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APPENDIX I
GREEN AND SUSTAINABLE REMEDIATION FOOTPRINT ANALYSIS

for

Laboratory for Energy-related Health Research/ Old Campus Landfill Superfund Site University of California, Davis

prepared for

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ACRONYMS AND ABBREVIATIONS

Battelle	Battelle Memorial Institute
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CH_4	methane
CO_2	carbon dioxide
FS – Volume 1	*Final Feasibility Study for the University of California, Davis Areas Volume 1: Soil/Solid Waste and Soil Gas*
GHG	greenhouse gas
GSR	green and sustainable remediation
ITRC	Interstate Technology and Regulatory Council
LTM	long-term monitoring
NO_x	nitrogen oxides
N_2O	nitrous oxide
PM_{10}	particulate matter with diameter less than 10 micrometers
PVC	polyvinyl chloride
RAC	remedial action construction
RACER	Remedial Action Cost Engineering and Requirements
RI	remedial investigation
Site	Laboratory for Energy-related Health Research/Old Campus Landfill Superfund Site
SO_x	sulfur oxides
UC Davis	University of California, Davis
US EPA	United States Environmental Protection Agency

APPENDIX I–GREEN AND SUSTAINABLE REMEDIATION FOOTPRINT ANALYSIS

Although green remediation is not considered one of the nine criteria for evaluation of remedial alternatives under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), according to the *Superfund Green Remediation Strategy* (US EPA, 2010), the use of green remediation practices falls within the statutory and regulatory framework of the Superfund Remedial Program. According to the United States Environmental Protection Agency (US EPA), "Green remediation comprises a range of best practices that may be applied throughout the Superfund cleanup process … The best management practices of green remediation provide potential means to improve waste management; conserve or preserve energy, fuel, water, and other natural resources; reduce [greenhouse gas] emissions; promote sustainable long-term stewardship; and reduce adverse impacts on local communities during and after remediation activities."

This appendix presents sustainable remediation metrics for the ten alternatives proposed in the *Final Feasibility Study for the University of California, Davis* (UC Davis) *Areas Volume 1: Soil/Solid Waste and Soil Gas* (FS – Volume 1) for the University of California, Davis Laboratory for Energy-related Health Research/Old Campus Landfill Superfund Site (Site). The SiteWise™ Version 2 (Battelle, 2011) green and sustainable remediation (GSR) tool was utilized to generate estimates for energy consumption, greenhouse gas (GHG) emissions, common air pollutant (nitrogen oxides [NO_x], sulfur oxides [SO_x], and particulate matter with diameter less than ten micrometers [PM_{10}]) emissions, water consumption, resource consumption, and accident fatality risks. The SiteWise™ Version 2 Tool for Green and Sustainable Remediation is an Excel-based spreadsheet jointly developed by the United States Navy, United States Army Corps of Engineers, and Battelle (Battelle, 2011) and is cited as an example of a publicly-available tool in the Interstate Technology and Regulatory Council (ITRC) document *Green and Sustainable Remediation: A Practical Framework* (ITRC, 2011). SiteWise™ is designed to calculate the environmental footprint of remedial alternatives to provide a baseline numerical assessment and identify aspects of a particular remedy that are the largest contributors to the footprint.

SiteWise™ summarizes remediation activities into four phases that are calculated separately in different modules: remedial investigation (RI), remedial action construction (RAC), remedial action operation, and long-term monitoring (LTM). For the purposes of the FS – Volume 1, only the RAC module was utilized for the baseline assessment. The RI phase is already complete at the Site (Geomatrix, 2004), so no metrics were calculated for this phase. Remedial action operations and long-term monitoring are primarily related to enforcing institutional controls, monitoring groundwater and storm water, and periodic operations and maintenance of the drainage system and surface covers/caps. The remedial action operations and long-term monitoring activities of each of the FS – Volume 1 alternatives would be similar (except for the more frequent repaving of the asphalt caps under Alternative SW-5), and annual costs of these activities are less than one percent of the total present value of each remedial alternative. Consequently, the remedial action operation and long-term monitoring phases were not calculated for this assessment.

Inputs into each of the four SiteWise™ phase modules are summarized into four categories: (1) material production of consumable materials that cannot be reused (e.g., well materials, concrete,

import fill); (2) transportation of personnel, equipment, and materials to and from the Site; (3) on-Site operations, including equipment operations; and (4) management and disposal of waste from the Site. Emissions associated with consumable material production are based on a life-cycle analysis of the material (e.g., polyvinyl chloride [PVC] pipe for well installation), whereas emissions associated with non-consumables (e.g., trucks, backhoes) consider only those emissions generated during the remedial action. Attachment I-1 contains Site-specific assumptions and describes how input values for each of the four categories were estimated for the RAC module used in this evaluation. Attachment I-1a compares the inputs to the model for each remedial alternative in the FS – Volume 1 and provides additional details on calculating the inputs. Unless otherwise stated, model inputs were derived from the Assembly Level Reports generated during cost estimation with the Remedial Action Cost Engineering and Requirements (RACER) cost estimation tool (Appendix F; Attachments F-2c, F-3c, F-4c, F-5c, F-6c, F-7c, F-8c, F-9c, and F-10c).

Outputs of the SiteWise^{TM} tool are summarized into five categories: (1) consumables – life-cycle materials production; (2) transportation – personnel; (3) transportation – equipment, materials, and waste; (4) equipment use and miscellaneous – on-Site equipment use; and (5) residual handling – off-Site landfill operations.

Attachment I-2 contains the SiteWise^{TM} tool completed for the FS – Volume 1 alternatives. Alternative-specific subfolders contain two spreadsheets, one that documents the input values, and one that summarizes the model output and allows for a more detailed analysis to evaluate which factors predominantly affect a specific metric. The root-level FinalSummary.xls spreadsheet compares the nine remedial alternatives against one another (Alternatives SW-2 through SW-10). Further information on the structure and functioning of the SiteWise^{TM} Version 2 model can be obtained in Battelle (2011).

The SiteWise^{TM} model was not run for Alternative SW-1, No Action/No Further Action, as there are no activities associated with this alternative that would generate greenhouse gas emissions, common air pollutant emissions, energy consumption, or accident fatality risk. Furthermore, soil gas samples collected in 2009 indicate that methane was not detected in the land disposal units (Appendix A of the FS – Volume 1). Monitoring well decommissioning under Alternative SW-1 would be deferred to the No Action/No Further Action alternative in the *Feasibility Study for the University of California, Davis* (UC Davis) *Areas Volume 2: Groundwater*.

Table I-1 summarizes the output metrics for each remedial alternative (Alternatives SW-1 through SW-10). Although total energy consumption was estimated, electricity consumption was not estimated in this analysis because the proposed activities do not rely on electricity-powered equipment. GHG emissions include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O); CH_4 and N_2O emissions are converted to CO_2-equivalent emissions within SiteWise^{TM} and summarized as total GHG emissions. Common air pollutant (NO_x, SO_x, and PM_{10}) emissions are reported individually. Metrics of resource consumption include water consumption and the tons of landfill space taken up by hazardous and non-hazardous waste generated at the Site and sent off-Site for disposal. Fatality risks from accidents related to remedial activities are also reported.

