60% Remedial Design Basis of Design Report

# Appendix L
# Green Remediation Evaluation and Implementation Approach

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# ABBREVIATIONS

| | |
|---|---|
| AC | activated carbon |
| BMP | best management practice |
| BODR | *Basis of Design Report* |
| $CH_4$ | methane |
| CO | carbon monoxide |
| $CO_2$ | carbon dioxide |
| $CO_2$-eq | carbon dioxide equivalent |
| Crowley | Crowley Maritime |
| CWA | Clean Water Act |
| EmF | emission factor |
| ENR | enhanced natural recovery |
| EPA | U.S. Environmental Protection Agency |
| ESA | Endangered Species Act |
| FS | Feasibility Study |
| g | gram |
| g/hp-hr | grams of pollutant per horsepower-hour |
| GHG | greenhouse gas |
| GWP | global warming potential |
| HC | hydrocarbon |
| hp | horsepower |
| LDW | Lower Duwamish Waterway |
| LDWG | Lower Duwamish Waterway Group |
| MOVES3.0.2 | Motor Vehicle Emission Simulator |
| $N_2O$ | nitrous oxide |
| $NO_x$ | nitrogen oxide |
| OSWER | Office of Solid Waste and Emergency Response |
| PM | particulate matter |
| $PM_{10}$ | particulate matter less than 10 microns in diameter |
| $PM_{2.5}$ | particulate matter less than 2.5 microns in diameter |
| RAA | remedial action area |
| RAO | remedial action objective |
| RCRA | Resource Conservation and Recovery Act |
| RD | remedial design |
| RDWP | *Remedial Design Work Plan for the Lower Duwamish Waterway Middle Reach* |
| RM | river mile |
| RMC | residuals management cover |

| | |
|---|---|
| ROD | *Record of Decision* |
| SMA | sediment management area |
| $SO_2$ | sulfur dioxide |
| TSCA | Toxic Substances Control Act |
| VOC | volatile organic compound |

# 1 Introduction

This appendix presents the *Green Remediation Evaluation and Implementation Approach* for the sediment remedy for the middle reach (river miles [RMs] 1.6 to 3.0) and upper reach Sediment Management Area (SMA) 10[1] of the Lower Duwamish Waterway (LDW) Superfund Site in King County, Washington. The remedy was selected in the U.S. Environmental Protection Agency's (EPA's) November 2014 *Record of Decision* (ROD; EPA 2014); this evaluation is consistent with the *Remedial Design Work Plan for the Lower Duwamish Waterway Middle Reach* (RDWP; Anchor QEA and Windward 2022) as a component evaluation associated with the remedial design (RD). This evaluation was prepared on behalf of the City of Seattle, King County, and The Boeing Company, collectively referred to as the Lower Duwamish Waterway Group (LDWG).

This *Green Remediation Evaluation and Implementation Approach* reflects the information in the Intermediate (60%) RD. It also builds upon previous green remediation analyses conducted for the LDW Feasibility Study (FS; AECOM 2012) and for the LDW Upper Reach RD (Anchor QEA and Windward 2024). This Intermediate (60%) RD *Green Remediation Evaluation and Implementation Approach* builds on the previously developed air emissions calculations and also presents an environmental footprint evaluation for all five core elements identified by EPA's Office of Solid Waste and Emergency Response (OSWER) in the *Superfund Green Remediation Strategy* (EPA 2010).

## 1.1 Purpose

According to EPA's OSWER *Superfund Green Remediation Strategy* (EPA 2010), "green remediation is generally recognized as a major step in maximizing the environmental outcome of a contaminated land cleanup" by incorporating specific strategies into remedial actions that reduce their environmental footprint to achieve greater net environmental benefits.

Therefore, and as described in the RDWP (Anchor QEA and Windward 2022), the purpose of the *Green Remediation Evaluation and Implementation Approach* is as follows:

1. Establish the project's environmental footprint for the sediment remedy presented in the Intermediate (60%) RD *Basis of Design Report* (BODR) through the five core elements identified in the framework of the *Superfund Green Remediation Strategy* (EPA 2010): air, water, materials and waste, energy, and land and ecosystems (see Section 2).
2. Identify potential applicable greener construction activities, technologies, and practices that could be applied to the extent practicable during the sediment remedy implementation (e.g., dredging and excavation; sediment transloading and/or transfer to appropriate facilities, upland transportation, and disposal; procurement and delivery of raw materials to the site; material placement; habitat restoration; and structural work), in an effort to reduce the project's

[1] Per *Basis of Design Report* (BODR) Section 2.2.4, SMA 10 is a deferred cleanup area from the LDW upper reach. SMA 10 has been incorporated into the middle reach design as part of this Intermediate (60%) RD and for the purposes of this appendix.

environmental footprint (consistent with the EPA Region 10's *Clean and Green Policy* [EPA 2009a]) while still achieving the ROD remedial action objectives (RAOs) and protectiveness requirements in a timely manner.

This appendix includes the following information:

- Section 2 (Green Remediation Framework), which summarizes the available green remediation EPA guidance and policy that were considered in this evaluation
- Section 3 (Construction Activities Required for the Sediment Remedy), which describes the primary, secondary, and ancillary construction activities that are anticipated to be required for the sediment remedy
- Sections 4 through 8 (Green Remediation Core Elements 1 through 5), which evaluate key metrics used to assess the project's environmental footprint for each EPA core element (i.e., air emissions, use of water, use of materials and waste generation, use of energy, and protection of land and ecosystems)
- Section 9 (Implementation Approach: Best Management Practices), which summarizes the potential most applicable best management practices (BMPs) to limit the impacts of the sediment remedy

The development of this appendix is based on the BODR's Intermediate (60%) RD criteria, available information to date for the middle reach, and other key elements for implementing the sediment remedy, as well as engineering best professional judgment.

# 2 Green Remediation Framework

In August 2009, the OSWER[2] issued the green remediation policy, known as the *Principles for Greener Cleanups*, which focuses on evaluating the environmental footprint of cleanup activities (EPA 2009a). The policy goal is to "evaluate cleanup actions comprehensively to ensure protection of human health and the environment and to reduce the environmental footprint of cleanup activities, to the maximum extent possible" and identifies five core elements of a green cleanup assessment that should be used in selecting and implementing protective cleanup activities.

In line with the OSWER *Principles for Greener Cleanups*, EPA Region 10 also issued the *Clean and Green Policy* (EPA 2009b) in August 2009, with the goal of promoting sustainable strategies in order to improve the environmental benefits of federal cleanup programs. Specific objectives of the *Clean and Green Policy* are as follows:

- "*Protect human health and the environment by achieving RAOs.*
- *Support sustainable human use and reuse of remediated land.*
- *Minimize impacts to water quality and water resources.*
- *Reduce air toxics emissions and greenhouse gas production.*
- *Minimize material use and waste production.*
- *Conserve natural resources and energy*" (EPA 2009b).

In addition, the Office of Superfund Remediation and Technology Innovation, through the 2010 *Superfund Green Remediation Strategy* (EPA 2010), established a green remediation program management tool designed to help the Superfund Remedial Program in limiting and reducing negative environmental effects that might occur during an environmental cleanup. The five core elements described in the *Superfund Green Remediation Strategy* provide a framework for developing BMPs that can lead toward the green remediation objective; these five core elements are as follows:

- "*Air and Atmosphere: Many Superfund cleanups involve onsite and offsite emissions of GHGs and air pollutants from activities such as treatment processes, operation of heavy machinery, and transportation of routine vehicles and cargo trucks. These emissions may be reduced by applying the most appropriate advanced technologies and sound field practices.*"
- "*Water: Superfund cleanups may also involve consumption of significant amounts of water for treatment processes and typically need management of surface water. Green remediation strategies focus on reducing water consumption, reusing treated water, and using efficient techniques to manage and protect surface water and groundwater.*"
- "*Materials and Waste: Site remediation may use significant amounts of raw materials and sometimes generates its own hazardous and non-hazardous wastes, including materials and*

[2] As of December 2015, OSWER is now known as the Office of Land and Emergency Management (https://19january2017snapshot.epa.gov/aboutepa/oswer-olem_.html).

*debris that often are shipped offsite. Green remediation strategies offer opportunities to reduce materials consumption and waste generation, use recycled and local materials and spent products, and purchase environmentally preferred products*."

- "*Energy: Many Superfund cleanups involve energy intensive technologies. Green remediation strategies focus on opportunities to improve energy efficiency and use renewable energy sources*."
- "*Land and Ecosystems: Superfund sites often involve degraded onsite and offsite ecosystems and may have conditions that make the site unsafe for human or other use. Green remediation strategies focus on remedial actions that minimize further harm to the area, protect land resources and ecosystems at or near the site, and foster the return of sites to ecological, economic, social, or other uses*" (EPA 2010).

Furthermore, in February 2012, the Office of Superfund Remediation and Technology Innovation released the *Methodology for Understanding and Reducing a Project's Environmental Footprint* (EPA 2012). It provides a framework for evaluating the environmental footprint associated with any remedial action (cleanup activities), understanding the remedy components with the greatest influence, and determining key metrics for each of the green remediation core elements.

## 2.1 LDW ROD Requirements on Green Remediation

The LDW ROD includes requirements for green remediation practices (see Section 13.2.5 of the ROD; EPA 2014) to be considered in the selected remedy, to the extent practicable. These ROD requirements included the following practices, consistent with EPA Region 10's *Clean and Green Policy* (EPA 2009b):

- "*Use renewable energy and energy conservation and efficiency approaches, including Energy Star equipment.*
- *Use cleaner fuels such as low-sulfur fuel or biodiesel, diesel emissions controls and retrofits, and emission reduction strategies.*
- *Use water conservation and efficiency approaches including Water Sense products.*
- *Use reused or recycled materials within regulatory requirements.*
- *Minimize transportation of materials and use rail rather than truck transport to the extent practicable*" (EPA 2014).

This appendix presents strategies that incorporate these LDW ROD requirements on green remediation into the sediment remedy.

## 2.2 Other Related Green Remediation Guidance and Policy Documents

In addition to the key EPA policy documents described previously (2009 Region 10's *Clean and Green Policy* [EPA 2009a], the 2010 *Superfund Green Remediation Strategy* [EPA 2010], and the 2012

*Methodology for Understanding and Reducing a Project's Environmental Footprint* [EPA 2012]), the following documents were reviewed and considered to assess whether additional elements could be incorporated into the development of the green remediation evaluation in this appendix:

- *Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites* (EPA 2008)
- Considerations of Greener Cleanup Activities in the Superfund Cleanup Process Memorandum (EPA 2016)
- *Standard Guide for Greener Cleanups* (ASTM 2025)
- *Standard Guide for Integrating Sustainable Objectives into Cleanup* (ASTM 2020)
- *Green Remediation Best Management Practices: An Overview* (EPA 542-F-22-003, April 2022; EPA 2022a)
- *Green Remediation Best Management Practices: Integrating Renewable Energy* (EPA 542-F-22-003, March 2022; EPA 2022b)

Specific green remediation practices and BMPs applicable to each of the five green remediation core elements were also reviewed and considered for Section 9 of this appendix. These documents, sourced from the *Green Remediation Best Management Practices* fact sheet series produced by EPA are available at EPA's "Contaminated Site Clean-Up Information (CLU-IN)" website and include the following specific fact sheets:

- *Green Remediation Best Management Practices: Cleaner Fuels and Air Emissions for Site Cleanups* (EPA 542-F-23-001, March 2023; EPA 2023)
- *Green Remediation Best Management Practices: Integrating Renewable Energy into Site Cleanup* (EPA 542-F-11-006, April 2011; EPA 2011a)
- *Introduction to Green Remediation* (May 2011; EPA 2011b)
- *Green Remediation Best Management Practices: Materials and Waste Management* (EPA 542-F-13-003, December 2013; EPA 2013)
- *Green Remediation Best Management Practices: Excavation and Surface Restoration* (EPA 542-F-19-002, August 2019; EPA 2019)
- *Green Remediation Best Management Practices: Integrating Renewable Energy* (EPA 542-F-22-001; EPA 2022b)

This appendix has been developed to be consistent, to the extent practicable, with the above EPA green remediation guidance and policy documents, the outlined evaluation methodology, and the application of sustainable cleanup activities, technologies, and practices.

## 2.3 Methodology

As stated in Section 1.1, the purpose of this appendix is to establish the environmental footprint of the sediment remedy and evaluate potential greener construction activities, technologies, and

practices. A cleanup project's environmental footprint is defined by *Methodology for Understanding and Reducing a Project's Environmental Footprint* (EPA 2012) as the combined effect that the multiple project components may have on the environment. Conducting an environmental footprint analysis benefits the project as follows: 1) estimating footprint reductions that might be achieved from making project improvements; and 2) identifying aspects of a cleanup project that dominate the footprint, allowing the project design team to more specifically target those aspects during RD and implementation.

The environmental footprint of a project can be conceptually quantified by evaluating the five green remediation core elements through defined metrics, which are designed to not only reflect parameters that a project design team has a relatively direct ability to change but also encourage practices that would result in favorable changes to the metric values. It is important to note that the construction activities and the Intermediate (60%) RD criteria and assumptions serve as the starting point for the development of the environmental footprint of the sediment remedy in this appendix. Results from the quantification of the environmental footprint will help identify potential BMPs that will be prescribed in the Specifications, either as requirements or as additional potential practices and procedures to promote and encourage a green and sustainable remedy.

Section 2 and Table 2.1 of *Methodology for Understanding and Reducing a Project's Environmental Footprint* (EPA 2012) present the core elements and typical metrics to be considered for a cleanup project; Section 3 of the same document presents the step-by-step process to quantify applicable metrics. The core elements and metrics selected for the environmental footprint of the middle reach sediment remedy in this appendix are as follows[3]:

- Total air emissions (Section 4)
- Total water use (Section 5)
- Total use of raw materials and total generated waste (Section 6)
- Total energy use (Section 7)

The methodology adopted from *Methodology for Understanding and Reducing a Project's Environmental Footprint* (EPA 2012) for this appendix "does not constitute an EPA requirement. Use of this methodology is intended to support the remedial process and to help improve the environmental outcome of cleanup efforts but not to disrupt, delay, or otherwise reduce protectiveness of a remedy" (EPA 2012).

[3] Quantitative metrics are not provided for the green remediation core element 5, "protection of land and ecosystems," because this core element is described using qualitative metrics, consistent with *Methodology for Understanding and Reducing a Project's Environmental Footprint* (EPA 2012).

