2,000 tons/day) is included in this appendix (Increased Production Rate - Table I-1 to Table I-41).

Variation in the scope of each remedial alternative is another contributing factor to cost uncertainty. Changes in the volume of sediment dredged and disposed has a much greater influence on cost than changes of a proportionately similar magnitude in area remediated using containment-oriented technologies (i.e., capping and ENR). Two dredge volumes were developed for each alternative based on spatial interpretation of the estimated depth to the lower limit of contamination (>SQS) and depth to the top of the lower alluvium (See Appendix E). These “neat” volumes, combined with reasonable design and over-dredge allowances, were assumed to bracket the low and high ends of the quantity of material removed by dredging. The effect of bracketing these dredge material volumes on the estimated costs of the remedial alternatives is summarized in Table I-2. An increase in dredging volume will translate into higher construction, transportation, and disposal costs.

It is important to recognize that the cost estimates developed in this FS do not consider inflation, an assumption consistent with CERCLA cost estimation guidance. The duration of the construction and monitoring phases of many alternatives presented herein is likely to span a lengthy period (e.g., >10 years), which, depending on economic conditions, could see significant inflationary pressures thereby resulting in increased overall construction costs. In particular, fuel prices and landfill tipping fees are not likely to remain at current levels. Increases in fuel prices will translate into higher construction, transportation, and disposal costs.

I.4 References

Allied Waste Services 2008. Personal communication between Joe Casalini of Allied Waste Services and S. Shankar of AECOM (dba ENSR) regarding dredge material disposal costs and transport requirements. October 2008.

U.S. Environmental Protection Agency (EPA) 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*. EPA 540-R-00-002, OSWER 9355.0-75. July 2000.

Table I-1 Effect of Dredge Production Rates On Cost Revised 20-Apr-09

LOWER DUWAMISH WATERWAY
SEDIMENT CLEANUP - FS ESTIMATE
SEATTLE, WASHINGTON

Alternative Number	1	2	3a	3b	3c	3d	4a	4b	4c	4d	5
Depth to Contamination - Low Production Rate											
Capital Cost	$0	$156,060,526	$189,445,714	$205,640,814	$247,409,615	$284,197,380	$358,977,627	$414,791,224	$465,729,536	$589,414,686	$1,215,567,135
Indirect Construction Cost	$0	$10,920,000	$11,240,000	$10,990,000	$10,750,000	$9,570,000	$9,020,000	$8,680,000	$7,860,000	$6,240,000	$10,180,000
Total Cost	**$50,000,000**	**$166,980,500**	**$200,685,700**	**$216,630,800**	**$258,159,600**	**$293,767,400**	**$367,997,600**	**$423,471,200**	**$473,589,500**	**$595,654,700**	**$1,225,747,100**
Depth to Contamination - High Production Rate											
Capital Cost	$0	$137,987,075	$171,147,081	$184,922,304	$224,682,842	$258,204,751	$320,626,734	$370,889,276	$417,200,325	$534,859,905	$1,078,692,545
Indirect Construction Cost	$0	$10,920,000	$11,240,000	$10,990,000	$10,750,000	$9,570,000	$9,020,000	$8,680,000	$7,860,000	$6,240,000	$10,180,000
Total Cost	**$50,000,000**	**$148,907,100**	**$182,387,100**	**$195,912,300**	**$235,432,800**	**$267,774,800**	**$329,646,700**	**$379,569,300**	**$425,060,300**	**$541,099,900**	**$1,088,872,500**
Percent Increase in Costs from High Production R		**12%**	**10%**	**11%**	**10%**	**10%**	**12%**	**12%**	**11%**	**10%**	**13%**

Table I-2 Effect of Dredge Volumes on Cost Revised 21-Apr-09

LOWER DUWAMISH WATERWAY
SEDIMENT CLEANUP - FS ESTIMATE
SEATTLE, WASHINGTON

Alternative Number	1	2	3a	3b	3c	3d	4a	4b	4c	4d	5
Depth to Contamination - Low Production Rate											
Capital Cost	$0	$156,060,526	$189,445,714	$205,640,814	$247,409,615	$284,197,380	$358,977,627	$414,791,224	$465,729,536	$589,414,686	$1,215,567,135
Indirect Construction Cost	$0	$10,920,000	$11,240,000	$10,990,000	$10,750,000	$9,570,000	$9,020,000	$8,680,000	$7,860,000	$6,240,000	$10,180,000
Total Cost	**$50,000,000**	**$166,980,500**	**$200,685,700**	**$216,630,800**	**$258,159,600**	**$293,767,400**	**$367,997,600**	**$423,471,200**	**$473,589,500**	**$595,654,700**	**$1,225,747,100**
Depth to Alluvium - Low Production Rate											
Capital Cost	$0	$198,233,674	$238,921,816	$279,608,315	$332,158,110	$388,427,710	$496,012,027	$570,383,821	$650,074,931	$826,281,807	$1,732,555,818
Indirect Construction Cost	$0	$10,920,000	$11,240,000	$10,990,000	$10,750,000	$9,570,000	$9,020,000	$8,680,000	$7,860,000	$6,240,000	$10,180,000
Total Cost	**$50,000,000**	**$209,153,700**	**$250,161,800**	**$290,598,300**	**$342,908,100**	**$397,997,700**	**$505,032,000**	**$579,063,800**	**$657,934,900**	**$832,521,800**	**$1,742,735,800**
Percent Increase in Costs from Depth to Contamination		**25%**	**25%**	**34%**	**33%**	**35%**	**37%**	**37%**	**39%**	**40%**	**42%**