Lower Duwamish Waterway Group

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

Appendix L – Sustainability Metrics Estimation
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

April 24, 2009

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Draft Memorandum

Date: April 24, 2009

To: Lower Duwamish Waterway Group

From: Erika Germiniani; Merv Coover; Shashi Shankar

Subject: Sustainability Metrics Estimation, Draft Feasibility Study for the Lower Duwamish Waterway

This memorandum presents the methodology used for estimating sustainability metrics relevant to the evaluation of remedial alternatives developed in Section 8 of the FS. The sustainability analysis was performed on a MS Excel platform and yielded metrics associated with the following factors:

- Gas emissions
  - CO_2 emissions
  - CO emissions
  - NO_x emissions
  - SO_x emissions
- Workplace accidents
  - Expected number of accidents during remediation activities
  - Expected number of deadly accidents during remediation activities
- Energy consumption
- Ecological footprint.

Calculation Approach for Sustainability Metrics

Remediation Activities Evaluated

Sustainability calculations were developed for the primary construction and transportation activities associated with the active remedial alternatives:

- **Dredge** of sediment by barge-mounted derrick-crane and barge-mounted backhoe.
- **Transload** sediment to the off-loading facility by barge and tugboat. Off-load the material at the trans-loading area (by crane) into containers.
- **Transport** containers by truck to railcar intermodal facility followed by rail transport to regional landfill (as one loaded trip and one unloaded trip). Transport sand from the quarry to the site for capping.
- **Cap** with clean sand.

No specific assumptions were made concerning the following typical project activities: site characterization, site preparation, site closure, or landfill management. Site characterization was not considered because it is beyond the scope of cleanup activities and, according to Toffoletto et al. (2005) and Cadotte et al. (2007), the related impacts can be assumed to be similar for all of the alternatives. Site

preparation includes producing the equipment and materials necessary to implement the different remediation technologies and transporting them to the site. Even if the production of goods could represent an important part of the total impact, a majority of these goods could be reused elsewhere. Therefore, it does not seem reasonable to load the impact to a specific site. The distance covered during the transportation of goods is usually not known at the FS level. Site closure involves the decommissioning of the equipment and management of the residual waste material. Impacts caused by decommissioning are expected to be negligible. Management of a landfill is beyond the scope of the FS because it is managed as an operational requirement by the landfill.

Inventory of Metrics

"*Gas emission*" includes estimates of carbon dioxide (CO_2) emissions, the most important greenhouse gas (GHG) after water vapor, nitrogen oxides (NO_x), carbon monoxide (CO), and sulphur oxides (SO_x). These gases are calculated using an emission factor approach, where the emission factors represent the mass of gas emitted per unit of activity data and are normally referred to as "default" emissions. The major uncertainty for an emission factor is related to the degree of similarity between the target equipment/process the factor is used for and the equipment/process the factor was derived from. Collection of activity data (e.g., throughput, operating hours, etc.) requires a good knowledge of the equipment and facilities involved. Usually, emission factors estimate CO_2 emissions more accurately than CO, NO_x, and SO_x emissions, whose estimates are affected by specific characteristics of the fuel, equipment, and the operating conditions.[1]

Energy consumption refers to thermal and electrical energy consumption. Thermal energy consumption arises from fuel combustion, based on the average heating value for diesel fuel (41.75 MJ/l), and it is directly related to the amount of diesel fuel consumed during the project. Electrical energy consumption is related to the electricity purchased from the grid and is estimated as the product of equipment power demand and utilization time.

Workplace accidents represent the expected number of work-related accidents and deaths during the activities. This information is calculated using available data for workplace activities similar to those planned for the remediation of the LDW.

Ecological footprint is defined as the summation of the direct and indirect land use (Althaus 2007). Remedial actions are associated with direct land use in terms of land occupation, and indirect land use in terms of the CO_2 emissions caused by fossil fuel combustion or energy consumption. Because the designed alternatives don't include land occupation, the ecological footprint consists of the wooded or agricultural surface necessary to absorb the CO_2 produced during the remediation activities, based on a specific vegetation growing rate. Storage of carbon in a stable solid form occurs through direct and indirect fixation of atmospheric CO_2. Carbon is stored by plants as they photosynthesize atmospheric CO_2 into plant biomass. Subsequently, some of this plant biomass is indirectly stored as soil organic carbon during decomposition processes. Therefore, indirect land use is derived from several factors, including the annual amount of CO_2 emissions, the carbon fixed in the form of biomass as dry matter (d.m.), usually estimated as 2.02 g CO_2/1 g d.m., and annual vegetation growth rate.