# 3 Construction Activities Required for the Sediment Remedy

As stated in the *Methodology for Understanding and Reducing a Project's Environmental Footprint* (EPA 2012), construction activities associated with the middle reach sediment remedy are the baseline for determining the project's environmental footprint, meant to comprehensively include the work required to implement, understand the sediment remedy components with the greatest influence, and appropriately represent the environmental impacts and effects the project may potentially generate on the environment. It is important to note that this appendix uses conceptual specific assumptions associated with the remediation construction activities based on past engineering experience with similar projects; therefore, the potential environmental impacts calculated herein are also conceptual in nature. The actual means, methods, and equipment to be used during construction will be proposed by the contractor and will affect the environmental impacts that result from the selected contractor's specific equipment used for the construction activities.

Defining the construction activities is also an opportunity to implement green remediation practices, consistent with the goals of the *Superfund Green Remediation Strategy* (EPA 2010). The anticipated construction activities needed to implement the sediment remedy can be classified as primary (major construction activities), secondary (minor construction activities), and ancillary (additional activities that are indirectly required or associated with the sediment remedy implementation). For the purposes of this evaluation, all of the equipment used in the primary and secondary construction activities is assumed to be operated using hydrocarbon (HC) fuels. The construction activities associated with the middle reach sediment remedy are described in detail in this section.

The following anticipated construction activities and associated assumptions (e.g., equipment types) are considered representative for the purposes of this evaluation; however, the selected contractor will identify actual proposed equipment, materials suppliers, rail service providers, and disposal facilities in the contractor's Remedial Action Work Plan.

## 3.1 Primary Construction Activities

The following construction activities are identified as primary because they represent the major construction activities conducted within or outside of the project site and directly contribute to the project's environmental footprint:

- Sediment removal (assumed mechanical dredging, using either a barge-mounted precision excavator or barge-mounted derrick crane/bucket) under these scenarios[4]:
  - Open-water dredging (primarily within the federal navigation channel and in unobstructed areas of the site)
  - Nearshore dredging (including slope dredging and any other slow dredging)

[4] For this *Green Remediation Evaluation and Implementation Approach*, dredge materials are assumed to be passively dewatered on barges; therefore, no environmental impacts (e.g., air emissions) would result from potential dewatering activities.

  - Restricted access dredging (when working adjacent to existing structures)
  - Tidally restricted dredging (when working in shallow locations of the site subject to a tide window)
  - Shoreline/bank excavation
- Excavation behind a cofferdam (i.e., in the dry) for a localized area of the site (remedial action areas [RAAs] 24B through 24D; assumed land-based equipment)
- Identified debris removal, using an excavator, where possible, or potentially conventional derrick with clamshell, grapple, or vibratory hammer for the removal of large debris[5]
- Removal of a submerged barge in RAA 14A, using a barge-mounted derrick crane
- Sediment in-water transportation of non-hazardous dredged sediments and identified debris
  - Transportation (via tugboat and barge) of dredged sediments to the transload facility (located within the LDW vicinity)
- Offloading of the dredge sediments and identified debris at the transload facility into stockpiles, loading stockpiles into containers, and loading containers onto railcars for off-site disposal
  - Transportation (via rail) of dredged sediments to the upland Subtitle D landfill (assumed to be located in Arlington, Oregon) for final disposal
  - Water treatment of dredge effluent generated from transloaded sediment materials at the transload facility
- Sediment transfer, upland transportation, and off-site disposal of containerized Toxic Substances Control Act (TSCA) waste, Resource Conservation and Recovery Act (RCRA) hazardous waste, and Washington State dangerous waste materials. This work includes the following:
  - Transportation (via truck) of containerized sediments to the transfer facility (assumed to be located in south Seattle)
  - Transfer of the containerized sediments at the transfer facility onto railcars for off-site disposal
  - Transportation (via rail) of containerized sediments to the upland Subtitle C landfill (assumed to be located in Arlington, Oregon) for final disposal (with the exception of the Washington State dangerous waste, which can be disposed at an upland Subtitle D landfill, assumed to be located in Arlington, Oregon)
- Material transportation and placement of clean materials and amendment to the middle reach. Clean materials (i.e., coarse sand, gravelly sand, sandy gravel, and quarry spalls that meet specified quality criteria) are intended for backfill, enhanced natural recovery (ENR), residuals management cover (RMC), amended ENR, and standard and modified engineered

[5] Large debris assumed to be generally greater than 1 cubic foot in volume and containing concrete rubble/blocks, derelict broken timber piling, tires, pipes, etc.

caps. Amendment is assumed to be activated carbon (AC), used in amended ENR[6] and in cap chemical isolation layer[7]. The materials are assumed to be placed via mechanical placement, using barge-mounted precision excavator or barge-mounted derrick crane/bucket. This work includes the following:

  - Transportation of clean materials to the LDW, either:
    - Transportation (via truck) of clean materials from a local quarry to an onshore staging area (outside of the LDW middle reach)
    - Transportation (via tug and barge) of clean materials from an onshore staging area (outside of the LDW middle reach) to the LDW middle reach
  - Transportation of other materials to the LDW, either:
    - Transportation (via truck) of AC from a vendor in Ridgefield, Washington, to the middle reach
    - Transportation of cement to middle reach for pre-treatment of RCRA hazardous waste prior to off-site disposal
  - Placement of coarse sand for RMC, ENR, and habitat substrates
  - Placement of gravelly sand for backfill
  - Placement of gravelly sand/AC blend for amended ENR
  - Placement of gravelly sand, sandy gravel, and quarry spall materials for standard and modified engineered caps
- Structural work:
  - Timber pile removal and replacement with steel pipe piles (multiple RAAs)
  - Demolition of derelict structures (RAAs 24B through 24D, 8F, and 8H)
- Re-routing of outfalls OF27 and OF28 (RAAs 24B and 24C)
- Double-wall cofferdam installation and removal (RAA 24D)
- Shoring wall installation and removal (RAAs 24B through 24D)

## 3.2 Secondary Construction Activities

The following anticipated activities are identified as secondary because they represent the minor construction activities to be conducted within the project site and, although minimal, these activities contribute to the project's environmental footprint:

- Mobilization/demobilization and site preparation:
  - Equipment mobilization and demobilization from the site
  - Clearing and grubbing of shoreline/banks from existing vegetation
- Bathymetric and topographic surveying
- Environmental compliance

[6] AC for amended ENR used for RAAs 5A, 8C, 8G, 9L, 9M, and 20A
[7] AC for cap chemical isolation layer used for RAAs 5B, 8B, 9A, 9D, and 26

  - Confirmational sediment sampling and environmental monitoring
- Site closure
  - Equipment decontamination

## 3.3 Ancillary Activities (Not Evaluated)

Ancillary activities, or activities indirectly required or associated with the implementation of the sediment remedy, are sourced elsewhere and not dependent on the remedy itself; therefore, they are not considered applicable activities to the project's environmental footprint. Ancillary activities may include the following:

- Import and purchase of electricity,[8] heating/cooling, or steam, and related transmission and distribution
- Mining/quarrying/excavation from borrow pits of raw materials and aggregates required for backfill, RMC, ENR, amended ENR, and standard and modified engineered caps
- Manufacturing of construction equipment and materials
- Manufacturing of staging equipment and temporary/support facilities
- Extraction, production, refinement, and transportation of fuels, lubricants, etc.
- Transport/commuting of workers to/from the project site
- Landfill emissions, management, and operations

Therefore, ancillary activities are not further considered or evaluated in this appendix.

[8] The contractor temporary facilities/trailers may potentially consume electricity for use and operation during construction, which could result in indirect air emissions; however, these air emissions are considered of de minimis contribution when compared to the air emissions generated from the primary and secondary construction activities identified in Sections 3.1 and 3.2 of this appendix.

# 4 Green Remediation Core Element 1: Air Emissions

Conventional sediment remediation involves construction activities that consume a significant amount of gasoline, diesel, and other fuels to power heavy equipment. These fuels release air pollutants that contribute to greenhouse gas (GHG) and pollution accumulation in the atmosphere. For this appendix, the evaluation of the green remediation core element 1 was conducted using air emission metrics. Air emissions were estimated for primary and secondary construction activities (as described in Section 3) for the following air constituents:

- HC
- Volatile organic compounds (VOCs)
- Carbon monoxide (CO)
- Nitrogen oxides ($NO_X$)
- Particulate matter less than 10 microns in diameter ($PM_{10}$)
- Particulate matter less than 2.5 microns in diameter ($PM_{2.5}$)
- Sulfur dioxide ($SO_2$)
- Carbon dioxide ($CO_2$), also a key GHG

This section discusses air emission sources and categories (Section 4.1), equipment assumptions for local average market conditions[9] (Section 4.2), assumed fuel usage inputs for the air emission calculations based on time or mass-distance traveled (Section 4.3), technical resources for associated air emission factors (EmFs; Section 4.4), and the results and conclusions of the air emission calculations (Sections 4.5 and 4.6).

## 4.1 Air Emissions Sources and Categories

The 2012 *Methodology for Understanding and Reducing a Project's Environmental Footprint* (EPA 2012) and relevant emissions accounting protocols (WRI/WBCSD 2004, 2015; EPA 2005) specify establishing "operational boundaries" for the emissions-generating entity under consideration (referred to as the "reporting entity," which can be a country, company, or project). For this appendix, the LDW middle reach project is defined as the "reporting entity."

The air emission calculation process involves the following: 1) identifying air emissions sources associated with its "operations" (in this case the anticipated construction activities associated with the implementation of the sediment remedy); and 2) categorizing the resultant air emissions as direct ("Scope 1"), indirect ("Scope 2"), or optional ("Scope 3," or other indirect), per EPA (2005, 2012) and

[9] Local average market conditions are based on a survey conducted among local contractors about their existing equipment fleet. This term is further described in Section 4.2.

the World Resources Institute and World Business Council for Sustainable Development (WRI/WBCSD 2004, 2015),[10] which are defined for this project in the following subsections.

The middle reach is a working waterway, and industrial activities and public use will occur simultaneously with anticipated cleanup construction activities. This air emissions inventory evaluates the incremental increase in air emissions related to the middle reach cleanup construction only (during the total duration of construction) and does not consider day-to-day air emissions within or adjacent to the middle reach associated with waterway industrial activities or public uses or adjacent upland operations.

### *4.1.1 Direct Air Emissions (Due to Primary and Secondary Construction Activities)*

Direct air emissions are from sources derived from conducting remedial construction activities and owned or controlled by the "reporting entity" (the LDW middle reach project). In this case, direct air emissions sources include primary and secondary construction activities (as described in Sections 3.1 and 3.2), such as stationary, mobile, and process-related sources from owned or controlled construction equipment and vehicles used to carry out removal (dredging and/or excavation); sediment transload at a transload facility or sediment transfer of containerized material at a transfer station (as applicable); upland transportation;[11] disposal;[12] material placement; structural work; surveying; and environmental compliance activities.

Direct air emissions were generally estimated for these activities based on assumptions associated with the type and number of equipment and vehicles, the duration of their use based on the specific function, the effective operation time, and the daily fuel consumption. Direct air emissions inventory has been based entirely on calculating fossil fuel consumption (primarily diesel fuel).[13] However, the opportunities for renewable energy source use during the sediment remedy implementation are identified in Sections 7.2 and 9.4 of this appendix and, as discussed therein, could be further

[10] "Direct," "indirect," and "optional" emissions categories are designations presented in *Climate Leaders Greenhouse Gas Inventory Protocol* (EPA 2005). Scopes 1, 2, and 3 are associated descriptive terms, as well as corresponding designations presented in *The Greenhouse Gas Protocol* (WRI/WBCSD 2004, 2015).

[11] Under the more recent EPA GHG guidance and its terminology (WRI/WBCSD 2015), transportation of imported clean materials to the site and sediment transportation/disposal off site are considered "Scope 3 upstream/downstream transportation." However, for the purposes of this appendix, transportation of contaminated sediment off site and clean materials to the site is included under the direct emission category (Scope 1) because it represents major construction activities of the LDW middle reach remedy.

[12] Although transload/transfer, upland transportation, and off-site disposal of dredge sediments will likely be conducted outside of the site and may fall under the control of another "reporting entity" (i.e., subcontractors), the air emissions resulting from these activities are of significant magnitude relative to the indirect air emissions. Therefore, these air emissions are included in this inventory in the direct emissions category because they are key components of the remedial construction activities from the LDW middle reach project.

[13] For the purposes of this appendix at Intermediate (60%) RD, sulfur content of diesel fuel is assumed to be 15 parts per million (ultra-low-sulfur diesel).

evaluated during RD and implemented in specific construction activities, where feasible, to help reduce the air emissions associated with the sediment cleanup activities.

### *4.1.2 Indirect Air Emissions (Not Evaluated)*

Indirect air emissions are a consequence of conducting remedial construction activities but occur at sources owned or controlled by a separate, different "reporting entity." Examples of indirect air emission sources might include importing/purchasing electricity, heating/cooling, or steam and related transmission/distribution; extraction/quarrying/excavation of raw materials; manufacturing of construction equipment and materials; extraction, production, refinement, and transportation of purchased fuels, lubricants, etc.; employee transport and commuting; and landfill air emissions due to operations at the disposal facility. These indirect air emissions are related to the ancillary activities described in Section 3.3.

These types of air emissions have not been quantified for the project and are not evaluated because they are considered beyond the scope of this analysis; it is unknown to what extent they would be accounted for in any inventories conducted by other "reporting entities" (i.e., manufacturers, vendors, contractors). Therefore, indirect air emissions are not further considered or evaluated in this appendix.

### *4.1.3 Other Greenhouse Gas Emission Contributions (Not Evaluated)*

GHGs are gases that are trapped in the atmosphere due to the combustion of fossil fuels (coal, natural gas, and oil), solid waste, trees, and other biological materials and as a result of livestock and other agricultural practices, land use, and the decay of organic waste in municipal solid waste landfills (EPA 2025a). The largest GHG contributors are $CO_2$, methane ($CH_4$), and nitrous oxide ($N_2O$); other GHGs are emitted in smaller quantities. Total GHG emissions are typically reported as metric tons (tonnes) of carbon dioxide equivalents ($CO_2$-eq), calculated by multiplying the tonnes of each GHG emitted by that GHG's global warming potential[14] (GWP; EPA 2005) and summing the results. Therefore, $CH_4$ and $N_2O$ can be typically included in the $CO_2$-eq total.