Figures I-1 and I-2 illustrate greenhouse gas emissions and total energy use, respectively, for each alternative. Greenhouse gas emissions are similar for Alternatives SW-4 through SW-8. Emissions increase by almost a factor of three for Alternatives SW-9 and SW-10, primarily due to

the substantial increase in transportation mileage associated with off-Site disposal of waste. There is also a notable increase in emissions associated with residual handling; the residual handling category is associated with emissions generated at the final disposal landfills after waste is received at the disposal facilities. Under Alternatives SW-3 through SW-10, appreciable emissions are generated during the life-cycle production and consumption of consumable materials (e.g., PVC for wells, concrete, steel, etc.). The total energy use (Figure I-2) shows a similar pattern to the greenhouse gas emissions (Figure I-1).

NO_x, SO_x, and PM_{10} emissions are shown on Figures I-3, I-4, and I-5, respectively. Emissions of these common air pollutants are relatively low under Alternatives SW-2 through SW-7. Total emissions more than double under Alternative SW-8, and increase by more than a factor of four under Alternatives SW-9 and SW-10. The dominant driver of NO_x and SO_x emissions for Alternatives SW-2 through SW-8 is on-Site use of equipment. Since Alternatives SW-8 through SW-10 would take two years to complete construction, NO_x and SO_x emissions attributed to on-Site equipment use approximately double when compared to the alternatives that would be completed in one year (Alternatives SW-3 through SW-7). The largest increase in NO_x and SO_x emissions under Alternatives SW-9 and SW-10 are attributable to activities at the final disposal landfills. While on-Site equipment use contributes to PM_{10} emissions, the dominant source of PM_{10} emissions is related to activities at the final landfill destinations.

Figure I-6 shows the accident fatality risk for each alternative. Although there is some risk associated with on-Site construction activities, the accident fatality risk is primarily driven by the transportation of materials, equipment, and waste to and from the Site during construction activities.

REFERENCES

Battelle Memorial Institute (Battelle), 2011. *SiteWise™ Version 2 User Guide*, June.

Geomatrix, 2004. *Final UC Davis Remedial Investigation Report, LEHR/SCDS Environmental Restoration*, December.

Interstate Technology and Regulatory Council (ITRC), 2011. *Green and Sustainable Remediation: A Practical Framework*. Technical/Regulatory Guidance, November.

United States Environmental Protection Agency (US EPA), 2010. *Superfund Green Remediation Strategy*, Office of Solid Waste and Emergency Response and Office of Superfund Remediation and Technology Innovation, September.

FIGURES

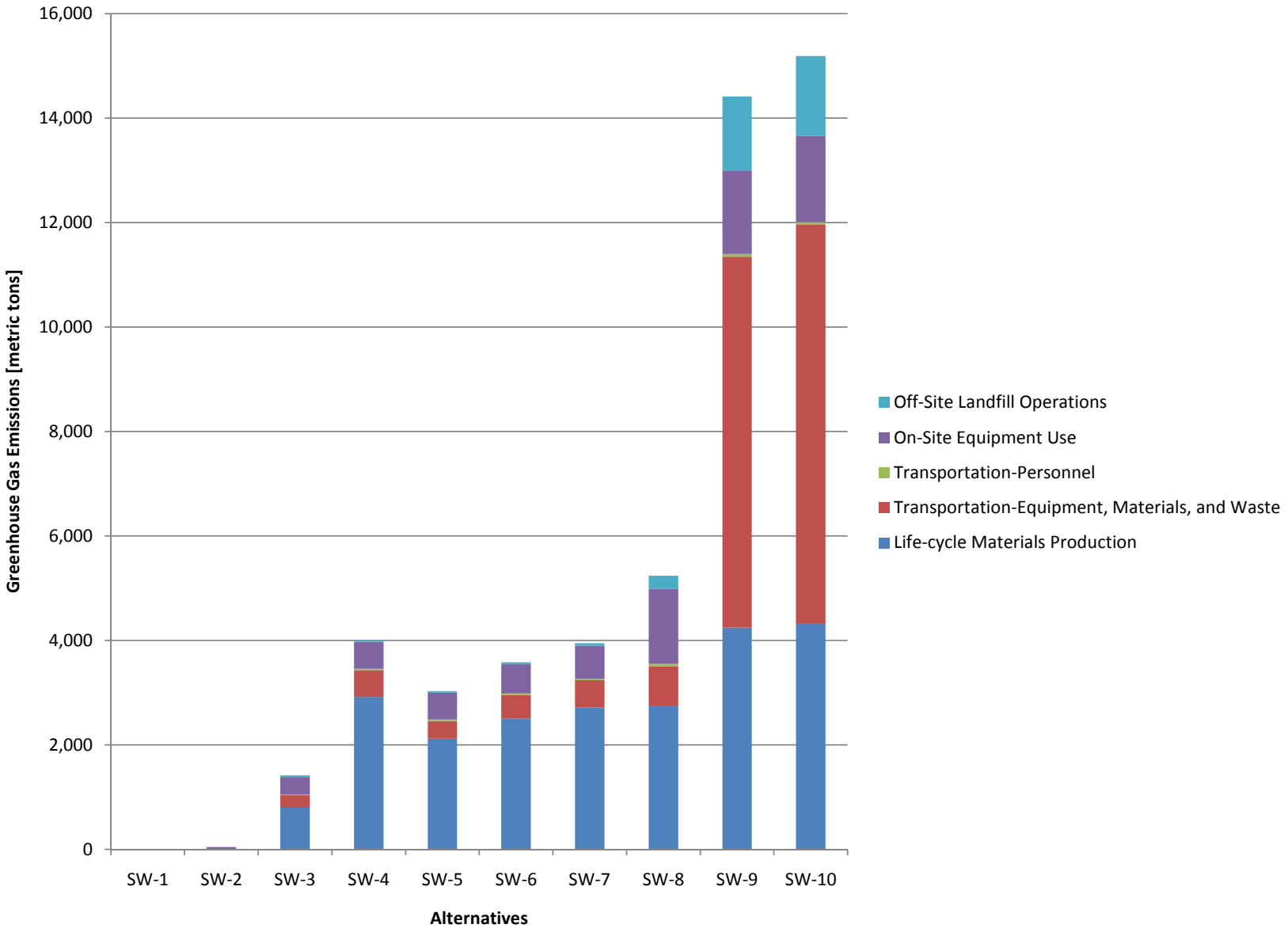

Figure I-1. Greenhouse Gas Emissions Estimates by Alternative - Green and Sustainable Remediation Footprint Analysis, LEHR/OCL, UC Davis