Input Data Requirements

Two categories of data were compiled to perform the sustainability analyses: background and site-specific (Goedkoop et al. 2008). The background data are comprised of generic factors and constants

[1] World Resource Institute, *Designing a Customized Greenhouse gas calculation tool*, The Greenhouse Gas Protocol.

found in databases and literature. The site-specific data relate to the manner in which the remedial alternatives are assumed to be implemented (e.g., number and characteristics of equipment, labor requirements, production rates, and transportation distances).

Background data used for the calculation were obtained mostly from EPA references (1995a and 1995b) and the U.S. Department of Labor (USDOL) (USDOL 2007, 2008). In particular, the EPA reports document gas emission factors related to different sources (stationary internal combustion engines or mobile sources), dust emission equation for heavy construction and plowing operations, and transport on paved and unpaved roads.

The sustainability metrics were calculated based on the activities scheduled for each alternative. Background data and site-specific data, as classified for the planned activities, are reported in Tables L-1 and L-2, respectively.

Results

Table L-3 presents the summary output for the remedial alternatives. Figure L-1 presents a detailed interpretation of CO_2 emissions for Alternative 3c, as an example. The percentage of CO_2 emissions for each activity (miscellaneous, transloading, transportation, dredging, and capping) is approximately constant among the various remedial alternatives. As noted from Figure L-1, the relatively higher emissions correspond to transloading of sediment to the off-loading facility and transportation of sediments to the landfill.

References

Toffoletto 2005. Toffoletto L., Deschênes L. and Samson R., "*LCA of ex-situ bioremediation of diesel-contaminated soil*", Int. J. LCA, Ecomed publishers, 2005, 10(6), 406-416.

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United States Environmental Protection Agency January 1995a. *Compilation of Air Pollutant Emission Factors, Volume I, Stationary Point and Area Sources*, AP 42, Fifth Edition. January 1995.

United States Environmental Protection Agency January 1995b. *Compilation of Air Pollutant Emission Factors, Volume II, Appendix H: Highway Mobile Source Emission Factor Tables*, AP 42, Fifth Edition. January 1995.

U.S. Department of Labor 2007 *Supplemental News Release Tables - SNR05*, *Industry Injury and illness Data*. 2007.

U.S. Department of Labor 2008. *Census of Fatal Occupational Injuries*, 2008.

Table L-1 Background Input Data

Background Miscellaneous

Description	Units	Value	References
Emission factor for CO_2	lb/hp	1.15	AP 42, EPA, Fifth Edition, Volume I - Stationary Internal Combustion Sources - Gasoline and Diesel Industrial Engines (power output Emission factor_uncontrolled sources; assumes 99% conversion of carbon in fuel to CO_2 with 87 weight % carbon in diesel and an average brake-specific fuel consumption (BSFC) of 4.256 kg/kw h).
Emission factor for CO	lb/hp	0.00668	
Emission factor for NOx	lb/hp	0.031	
Emission factor for SOx	lb/hp	0.00205	
Emission factor for CO_2	lb/gal	26.635	AP 42, EPA, Fifth Edition, Volume I - Stationary Internal Combustion Sources - Gasoline and Diesel Industrial Engines (fuel input emission factor_uncontrolled sources; assumes 99% conversion of carbon in fuel to CO_2 with 87 weight % carbon in diesel, diesel heating value of 19,300 Btu/lb). Fuel density: 0.85 kg/l
Emission factor for CO	lb/gal	0.154438	
Emission factor for NOx	lb/gal	0.716916	
Emission factor for SOx	lb/gal	0.0414509	
Work accidents rate for heavy and civil engineering construction	Accidents/ worker/year	0.05100	U.S. Department of labor (Industry Injury and illness Data, 2007 - Supplemental News Release Tables SNR05)
Deadly work accidents rate for operating engineers and other construction equipment operators	Accidents/ worker/year	0.00011	U.S. Department of Labor, Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Energy content of diesel fuel	MJ/gal	189.9625	Commonly accepted heating values for diesel fuel (EPA)
Average break-specific fuel consumption	Gal/hp h	0.04257	AP 42, EPA, Fifth Edition, Volume I - Stationary Internal Combustion Sources - Gasoline and Diesel Industrial Engines (Average break-specific fuel consumption)