For all diesel fuel vehicle types tracked as part of this inventory, the EmFs are 0.94 gram per gallon for $N_2O$, 1.01 grams per gallon for $CH_4$, and 10.21 kilograms per gallon for $CO_2$ (EPA 2025b). Although the GWPs of $N_2O$ and $CH_4$ are 273 and 27, respectively,[15] the contribution of $CO_2$ to $CO_2$-eq is more than 30 times greater than the collective contribution of $N_2O$ and $CH_4$.[16] For this reason, GHG emissions from $N_2O$ and $CH_4$ would not be discernible in a $CO_2$-eq total reported to two significant figures (as is typical engineering practice for this type of evaluation); therefore, they have

[14] The GWP represents the effect a given GHG has on global warming in the atmosphere relative to one unit of $CO_2$. GWPs for all of the GHGs are listed in *Climate Leaders Greenhouse Gas Inventory Protocol – Design Principles*, Table 6-3 (EPA 2005).

[15] For every tonne of GHG emitted, the contributions to global warming associated with $N_2O$ and $CH_4$ are 273 and 27 (IPCC 2024) times higher, respectively, than for $CO_2$.

[16] For each gallon of diesel fuel burned, the $CO_2$ contribution over the combined $N_2O$ and $CH_4$ contribution is equal to 10,210 grams $CO_2$/[(0.94 grams $N_2O$ x 273) + (1.01 grams $CH_4$ x 27)] = 35.9.

not been included in this inventory due to this de minimis contribution. Therefore, $CO_2$ and $CO_2$-eq should be considered equivalent in the air emissions inventory of this appendix.

## 4.2 Local Average Market Conditions and Associated Equipment Assumptions

EPA has developed an engine classification for on-road vehicles (light and heavy duty, locomotives, motorcycles, etc.) and nonroad equipment/engines (marine engines/vessel, construction equipment) called the Tier System, with the purpose of identifying air emission standards corresponding to when a specific engine was manufactured and help reduce engine emissions (EPA 2025b). The EPA emission standards for each tier are specific to the type of equipment (on-road vehicles, nonroad equipment/engines), the year of manufacture, and the engine power. The following is the definition of EPA's Tier System[17]:

- Pre-Tier Engines: All equipment manufactured prior to 1996; it is assumed that this equipment was produced without a requirement to meet specific air emission standards
- Tier 1 Engines: All equipment manufactured between 1997 and 2005
- Tier 2 Engines: All equipment manufactured between 2001 and 2010
- Tier 3 Engines: All equipment manufactured between 2006 and 2011
- Tier 4 Engines: All equipment manufactured in 2008 and later

Prior to developing the Intermediate (60%) RD, a survey was conducted (in summer 2025 and spring 2026) among local marine construction contractors to understand the age of their fleet equipment and associated EPA Tier engine classification. Therefore, a local market average condition was established to reflect the approximate distribution of engine tiers and the age of construction equipment currently in active use (as of 2026) in the Puget Sound area of Washington. As part of the air emission analysis in this appendix, the EPA's Tier System was used to classify the potential types of equipment to be used for the various construction activities and, therefore, calculate the air emissions and evaluate the impact on overall emissions.

Engine tier distribution and equipment assumptions for the local market average condition are presented in this appendix in Table L4-1 for each of the primary construction activities; all equipment and associated engines are assumed to be either Pre-Tier, Tier 2, or Tier 4 engines (based on local marine construction contractor survey, no construction equipment was identified by the survey to be considered Tier 1 or Tier 3 engines).

[17] Note that the model year range between tiers overlaps in some cases because model year requirements vary based on the horsepower (hp) of the equipment (e.g., a 50-hp engine manufactured in 2003 was required to meet Tier 1 emission standards, and a 160-hp engine manufactured in the same year [2003] was required to meet instead Tier 2 emission standards; EPA 2025b). The range in model years provided in this appendix represents the widest possible range for the specific tier.

For the purposes of this appendix, air emission calculations for the local average market condition are presented to showcase potential air emissions caused by the LDW middle reach remedy using average equipment conditions and to understand potential improvements that could inform and aid in establishing specification requirements (i.e., minimum tier level required).

## 4.3 Air Emission Calculation Inputs

Direct air emissions for primary and secondary construction activities are calculated based on estimating diesel fuel usage for each construction activity on a time basis (for construction equipment and vehicles) and on a mass-distance basis (for placement material and dredged sediment transport). Emissions were then calculated using available EmFs from various EPA sources (see Section 4.4).

Table L4-2 presents the inputs for the direct air emissions calculations by construction activity, including quantities (i.e., dredged sediment and placement material volumes), production rates for each construction activity (both obtained from BODR Appendix N[18]), anticipated daily fuel usage or distance traveled, and estimated daily equipment operation rates and durations (assumed based on professional judgment and experience from similar projects).

### *4.3.1 Time-Based Fuel Usage Estimates*

For all direct air emissions-generating activities (except for transportation of placement material and dredged sediment), the following input parameters were used to estimate total diesel fuel usage:

- Assumed construction vehicle, or equipment types and numbers
- Estimated daily vehicle operation and uptime (effective operation time)
- Estimated fuel consumption rates
- Total implementation time (defined as total quantity divided by the specific production rate for each construction activity)

Table L4-3 presents a list of the assumptions for equipment and vehicles and fuel usage per piece of equipment.

### *4.3.2 Mass-Distance-Based Fuel Usage Estimates*

For activities related to transportation of placement material and dredged sediments, a mass-distance-traveled approach was used to estimate total fuel usage. The mass of dredged sediments and clean materials placed and the distance traveled during transportation (via rail, truck,

[18] Consistent with Appendix N, this appendix uses nine construction seasons as the total project duration for the Intermediate (60%) RD green remediation evaluation. LDW upper reach SMA 10 construction activities and associated quantities are included in this appendix and added up to their respective LDW middle reach green remediation construction activities line items.

or barge) were accounted for, and available ton-mile[19]-based fuel economy factors (EPA 2025b) were used to calculate total fuel usage.

Input parameters to estimate fuel usage due to transportation of non-hazardous dredged sediments for Subtitle D disposal (via rail), containerized sediments for Subtitle C disposal (via truck and rail)[20], and clean materials placed (via truck and tug/barge) included the mass of materials (in tons) and distances traveled (in miles). Assumptions related to rail, truck (on-road and nonroad), and barge diesel fuel consumption and transport capacity are presented in Tables L4-4, L4-5a, L4-5b, and L4-6, respectively.

## 4.4 Air Emission Factor Sources

Air EmFs for HC, VOCs, CO, $NO_X$, $PM_{10}$, $PM_{2.5}$, $SO_2$, and $CO_2$ are either provided in or are calculated using assumptions from EPA's *Exhaust and Crankcase Emission Factors for Nonroad Compression-Ignition Engines in MOVES3.0.2* document (EPA 2021)[21]. Air EmFs (in grams of pollutant per horsepower-hour [g/hp-hr]) vary based on the horsepower (hp) of the equipment; the equipment and associated engine power assumed in this appendix are listed in Table L4-3.

### *4.4.1 Air Emission Factors for HC, VOCs, CO, $NO_X$, and PM*

Air EmFs for HC, VOCs, CO, $NO_X$, $PM_{10}$, and $PM_{2.5}$ are provided in Table A-4 in Appendix A of the Motor Vehicle Emission Simulator MOVES3.0.2 (EPA 2021) for on-road vehicles (light- and heavy-duty, locomotives, motorcycles, etc.) and nonroad equipment/engines (marine engines/vessel, construction equipment). Based on an analysis of particle size distribution data of particulate matter (PM) emissions from diesel engines, all PM emissions are assumed to be smaller than 10 microns, and 97% of PM emissions are smaller than 2.5 microns (EPA 2021). Therefore, no adjustment was applied to the PM emission factor to calculate total $PM_{10}$ emissions, and an adjustment of 0.97 was applied to the PM emission factor to calculate total $PM_{2.5}$ emissions.

Air EmFs for HC, VOCs, CO, $NO_X$, $PM_{10}$, and $PM_{2.5}$ for rail, trucks, and vessels (mass-distance-based air emission estimates) and for the various tier engines (equipment assumptions described in Section 4.2) are presented in Tables L4-4, L4-5a, L4-5b, and L4-6, respectively. Air EmFs for HC, VOCs, CO, $NO_X$, $PM_{10}$, and $PM_{2.5}$ for construction equipment and vehicles (time-based air emission estimates) and for the various tier engines (local average market conditions and equipment assumptions in Section 4.2) are presented in Table L4-7.

[19] A unit of freight transportation is equivalent to a ton of freight moved 1 mile.
[20] With the exception of the containerized Washington State dangerous waste, which can be disposed at a Subtitle D facility
[21] Although EPA's simulator tool MOVES5 has been available since 2024 (EPA 2025c), the Air EmFs in the tool have not been updated since 2021.

### *4.4.2 Air Emission Factors for $SO_2$ and $CO_2$*

Air EmFs for $SO_2$ and $CO_2$ were calculated based on relationships provided in MOVES3.0.2 (EPA 2021). Equations L4-1 and L4-2 use a brake-specific fuel consumption factor, which is provided in Table A-4 in Appendix A of MOVES3.0.2 (EPA 2021), to compute $CO_2$ and $SO_2$ air EmFs, respectively.

**Equation L4-1**

$$SO_2 = \left(BSFC * \frac{lb}{g} * (1 - \text{soxcnv}) - \text{HC}\right) * 0.01 * soxdsl * \frac{Mass\ SO_2}{Mass\ S}$$

where:

| | | |
|---|---|---|
| $SO_2$ | = | sulfur dioxide emission factor (g/hp-hr) |
| BSCF | = | horsepower-specific brake-specific fuel consumption (unitless) |
| HC | = | hydrocarbon emission factor (g/hp-hr) |
| soxcnv | = | fraction of fuel sulfur converted to direct PM (unitless) |
| $\frac{lb}{g}$ | = | conversion factor from pounds to grams (unitless; 453.6) |
| soxdsl | = | percent of sulfur in nonroad diesel fuel by weight (%) |
| Mass S | = | mass of sulfur (gram [g]) |
| Mass $SO_2$ | = | mass of sulfur dioxide (g) |

**Equation L4-2**

$$CO_2 = \left(BSFC * \frac{lb}{g} - HC\right) * \frac{Mass\ C}{Mass\ Diesel} * \frac{Mass\ CO_2}{Mass\ C}$$

where:

| | | |
|---|---|---|
| $CO_2$ | = | carbon dioxide emission factor (g/hp-hr) |
| BSCF | = | horsepower-specific, brake-specific fuel consumption (unitless) |
| HC | = | hydrocarbon emission factor (g/hp-hr) |
| $\frac{lb}{g}$ | = | conversion factor from pounds to grams (unitless; 453.6) |
| Mass C | = | mass of carbon (g) |
| Mass Diesel | = | mass of diesel (g) |
| Mass $CO_2$ | = | mass of carbon dioxide (g) |

Air EmFs for $SO_2$ and $CO_2$ for rail, trucks, and barges (mass-distance-based air emission estimates) and for the various tier engines (equipment assumptions described in Section 4.2) are presented in Tables L4-4, L4-5a, L4-5b, and L4-6, respectively. Air EmFs for $SO_2$ and $CO_2$ for construction equipment and vehicles (time-based air emission estimates) and for the various tier engines (local

average market conditions and equipment assumptions described in Section 4.2) are presented in Table L4-7.

## 4.5 Air Emission Results

A detailed summary of total direct air emissions (in tonnes) by construction activity and for each of the eight air constituents is presented in Table L4-8, for assumed Pre-Tier, Tier 2, and Tier 4 engines (regardless of any equipment distribution). Applying the engine tier distribution and equipment assumptions listed in Table L4-1, high-level summaries of the total direct air emissions (in tonnes), associated with the local average market conditions for each of the eight air constituents are presented in Table L4-9 and Figures L4-1 and L4-2, respectively, broken out by construction activity.

As depicted in Figure L4-1 (reflective of the local market average condition), and for all air constituents evaluated, the construction activities that represent the vast majority of the total direct air emissions are: 1) sediment removal and 2) sediment transload, containerized sediment transfer, upland transportation, and disposal,[22] followed by 3) clean material transportation and placement.

As shown in Figure L4-1, the five air constituents in the local average market condition that contribute the most to the direct air emissions due to the sediment removal activity are $PM_{10}$ and $PM_{2.5}$ (21%) and $NO_X$, HC, and VOCs (20%). The remaining three air constituents ($SO_2$, $CO_2$, and CO) account for between 16% and 18% of direct air emissions for this same construction activity. For the activity that includes sediment transload, containerized sediment transfer, upland transportation, and disposal, the three air constituents that contribute the most to the direct air emissions are $CO_2$ (30%), $SO_2$ (29%), and CO (22%); the remaining five air constituents (HC, VOCs, $PM_{10}$, $PM_{2.5}$, and $NO_X$) account for between 8% and 12% of direct air emissions for this same construction activity. For total direct emissions from the clean material placement activity, the five air constituents that contribute the most to the direct air emissions are $PM_{10}$ and $PM_{2.5}$ (54%), $NO_X$ (52%), and HC and VOCs (51%); the remaining three air constituents ($CO_2$, CO, $SO_2$) account for between 42% and 46% of direct air emissions for this same construction activity.

Applying the engine tier distribution and equipment assumptions associated with the local average market condition (listed in Table KL-1), high-level summaries of the total direct air emissions (in tonnes) for each of the eight air constituents are presented in Table L4-10 and Figure L4-2, broken out by equipment type. Among all vehicle and equipment types for each of the construction activities, the use of various vessels (including tugboats, push boats, and work boats)[23] accounts for the majority of the total direct air emissions consistently, as shown in Figure L4-2, six of eight air constituents (CO, $NO_X$, HC, VOCs, $PM_{10}$, and $PM_{2.5}$) are the primary contributors with total direct

[22] However, for $PM_{10}$ and $PM_{2.5}$ only, total direct air emissions associated with the structural work activity are greater than for those for the activity that includes sediment transload, containerized sediment transfer, upland transportation, and disposal.

[23] Tugboats, push boats, and work boats are vessels used during construction not only to haul dredge sediment to the transload or transfer facilities but also to haul clean materials for placement to the site and position other marine construction equipment.

emissions ranging from 67% to 82%. Rail transportation constitutes one third of the direct emissions through three air constituents (CO, $CO_2$, and $SO_2$), of which specific emissions vary between 16% and 19% of the total direct emissions. Use of cranes for removal and placement activities accounts for approximately 7% to 12% of the direct emissions for all air constituents. Truck transportation includes upland transportation of containerized sediments to a transfer facility and hauling cement, AC, and clean placement materials into the site; therefore, air emissions from this activity results into $SO_2$, CO, $NO_X$, and $CO_2$ being the only air constituents contributing between 1% to 6%.