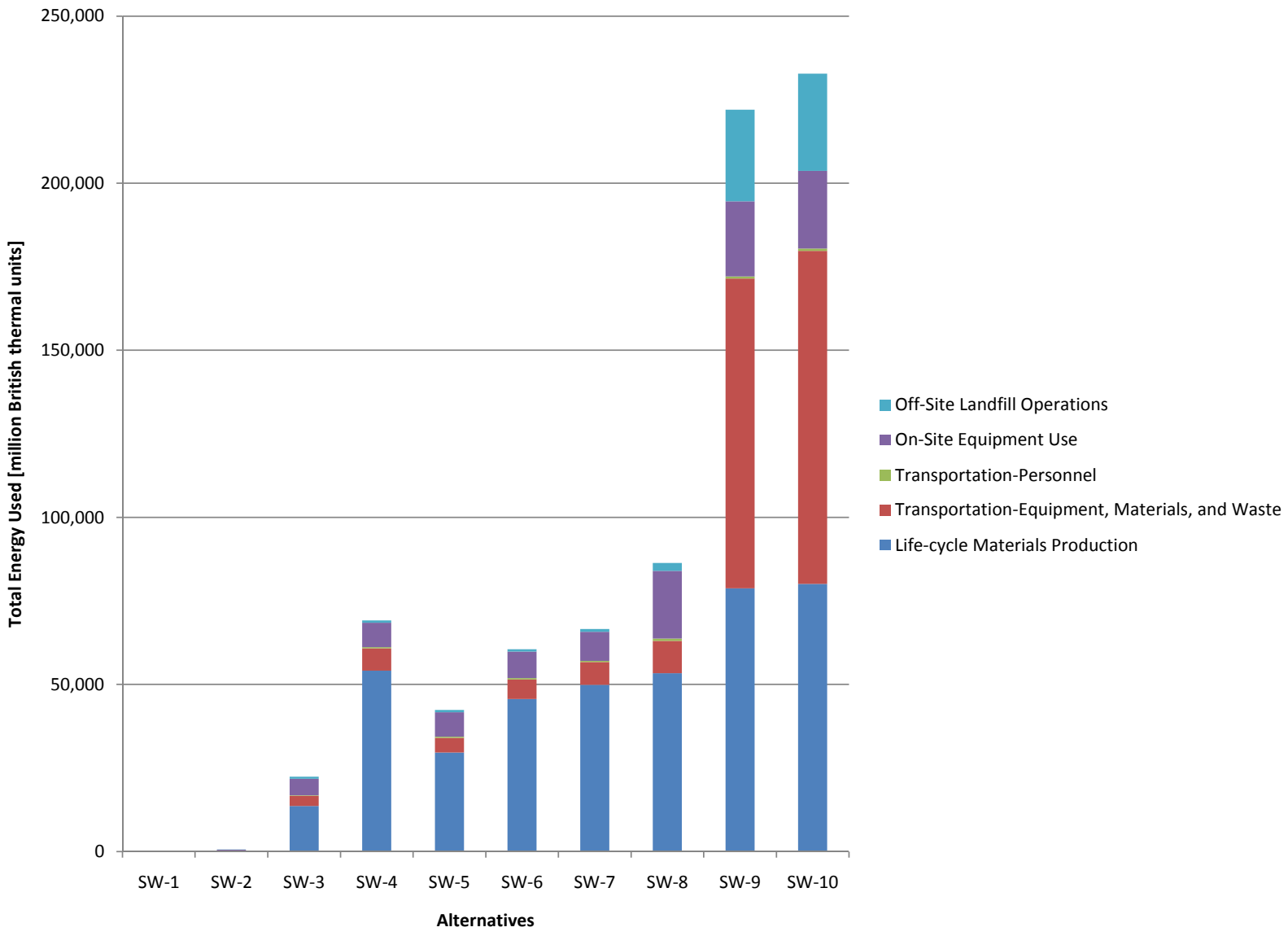

Figure I-2. Total Energy Use Estimates by Alternative - Green and Sustainable Remediation Footprint Analysis, LEHR/OCL, UC Davis

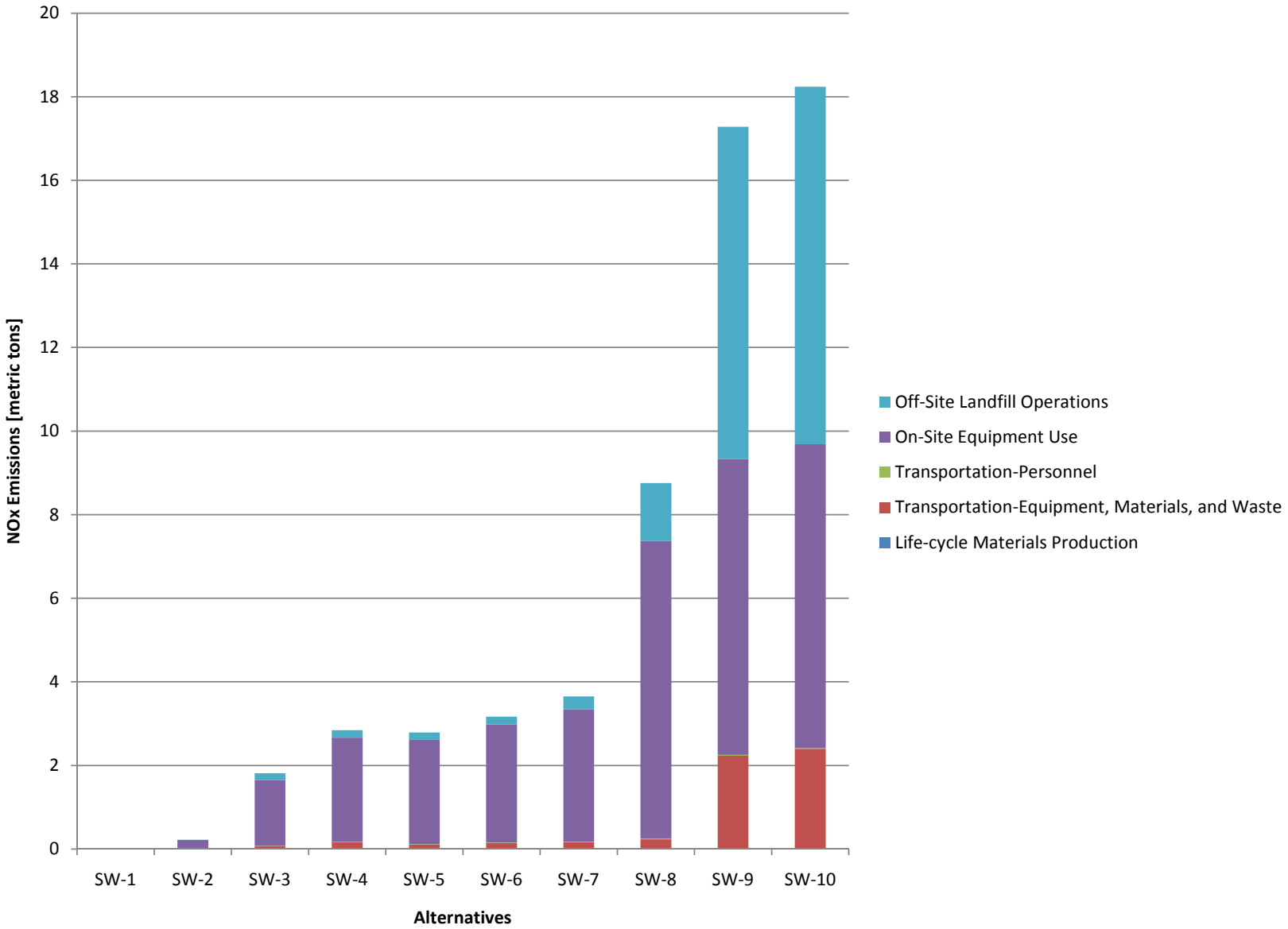

Figure I-3. Nitrogen Oxides (NO_x) Emissions Estimates by Alternative - Green and Sustainable Remediation Footprint Analysis, LEHR/OCL, UC Davis