Background Transloading

Description	Units	Value	References
Emission factor for CO_2	lb/hp	1.15	AP 42, EPA, Fifth Edition, Volume I - Stationary Internal Combustion Sources - Gasoline and Diesel Industrial Engines (fuel input Emission factor_uncontrolled sources; assumes 99% conversion of carbon in fuel to CO_2 with 87 weight % carbon in diesel, diesel heating value of 19,300 Btu/lb). Fuel density: 0.85 kg/l
Emission factor for CO	lb/hp	0.00668	
Emission factor for NOx	lb/hp	0.031	
Emission factor for SOx	lb/hp	0.00205	
Emission factor for CO_2	lb/gal	26.635	AP 42, EPA, Fifth Edition, Volume I - Stationary Internal Combustion Sources - Gasoline and Diesel Industrial Engines (fuel input Emission factor_uncontrolled sources; diesel heating value of 19,300 Btu/lb)
Emission factor for CO	lb/gal	0.154438	
Emission factor for NOx	lb/gal	0.716916	
Emission factor for SOx	lb/gal	0.0414509	
Tug load factor	-	0.4	Analysis of commercial marine vessel emissions and fuel consumption data (Suggested load factor for general cargo vessel type in slow cruise mode as percent of maximum
Tug load factor	-	0.2	
Work accidents rate for inland water freight transportation	Accidents/ worker/year	0.03600	U.S. Department of labor (Industry Injury and Illness Data, 2007 - Supplemental News Release Tables SNR05)
Deadly work accidents rate for operating engineers and other construction equipment operators	Accidents/ worker/year	0.00030	U.S. Department of Labor, Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Work accidents rate for heavy and civil engineering construction	Accidents/ worker/year	0.05100	U.S. Department of labor (Industry Injury and illness Data, 2007 - Supplemental News Release Tables SNR05)
Deadly work accidents rate for operating engineers and other construction equipment operators	Accidents/ worker/year	0.00011	U.S. Department of Labor, Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Energy content of diesel fuel	MJ/gal	189.9625	Commonly accepted heating values for diesel fuel (EPA)
Average break-specific fuel consumption	gal/hp h	0.04257	AP 42, EPA, Fifth Edition, Volume I - Stationary Internal Combustion Sources - Gasoline and Diesel Industrial Engines (Average break-specific fuel consumption)

Table L-1 Background Input Data (continued)

Background Transportation

Description	Units	Value	References
Emission factor for CO_2	lb/MJ	0.03364	The Green House Gas Protocol (CO2 emissions from transport or mobile sources)
Emission factor for CO	lb/mi	0.02004	AP 42, EPA, Fifth Edition, Volume II, based on the MOBILE5 highway vehicle emission factor (App H: Highway Mobile Source Emission Factor Tables - Heavy-duty Diesel Trucks) http://www.epa.gov/otaq/ap42.htm#nonroad
Emission factor for NOx	lb/mi	0.01311	
Emission factor for CO	lb/gal	0.154438	AP 42, EPA, Fifth Edition, Volume I - Stationary Internal Combustion Sources - Gasoline and Diesel Industrial Engines (fuel input emission factor_uncontrolled sources; diesel heating value of 19,300 Btu/lb)
Emission factor for NOx	lb/gal	0.716916	
Emission factor for SOx	lb/gal	0.0414509	
Emission factor for CO_2	lb/hp	1.15	AP 42, EPA, Fifth Edition, Volume I - Stationary Internal Combustion Sources - Gasoline and Diesel Industrial Engines (fuel input emission factor_uncontrolled sources; assumes 99% conversion of carbon in fuel to CO2 with 87 weight % carbon in diesel, diesel heating value of 19,300 Btu/lb). Fuel density: 0,85 kg/l
Emission factor for CO	lb/hp	0.00668	
Emission factor for NOx	lb/hp	0.031	
Emission factor for SOx	lb/hp	0.00205	
Tug load factor	-	0.4	Analysis of commercial marine vessel emissions and fuel consumption data (Suggested load factor for general cargo vessel type in slow cruise mode as percent of maximum continuous rating)
R10	lb/Vmi	0.01487	Emissions Factors & AP 42,EPA, Fifth Edition - miscellaneous sources - (paved roads)
R2.5	lb/Vmi	0.00213	
W	long ton	25.4	
C10	lb/Vmi	0.0004256	
C2.5	lb/Vmi	0.0003248	
Work accidents rate for general freight trucking, local	Accidents/ worker/year	0.05200	U.S. Department of labor (Industry Injury and illness Data, 2007 - Supplemental News Release Tables SNR05)
Deadly work accidents rate for truck transportation	Accidents/ worker/year	0.00026	U.S. Department of Labor, Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Work accidents rate for rail transportation	Accidents/ worker/year	0.02200	U.S. Department of labor (Industry Injury and illness Data, 2007 - Supplemental News Release Tables SNR05)
Deadly work accidents rate for rail transportation	Accidents/ worker/year	0.00006	U.S. Department of Labor, Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Work accidents rate for inland water freight transportation	Accidents/ worker/year	0.036	U.S. Department of labor (Industry Injury and illness Data, 2007 - Supplemental News Release Tables SNR05)
Deadly work accidents rate for water transportation	Accidents/ worker/year	0.000299	U.S. Department of Labor, Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Energy content of diesel fuel	MJ/gal	189.9625	Commonly accepted heating values for diesel fuel (EPA)
Average break-specific fuel consumption	Gal/hp h	0.04257	AP 42, EPA, Fifth Edition, Volume I - Stationary Internal Combustion Sources - Gasoline and Diesel Industrial Engines (Average break-specific fuel consumption)