## 4.6 Conclusions

In conclusion, the local average market conditions scenario represents a realistic distribution of tier engines, based on current availability of construction marine equipment in the Puget Sound area for sediment remediation. The engine tier distribution in the local average market condition will inform, as appropriate, the basis for establishing potential minimum tier level specification requirements for the contractor and their selection of their equipment. Minimum tier level specification requirements will reduce, to the extent practicable, air emissions during sediment remedy implementation.

Section 9.1 presents the potential BMPs that could apply to the various construction activities of the middle reach sediment remedy and help reduce air emissions during remedial construction.

# 5 Green Remediation Core Element 2: Use of Water

As part of the 2012 *Methodology for Understanding and Reducing a Project's Environmental Footprint* (EPA 2012), use of water was evaluated as green remediation core element 2. For this analysis, water use is defined as water that is extracted from a potable or non-potable source for use in sediment remediation or other construction activities (e.g., transload, dust control, or decontamination) and does not include water derived from dewatering dredge materials. Water use within the context of sediment remediation is assumed to be relatively minimal for most remedial technologies. The most common non-potable water uses (outside of personnel use) identified in the implementation of the sediment remedy are water spraying for dust control purposes, water used in equipment decontamination, and additional water needs at the transload facility.

Water spraying to address dust control is expected to be limited to application at the on-site upland staging area, where equipment and materials may be staged during construction. It is assumed that water would be applied at a rate of 4,000 gallons (equivalent of one water truck) per week to limit dust production during construction in the summer months (July through September). However, the in-water work window for the LDW is from October to February, outside of the summer months, so water is expected to be applied at a significantly lower rate if the work happens as scheduled. It is expected that a minimal amount of water will be needed for dust suppression over the course of construction.

In addition to dust control, equipment decontamination is expected to contribute to water use at the site. Decontamination is anticipated to occur during mobilization (prior to the start of construction), prior to transitioning from dredging to material placement activities, and during demobilization (at the end of each construction season). The decontamination process is limited to only equipment that comes into contact with dredged sediments (i.e., material handling buckets, barges, and any other equipment that comes into contact with potentially contaminated sediment) and is expected to require less than 5,000 gallons of water for each construction season.

Additionally, non-potable water is also required for the decontamination of dredging equipment that has been used in the removal of hazardous waste (i.e., moving from removal of TSCA waste/RCRA hazardous waste to the removal of non-hazardous material). Decontamination typically involves pressure washing or rinsing dredging buckets, clamshells, and other support equipment to prevent cross-contamination of sediments between dredging work areas with different levels of contamination and, especially, to comply with EPA and state requirements for handling hazardous waste. It is assumed that a total of 25 decontamination events (transitioning from removal of TSCA waste/RCRA hazardous waste/dangerous waste materials to removal of non-hazardous bulk sediment material) would be required for the removal areas (RAAs 8B, 8F, 9A through 9E, 20B, 21A, 24B through 24G, 30H, 31B through 31D, and SMA 10). Typical water use for equipment

decontamination can be assumed at approximately 1,000 gallons per event for dredging operations. This volume accounts for rinsing of multiple pieces of equipment in the staging area and includes both initial and end-of-day decontamination. Because the process is limited to equipment that comes into direct contact with dredged sediments (i.e., material handling buckets), total water demand for decontamination is expected to be 25,000 gallons over the course of construction. Decontamination water will be contained and disposed of by the contractor in compliance with the relevant specification requirements.

Water use at the transload facility is also expected to be low; it is assumed that the transload facility would require less than 1,000 gallons of water during the course of each construction season.

Overall, it is assumed that all of the water use described in this section is non-potable water (either rain collected water or river water); thus, no potable water usage is considered in this appendix. The total non-potable water consumption for the potential high-end range of nine construction seasons is expected to be approximately 79,000 gallons. Section 9.2 presents standard BMPs that are typical to help reduce water consumption during remediation activities.

# 6 Green Remediation Core Element 3: Use of Materials and Waste Generation

Consistent with the 2012 *Methodology for Understanding and Reducing a Project's Environmental Footprint* (EPA 2012), the green remediation core element 3 (use of materials and waste generation) focuses on quantification of raw, recycled, and waste materials associated with the LDW middle reach sediment remedy with the intent of reducing raw material usage and waste generation and increasing material recycling, all to the extent practicable. Overall, the benefits of quantifying this core element may include the following:

- Reducing the depletion of natural resources, such as sand, gravel, and quarry spalls
- Reducing the use of landfills for disposal
- Reducing the environmental impact of the production of new materials
- Reducing the overall project cost

Table L6-1 presents the quantities of raw and waste materials identified from construction activities required for the sediment remedy.

The two largest uses of clean raw materials for the sediment remedy are anticipated to be for material placement activities (approximately 340,400 tons of coarse sand, gravelly sand, sandy gravel, and quarry spalls used for backfill, RMC, ENR, standard and modified engineered capping) and for structural work (double-wall cofferdam and shoring wall installation, which is expected to require purchase of approximately 27,500 square feet of sheet piles [Table L6-1]). Purchasing of virgin AC material (approximately 180 tons) for amended ENR and standard/modified engineering cap isolation layer applications is also anticipated, as well as purchasing of cement (approximately 500 tons) for pre-treatment (stabilization) of RCRA hazardous waste prior to off-site disposal.

Consistent with Section 9.5.2 of the BODR, it was assumed in this appendix that all materials for placement activities will be regionally sourced from commercially available suppliers (i.e., sand and gravel quarries) that can supply materials for backfill/amended ENR (gravelly sand), for RMC/ENR/cap chemical isolation layers (coarse sand) and for standard and modified engineered caps (gravelly sand, sandy gravel and quarry spalls). These materials will need to meet design quantities, delivery schedules, gradations, and chemical quality criteria established in RD for each material type. As stated in the BODR (Section 9.5.2), beneficial use of clean dredged material was evaluated as a potential source of materials, but it entails significant coordination and timing complications, among other issues, and for recent cleanup projects, it has been difficult to accomplish. Given the anticipated schedule for cleanup in the middle reach, beneficial use of clean dredged material is not included as part of the Intermediate (60%) RD assumptions.

The largest source of waste generated is the contaminated dredged/excavated sediment, consisting of approximately 436,800 cubic yards, equivalent to 633,940 tons, to be disposed of in permitted off-site landfill facilities. This tonnage includes 20,890 tons of sediment material identified as TSCA waste, RCRA hazardous waste, and dangerous waste, which will be segregated and containerized for off-site truck and rail transportation (Table L6-1). The beneficial use of dredged contaminated sediments after treatment was also investigated for the LDW project; however, the investigation concluded that a treatment step may not produce sediment concentrations low enough to be suitable for direct beneficial use applications; therefore, beneficial use of contaminated sediments was not further considered (AECOM 2012).

In addition to dredged sediments, approximately 27 timber piles, eight steel piles, a 1,000-ton submerged barge, 27,500 square feet of cofferdam/shoring wall sheet piles, and approximately 1,650 tons of identified debris are anticipated to be removed from the site and will generate additional waste (Table L6-1). Identified debris in the middle reach was characterized as marine debris that likely contains contaminated sediment. This debris includes concrete, timber piling, human-made rubble, and tree trunks; therefore, there is no ability for this material to be recycled. General standard requirements do not allow debris (that is contaminated or in contact with contamination) to be recycled or reused. Steel waste of significant large dimensions (such as the eight steel piles and 1,000-ton submerged barge) may potentially be recycled.

Section 9.3 presents the potential BMPs that could be applicable to the various construction activities of the LDW middle reach sediment remedy and help reduce raw material use and waste generation.

# 7 Green Remediation Core Element 4: Use of Energy

Significant amounts of energy, specifically originating from fossil fuels, are expected to be consumed to power engines and equipment, facilitate transport activities, and run operations associated with the LDW middle reach sediment remedy. As part of the 2012 *Methodology for Understanding and Reducing a Project's Environmental Footprint* (EPA 2012), use of energy based on fossil fuel consumption (e.g., gasoline or diesel) to carry out the sediment remedy was evaluated as a metric for green remediation core element 4; potential options to use renewable energy are also discussed.

## 7.1 Total Energy Use

Typical sediment remedies are primarily conducted with diesel-powered engines and equipment. Diesel fuel consumption is assumed to be the key metric that quantifies the total energy that is anticipated to be used for the middle reach remedy implementation. Table L7-1 presents the approximate volume of diesel fuel consumed for each construction activity for the overall LDW project. The highest energy consumption is anticipated to occur for the upland transportation and disposal of hazardous and non-hazardous sediment material (approximately 403,500 gallons), followed by mechanical transloading (approximately 262,600 gallons) at the transload facility and all types of dredging and excavation (approximately 186,900 gallons). Additionally, the activities of structural work, material placement, and transportation of clean placement material to the site account for an energy consumption of approximately 82,400, 163,100, and 59,300 gallons of diesel fuel, respectively.

The re-routing of two outfalls in RAAs 24B through 24D will likely require a diesel-powered pump generator to maintain a continuous flow of the outfalls' discharge through a bypass pipe further downstream during construction. Based on an assumed specification of a standard 8-inch diesel pump, with an average fuel consumption rate of 4.3 gallons per hour, continuous operation over a four-and-a-half-month period (approximately 3,240 hours) would require about 13,930 gallons of diesel. Although a diesel-powered generator is more commonly used for this application, an electric pump could also be utilized to reduce diesel consumption. If utilized, energy consumption for the electric pump is anticipated to be minimal.

Additionally, for the dewatering activities at the RM 2.2 inlet (RAAs 24B through D), it is assumed that an electrically powered pump (e.g., DV 100CE or equivalent) will be used. The electric pump is anticipated to operate over approximately 5 months (estimated to be approximately 133 days) during the construction season. Because the pump is electrically powered and has a relatively low power demand compared to other construction equipment, the associated energy consumption is expected to be minimal and would contribute only a negligible amount to the overall project energy use.

Consistent with Section 9.2.1.1 of the BODR, it is assumed that the middle reach project has a commercial transload facility in close proximity (Duwamish Reload Facility, operated by WM [formerly Waste Management]) that could readily be used for transloading dredged materials from barges and loading into trucks or railcars for transportation to a disposal facility. Because a project-specific transload facility is not further considered in RD, the contractor will be responsible for identifying and proposing the actual transload facility in the Remedial Action Work Plan. Therefore, it is assumed that for the purposes of this appendix, all transloading activities related to non-hazardous dredged sediment would occur at a commercial facility that operates only a diesel-powered crane for transloading.

Minor construction activities, such as surveying and environmental monitoring, are expected to use the least amount of diesel-based energy (3,500 and 2,100 gallons of diesel). Based on the Intermediate (60%) RD assumptions, the middle reach sediment remedy is anticipated to use approximately 1,164,000 gallons of diesel energy during construction.

It is noted that the contractor's selection of electric-powered equipment (where available) can reduce fuel consumption and consequently reduce associated air emissions from various construction activities.

## 7.2 Potential Renewable Energy Use

With recent advancements in electric-powered engines, manufacturers are beginning to produce electric-powered construction equipment alongside their legacy diesel equipment. According to Seattle City Light[24], 88% of all electric energy generated in 2024 was from renewable sources (77% hydropower and 11% wind power), and another 7% came from low- to no-emission sources (nuclear and biogas); the remaining 5% came from unspecified sources. This means the use of electric-powered equipment can be nearly emission-free.

Seattle City Light is the main electrical utility company likely to provide electricity to the project. Depending on the power source (i.e., grid system of electrical generation/transmission/distribution) used, GHG emissions generated from a specific grid could have a higher or lower effect on the overall environmental footprint posed from electricity use. However, the purchase of electricity (and the electricity's source) will be up to the contractor, which will be selecting its construction equipment for this project and determining the electricity requirements (if any) for equipment and facility operations.

### *7.2.1 Transload Electrification*

Because one of the highest diesel energy consumption sources is derived from sediment transloading activities, significant energy savings could be realized with an electric-powered crane.

[24] Seattle City Light website: https://www.seattle.gov/city-light/about-us/what-we-do; accessed July 17, 2026.

Of the approximately 262,600 gallons of diesel anticipated to be consumed in the mechanical transloading process (which includes the use of a tugboat, a 100-ton crane, and a front-end loader), the diesel-powered offloading crane represents approximately 70% of the total fuel consumption (or 183,800 gallons of diesel fuel). Therefore, using an electric-powered crane or excavator to offload dredge material would reduce the total diesel energy consumption to approximately 78,800 gallons. The commercial transload facility located in the LDW, the Duwamish Reload Facility, is currently using electric power for transloading operations off of barges. The selection of this transload facility by the contractor could eliminate fuel consumption and substantially reduce associated air emissions for the offloading portion of the transloading process (but would not affect the tugboat fuel consumption).

### *7.2.2 Marine Vessel Electrification*

In addition to electrifying land-based construction equipment, contractors are also beginning to evaluate electrifying water-based dredge equipment. In 2021, the Port of Long Beach completed a 10-year-long, approximately $1.5-billion electrification project at the Long Beach Container Terminal at Middle Harbor and is now able to conduct nearly all operations (including maintenance dredging) using electricity, with zero net emissions.[25] To supply the electrical power required by the Long Beach Container Terminal, the Port of Long Beach installed four electrical substations capable of delivering shore power to nearby vessels. The installation of these substations took more than 4 years and cost approximately $185 million. This has resulted in overall air emissions reductions, cheaper operating/maintenance costs, and downtime optimization (i.e., no need for refueling and less maintenance) during in-water construction activities.

Currently, there are no substations along the LDW middle reach capable of delivering sufficient electrical power to perform electric dredging, and it is assumed that at least two substations or equivalent temporary power drops would be needed to potentially allow for electric dredging in the entire LDW middle reach area.

As part of the survey among local marine construction contractors discussed in Section 4.2, each contractor was asked about the potential for the conversion of their existing diesel-powered equipment into electric-powered. A summary of challenges and concerns identified follows:

- There is no current availability of electric-powered dredges in Washington state, so equipment would be required to be either:
  - Retrofitted (with an estimated average cost of $200,000 per piece of equipment)
  - Shipped from southern California (with an estimated mobilization cost of $200,000 per piece of equipment)
  - Purchased new (with an estimated cost of $1,000,000 per piece of equipment)

[25] Port of Long Beach website: https://polb.com/port-info/news-and-press/port-reaches-milestone-at-long-beach-container-terminal-08-20-2021/; accessed on July 17, 2026.