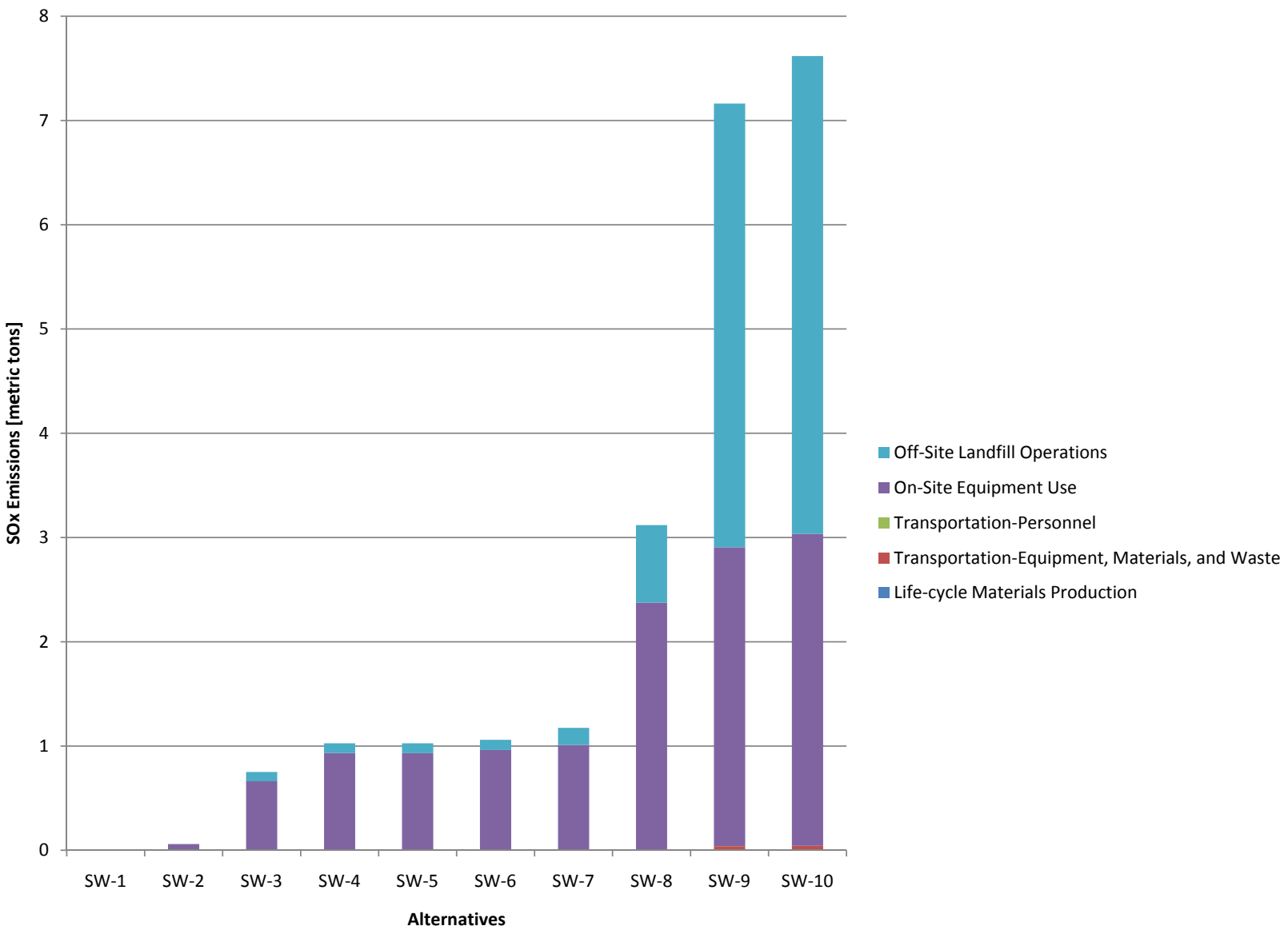

Figure I-4. Sulfur Oxides (SO_x) Emissions Estimates by Alternative - Green and Sustainable Remediation Footprint Analysis, LEHR/OCL, UC Davis

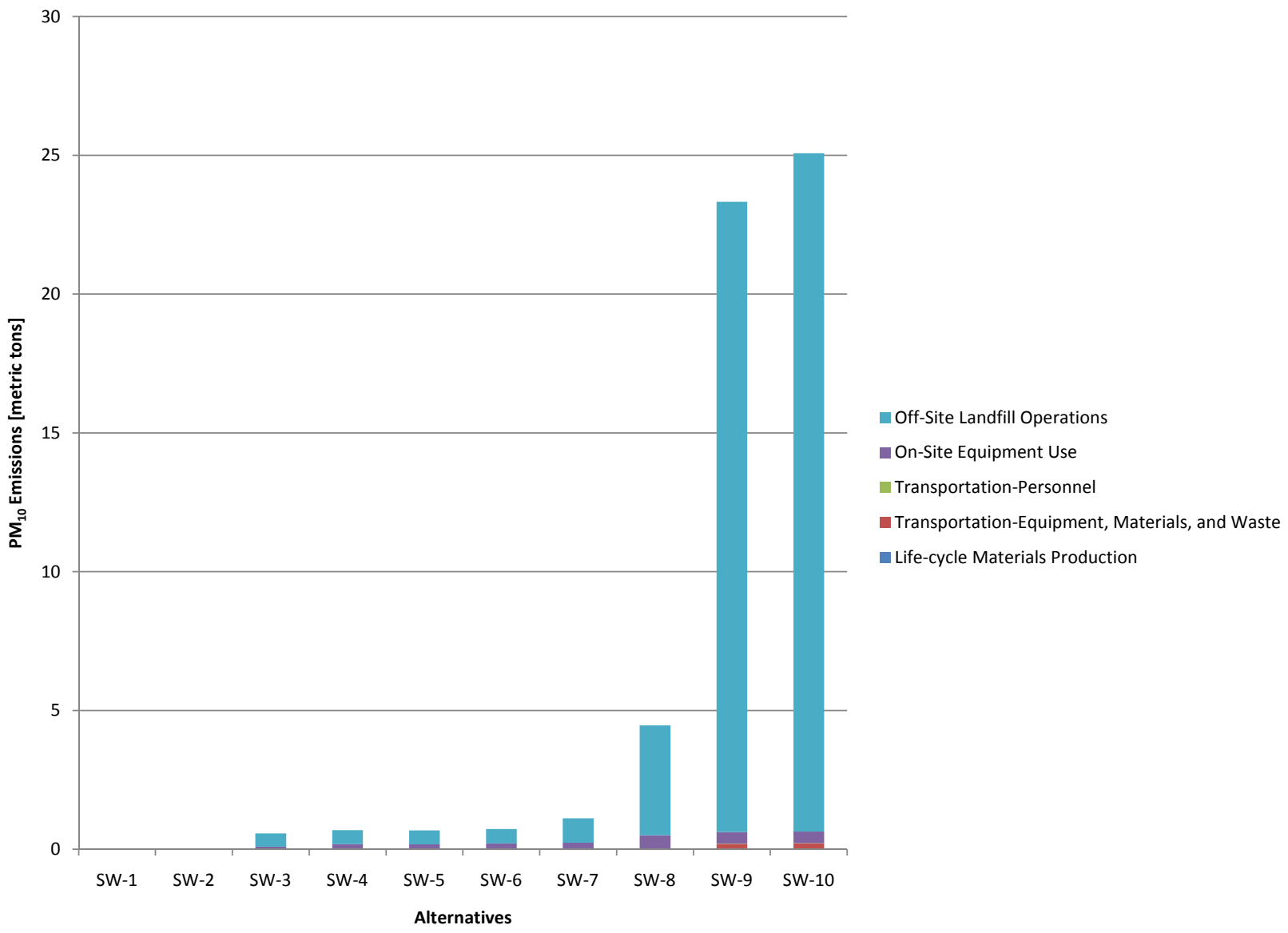

Figure I-5. Particulate Matter with a Diameter Less than 10 Micrometers (PM_{10}) Emissions Estimates by Alternative - Green and Sustainable Remediation Footprint Analysis, LEHR/OCL, UC Davis