Background Dredging

Description	Units	Value	References
Emission factor for CO_2	lb/hp	1.15	AP 42, EPA, Fifth Edition, Volume I - Stationary Internal Combustion Sources - Gasoline and Diesel Industrial Engines (fuel input emission factor_uncontrolled sources; assumes 99% conversion of carbon in fuel to CO2 with 87 weight % carbon in diesel, diesel heating value of 19,300 Btu/lb). Fuel density: 0,85 kg/l
Emission factor for CO	lb/hp	0.00668	
Emission factor for NOx	lb/hp	0.031	
Emission factor for SOx	lb/hp	0.00205	
Emission factor for CO_2	lb/gal	26.635	AP 42, EPA, Fifth Edition, Volume I - Stationary Internal Combustion Sources - Gasoline and Diesel Industrial Engines (fuel input emission factor_uncontrolled sources; diesel heating value of 19,300 Btu/lb)
Emission factor for CO	lb/gal	0.154438	
Emission factor for NOx	lb/gal	0.716916	
Emission factor for SOx	lb/gal	0.0414509	
Load factor for boat	-	0.20	Analysis of commercial marine vessel emissions and fuel consumption data (Suggested load factor for all non ocean going vessel type in maneuvering mode as percent of maximum continuous rating)
Work accidents rate for inland water freight transportation	Accidents/ worker/year	0.03600	U.S. Department of labor (Industry Injury and illness Data, 2007 - Supplemental News Release Tables SNR05)
Deadly work accidents rate for water transportation	Accidents/ worker/year	0.00030	U.S. Department of Labor, Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Work accidents rate for heavy and civil engineering construction	Accidents/ worker/year	0.51000	U.S. Department of labor (Industry Injury and illness Data, 2007 - Supplemental News Release Tables SNR05)
Deadly work accidents rate for operating engineers and other construction equipment operators	Accidents/ worker/year	0.00107	U.S. Department of Labor, Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Energy content of diesel fuel	MJ/gal	189.9625	Commonly accepted heating values for diesel fuel (EPA)
Average break-specific fuel consumption	gal/hp h	0.04257	AP 42, EPA, Fifth Edition, Volume I - Stationary Internal Combustion Sources - Gasoline and Diesel Industrial Engines (Average break-specific fuel consumption)

Table L-1 Background Input Data (continued)

Background Capping

Description	Units	Value	References
Emission factor for CO_2	lb/hp	1.15	AP 42, EPA, Fifth Edition, Volume I - Stationary Internal Combustion Sources - Gasoline and Diesel Industrial Engines (fuel input emission factor_uncontrolled sources; assumes 99% conversion of carbon in fuel to CO2 with 87 weight % carbon in diesel, diesel heating value of 19,300 Btu/lb). Fuel density: 0,85 kg/l
Emission factor for CO	lb/hp	0.00668	
Emission factor for NOx	lb/hp	0.031	
Emission factor for SOx	lb/hp	0.00205	
Emission factor for CO_2	lb/gal	26.635	AP 42, EPA, Fifth Edition, Volume I - Stationary Internal Combustion Sources - Gasoline and Diesel Industrial Engines (fuel input emission factor_uncontrolled sources; diesel heating value of 19,300 Btu/lb)
Emission factor for CO	lb/gal	0.154438	
Emission factor for NOx	lb/gal	0.716916	
Emission factor for SOx	lb/gal	0.0414509	
Load factor for boat	-	0.2	Analysis of commercial marine vessel emissions and fuel consumption data (Suggested load factor for all non ocean going vessel type in maneuvering mode as percent of maximum continuous rating)
Work accidents rate for inland water freight transportation	Accidents/ worker/year	0.03600	U.S. Department of labor (Industry Injury and illness Data, 2007 - Supplemental News Release Tables SNR05)
Deadly work accidents rate for water transportation	Accidents/ worker/year	0.00030	U.S. Department of Labor, Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Work accidents rate for heavy and civil engineering construction	Accidents/ worker/year	0.05100	U.S. Department of labor (Industry Injury and illness Data, 2007 - Supplemental News Release Tables SNR05)
Deadly work accidents rate for operating engineers and other construction equipment operators	Accidents/ worker/year	0.00107	U.S. Department of Labor, Bureau of Labor Statistics, Census of Fatal Occupational Injuries, 2008
Energy content of diesel fuel	MJ/gal	189.9625	Commonly accepted heating values for diesel fuel (EPA)
Average break-specific fuel consumption	gal/hp h	0.04257	AP 42, EPA, Fifth Edition, Volume I - Stationary Internal Combustion Sources - Gasoline and Diesel Industrial Engines (Average break-specific fuel consumption)