- Additional capital investment for ancillary equipment required to support electric-powered dredging would be needed:
  - Procurement of electric cable, cable reel, transformers, protective housing for cable (with a total estimated cost between $200,000 and $400,000)
  - Development of infrastructure consisting of multiple electric terminals (with an estimated cost between $100,000 and $300,000 per terminal location); costs estimated in coordination with the local electric utility (Seattle City Light)
- Specific electric equipment technical and logistical requirements and considerations limit the implementability of electric dredging and/or could delay completion of the remedial action in the middle reach:
  - Electric dredges are likely limited to a 1-mile radius around the electric terminal; ideally, power sources would be located on both sides of the river to cover all potential dredging areas.
  - Battery-powered equipment currently has limited reliability and does not supply enough active time to be feasible (maximum of 4-hour capacity) without multiple redundant equipment dedicated to a single task.
  - Management of electric tether (i.e., electric cable connecting shore power to the dredge):
    - May add up to 20% additional downtime on construction activities as reeling of the cable is an intensive activity, when moving from one dredging location to another, and contractors may be unfamiliar with the equipment
    - Additional barge, tugboat, and deckhands required for the additional tether-related activities
    - Electric tether would be ideally placed along the shoreline; floating cable across the LDW is an option but would necessarily require protective housings, adding additional cost and complexity/logistics/coordination for LDW navigation
  - Shallow water presents increased risk of damage to electric cable
  - A high level of coordination is required for vessel traffic and Tribal fishing because all electric dredging equipment (dredge, cable, and additional vessels and equipment for the additional tether-related activities) will block or partially block navigation areas within the LDW. Given the many users navigating the LDW, this level of coordination may not be feasible or fully effective to prevent accidents.
- Timing for implementation:
  - Local contractors and Seattle City Light identified a minimum lead time of approximately 1 year to be able to accommodate and implement electric dredges and required infrastructure in the Seattle area (including time for procurement and retrofitting of dredging equipment, electric terminal design and installation, etc.)

- Unproven technical feasibility with Pacific Northwest contractors; local contractors are unfamiliar and inexperienced with electric dredging operations
- Contracting, safety, and liability issues: Because electric dredging has not been implemented on a congested waterway analogous to the LDW, the ability to successfully bid such a project is unknown. Risks to waterway users may not be acceptable. Equitable sharing of risks and liabilities between the Contractor and Owner would be challenging.

Many of these challenges would require additional capital investment to purchase, develop, or retrofit existing equipment. The feasibility of implementing electrical dredging also depends upon the timing of when remedial action will occur.

Additionally, research was conducted to evaluate the availability and feasibility of using electric or hybrid tugboats. As noted in Section 4.5, tugboats and other various vessels (including push boats and work boats) account for the majority of the total direct air emissions generated during construction activities because of the Pre-Tier engine they hold. Tugboats are used in dredging operations to haul barged dredged sediment to the transload facility, to haul barged clean materials for placement at the site, and to position other marine equipment during dredging and backfilling/capping operations. Although the use of electric or hybrid tugboats could improve air quality by fewer emissions during remedial activities, their current availability in the U.S. is very limited—these marine vessels are generally not commercially available for purchase (but rather only on demand for manufacturing). Only two examples of electric or hybrid tugboats exist in the marine industry and have been implemented in the U.S.:

- *Carolyn Dorothy*: It is a diesel-electric hybrid tugboat, built by the Foss Rainer Shipyard in 2009. Its only current use is in San Pedro Bay, California.
- *eWolf*: It is the first all-electric ship (powered by an integrated electrical propulsion package), assist harbor tugboat in the U.S., built to American Bureau of Shipping class by the Master Boat Builders in Coden, Alabama, for Crowley Maritime (Crowley) and launched in 2024. Its only current use is at the Port of San Diego, California, where a microgrid recharging station was specifically constructed by Crowley to charge the vessels batteries (generally a 4-hour power life). The *eWolf* costs are estimated to be approximately double the cost of a conventional tugboat with similar power output.

### *7.2.3 Freight Trucking Electrification*

Electric freight trucks are not commercially available, and, like marine vessel electrification, the challenges in freight truck electrification include additional capital investment to purchase, develop, or retrofit existing trucking equipment and operation and to establish truck charging stations. This impacts the feasibility of implementing the electrification of freight trucks at this time for LDW cleanup.

### *7.2.4 Use of Biodiesel*

Biodiesel represents another potential renewable energy source. Biodiesel is a renewable, biodegradable alternative to standard diesel fuel that is made by mixing modified vegetable oils and diesel fuel. Because of the increasing interest in the use of biodiesels in the early 2000s, EPA conducted a "comprehensive analysis of the emission impacts of biodiesel using publicly available data" (EPA 2002).

For use in a conventional diesel engine, biodiesel must be mixed with conventional diesel fuel. Using a common biodiesel mixture of 20% biodiesel and 80% conventional diesel, the EPA emissions analysis measured reductions in PM (10.1%), HC (21.1%), and CO (11.0%) and no change or an increase in $NO_X$ emissions. The 2002 EPA study indicated no change or an increase in $CO_2$ emissions; however, when comparing emission factors from EPA's Emission Factors Hub (EPA 2025a), it can be established that fuel with 20% biodiesel and 80% conventional diesel should produce a reduction of about 1.5% in $CO_2$ emissions. However, fuel efficiency is also expected to be reduced when using biodiesel, increasing operating equipment times.

Therefore, no overall net emission reductions or environmental benefits are identified.

In addition to marginal improvements in emissions, biodiesel availability in the region is very limited. According to the U.S. Department of Energy's Alternative Fuels Data Center (https://afdc.energy.gov/), only one commercial fueling station supplies biodiesel within 100 miles of the project area (Dr. Dan's Alternative Fuelwerks, located near the Ballard neighborhood of Seattle).

Although the use of biodiesel may provide some localized air quality and public health benefits, the overall emissions reductions are outweighed by the equipment operating challenges and the logistical challenges associated with limited biodiesel suppliers in the vicinity of the LDW and project site. Therefore, biodiesel was not considered further as an alternative energy source for the middle reach. In comparison, and as described in Section 4.6, the requirement of higher tier engines, to the extent practicable, could provide more reliable lower air emissions during sediment remedy implementation.

### *7.2.5 Conclusions*

Section 9.4 presents the potential BMPs that could be applicable to the various construction activities of the LDW middle reach sediment remedy and help reduce consumption of diesel-powered energy. In addition to the BMPs listed in Section 9.4, the *Methodology for Understanding and Reducing a Project's Environmental Footprint* (EPA 2012) identifies the use of biodiesel in place of diesel fuel for heavy equipment use or transportation only if local supply of biodiesel is made largely available in the near future in the vicinity of the project site.

# 8 Green Remediation Core Element 5: Protection of Land and Ecosystems

The protection of land and the ecosystem is another important aspect of green remediation. Ecosystems have physical, biological, and chemical elements that facilitate the transfer and storage of materials and energy through the environment. The ROD (EPA 2014) describes the criteria to define the areas that are considered habitat for compliance with Section 404 of the Clean Water Act (CWA) and Section 7 of the Endangered Species Act (ESA).

Per the 2012 *Methodology for Understanding and Reducing a Project's Environmental Footprint* (EPA 2012), this green remediation core element 5 involves limiting degradation and/or enhancing the ecology of the project (the LDW middle reach) and other affected areas through a qualitative description of the effects of the sediment remedy on land and ecosystems. BMPs provide tools for preserving existing wildlife habitat during remediation and accelerating the beneficial reuse of previously degraded land to enhance biodiversity following remediation actions.

The LDW middle reach sediment remedy will primarily be implemented from water-based vessels, but limited excavation of intertidal areas and banks may require land-based excavation equipment, land access, and specific staging areas to manage the excavated material (see Section 9.1.2 of the BODR); in those cases, clearing and grubbing of existing vegetation will be needed. In addition, an on-site upland staging area may be necessary to stockpile clean placement material or as a location to move equipment from the uplands into the water. For the protection of land, selection of an upland staging area (if required) and transloading facility should be limited to areas already developed for industrial use to avoid clearing trees and other potential habitat.

As with all in-water projects, work is restricted to specific windows designed to reduce impacts on the aquatic ecosystem. Approved in-water construction activities will occur during fish windows designated for the LDW (generally from October through February) to protect threatened or endangered species under the ESA.

In summary, this element is already addressed by Section 10.5 of the BODR, in which an evaluation of potential impacts to all habitat types, including ROD-defined "habitat areas" (EPA 2014), from implementation of remedial activities will be conducted to comply with the CWA Section 404 and Section 7 of the ESA. The design for the middle reach will seek to maintain or improve habitat to the extent practicable. If it is determined that the existing habitat cannot be maintained or improved after RD for all three reaches of the LDW, a draft and final Compensatory Mitigation Plan will be included in the RD submittals for the lower reach. Section 9.5 of this appendix presents additional potential BMPs that could be applicable to the various construction activities of the middle reach sediment remedy and help in protecting land and ecosystems.

# 9 Implementation Approach: Best Management Practices

This section presents a comprehensive list of potential BMPs that might apply to the five green remediation core elements identified in the *Superfund Green Remediation Strategy (*EPA 2010) in relation to the middle reach sediment remedy and its anticipated construction activities. Potential applicable BMPs, consistent with the Intermediate (60%) RD, are described in the following sections.

BMPs will be prescribed in the Specifications either as requirements or as additional potential practices and procedures to promote and encourage a green and sustainable remedy. BMPs will consider the availability of more advanced technologies and materials for feasibility and implementability of greener practices into the sediment remedy and in conjunction with procurement restrictions. The contractor will have inherent motivation to select other specific BMPs listed in this section in cases where such BMPs will increase efficiency and reduce cost and therefore have an appropriate return on investment that justifies their use.

## 9.1 BMPs for Air Pollutant Emission Reduction

The *Green Remediation Best Management Practices: Cleaner Fuel and Air Emissions for Site Cleanups* (EPA 2023) establishes the following potential BMPs to reduce emissions of air pollutants during sediment remedy implementation:

- Selection of Appropriately Sized Vehicles: Selection of appropriately sized vehicles for the construction activity is key to reducing emissions of air pollutants. Using undersized equipment may result in longer construction durations, which translates into greater fuel consumption, therefore increasing air emissions. Similarly, using oversized equipment may result in wasted fuel and associated higher air emissions.
- Effective Operation and Maintenance: To increase the efficiency of vehicles and construction equipment, the following BMPs are available:
  - Engine idling restrictions for construction equipment
  - Automatic shut-down devices programmed to cut an engine after a predetermined time limit (such as 3 minutes) unless engine operation is needed for intermittent activities
  - Preventive maintenance to ensure peak operating efficiency (e.g., engine tune-ups according to manufacturer recommendations, checking fuel tank for dirt/insects, keeping tight connections and moving parts well-lubricated, periodic replacement of filters in air and fuel systems, use of manufacturer's recommended grade of motor oil)
  - Changes in daily routines (e.g., selecting high-quality equipment lubricants made of biodegradable ingredients; cleaning up any spilled fuels immediately to limit damage to vehicles or engine bodies; handling all materials used to absorb fuel spills in accordance with health and safety requirements and storing the material in noncombustible

containers; properly disposing or recycling spent materials or liquid waste such as tires, transmission or brake fluids, used oil and filters, wash-rack waste, coolant, and spent solvent; simple changes in driving techniques [such as reducing rapid acceleration, braking, and excessive speeds, and removing unneeded items in a vehicle])
  - Effective fleet management (e.g., planning to reduce fuel consumption through efficient transportation routes, transfer of only full loads, selection of appropriately sized vehicles, and low-carbon commuting and travel by workers)
- Advanced Diesel Technologies: Clean diesel technologies applied to on-road and nonroad (i.e., off-road) vehicles can significantly reduce diesel pollution created during remediation. As discussed in Section 4.2, requirements (i.e., minimum tier level required) will be established in the Specifications for the contractor to reduce air emissions during sediment remedy implementation. Diesel engines tend to last longer than gasoline engines and are commonly retrofitted with a form of advanced exhaust after treatment to reduce emissions. Forms of advanced technology are diesel oxidation catalysts, diesel particulate filters, partial diesel particulate filters, and selective catalytic reduction.
- Alternative Fuels: The use of biofuels and biodiesel blends provides opportunities for reducing PM and $SO_2$ emissions.[26]
- Fuel Additives: Additives can enhance fuel performance and often result in improved fuel economy and lower air emissions (e.g., emulsified diesel).
- Fuel-Efficient or Alternative-Fuel Vehicles: The following are options for fuel-efficient or alternative-fuel vehicles:
  - Replacement of aging vehicles with newer ones operated by more fuel-efficient engines or relying on alternative fuel can significantly reduce fossil fuel consumption and associated air emissions.
  - Deploying vehicles with higher fuel efficiency for both on-site and off-site activities should also lead to lower fuel costs for site cleanup.
  - Alternative vehicles include those using electric, hybrid gasoline/electric, or compressed natural gas fuel systems.

## 9.2 BMPs for Water Use

The *Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites* (EPA 2008) and *Green Remediation Best Management Practices: Excavation and*

[26] As of 2010, the use of ultra-low sulfur diesel is a requirement for all nonroad and all new on-road diesel-powered vehicles and equipment with engine ratings of 50 hp or more, according to the *Green Remediation Best Management Practices: Cleaner Fuel and Air Emissions for Site Cleanups* (EPA 2023).

*Surface Restoration* (EPA 2019) establish the following potential BMPs for water use during remedy implementation:

- Limiting Water Consumption: Any construction activity should limit freshwater and potable water consumption (e.g., using native vegetation requiring little or no irrigation or using high-efficiency water fixtures, valves, and piping).
- Maximize Water Reuse: Any construction activity should maximize water reuse during daily operations and treatment processes.

As discussed in Section 5, all water use for the construction activities of the project (e.g., transload, dust control, or decontamination) that was evaluated in this appendix is assumed to be non-potable water (i.e., collected rainwater or river water), and no potable water usage is anticipated. Because non-potable water use is low during remedy implementation, no specific BMPs apply. However, water conservation approaches may be implemented to the extent applicable or practicable during remedial activities, through reducing overall water usage and implementing water reuse opportunities where feasible.

BMPs aimed at protecting water quality during dredging operational activities are described in detail in Section 10.2 of the BODR.