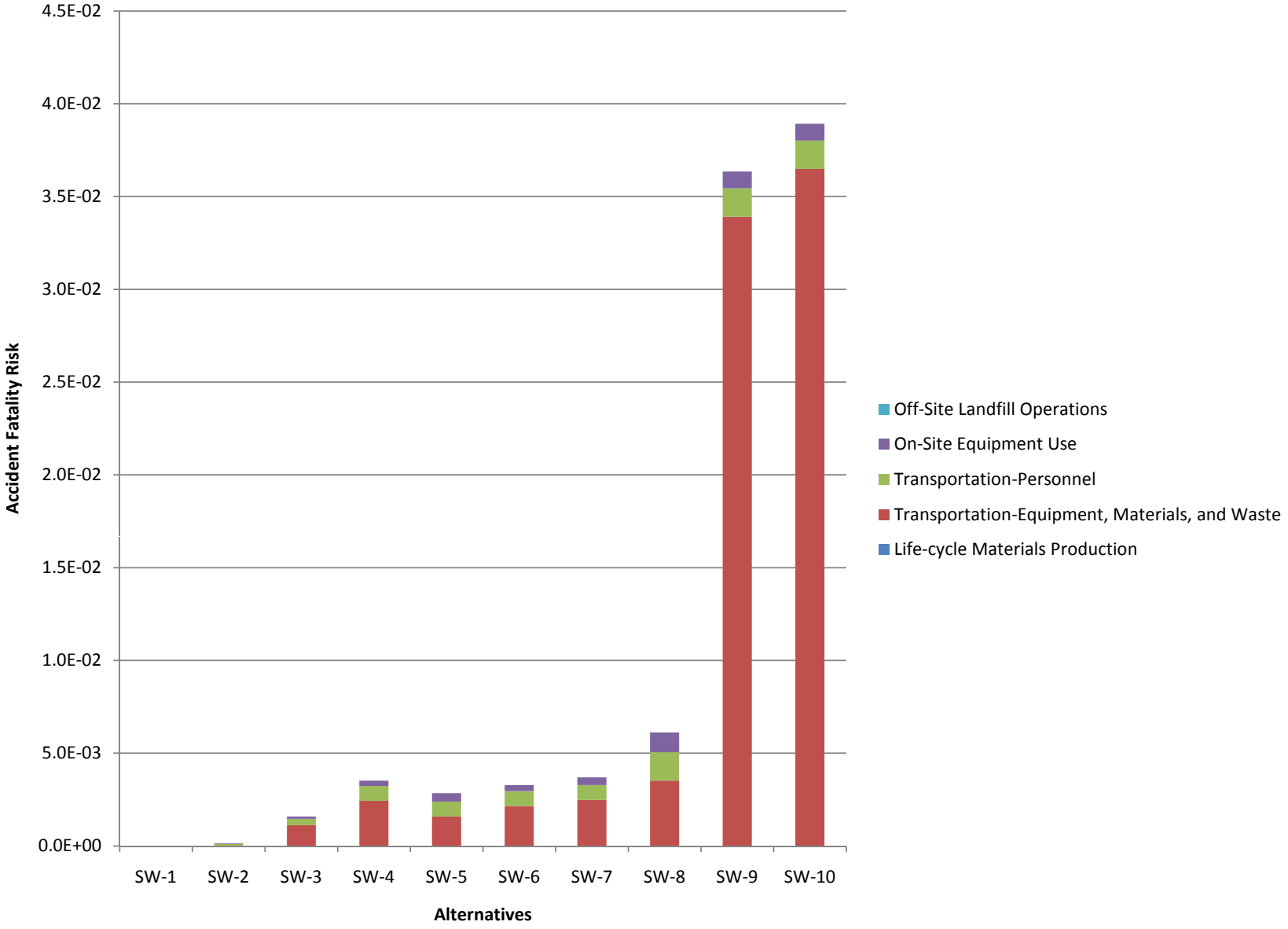

Figure I-6. Accident Fatality Risk Estimates by Alternative - Green and Sustainable Remediation Footprint Analysis, LEHR/OCL, UC Davis

TABLE

Table I-1. Site Environmental Footprint for the FS - Volume 1 Remedial Alternatives - Green and Sustainable Remediation Footprint Analysis, UC Davis LEHR/OCL

Remedial Alternatives	GHG Emissions[a]	Total Energy Used	Diesel Fuel Equivalent[b]	NO_x Emissions	SO_x Emissions	PM_{10} Emissions	Water Consumption	Non-Hazardous Waste Landfill Space	Hazardous Waste Landfill Space	Accident Fatality Risk[c]
	Metric Tons	MMBTUs	Gallons	Metric Tons	Metric Tons	Metric Tons	Gallons	Tons	Tons	
SW-1	0	0	0	0.0	0.0	0.0	0	0	0	0.00E+00
SW-2	42	550	3,958	0.2	0.1	0.02	414,250	0	4	1.52E-04
SW-3	1,415	22,408	161,205	1.8	0.8	0.6	1,243,750	33	2,361	1.59E-03
SW-4	4,002	69,151	497,488	2.8	1.0	0.7	3,724,930	0	2,516	3.52E-03
SW-5	3,029	42,343	304,626	2.8	1.0	0.7	3,724,930	0	2,516	2.85E-03
SW-6	3,582	60,507	435,302	3.2	1.1	0.7	3,724,930	0	2,626	3.28E-03
SW-7	3,945	66,589	479,061	3.7	1.2	1.1	3,724,930	1,798	2,752	3.69E-03
SW-8	5,236	86,356	621,266	8.8	3.1	4.5	7,046,610	17,989	3,481	6.12E-03
SW-9	14,414	221,962	1,596,852	17.3	7.2	23.3	7,046,610	16,396	98,835	3.64E-02
SW-10	15,187	232,758	1,674,518	18.2	7.6	25.1	7,046,610	20,264	104,005	3.89E-02

Notes:

Results from SiteWise™ Version 2 (Battelle, 2011), see Attachment I-2

[a] Greenhouse gas emissions include contributions from carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)

[b] MMBTUs converted to gallons of diesel fuel, using the conversion factor in Exhibit 3.13 in US EPA (2011)

[c] The accident fatality risk estimated in SiteWise™ includes the risk from both on-Site workers during remedial construction and from traffic accidents of off-Site transportation of personnel, equipment, materials, and waste

Acronyms/Abbreviations:

GHG - greenhouse gas

NO_x - nitrogen oxides

SO_x - sulfur oxides

PM_{10} - particulate matter with diameter less than 10 micrometers

MMBTUs - million British thermal units

US EPA - United States Environmental Protection Agency

References:

Battelle Memorial Institute (Battelle), 2011. *SiteWise™ Version 2 User Guide,* June.

United States Environmental Protection Agency, 2011. *Methodology for Understanding and Reducing a Project's Environmental Footprint: Draft for Public Input,* September.