Background Carbon Footprint

Description	Units	Value	References
CO_2 absorbed	-	2.02	Alfredo Provini et al., Ecologia Applicata, 2003
Growth rate for Douglas Fir in Pacific Coast	Long ton dm/acre year	2.058	Representative Carbon Sequestration Rates and Saturation Periods for Key Agricultural & Forestry Practices, EPA
Growth rate for agricultural land	Long ton ss/acre year	2.579	Alfredo Provini et al., Ecologia Applicata, 2003

Table L-2 Site-specific Data Input for the Remedial Alternatives

Miscellaneous Input

Description	Equipment	Units	Alt 1	Alt 2	Alt 3a	Alt 3b	Alt 3c	Alt 3d	Alt 4a	Alt 4b	Alt 4c	Alt 4d	Alt 5	-	-
Volume	Loader	Cubic yard	0	196,728	416,434	446,557	559,196	629,291	836,091	979,491	1,118,954	1,383,774	2,876,836	0	0
	Dozer	Cubic yard	0	0	0	0	0	0	0	0	0	0	0	0	0
Area	Loader	Acres	0	14	14	14	14	14	14	14	14	14	14	0	0
	Dozer	Acres	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel consumption	Loader	Gallon/hour	0	7	7	7	7	7	7	7	7	7	7	0	0
	Dozer	Gallon/hour	0	0	0	0	0	0	0	0	0	0	0	0	0
Power rating	Loader	hp	0	532	532	532	532	532	532	532	532	532	532	532	0
	Dozer	hp	0	0	0	0	0	0	0	0	0	0	0	0	0
Excavation rate (>0)	Loader	Cubic yard/hour	59	59	59	59	59	59	59	59	59	59	59	59	59
	Dozer	Cubic yard/hour	59	59	59	59	59	59	59	59	59	59	59	59	59
Number of construction equipment operators	-	Worker	0	2	2	2	2	2	2	2	2	2	2	0	0
OTHER CATEGORIES	-	Worker	0	0	0	0	0	0	0	0	0	0	0	0	0

Transloading Input

Description	Equipment	Units	Alt 1	Alt 2	Alt 3a	Alt 3b	Alt 3c	Alt 3d	Alt 4a	Alt 4b	Alt 4c	Alt 4d	Alt 5	-	-
Volume	Tugs A	Cubic yard	0	408,364	208,217	223,279	279,598	314,646	418,046	489,746	559,477	691,887	1,438,418	0	0
	Tugs B	Cubic yard	0	408,364	208,217	223,279	279,598	314,646	418,046	489,746	559,477	691,887	1,438,418	0	0
Off-loading volume meterial to storage containers	Derrick crane	Cubic yard	0	816,728	416,434	446,557	559,196	629,291	836,091	979,491	1,118,954	1,383,774	2,876,836	0	0
Fuel consumption	Tugs A_full engine	Gallon/hour	0	85	85	85	85	85	85	85	85	85	85	0	0
	Tugs B_full engine	Gallon/hour	0	85	85	85	85	85	85	85	85	85	85	0	0
	Tugs A_idle mode	Gallon/hour	0	15	15	15	15	15	15	15	15	15	15	0	0
	Tugs B_idle mode	Gallon/hour	0	15	15	15	15	15	15	15	15	15	15	0	0
	Derrick crane	Gallon/hour	0	25	25	25	25	25	25	25	25	25	25	0	0
Power rating	Tugs A	hp	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tugs B	hp	0	0	0	0	0	0	0	0	0	0	0	0	0
	Derrick crane	hp	0	0	0	0	0	0	0	0	0	0	0	0	0
Distance from the site to the offloading area	Tugs	Miles	0.0	10.3	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	0.0	0
Speed (>0)	Tugs	Miles/hour	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Barge capacity (>0)	Barge	Cubic yard	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000
offloading rate by derrick crane (>0)	Derrick crane	Cubic yard/hour	60	60	60	60	60	60	60	60	60	60	60	60	60
Number of water equipment operators	-	Worker	0	3	3	3	3	3	3	3	3	3	3	0	0
Number of construction equipment operators (Includes workers needed for soil washing)	-	Worker	0	3	3	3	3	3	3	3	3	3	10	0	0
Off-loading area from barge to storage containers	-	Acres	0	5	5	5	5	5	5	5	5	5	5	0	0