## 9.3 BMPs for Use of Materials and Waste Generation Reduction

BMPs intended to reduce the use of raw materials and waste generation will be established in consideration of procurement restrictions (i.e., the implementing entity could be a public entity). Some of the BMPs may be noncompetitive and therefore not acceptable for project implementation (e.g., selection of a greener supplier or specific greener products).

The *Green Remediation Best Management Practices: Materials and Waste Management* (EPA 2013) establishes the following potential BMPs to reduce waste generation and the use of virgin materials during remedy implementation:

- Purchase of Greener Products: The incorporation of greener products should begin during the planning stages of the cleanup, to facilitate sustainable materials management[27] during construction. The following BMPs are available:
  - Choose local material suppliers where opportunities are available and appropriate (i.e., a material that is required) to reduce fuel consumption associated with delivery (if allowed under procurement rules).
  - Choose suppliers that will take back unused materials.

[27] The *Green Cleanups Contracting and Administrative Toolkit* (EPA 2015) is useful EPA guidance, which includes sample procurement and contract language and criteria for sustainable materials management.

- Promote Material Reuse and/or Recycling: The following BMPs are available during remedy implementation to promote material reuse and recycling:
  - Use reconstituted reactive media whenever feasible (e.g., regenerated rather than virgin AC).
  - Use non-virgin and/or locally sourced backfill, sand, and armor materials (e.g., beneficial use) provided that gradation and chemical quality criteria can be ensured.
  - Salvage and sort clean materials with potential value for on-site reuse (such as marina docks or other structural elements that must be moved) or recycling (e.g., metal, concrete).

## 9.4 BMPs for Energy Use Reduction and Renewable Energy Promotion

The *Green Remediation Best Management Practices: Integrating Renewable Energy into Site Cleanup* (EPA 2011a) and *Green Remediation Best Management Practices: Integrating Renewable Energy* (EPA 2022b) establish the following potential BMPs to reduce energy use and maximize the use of renewable energy during remedy implementation:

- Assessing and Optimizing Energy Use: To the extent possible, replace aging equipment with newer models meeting higher energy conservation standards or utilizing alternative energy sources (e.g., using electric-powered equipment in place of conventional diesel equipment).
- Maximizing Energy Efficiency and Monitoring Energy Demand: General BMPs for energy conservation and efficiency include the following:
  - Follow equipment vendor recommendations for routine maintenance, conduct periodic inspections, and quickly repair/upgrade industrial equipment such as fans, pumps, air compressors, and others when needed.
  - Track energy consumption through tools such as plug-in meters and whole-system meter devices.

## 9.5 BMPs for Land Resource/Ecosystem Protection

Section 10.5 of the BODR presents some examples of design measures to offset aquatic habitat modifications (areas defined as above -10 feet mean lower low water) that may be incorporated into the LDW middle reach sediment remedy to the extent practicable and for compliance with the ROD (EPA 2014), Section 404 of the CWA, and Section 7 of the ESA. Additional BMPs for the protection of land resources and ecosystems will be presented in the forthcoming *Biological Assessment*.

The *Green Remediation Best Management Practices: Excavation and Surface Restoration* (EPA 2019) and the *Ecosystem Services at Contaminated Site Cleanups* (EPA 2017) establish the following additional BMPs for the protection of land resources and ecosystems:

- Safeguarding Land and Ecosystems
  - Restrict machinery, vehicle, and worker traffic to well-defined corridors that are minimally obtrusive and reduce soil compaction and land disturbance during site activities.
  - Include design work zones, traffic plans, and construction phases to limit or avoid habitat disruption.
  - Limit removing trees in staging areas/uncontaminated zones, to the extent practicable.
- Site Preparation and Land Restoration
  - Restore and/or maintain habitat in ways that mirror existing general conditions.

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# Tables

**Table L4-1**
**Local Average Market Conditions and Equipment Assumptions for Air Emissions**

| Category | Activity | Equipment Type | Notes | Based on Fuel Consumption or Distance | Production Rate or Duration (days) or Distance (miles) | EPA Tier System[1] and Local Average Market Conditions[2] | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Pre-Tier | Tier 2 | Tier 4 |
| Mobilization/Demobilization/Site Preparation | Mobilization/Demobilization | Tug Boat (800 hp) | Mobilization of 2 derrick barges and 3 material handling barges to the site per construction season | Fuel Consumption | 36 days | 100% | 0% | 0% |
| | Site Clearing and Grubbing | Mini Excavator (60 hp) | Used for site clearing and grubbing | Fuel Consumption | 36 days | 0% | 20% | 80% |
| Structural Work | Pulling of Timber Piling and Replacement with Steel Piles | Crane (150-ton) | Pulling/installation of piles and temporary dismantling of structures | Fuel Consumption | 25 piles per day | 30% | 30% | 40% |
| | | Push Boat (800 hp) | Move barge | Fuel Consumption | 25 piles per day | 100% | 0% | 0% |
| | | Work Boat (Two-stroke) | Transportation for crew members, also assist with pile removal and installation | Fuel Consumption | 25 piles per day | 100% | 0% | 0% |
| | Re-Routing of Outfalls OF27 and OF28 – RAAs 24B-D | Hydraulic Excavator (180 hp) | Used for upland pipe route excavation | Fuel Consumption | 500 cy per day | 0% | 80% | 20% |
| | | Front-end Loader (Rough Terrain Forklift) | Assist in transloading and placement of pipes | Fuel Consumption | 500 cy per day | 0% | 50% | 50% |
| | Double-Wall Cofferdam and Shoring Wall Installation and Removal – RAAs 24B-D | Crane (150-ton) | Pulling/installation of sheet piles | Fuel Consumption | 153 days | 30% | 30% | 40% |
| | | Front-end Loader (Rough Terrain Forklift) | Assist in transloading of equipment | Fuel Consumption | 153 days | 0% | 50% | 50% |
| | | Work Boat (Two-stroke) | Transportation for crew members, also assist with cofferdam installation and removal activities | Fuel Consumption | 153 days | 100% | 0% | 0% |
| | | Push Boat (800 hp) | Move barge | Fuel Consumption | 153 days | 100% | 0% | 0% |
| | Removal of Submerged Barge – RAA 14A | Crane (150-ton) | Temporary dismantling of barge and removal of barge parts | Fuel Consumption | 200 ton/day | 30% | 30% | 40% |
| | | Push Boat (800 hp) | Move barge | Fuel Consumption | 200 ton/day | 100% | 0% | 0% |
| | | Work Boat (Two-stroke) | Transportation for crew members, also assist with barge removal activities | Fuel Consumption | 200 ton/day | 100% | 0% | 0% |
| | Demolition of Derelict Structures – RAAs 24B-D, 8F, 8H | Crane (150-ton) | Pulling and removal of the derelict structure | Fuel Consumption | 28 | 30% | 30% | 40% |
| | | Front-end Loader (Rough Terrain Forklift) | Assist in transloading of timber/wood waste | Fuel Consumption | 28 | 0% | 50% | 50% |
| | | Work Boat (Two-stroke) | Transportation for crew members, also assist with structure removal activities | Fuel Consumption | 10 | 100% | 0% | 0% |
| | | Push Boat (800 hp) | Move barge | Fuel Consumption | 10 | 100% | 0% | 0% |

**Table L4-1**
**Local Average Market Conditions and Equipment Assumptions for Air Emissions**

| Category | Activity | Equipment Type | Notes | Based on Fuel Consumption or Distance | Production Rate or Duration (days) or Distance (miles) | EPA Tier System[1] and Local Average Market Conditions[2] | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Pre-Tier | Tier 2 | Tier 4 |
| Sediment Removal | Open-Water, Nearshore/Slope/Slow, Restricted Access, Tidally Restricted Dredging, Shoreline/Bank Excavation; Contingency Re-Dredging; Identified Debris Removal | Crane (150-ton) | Used for open-water, nearshore, contingency re-dredging, identified debris removal, and contaminated riprap removal | Fuel Consumption | Ranging from 390 to 990 cy per day | 30% | 30% | 40% |
| | | Hydraulic Excavator (180 hp) | Used for restricted access dredging, shoreline/bank excavation, and tidally restricted dredging | Fuel Consumption | Ranging from 180 to 500 cy per day | 0% | 80% | 20% |
| | | Hydraulic Excavator (Tidally Restricted Work Only) | Used for tidally restricted dredging | Fuel Consumption | 180 cy per day | 0% | 80% | 20% |
| | | Push Boat (800 hp) – Hydraulic Excavator | Move barge | Fuel Consumption | Ranging from 180 to 330 cy per day | 100% | 0% | 0% |
| | | Push Boat (800 hp) – Crane | Move barge | Fuel Consumption | Ranging from 500 to 990 cy per day | 100% | 0% | 0% |
| | | Front-end Loader (Rough Terrain Forklift) | Assist in transloading of sediment | Fuel Consumption | Ranging from 500 to 990 cy per day | 0% | 50% | 50% |
| | | Work Boat (Two-stroke) – Crane | Transportation for crew members, also assist with ancillary dredging, debris removal activities | Fuel Consumption | Ranging from 500 to 990 cy per day | 100% | 0% | 0% |
| | | Work Boat (Two-stroke) – Hydraulic Excavator | Transportation for crew members, also assist with ancillary dredging, debris removal activities | Fuel Consumption | Ranging from 180 to 330 cy per day | 100% | 0% | 0% |
| Sediment Transloading, Upland Transportation, Subtitle C and Subtitle D Disposal [3] | | Tug Boat (3,000 hp) | Barge transport of sediment to and from transload facility (assumed 5 miles, one-way) | Distance | 5 miles | 100% | 0% | 0% |
| | | Offloading Crane (100-ton) | Transload sediment from barge to truck or railcar | Fuel Consumption | 990 cy per day | 0% | 70% | 30% |
| | | Front-end Loader (Rough Terrain Forklift) | Assist in transloading of sediment to truck or railcar | Fuel Consumption | 990 cy per day | 0% | 50% | 50% |
| | | Rail (Locomotive and Train) | Rail transport of dredged sediments from intermodal facility to a Subtitle C disposal facility in Arlington, OR (300 miles, one-way) [4] | Distance | 300 miles | 0% | 0% | 100% |
| Containerized Sediment Transfer, Upland Transportation, and Subtitle C Disposal [4] | | Truck (20-ton Dump Truck) [5] | Upland transport of dredged sediments to a nearby intermodal facility for loading onto a railcar | Distance | 20 miles | 0% | 0% | 100% |
| | | Rail (Locomotive and Train) | Rail transport of dredged sediments from intermodal facility to a Subtitle D disposal facility in Arlington, OR (300 miles, one-way) [4] | Distance | 300 miles | 0% | 0% | 100% |

**Table L4-1**
**Local Average Market Conditions and Equipment Assumptions for Air Emissions**

| Category | Activity | Equipment Type | Notes | Based on Fuel Consumption or Distance | Production Rate or Duration (days) or Distance (miles) | EPA Tier System[1] and Local Average Market Conditions[2] | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Pre-Tier | Tier 2 | Tier 4 |
| Clean Material Transportation and Placement | Delivery of Clean Materials; Open-Water, Nearshore/Slope/Slow, Restricted Access, Tidally Restricted, Underpier, and Land-based Placement | Truck (20-ton Dump Truck) [6] | Upland transport of capping, backfill, ENR, and RMC materials from local quarry to shore (assumed 20 miles) | Distance | 20 miles | 0% | 0% | 100% |
| | | Truck (20-ton Freight Truck) [7] | Upland transport of activated carbon from Ridgefield, WA | Distance | 150 miles | 0% | 0% | 100% |
| | | Tug Boat (3,000 hp) | Barge transport of capping, backfill, ENR, and RMC materials from shore to LDW MR site (assumed 20 miles) | Distance | 20 miles | 100% | 0% | 0% |
| | | Crane (150-ton) | Used for open-water and nearshore material placement | Fuel Consumption | Ranging from 550 to 960 cy per day | 30% | 30% | 40% |
| | | Hydraulic Excavator (180 hp) | Used for restricted access and upland material placement | Fuel Consumption | Ranging from 120 to 510 cy per day | 0% | 80% | 20% |
| | | Push Boat (800 hp) – Hydraulic Excavator | Move barge | Fuel Consumption | Ranging from 120 to 510 cy per day | 100% | 0% | 0% |
| | | Push Boat (800 hp) – Crane | Move barge | Fuel Consumption | Ranging from 550 to 960 cy per day | 100% | 0% | 0% |
| | | Front-end Loader (Rough Terrain Forklift) | Assist in transloading of sediment | Fuel Consumption | Ranging from 550 to 960 cy per day | 0% | 50% | 50% |
| | | Work Boat (Two-stroke) – Crane | Transportation for crew members, also assist with ancillary material placement activities | Fuel Consumption | Ranging from 550 to 960 cy per day | 100% | 0% | 0% |
| | | Work Boat (Two-stroke) – Hydraulic Excavator | Transportation for crew members, also assist with ancillary material placement activities | Fuel Consumption | Ranging from 120 to 510 cy per day | 100% | 0% | 0% |
| Surveys, Confirmational Sediment Sampling, and Environmental Monitoring | | Work Boat (Two-stroke) | Conduct survey and sampling activities | Fuel Consumption | 1,828 days | 100% | 0% | 0% |

**Table L4-1**
**Local Average Market Conditions and Equipment Assumptions for Air Emissions**

Notes:

LDW Upper Reach SMA 10 construction activities and associated quantities are included in this appendix and added up to their respective LDW middle reach green remediation construction activities line items.

The air emissions inventory for this *Green Remediation Evaluation and Implementation Approach* was based entirely on tracking fossil fuel consumption (primarily diesel fuel with 15 ppm sulfur content [ultra-low-sulfur diesel]).