ATTACHMENT I-1

SITEWISE™ VERSION 2 GREEN AND SUSTAINABLE REMEDIATION TOOL ASSUMPTIONS AND INPUTS

ATTACHMENT I-1: Sitewise™ Version 2 Green and Sustainable Remediation Tool Assumptions and Inputs

ACRONYMS AND ABBREVIATIONS

Battelle	Battelle Memorial Institute
BCY	bank cubic yard
CY	cubic yards
DDC	density-driven convection
FS – Volume 1	*Final Feasibility Study for the University of California, Davis Areas Volume 1: Soil/Solid Waste and Soil Gas*
GAC	granular activated carbon
GCL	geosynthetic clay liner
HDPE	high-density polyethylene
HP	horsepower
HSU	hydrostratigraphic unit
LCY	loose cubic yard
LFU	landfill unit
LLRW	low-level radioactive waste
mil	1/1,000th of an inch
PTW	principal threat waste
PVC	polyvinyl chloride
RACER	Remedial Action Cost Engineering and Requirements
RCRA	Resource Conservation and Recovery Act
Site	Laboratory for Energy-related Health Research/Old Campus Landfill Superfund Site

OVERVIEW

This attachment outlines assumptions used to calculate the input values used in the SiteWise™ green and sustainable remediation Excel-based spreadsheet tool (Battelle, 2011). This

tool was used to calculate sustainable remediation metrics for remedial alternatives proposed in the *Final Feasibility Study for the University of California, Davis Areas Volume 1: Soil/Solid Waste and Soil Gas* (FS – Volume 1) at the Laboratory for Energy-related Health Research and the Old Campus Landfill Superfund Site (Site) at the University of California, Davis. Input values can be found in Attachment I-1a (Attachment_I-1a_Table_SiteWise_AssumptionsAndInputs.xlsx).

Data were compiled from the FS – Volume 1 tables (Table 6-2, Table 6-3), the Remedial Action Cost Engineering and Requirements (RACER) Cost Assumptions (Appendix F, Attachments F-2a, F-3a, F-4a, F-5a, F-6a, F-7a, F-8a, F-9a, F-10a), and the RACER Assembly Level Reports (Appendix F, Attachments F-2c, F-3c, F-4c, F-5c, F-6c, F-7c, F-8c, F-9c, F-10c). Text in *italics* denotes an assembly description, as calculated by RACER.

Professional judgment was utilized to estimate what quantity of materials would make a meaningful contribution to the total volume of materials. In particular, for the bulk materials category, the top six contributors by volume were used as inputs.

For calculations involving time, it was assumed that each month contains four weeks, each week involves five days of remedial action, and each day would involve eight hours of work.

MATERIAL PRODUCTION

WELL MATERIALS

Well material estimates are from the RACER Cost Assumptions (Appendix F, Attachments F-2a, F-3a, F-4a, F-5a, F-6a, F-7a, F-8a, F-9a, F-10a).

For density-driven convection (DDC) wells and temporary piezometers, the total depth was taken as the sum of three nested piezometers at 30-foot (shallow), 52-foot (intermediate), and 76-foot (deep) depths, for a total length of 158 feet.

TREATMENT CHEMICALS AND MATERIALS

None of the remedial alternatives propose on-Site chemical treatment as a component. Although some *ex situ* treatment of soil/solid waste is assumed for Alternatives SW-3 through SW-10, the treatment chemicals are unknown at this time, and thus no footprint calculations were made. It is assumed that treatment volumes would be a small component of the total volume of waste generated, and thus would not contribute appreciably to the total Site environmental footprint.

TREATMENT MEDIA

None of the remedial alternatives propose on-Site treatment media (virgin granular activated carbon [GAC], regenerated GAC, ion exchange resin) as a component.

CONSTRUCTION MATERIALS

Material 1: HDPE Liner. 40-mil (1 mil is equal to 1/1000th of an inch) high-density polyethylene (HDPE) liner used in the capping material. Surface area estimates are from RACER (*40 Mil Polymeric Liner, High-density Polyethylene*).

Material 2: HDPE Liner. 60-mil HDPE liner used for drum staging and to line the extended detention basins. Total surface area estimates are from RACER (*60 Mil Polymeric Liner, High-density Polyethylene*).

Material 3: General Concrete. For Alternative SW-3, the area of concrete is the surface area of the Landfill Unit (LFU) No. 1 drainage channel (*Shallow Concrete Ditching*), assumed to be three feet wide at the bottom, three feet deep, with 2:1 side slopes; the thickness of the drainage channel is assumed to be two inches. For Alternatives SW-4, SW-5, and SW-6, the area of concrete is the surface area of the LFU-3 concrete-lined drainage channel (*Concrete Ditching, 7' Bottom, 7' Deep, 2:1 Side Slopes*); the thickness of the drainage channel is assumed to be two inches. Additional concrete is estimated below in the "Bulk Material Quantities" category.

WELL DECOMMISIONING

Well decommissioning estimates are from the RACER Cost Assumptions (Appendix F, Attachments F-2a, F-3a, F-4a, F-5a, F-6a, F-7a, F-8a, F-9a, F-10a). The input depth was taken as the average depth of the decommissioned wells for each well diameter. For this assessment, it is assumed that soil would be used for well decommissioning.

BULK MATERIAL QUANTITIES

General: The volume of grout is estimated as the linear feet of grout (e.g., *2" Well, Portland Cement Grout*) multiplied by the annular area between the outer borehole and inner well casing. The borehole diameter was assumed to be eight inches for a 2-inch diameter well, 11 inches for a 4-inch diameter well, and 16 inches for the nested piezometers and DDC wells. To account for the thickness of the well casing, 0.5 inches was added to the inner well casing diameter (e.g., 2.5 inches for a 2-inch diameter well). The grout was assumed to be 96 percent concrete and four percent bentonite.

Material 1: Bentonite. The volume of bentonite is estimated as the volume of bentonite from well grout, as explained above, plus the volume of bentonite in the multiple-layer cap geosynthetic clay liner (GCL), calculated as the surface area multiplied by the thickness of the GCL (*Bentonite, rolls, with geotextile fabric both sides, 3/8" thick*).

Material 2: Concrete. The volume of concrete is estimated as the volume of concrete from well grout, as explained above, plus the volume of concrete in the surface pads that anchor the monitoring wells (*Surface Pad, Concrete, 2' x 2' x 4"*). For Alternative SW-8, the concrete estimates also include the volume of a sump (*5' x 5' x 5' Reinforced Concrete Sump*) and slab for the leachate collection tank (*6" Structural Slab on Grade*). In addition, the concrete estimates include headwalls (46 cubic feet of concrete estimated per headwall) and lift station sumps (39 cubic feet of concrete estimated per lift station) installed as part of the storm water drainage system. Since SiteWise™

does not have a material input for asphalt, the volume of material for the SW-5 asphalt caps was input as concrete (*Asphalt Pavement- 6" Base Course Layer, 3" Topping*).

Material 3: Soil. The total input volume of soil is the sum of the volume of *Unclassified Fill, 6" Lifts, Off-Site, Includes Delivery, Spreading, and Compaction* and the volume of *Loam or topsoil, imported topsoil, 6" deep, furnish and place* used for capping (excluding volumes assumed for operations and maintenance). For Alternative SW-4, the volume of *Silty/Clayey Loam, Delivered, Dumped & Spread*, used for the evapotranspiration caps, was also added to the soil volume.