Table L-2 Site-specific Data Input for the Remedial Alternatives (continued)

Transportation Input

Description	Equipment	Units	Alt 1	Alt 2	Alt 3a	Alt 3b	Alt 3c	Alt 3d	Alt 4a	Alt 4b	Alt 4c	Alt 4d	Alt 5	-	-
Volume	Truck 1	Cubic yard	0	0	0	0	0	0	0	0	0	0	0	0	0
	Truck 2 (round trip)	Cubic yard	0	196,728	416,434	446,557	559,196	629,291	836,091	979,491	1,118,954	1,383,774	2,876,836	0	0
	Railcar	Cubic yard	0	196,728	416,434	446,557	559,196	629,291	836,091	979,491	1,118,954	1,383,774	2,876,836	0	0
	Tug	Cubic yard	0	0	0	0	0	0	0	0	0	0	0	0	0
Distance	Truck 1 (average distance)	Miles	0	0	0	0	0	0	0	0	0	0	0	0	0
	Truck 2 (round trip)	Miles	0	24	24	24	24	24	24	24	24	24	24	0	0
	Railcar	Miles	0	284.3	284.3	284.3	284.3	284.3	284.3	284.3	284.3	284.3	284.3	0	0
power rating	Tug	hp	522	0	0	0	0	0	0	0	0	0	0	522	522
	Tug	hp	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel consumption	Truck	Gallons/miles	0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0	0
	Railcar	Gallons/miles	0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	0	0
	Tug	Gallons/hour	0	85	85	85	85	85	85	85	85	85	85	0	0
Number of "wet" days	-	Days	0	60	60	60	60	60	60	60	60	60	60	0	0
Number of the days in the averaging period	-	Days	120	120	120	120	120	120	120	120	120	120	120	120	120
Load capacity	Truck	Cubic yard	45	45	45	45	45	45	45	45	45	45	45	45	45
	Railcar	Cubic yard	150	150	150	150	150	150	150	150	150	150	150	150	150
Transportation rate (>0)	Tug	Cubic yard/hour	58.8	58.8	58.8	58.8	58.8	58.8	58.8	58.8	58.8	58.8	58.8	58.8	58.8
Speed	Truck 2	Miles/hour	40	40	40	40	40	40	40	40	40	40	40	40	40
	Railcar	Miles/hour	50	50	50	50	50	50	50	50	50	50	50	50	50
Number of trucks used for transportation (>0)	Truck	-	7	7	7	7	7	7	7	7	7	7	7	7	7
Number of operators for truck transportation	-	Worker	0	7	7	7	7	7	7	7	7	7	7	0	0
Number of operators for rail transportation	-	Worker	0	8	8	8	8	8	8	8	8	8	8	0	0
Number of water equipment operators	-	Worker	0	0	0	0	0	0	0	0	0	0	0	0	0