Based on the survey performed among local marine construction contractors to establish the local market average condition, contractors provided an approximate number of operating hours for each piece of construction equipment. Therefore, the specifications will identify, as a requirement for the

1. The EPA "Tier System" emission standards for each tier are specific to the type of equipment (on-road vehicles and nonroad equipment/engines), the year of manufacture, and the engine power. Pre-Tier engines are those manufactured prior to 1996. Tier 1 engines are those manufactured between 1997 and 2005. Tier 2 engines are those manufactured between 2001 and 2010. Tier 3 engines are those manufactured between 2006 and 2011. Tier 4 engines are those manufactured in 2008 and later.
2. For the purposes of defining the local average market conditions for the Intermediate (60%) RD *Green Remediation Evaluation and Implementation Approach,* engine tier distribution of construction equipment was assumed based on local marine construction contractor survey. In addition, no construction equipment was identified by the survey to be considered Tier 1 or Tier 3.
3. The assumption of a Subtitle D disposal facility in Oregon is only for the purposes of the *Green Remediation Evaluation and Implementation Approach* at Intermediate (60%) RD. The contractor will be responsible for identifying and proposing the actual disposal facility in the RAWP.
4. The assumption of a Subtitle C disposal facility in Oregon is only for the purposes of the *Green Remediation Evaluation and Implementation Approach* at Intermediate (60%) RD. The contractor will be responsible for identifying and proposing the actual disposal facility in the RAWP.
5. Truck transportation of dredge sediment material from the LDW middle reach to a transfer facility in south Seattle is assumed for all Subtitle C-level containerized sediment.
6. Truck transportation of clean materials assumed to be from a local quarry to an onshore staging area (outside of the LDW middle reach).
7. The assumption of acquiring GAC from a vendor in Ridgefield, Washington, is only for the purposes of the *Green Remediation Evaluation and Implementation Approach* at Intermediate (60%) RD. The contractor will be responsible for identifying and proposing the actual GAC vendor and source in the RAWP.

cy: cubic yard
ENR: enhanced natural recovery
EPA: U.S. Environmental Protection Agency
GAC: granular activated carbon
hp: horsepower
LDW: Lower Duwamish Waterway
MR: middle reach
OR: Oregon
ppm: part per million
RAWP: Remedial Action Work Plan
RD: Remedial Design
RMC: residuals management cover
SMA: sediment management area
WA: Washington

**Table L4-2**
**General Inputs for Air Emission Calculations**

| Construction Activity | Type of Vehicle/Equipment Used | SCC Description | Notes | Equipment Uptime | Equipment Quantity | Total Daily Diesel Usage (gal/day) | Shift Duration (hr) | Production Rate (quantity/day) | One-way Distance (miles) | Quantity Units | Quantity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***MOBILIZATION/DEMOBILIZATION/SITE PREPARATION*** | | | | | | | | | | | |
| **Equipment Mobilization/Demobilization (8 hours/day)** | | | | | | | | | | | |
| | Tug Boat (800 hp) | Diesel Inboard/Sterndrive (800 hp) | Assume mobilization/demobilization of 2 derrick rigs and 3 material barges. Assume 8 hrs/day for 4 days per construction season. | 0.2 | 5 | 225 | 8 | 0.75 | N/A | Construction season | 9 |
| **Site Clearing and Grubbing (8 hours/day)** | | | | | | | | | | | |
| | Mini Excavator | Diesel Excavators | Assume mobilization/demobilization of 1 mini-excavator. Assume 10 hrs/day for 4 days per construction season. | 0.7 | 1 | 14 | 10 | 0.60 | N/A | Construction season | 9 |
| ***STRUCTURAL WORK*** | | | | | | | | | | | |
| **Pulling of Timber and Steel Piling and Replacement with Steel Piles – Multiple RAAs (10 hrs/day)** | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. Assume pile removal or replacement occurs at 25 piles/day. | 0.7 | 1 | 112 | 10 | 25 | N/A | # piles | 70 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 25 | N/A | # piles | 70 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 25 | N/A | # piles | 70 |
| **Re-Routing of Outfalls OF27 and OF28 – RAAs 24B-D** | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 10-hr shift. Assume a total of 4 days. | 0.7 | 1 | 140 | 10 | 500 | N/A | cy soil | 733 |
| | Front-end Loader | Diesel Rough Terrain Forklifts | | 0.8 | 1 | 48 | 10 | 500 | N/A | cy soil | 733 |
| **Double-Wall Cofferdam and Shoring Wall Installation and Removal – RAAs 24B-D** | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. Assume a total of 153 Days (133 days to install and 20 days to remove sheet piles). | 0.7 | 1 | 112 | 10 | 1 | N/A | # of days | 153 |
| | Front-end Loader | Diesel Inboard/Sterndrive (800 hp) | | 0.8 | 1 | 48 | 10 | 1 | N/A | # of days | 153 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 1 | N/A | # of days | 153 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 1 | N/A | # of days | 153 |
| **Removal of Submerged Barge – RAA 14A** | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. Assume 20 ton removed per hour according to the structural team. | 0.7 | 1 | 112 | 10 | 200 | N/A | ton | 1,000 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 200 | N/A | ton | 1,000 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 200 | N/A | ton | 1,000 |
| **Demolition of Derelict Structures (RAA 24B-D, 8F, 8H)** | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. Assume a total of 28 days. RAA 24's derelict structure will be removed in the dry; therefore, a push and work boats will not be required. Production rate from structural team. | 0.7 | 1 | 112 | 10 | 200 | N/A | # of days | 54 |
| | Front-end Loader | Diesel Inboard/Sterndrive (800 hp) | | 0.8 | 1 | 48 | 10 | 200 | N/A | # of days | 54 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 200 | N/A | # of days | 54 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 200 | N/A | # of days | 54 |

**Table L4-2**
**General Inputs for Air Emission Calculations**

| Construction Activity | Type of Vehicle/Equipment Used | SCC Description | Notes | Equipment Uptime | Equipment Quantity | Total Daily Diesel Usage (gal/day) | Shift Duration (hr) | Production Rate (quantity/day) | One-way Distance (miles) | Quantity Units | Quantity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***SEDIMENT REMOVAL*** | | | | | | | | | | | |
| **Identified Debris Removal – Multiple RAAs (10 hours/day)** | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 1 | N/A | # of days | 28 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 1 | N/A | # of days | 28 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 1 | N/A | # of days | 28 |
| **Open-Water Dredging (10 hours/day)** | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 990 | N/A | cy sediment | 339,352 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 990 | N/A | cy sediment | 339,352 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 990 | N/A | cy sediment | 339,352 |
| **Nearshore/Slope/Slow Dredging (10 hours/day)** | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 580 | N/A | cy sediment | 52,373 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 580 | N/A | cy sediment | 52,373 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 580 | N/A | cy sediment | 52,373 |
| **Restricted Access Dredging (10 hours/day)** | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 140 | 10 | 330 | N/A | cy sediment | 17,068 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 330 | N/A | cy sediment | 17,068 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 330 | N/A | cy sediment | 17,068 |
| **Tidally Restricted Dredging (4 hours/day)** | | | | | | | | | | | |
| | Hydraulic Excavator (Tidally Restricted Work Only) | Diesel Excavators | Assume each work day contains one 4-hr shift. | 0.7 | 1 | 56 | 4 | 180 | N/A | cy sediment | 10,015 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 4 | 180 | N/A | cy sediment | 10,015 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 4 | 180 | N/A | cy sediment | 10,015 |
| **Contingency Redredging (10 hours/day)** | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 390 | N/A | cy sediment | 10,380 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 390 | N/A | cy sediment | 10,380 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 390 | N/A | cy sediment | 10,380 |
| **Shoreline/Bank Excavation (10 hours/day)** | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 140 | 10 | 500 | N/A | cy sediment | 7,669 |
| | Front-end Loader | Diesel Rough Terrain Forklifts | | 0.8 | 1 | 48 | 10 | 500 | N/A | cy sediment | 7,669 |

**Table L4-2**
**General Inputs for Air Emission Calculations**

| Construction Activity | Type of Vehicle/Equipment Used | SCC Description | Notes | Equipment Uptime | Equipment Quantity | Total Daily Diesel Usage (gal/day) | Shift Duration (hr) | Production Rate (quantity/day) | One-way Distance (miles) | Quantity Units | Quantity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***SEDIMENT TRANSLOADING OR CONTAINERIZED SEDIMENT TRANSFER, UPLAND TRANSPORTATION, AND DISPOSAL*** | | | | | | | | | | | |
| **Mechanical Transloading (10 hours/day)** | | | | | | | | | | | |
| | Tug Boat (3,000 HP) | Diesel Inboard/Sterndrive (3,000 hp) | Assume each work day contains one 10 hr-shift. Assume bulking factor of 5% for mechanical offloading. Assume tug boat transports dredge sediment to a transload facility 5 miles away (one-way). Total quantities encompass Subtitle D and Subtitle C bulk dredged sediments, TSCA, TSCA/RCRA dredge sediments, and debris from both MR and SMA 10, as well as the sunken barge. Excluding RAAs 24B-G. | 0.2 | 1 | N/A | 10 | N/A | 5 | ton | 663,934 |
| | 100-ton Crane | Diesel Cranes | | 0.7 | 1 | 112 | 10 | 990 | N/A | cy sediment | 464,246 |
| | Front-end Loader | Diesel Rough Terrain Forklifts | | 0.8 | 1 | 48 | 10 | 990 | N/A | cy sediment | 464,246 |
| **Subtitle D (Bulk Sediment and Dangerous Waste) – Upland Transportation and Disposal (10 hours/day)** | | | | | | | | | | | |
| | Truck (20-ton Dump Truck) | Diesel Off-highway Trucks | Assume Identified Debris from RAA 24B-G trucked from LDW middle reach to a transload facility. Assume 1 mile each way (2 miles round trip). | N/A | 1 | N/A | 10 | N/A | 2 | ton | 572 |
| | Rail | N/A | Assume non-hazardous contaminated bulk sediments, dangerous waste containerized sediments, identified debris, and contaminated riprap railed from transload facility to an off-site landfill disposal facility in Arlington, OR, for 300 miles (one-way). | N/A | 1 | N/A | N/A | N/A | 300 | ton | 664,506 |
| **Subtitle C (TSCA and RCRA) – Upland Transportation and Disposal (10 hours/day)** | | | | | | | | | | | |
| | Truck (20-ton Freight Truck) | Diesel Onroad Trucks | Assume cement used for stabilization is transported 4 miles by truck from Ashgrove Cement, Seattle, WA, vendor to LDW middle reach (one-way). | N/A | 1 | N/A | 10 | N/A | 4 | ton | 498 |
| | Truck (20-ton Dump Truck) | Diesel Off-highway Trucks | Assume PCB remediation waste and/or RCRA hazardous waste removed trucked from LDW middle reach to a transfer (intermodal) facility in south Seattle. Assume 3 miles each way (6 miles round trip). Quantity includes TSCA and Mixed TSCA Waste/RCRA Hazardous Waste from RAAs 24B through G). | N/A | 1 | N/A | 10 | N/A | 6 | ton | 3,635 |
| | Rail | N/A | Assume sediment disposal by rail to landfill in Arlington, OR for 300 miles (one-way). | N/A | 1 | N/A | N/A | N/A | 300 | ton | 3,635 |

**Table L4-2**
**General Inputs for Air Emission Calculations**

| Construction Activity | Type of Vehicle/Equipment Used | SCC Description | Notes | Equipment Uptime | Equipment Quantity | Total Daily Diesel Usage (gal/day) | Shift Duration (hr) | Production Rate (quantity/day) | One-way Distance (miles) | Quantity Units | Quantity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***CLEAN MATERIAL TRANSPORTATION AND PLACEMENT*** | | | | | | | | | | | |
| **Transportation of Clean Materials to LDW Middle Reach and LDW Upper Reach SMA 10** | | | | | | | | | | | |
| | Truck (20-ton Dump Truck) | Diesel Off-highway Trucks | Assume coarse sand, gravelly sand, sandy gravel, and quarry spalls are transported 20 miles from quarry to onshore staging area by truck and 20 miles to LDW middle reach by barge. | N/A | 1 | N/A | 10 | N/A | 20 | ton | 340,387 |
| | Tug Boat (3,000 hp) | Diesel Inboard/Sterndrive (3,000 hp) | | N/A | 1 | N/A | 10 | N/A | 20 | ton | 340,387 |
| | Truck (20-ton Freight Truck) | Diesel Onroad Trucks | Assume AC is transported 150 miles by truck from Ridgefield, WA, vendor to LDW middle reach (one-way). | N/A | 1 | N/A | 10 | N/A | 150 | ton | 174.3 |
| **Open-Water Placement of Coarse Sand for RMC (Neatline+ Daylight+ Stability+ Perimeter) (10 hours/day)** | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 960 | N/A | cy coarse sand | 26,203 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 960 | N/A | cy coarse sand | 26,203 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 960 | N/A | cy coarse sand | 26,203 |
| **Nearshore Placement of Coarse Sand for ENR + Perimeter RMC (10 hours/day)** | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 610 | N/A | cy coarse sand | 5,388 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 610 | N/A | cy coarse sand | 5,388 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 610 | N/A | cy coarse sand | 5,388 |
| **Restricted Access Placement of Coarse Sand ENR + Perimeter RMC (4 hours/day)** | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 4-hr shift. | 0.7 | 1 | 140 | 4 | 440 | N/A | cy coarse sand | 2,256 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 4 | 440 | N/A | cy coarse sand | 2,256 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 4 | 440 | N/A | cy coarse sand | 2,256 |
| **Restricted Access Placement of Coarse Sand ENR + Perimeter RMC (Underpier) (4 hours/day)** | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 4-hr shift. | 0.7 | 1 | 140 | 4 | 120 | N/A | cy coarse sand | 2,489 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 4 | 120 | N/A | cy coarse sand | 2,489 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 4 | 120 | N/A | cy coarse sand | 2,489 |
| **Open-Water Placement of Gravelly Sand Backfill (10 hours/day)** | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 790 | N/A | cy gravelly sand | 6,439 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 790 | N/A | cy gravelly sand | 6,439 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 790 | N/A | cy gravelly sand | 6,439 |
| **Nearshore/Slope/Slow Placement of Gravelly Sand for Backfill (Nearshore/Slope/Slow Backfilling) (10 hours/day)** | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 610 | N/A | cy gravelly sand | 34,733 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 610 | N/A | cy gravelly sand | 34,733 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 610 | N/A | cy gravelly sand | 34,733 |
| **Restricted Access Placement of Gravelly Sand Backfill (4 hours/day)** | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 4-hr shift. | 0.7 | 1 | 140 | 4 | 440 | N/A | cy gravelly sand | 6,147 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 4 | 440 | N/A | cy gravelly sand | 6,147 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 4 | 440 | N/A | cy gravelly sand | 6,147 |
| **Land-Based Equipment Placement of Gravelly Sand Backfill (10 hours/day)** | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 140 | 10 | 500 | N/A | cy gravelly sand | 8,121 |
| | Front-end Loader | Diesel Rough Terrain Forklifts | | 0.7 | 1 | 197 | 10 | 500 | N/A | cy gravelly sand | 8,121 |