Material 4: Gravel. The volume of gravel for bulk material storage is estimated from the total volume from RACER (*Gravel, 6" Lifts*). Since Alternatives SW-8, SW-9, and SW-10 would take two years to complete construction activities, it was assumed that the same gravel footprint could be used during both the first and second year to handle bulk storage of excavated material.

Material 5: Polyvinyl Chloride (PVC). The 40-mil PVC liner used for bulk material storage. Total surface area estimates are from RACER (*40 Mil Polymeric Liner, PVC*).

Material 6: Steel. The volume of steel was estimated from length estimates of 24-inch diameter corrugated metal pipe, assumed to be made of steel. The total volume of steel was estimated using the specified diameter of the pipe (24-inch), the assumed thickness (1/8-inch), and the linear length of the pipe; the linear length estimates are from RACER (*24" Corrugated Metal Pipe, Bituminous Coated & Paved*; *18' Complete, 24" Corrugated Metal Pipe Culvert with Headwalls*; *34' Complete, 24" Corrugated Metal Pipe Culvert with Headwalls*).

EQUIPMENT TRANSPORTATION

It was assumed that all transportation for personnel and equipment would be via road. Thus nothing was input into the air, rail, and water modes of transportation for both personnel and equipment.

PERSONNEL TRANSPORTATION - ROAD

Trip 1: On-Site Construction Personnel. It is assumed that construction personnel would commute from the surrounding region, with an estimated 50 mile round-trip distance. During the course of remedial action, it is estimated that ten people would be on-Site each day. The duration of remedial activity is estimated from the time the decontamination facilities are on-Site (*8' x 24' Decontamination Trailer with 4 Showers, HVAC, 2 Sinks*). It is assumed that each trip would involve two people in a light truck.

Trip 2: Off-Site Consultant Engineer/Manager/Field Technician Personnel. It is assumed that off-Site consultants, engineers, and field technicians would make 50 trips per year during the remedial action construction, at a round-trip distance of 130 miles. Alternatives SW-2 through SW-7 are estimated to take one year, and Alternatives SW-8, SW-9, and SW-10 are estimated to take two years. It is assumed that each trip would involve two people in a light truck. Under Alternative SW-2, which would not involve excavation of material, only 15 trips are assumed.

EQUIPMENT TRANSPORTATION - ROAD

Trip 1: Heavy Equipment. It is assumed that each load of heavy equipment transported to the Site would come from a 25-mile radius (50 mile round-trip) and would weigh approximately 20 tons. Four pieces of equipment are assumed for Alternative SW-2; 20 pieces of heavy machinery would be transported for Alternatives SW-3 through SW-10. It is further assumed that the equipment would be transported to and from the Site annually for two years under Alternatives SW-8, SW-9, and SW-10.

Trip 2: Materials Import. The quantity of materials brought to the Site for construction activities can be estimated as the sum of the "Bulk Materials Quantities" calculated above. Soil (material 3) was not included in this sum because import fill is calculated below (trip 4). Similarly, for Alternative SW-5, the import of concrete for the asphalt caps (portion of material 2) was estimated during the import fill material (trip 4) below, so the volume of concrete attributed to the asphalt caps was subtracted from the total volume of bulk material. It is assumed that each truck trip would import 20 cubic yards (CY) of material, and that each full load would carry the maximum weight permitted, 40 tons. It is also assumed that materials could be obtained within a 25-mile radius, so the round-trip distance would be 50 miles. The estimated truck miles account for round trips, so truck weights are set at 20 tons per load to account for the averaging of 40 tons one way and 0 tons for the return trip. Since SiteWise™ calculates fuel economy based on a linear interpolation of weight, this simple averaging is appropriate for the model.

Trip 3: Off-Site Waste Disposal. This input contains the total number of miles travelled for off-Site disposal of the waste generated by the remedial alternatives, as calculated on Table 6-3.

Trip 4: Import Fill Material. This input contains the total number of miles travelled for on-Site import of fill material, as calculated on Table 6-3.

Trip 5: Import Cap Fill Material. This input contains the total number of miles travelled for on-Site import of fill material used for cover/cap construction, as calculated on Table 6-3.

For trips 3, 4, and 5, it is assumed that each truck trip holds 20 CY of material, and with an assumed density of 1.0 ton per loose cubic yard (LCY) of material, each truck load containing soil and/or waste would weigh 20 tons; the round-trip weight would be 10 tons.

EQUIPMENT USE

EARTHWORK

Equipment 1: Excavator. This column contains the total volume of soil/solid waste excavated from the landfills in bank CY (BCY); as calculated in Table 6-2. Although principal threat waste (PTW) would be excavated from the historical and proposed exploratory trenches with a backhoe rather than an excavator, the volume of PTW from trenching is small compared to the total excavated volume, and thus it is assumed that the difference in emissions between these two types of equipment are small. Under Alternative SW-2, only PTW would be excavated, so the equipment type would be a loader/backhoe for this alternative.

Equipment 2: Loader/Backhoe. This column contains the total volume of exhumed soil/solid waste in LCY (Table 6-2) that would then be moved around the Site during the waste

characterization phase, (i.e., when the waste is sorted, sampled, and characterized as either low-level radioactive waste (LLRW), mixed waste, Resource Conservation and Recovery Act [RCRA] hazardous waste, non-RCRA hazardous waste, and non-hazardous waste). The total volume was multiplied by a factor of two to account for various Site emissions of heavy construction equipment (e.g., loaders, backhoes, bobcats) that would be used during the waste characterization phase.

Equipment 3: Loader/Backhoe. This column contains the total volume of exhumed soil/solid waste in LCY (Table 6-2) that would be loaded into a dump truck for off-Site disposal or consolidated within an on-Site corrective action management unit.

Equipment 4: Scraper. This column contains the estimated volume of soil that would be scraped as part of establishing the proper grades for the surface covers/caps. It is assumed that approximately one foot of soil would be scraped. Cover/cap surface areas are those areas assumed in the RACER Cost Assumptions (Appendix F, Attachments F-2a, F-3a, F-4a, F-5a, F-6a, F-7a, F-8a, F-9a, F-10a).

DRILLING

Drilling locations are the sum of boreholes for new hydrostratigraphic unit (HSU)-1 monitoring wells, HSU-2 monitoring wells, replacement DDC wells, and replacement temporary piezometers. A hollow stem auger drilling method is typically used at the Site. It is estimated that each well would require 20 hours of drill rig time for drilling and well completion.

In addition, it is assumed that well decommissioning would involve overdrilling the existing boreholes with a hollow stem auger. Drilling locations are the sum of the boreholes that would be decommissioned. It is estimated that each well would require ten hours of drill rig time for drilling and subsequent grouting of the decommissioned well.

TRENCHING

It is assumed that trenching associated with excavation of historical exploratory trenches and proposed exploratory trenches would be conducted with a backhoe; these volumes are already included in the total volume of excavated waste in the “Earthwork” category above. Emissions from other trenching during remedial construction, such as trenching for the storm water drainage enhancements, are assumed to be small compared to emissions from excavation.

PUMP OPERATION

None of the remedial alternatives propose pump operations as a component.

DIESEL AND GASOLINE PUMPS

None of the remedial alternatives would require diesel or gasoline pumps for the remedial action construction or operations; use of pumps for remedial action construction is assumed to be minimal compared to other on-Site activities.