Dredging Input

Description	Equipment	Units	Alt 1	Alt 2	Alt 3a	Alt 3b	Alt 3c	Alt 3d	Alt 4a	Alt 4b	Alt 4c	Alt 4d	Alt 5	-	-
Volume placed under water level	Barge-mounted derrick crane	Cubic yard	0	571,710	291,504	312,590	391,437	440,504	585,264	685,644	783,268	968,642	2,013,785	0	0
	Barge-mounted backhoe	Cubic yard	0	122,509	62,465	66,984	83,879	94,394	125,414	146,924	167,843	207,566	431,525	0	0
Volume placed above the water level	Barge-mounted backhoe	Cubic yard	0	122,509	62,465	66,984	83,879	94,394	125,414	146,924	167,843	207,566	431,525	0	0
Fuel consumption	Barge-mounted derrick crane	Gallons/hour	0	25	25	25	25	25	25	25	25	25	25	0	0
	Barge-mounted backhoe	Gallons/hour	0	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	0	0
	Survey boat	Gallons/hour	0	8	8	8	8	8	8	8	8	8	8	0	0
power rating	Barge-mounted derrick crane	hp	1,890	1,890	1,890	1,890	1,890	1,890	1,890	1,890	1,890	1,890	1,890	1,890	1890
	Barge-mounted backhoe	hp	532	532	532	532	532	532	532	532	532	532	532	532	532
	Survey boat	hp	250	250	250	250	250	250	250	250	250	250	250	250	250
dreadging rate (>0)	Barge-mounted derrick crane	Cubic yard/hour	60	60	60	60	60	60	60	60	60	60	60	60	60
	Barge-mounted backhoe	Cubic yard/hour	60	60	60	60	60	60	60	60	60	60	60	60	60
total time required for survey operation	Survey boat	Hour	0	710	770	1,220	760	1,430	810	1,480	990	2,310	2,310	0	0
number of water equipment operators	-	Worker	0	3	3	3	3	3	3	3	3	3	3	0	0
number of construction equipment operators	-	Worker	0	3	3	3	3	3	3	3	3	3	3	0	0
OTHER CATEGORIES	-	Worker	0	0	0	0	0	0	0	0	0	0	0	0	0
OTHER CATEGORIES	-	Worker	0	0	0	0	0	0	0	0	0	0	0	0	0
dredging area over water level	Barge-mounted backhoe	Acres	0	5.4	6.15	10.35	6.15	12.15	6.75	12.6	7.95	21.6	21.6	0	0

Table L-2 Site-specific Data Input for the Remedial Alternatives (continued)

Capping Input

Description	Equipment	Units	Alt 1	Alt 2	Alt 3a	Alt 3b	Alt 3c	Alt 3d	Alt 4a	Alt 4b	Alt 4c	Alt 4d
Volume	Barge-mounted derrick crane	Cubic yard	0	92,068	101,830	118,861	155,028	208,554	85,875	103,216	119,530	146,186
	precision excavator	Cubic yard	0	19,729	21,821	25,470	33,220	44,690	18,402	22,118	25,614	31,326
Volume above water (level 2)	precision excavator	Cubic yard	0	19,729	21,821	25,470	33,220	44,690	18,402	22,118	25,614	31,326
Area above water level	precision excavator	Acres	0	5.25	10.65	12.15	14.55	5.25	10.65	12.15	14.55	17.85
Fuel consumption	Barge-mounted derrick crane	Gallons/hour	0	25	25	25	25	25	25	25	25	25
	Precision excavator	Gallons/hour	0	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6
	Survey boat	Gallons/hour	0	8	8	8	8	8	8	8	8	8
Power rating	Barge-mounted derrick crane	hp	1,890	1,890	1,890	1,890	1,890	1,890	1,890	1,890	1,890	1,890
	precision excavator	hp	532	532	532	532	532	532	532	532	532	532
	Survey boat	hp	250	250	250	250	250	250	250	250	250	250
Capping placement rate (>0)	Barge-mounted derrick crane	Cubic yard/hour	92	92	92	92	92	92	92	92	92	92
	Precision excavator	Cubic yard/hour	92	92	92	92	92	92	92	92	92	92
Total time required for survey operation	Survey boat	Hour	0	60	60	30	80	30	80	30	80	70
Number of water equipment operators	-	Worker	0	3	3	3	3	3	3	3	3	3
Number of construction equipment operators	-	Worker	0	3	3	3	3	3	3	3	3	3
OTHER CATEGORIES	-	Worker	0	0	0	0	0	0	0	0	0	0
OTHER CATEGORIES	-	Worker	0	0	0	0	0	0	0	0	0	0

Table L-3 Sustainability Metrics Summary Output

SUMMARY			Alt_1		Alt_2		Alt_3a		Alt_3b		Alt_3c		Alt_3d	
GAS EMISSION	CO_2 emissions	long ton	CO_2	0	CO_2	15,208	CO_2	11,885	CO_2	12,812	CO_2	16,000	CO_2	18,184
	CO emissions	long ton	CO	0	CO	115	CO	125	CO	135	CO	168	CO	191
	NOx emissions	long ton	NO_x	0	NO_x	525	NO_x	565	NO_x	608	NO_x	760	NO_x	860
	SOx emissions	long ton	SO_x	0	SO_x	31	SO_x	35	SO_x	37	SO_x	47	SO_x	53
WORK ACCIDENTS	Expected number of accidents during remediation activities	-	NI	0.00000	NI	12.7156	NI	8.6738	NI	9.3179	NI	11.6789	NI	13.2015
	Expected number of deadly accidents during remediation activities	-	NF	0.0000	NF	0.0392	NF	0.0290	NF	0.0313	NF	0.0394	NF	0.0453
ENERGY	Energy consumption	MJ	E	0.00E+00	E	3.02E+08	E	3.26E+08	E	3.51E+08	E	4.39E+08	E	4.96E+08
ECOLOGICAL FOOTPRINT	Douglas Fir in Pacific cost	Acre	EF	0	EF	949	EF	963	EF	981	EF	1,009	EF	1,062

SUMMARY			Alt_4a		Alt_4b		Alt_4c		Alt_4d		Alt_5	
GAS EMISSION	CO_2 emissions	long ton	CO_2	23,331	CO_2	27,384	CO_2	31,226	CO_2	38,713	CO_2	80,153
	CO emissions	long ton	CO	248	CO	291	CO	332	CO	412	CO	854
	NOx emissions	long ton	NO_x	1,121	NO_x	1,314	NO_x	1,500	NO_x	1,858	NO_x	3,853
	SOx emissions	long ton	SO_x	69	SO_x	81	SO_x	92	SO_x	114	SO_x	236
WORK ACCIDENTS	Expected number of accidents during remediation activities	-	NI	17.2105	NI	20.1668	NI	23.0410	NI	28.4913	NI	67.7563
	Expected number of deadly accidents during remediation activities	-	NF	0.0550	NF	0.0644	NF	0.0737	NF	0.0911	NF	0.2067
ENERGY	Energy consumption	MJ	E	6.46E+08	E	7.58E+08	E	8.65E+08	E	1.07E+09	E	2.22E+09
ECOLOGICAL FOOTPRINT	Douglas Fir in Pacific cost	Acre	EF	944	EF	961	EF	1,004	EF	1,003	EF	1,067

Note – Green text indicates the lowest effects; red indicates the highest effects.

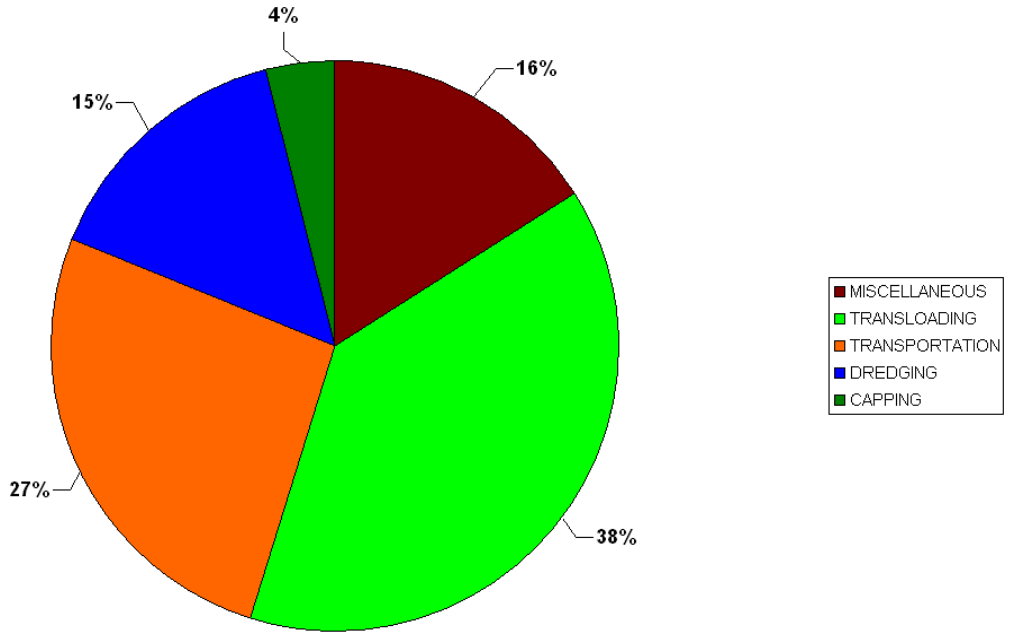

Figure L-1 Percentages of CO_2 Emissions Related to Each Activity for Alternative 3c