BLOWER, COMPRESSOR, MIXER, AND OTHER EQUIPMENT

None of the remedial alternatives would require blowers, compressors, mixers, or other similar equipment for the remedial action construction or operations. Equipment associated with waste sorting, screening, and characterization are handled in the "Internal Combustion Engines" category below.

GENERATORS

None of the remedial alternatives propose the use of generators to power ongoing remedial components, and any use of generators for remedial action construction is assumed to be minimal compared to other on-Site activities.

AGRICULTURAL EQUIPMENT

None of the remedial alternatives would involve agricultural equipment as a component.

CAPPING EQUIPMENT

Cover/cap surface areas are those areas assumed in the RACER Cost Assumptions (Appendix F, Attachments F-2a, F-3a, F-4a, F-5a, F-6a, F-7a, F-8a, F-9a, F-10a). It is assumed that it would take five days to complete grading at the Site. For Alternative SW-9, the time available for grading is estimated to be only three days due to the smaller surface area of the cap.

MIXING EQUIPMENT

None of the remedial alternatives would involve mixing equipment; any use of mixing equipment for remedial action construction is assumed to be minimal compared to other on-Site activities.

INTERNAL COMBUSTION ENGINES

Internal combustion engine input values were estimated for on-Site equipment associated with the waste characterization phase, and include a trommel screener, grizzly shaker, double-tray vibrating screening unit, and conveyor. The fuel consumption was estimated using the approach to quantify fuel use for heavy equipment, as outlined in the 2011 United States Environmental Protection Agency *Draft Methodology for Understanding and Reducing a Project's Environmental Footprint*. This approach calculated fuel usage by multiplying the horsepower (HP) by the number of operating hours multiplied by a brake-specific fuel capacity (0.050 gallons per HP-hour for diesel and biodiesel), and a partial load factor. For this assessment, the HP was estimated as 80 HP for the trommel screener and grizzly shaker and 50 HP for the conveyor and vibrating screening unit (based on a vendor survey of representative equipment). The hours of operation for the grizzly shaker and trommel screener were obtained from RACER; the conveyor and vibrating screening unit were assumed to operate the same length of time. The partial load factor was estimated at 0.75, as it was assumed that equipment would be operating at full capacity approximately 75 percent of the time.

OTHER FUELED EQUIPMENT

It is assumed that no additional fueled equipment would generate meaningful Site emissions.

OPERATOR LABOR

Operator labor hours were estimated for construction laborers and scientific and technical services at the Site from data in the RACER assembly descriptions. Site personnel were categorized as either construction laborers or scientific/technical personnel, depending on their role at the Site. Office-related tasks, monitoring, and operations and maintenance hours were not included in this analysis because they would not affect injury and fatality accident risks related to remedial action construction. The *OperatorLabor* tab in Attachment I-1a details the RACER assembly descriptions used to estimate the total hours of operator labor for each remedial alternative. SiteWise™ automatically estimates accident risks for equipment operators, so input hours for these personnel were not estimated in this category.

LABORATORY ANALYSIS

The input dollars spent on laboratory analyses were calculated as the total cost of RACER assembly descriptions that correspond to laboratory analyses. The *LaboratoryAnalysis* tab in Attachment I-1a details the RACER assembly descriptions used to estimate the total cost of laboratory analyses for each remedial alternative.

OTHER KNOWN ON-SITE ACTIVITIES

There are no current or proposed on-Site activities associated with soil/solid waste and soil gas that involve energy usage, water consumption, or greenhouse gas and air emissions. Soil gas samples collected in 2009 did not detect methane at the land disposal units (Appendix A of the FS – Volume 1).

RESIDUAL HANDLING

RESIDUE DISPOSAL/RECYCLING

The estimated distance and weight of waste disposal was input into the "Equipment Transportation – Road" category (trip 3) to better account for the four waste destinations (non-hazardous, hazardous, mixed waste/LLRW, and biological LLRW).

LANDFILL OPERATIONS

Operation 1: Hazardous. The volume of hazardous waste is the sum of LLRW, mixed waste, RCRA hazardous waste, non-RCRA hazardous waste, and hazardous building demolition waste, as calculated on Table 6-2. To convert volume to weight, it is assumed that the density of the waste is 1.0 tons per LCY. Given the length of time since land disposal activities at the Site, it is assumed that much of the organic material has already decayed at the Site, and that future methane emissions would be much less than a comparable municipal solid waste landfill; soil gas samples collected in

2009 did not detect methane at the land disposal units (Appendix A of the FS – Volume 1). Landfill methane emissions are not input into the footprint calculations.

Operation 2: Non-hazardous. The volume of non-hazardous waste is calculated on Table 6-2. Under Alternatives SW-3, SW-9, and SW-10, the volume of non-hazardous building demolition waste (Table 6-2) would also be taken off-Site for disposal. To convert volume to weight, it is assumed that the density of the waste is 1.0 tons per LCY. Landfill methane emissions are unknown and not input into the footprint calculations.

THERMAL/CATALYTIC OXIDIZERS

None of the remedial alternatives propose thermal/catalytic oxidizers as a component.

RESOURCE CONSUMPTION

WATER CONSUMPTION

It is conservatively assumed that water consumed on-Site would come from a potable water treatment facility. The total volume consumed is the sum of the following volumes:

- Equipment decontamination water volume, estimated as the gallons per minute consumption rate of the pressure washer (varies by alternative) multiplied by the estimated operating time of the pressure washer (*Operation of Pressure Washer, Including Water, Soap, Electricity, Labor*).
- For personnel decontamination in the decontamination facility, it is assumed that five people would shower for five minutes per day with a 4.5 gallon per minute showerhead for the duration of the field activities, estimated as the number of months the decontamination facilities would be on-Site (*8' x 24' Decontamination Trailer with 4 Showers, HVAC, 2 Sinks*).
- For demolition and decontamination during building removal, the volume of water consumed is estimated as the volume of *Process Water, Supplied by Water Line*.
- For dust control, it is estimated that 20,000 gallons of water per day would be necessary to control dust at the Site for the duration of the remedial activity (approximately 0.06 inches depth of water applied over an acre per day) (based on conversations with contractors).

To estimate the volume of water discharged to a wastewater treatment facility, it is assumed that all water used for decontamination would be disposed of at a wastewater treatment facility. It is further assumed that water used for dust control would evaporate and would not be discharged to a wastewater treatment facility.

ON-SITE LAND AND WATER RESOURCE CONSUMPTION

Fill generated on-Site for remedial alternatives has already been accounted for in the estimated volume of material excavated. Water consumed on-Site is conservatively estimated to

come from a potable water supply and is accounted for above. As a result, no values are input into this category.

REFERENCES:

Battelle Memorial Institute (Battelle), 2011. *SiteWise™ Version 2 User Guide*, June.

United States Environmental Protection Agency, 2011. *Methodology for Understanding and Reducing a Project's Environmental Footprint: Draft for Public Input*, September.

ATTACHMENT I-1A

TABLE OF SITEWISE™ ASSUMPTIONS AND INPUTS

See file in 'Appendix_I' Folder titled
Attachment I-1a_Table_SiteWise_AssumptionsAndInputs.xlsx

ATTACHMENT I-2

SITEWISE™ VERSION 2 GREEN AND SUSTAINABLE REMEDIATION TOOL INPUTS AND RESULTS

See files in 'Appendix_I/Attachment_I-2' Folder