**Table L4-2**
**General Inputs for Air Emission Calculations**

| Construction Activity | Type of Vehicle/Equipment Used | SCC Description | Notes | Equipment Uptime | Equipment Quantity | Total Daily Diesel Usage (gal/day) | Shift Duration (hr) | Production Rate (quantity/day) | One-way Distance (miles) | Quantity Units | Quantity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Open-Water Placement of Standard/Modified Engineered Cap (Gravelly Sand for Chemical Isolation Layer) (10 hours/day)** | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 790 | N/A | cy gravelly sand | 19,708 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 790 | N/A | cy gravelly sand | 19,708 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 790 | N/A | cy gravelly sand | 19,708 |
| **Open-Water Placement of Standard/Modified Engineered Cap (Sandy Gravel for Filter Layer and Sloped RMC) (10 hours/day)** | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 770 | N/A | cy gravel | 20,801 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 770 | N/A | cy gravel | 20,801 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 770 | N/A | cy gravel | 20,801 |
| **Open-Water Placement of Standard/Modified Engineered Cap (Quarry Spalls for Erosion Protection Layer and Sloped RMC) (10 hours/day)** | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 730 | N/A | cy quarry spalls | 73,592 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 730 | N/A | cy quarry spalls | 73,592 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 730 | N/A | cy quarry spalls | 73,592 |
| **Nearshore Placement of Standard/Modified Engineered Cap (Gravelly Sand for Chemical Isolation Layer) (10 hours/day)** | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 550 | N/A | cy quarry spalls | 2,751 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 550 | N/A | cy quarry spalls | 2,751 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 550 | N/A | cy quarry spalls | 2,751 |
| **Nearshore Placement of Standard/Modified Engineered Cap (Sandy Gravel for Filter Layer) (10 hours/day)** | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 540 | N/A | cy gravel | 3,683 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 540 | N/A | cy gravel | 3,683 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 540 | N/A | cy gravel | 3,683 |
| **Nearshore Placement of Standard/Modified Engineered Cap (Quarry Spalls for Erosion Protection Layer) (10 hours/day)** | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 510 | N/A | cy quarry apalls | 2,878 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 510 | N/A | cy quarry apalls | 2,878 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 510 | N/A | cy quarry apalls | 2,878 |
| **Restricted Access Placement of Standard/Modified Engineered Cap (Gravelly Sand for Chemical Isolation Layer) (10 hours/day)** | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 140 | 10 | 410 | N/A | cy gravelly sand | 1,761 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 410 | N/A | cy gravelly sand | 1,761 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 410 | N/A | cy gravelly sand | 1,761 |
| **Restricted Access Placement of Standard/Modified Engineered Cap (Sandy Gravel for Filter Layer and Sloped RMC) (10 hours/day)** | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 140 | 10 | 410 | N/A | cy gravel | 2,452 |
| | Push Boat | Diesel Inboard/Sterndrive (800 HP) | | 0.7 | 1 | 197 | 10 | 410 | N/A | cy gravel | 2,452 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 410 | N/A | cy gravel | 2,452 |
| **Restricted Access Placement of Standard/Modified Engineered Cap (Quarry Spalls for Erosion Protection Layer) (10 hours/day)** | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 140 | 10 | 390 | N/A | cy quarry spalls | 4,136 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 390 | N/A | cy quarry spalls | 4,136 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 390 | N/A | cy quarry spalls | 4,136 |

**Table L4-2**
**General Inputs for Air Emission Calculations**

| Construction Activity | Type of Vehicle/Equipment Used | SCC Description | Notes | Equipment Uptime | Equipment Quantity | Total Daily Diesel Usage (gal/day) | Shift Duration (hr) | Production Rate (quantity/day) | One-way Distance (miles) | Quantity Units | Quantity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Restricted Access Placement of Gravelly Sand/AC for Amended ENR (RAA 5A, 8C, 9L) (Underpier) (4 hours/day)** | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Cranes | Assume each work day contains one 4-hr shift. | 0.7 | 1 | 140 | 4 | 120 | N/A | cy gravelly sand/AC | 1,239 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 4 | 120 | N/A | cy gravelly sand/AC | 1,239 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 4 | 120 | N/A | cy gravelly sand/AC | 1,239 |
| **Tidally Restricted Access Placement of Coarse Sand (Perimeter RMC), Gravelly Sand (Backfill and Cap CIL), Gravelly Sand/AC (Amended ENR), Armor (Cap Erosion Layer – RAAs 5A, 9A-9D, 9F, 9I, 9L, 9M, 20A, 20C) (4 hours/day)** | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Cranes | Assume each work day contains one 4-hr shift. | 0.7 | 1 | 56 | 4 | 150 | N/A | coarse sand, gravelly sand, gravelly sand/AC, and quarry spalls | 13,072 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 4 | 150 | N/A | coarse sand, gravelly sand, gravelly sand/AC, and quarry spalls | 13,072 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 4 | 150 | N/A | coarse sand, gravelly sand, gravelly sand/AC, and quarry spalls | 13,072 |
| ***SURVEYS*** | | | | | | | | | | | |
| | Work Boat | Two-stroke Outboard (WB) | Assume one survey per day and each work day contains one 10 hr-shift. Assume a total of 1,151 survey events based on pre-construction (bathy and topo), post-dredge and post-placement surveys per RAA, post-construction (bathy and topo) for each construction seasons, contractor progress surveys for the construction duration, and as-built survey in the final construction season. | 0.2 | 1 | 3 | 10 | 1.00 | N/A | surveys | 1,151 |
| ***CONFIRMATIONAL SEDIMENT SAMPLING AND ENVIRONMENTAL MONITORING*** | | | | | | | | | | | |
| | Work Boat | Two-stroke Outboard (WB) | Assume one water quality monitoring event per dredge day and each work day contains one 10 hr-shift. Assume 699 water quality monitoring events. Assume 52 confirmational sediment sampling events. | 0.2 | 1 | 3 | 10 | 1.00 | N/A | monitoring events | 699 |

Notes:
Quantities and production rates obtained from Appendix N (Opinion of Probable Cost).
Equipment and daily equipment operation rates assumed based on engineering best professional judgment and experience in similar sediment projects.

AC: activated carbon
CIL: chemical isolation layer
cy: cubic yard
ENR: enhanced natural recovery
gal: gallon
hp: horsepower
hr: hour
LDW: Lower Duwamish Waterway
MR: middle reach
N/A: not applicable
OR: Oregon
PB: push boat
PCB: polychlorinated biphenyl
RAA: remedial action area
RCRA: Resource Conservation and Recovery Act
RMC: residuals management cover
SCC: Standard Classification Code
SMA: sediment management area
TSCA: Toxic Substances Control Act
WB: work boat
WA: Washington

**Table L4-3**
**Equipment Type and Fuel Usage Assumptions per Equipment Type**

| Equipment Type | Equipment Uptime (%) | Equipment Daily Use – Work Day (hours/day) | Fuel Consumption Rate (gal/hour) | Daily Diesel Fuel Usage (gal/day) |
|---|---|---|---|---|
| Hydraulic Excavator | 70% | 10 | 20 | 140 |
| Hydraulic Excavator (Tidally Restricted Work Only) | 70% | 4 | 20 | 56 |
| Front-end Loader | 80% | 10 | 6 | 48 |
| 150-ton Crane | 70% | 10 | 16 | 112 |
| 100-ton Crane | 70% | 10 | 16 | 112 |
| Tug Boat (3,000 hp) | 20% | 10 | 40 | 80 |
| Tug Boat (800 hp) | 20% | 8 | 28 | 45 |
| Push Boat | 70% | 10 | 28 | 197 |
| Work Boat | 20% | 10 | 1.5 | 3 |
| Mini Excavator | 70% | 10 | 2 | 14 |

Notes:
Equipment uptimes (effective operation time) and fuel consumption rates were from local contractors in Washington State and estimated for each type of equipment based on engineering best professional judgment and experience on other similar sediment projects.
Daily use of equipment is based on assumptions provided in Appendix N (Opinion of Probable Cost).
Daily diesel fuel usage is calculated as fuel consumption rate (gal/hour) × equipment uptime (%) × work day (hours/day).
Daily diesel fuel usage is calculated for a single piece of equipment. Assumed number of pieces of equipment is presented in Table L4-2.
gal: gallon
hp: horsepower

**Table L4-4**
**Rail Transportation Assumptions**

| Parameter | Pre-Tier | Tier 2 | Tier 4 | Unit | Comments/Reference |
|---|---|---|---|---|---|
| Diesel Fuel Economy for Train/Locomotive | 500 | | | ton-mile/gal | National average fuel consumption rate of 500 ton-miles/gal based from data collected by the Association of American Railroads (p. 2 of *Freight Railroads and Climate Change Fact sheet;* July 2025). |
| **Emission Factors** | | | | | |
| Hydrocarbons (HC) | 1.0 | 0.3 | 0.14 | g/bhp-hr | Source for Emission Factors (HC, CO, $NO_x$ and $PM_{10}$): *Locomotives: Exhaust Emissions Standards* (March 2016; OTAQ; EPA- 420-B-16-024).<br>Emission factors for rail transportation correspond to Tier 4 locomotives, manufactured after 2015. Equipment is upgraded every 15 years, and this is a reasonable assumption by the time the LDW project is implemented. Source: *Control of Emissions from Idling Locomotives* (December 2013; OTAQ; EPA-420-F-13-050).<br>Source for Conversion Factors: EPA Technical Highlights *Emission Factors for Locomotives* (April 2009; OTAQ; EPA-420-F-09-025).<br>In order to use emission factors in g/gal, as conversion factor of 20.8 bhp-hr/gal (for Large Line Haul and Passenger Locomotives) is available in Table 3.<br>VOC emissions are 1.053 times HC emissions, and $PM_{2.5}$ emissions are 0.97 times $PM_{10}$ emissions (p. 4).<br>$SO_2$ emissions are dependent upon fuel properties and not engine properties (p. 5):<br>$SO_2$ (g/gal) = (fuel density) × (conversion factor) × (64 g $SO_2$/32 g S) × (S content of fuel).<br>The current density of diesel fuel is 6.76 lb/gal (3,066 g/gal) (https://www.marathonpetroleum.com/content/documents/Operations/St_paul_park_sds/No2_Ultra_Low_Sulfur_Diesel_15ppm_Sulfur_Max.pdf).<br>The current sulfur content of diesel fuel is 15 ppm (ultra-low-sulfur diesel fuel; https://www.epa.gov/diesel-fuel-standards/diesel-fuel-standards-and-rulemakings).<br>The fraction of fuel sulfur converted to $SO_2$ is 97.8% (p. 5). Therefore, $SO_2$ (g/gal) = (3,066 g/gal) × (0.978) × (64 g $SO_2$ / 32 g S) × (15e-6) = 0.089 g/gal.<br>The $CO_2$ emission factor is 10.21 kg $CO_2$/gal, as in Table 8 - Scope 3 Category 4: Upstream Transportation and Distribution and Category 9: Downstream Transportation and Distribution, from *Emission Factors for Greenhouse Gas Inventories,* January 2025). |
| | 20.8 | 6.2 | 2.91 | g/gal | |
| Volatile Organic Compounds (VOCs) | 1.1 | 0.3 | 0.15 | g/bhp-hr | |
| | 21.9 | 6.6 | 3.07 | g/gal | |
| Carbon Monoxide (CO) | 5.0 | 1.5 | 1.5 | g/bhp-hr | |
| | 104.0 | 31.2 | 31.20 | g/gal | |
| Nitrous Oxides ($NO_X$) | 8.0 | 5.5 | 1.3 | g/bhp-hr | |
| | 166.4 | 114.4 | 27.04 | g/gal | |
| Particulate Matter 10 µm ($PM_{10}$) | 0.2 | 0.1 | 0.03 | g/bhp-hr | |
| | 4.6 | 2.1 | 0.62 | g/gal | |
| Particulate Matter 2.5 µm ($PM_{2.5}$) | 0.2 | 0.1 | 0.0291 | g/bhp-hr | |
| | 4.4 | 2.0 | 0.61 | g/gal | |
| Sulfur Dioxide ($SO_2$) | 0.09 | | | g/gal | |
| Carbon Dioxide ($CO_2$) | 10,210 | | | g/gal | |
| Distance from Intermodal Facility to Subtitle D Disposal Landfill Facility (Transport of Dredged Sediment) | 300 | | | miles | Dredged sediment is assumed to be transferred from an intermodal facility to an off-site disposal landfill facility, assumed to be located in Arlington, Oregon. |

Notes:
Ton-mile is a unit of freight transportation equivalent to a ton of freight moved 1 mile.
µm: micron
bhp: usable power
EPA: U.S. Environmental Protection Agency
g: gram
gal: gallon
hr: hour
kg: kilogram
lb: pound
LDW: Lower Duwamish Waterway
OTAQ: Office of Transportation and Air Quality
ppm: part per million
S: sulfur

**Table L4-5a**
**Nonroad Truck Transportation Assumptions**

| Parameter | Pre-Tier | Tier 2 | Tier 4 | Unit | Comments/Reference |
|---|---|---|---|---|---|
| **Dump Truck** | | | | | |
| Average Power | | 600 | | hp | Assumed truck capacity and fuel consumption based on engineering best professional judgement and experience on other similar sediment projects. |
| Capacity | | 20 | | tons | |
| Fuel Consumption | | 13 | | gal/hr | |
| $CO_2$ Emission Factor for Trucks | | 0.19 | | kg $CO_2$/ton-mile | Source: Table 8 - Scope 3 Category 4: Upstream Transportation and Distribution and Category 9: Downstream Transportation and Distribution," from *Emission Factors for Greenhouse Gas Inventories,* January 2025. Truck type - Medium- Heavy Duty Truck. |
| Diesel Fuel Economy for Trucks | | 148 | | ton-mile/gallon | Calculated as 27.46 kg/gal / 0.211 kg/ton-mile ≈ 130 ton-mile/gal |
| **Emission Factors** | | | | | |
| Hydrocarbons (HC) | 35.3 | 8.7 | 0.571 | g/gal | Source: *Exhaust and Crankcase Emission Factors for Nonroad Compression-Ignition Engines in MOVES3.0.2* (EPA-420-R-21-021, September 2021).<br>$PM_{2.5}$ emissions are 0.97 times $PM_{10}$ emissions (pg. 35).<br>$CO_2$ = [BSFC (lb/hp-hr) × 453.6(g/lb) - HC (g/hp-hr)] × 0.87 × (44/12) (p. 34).<br>$SO_2$ (g/hp-hr) = [BSFC(lb/hp-hr) × 453.6(g/lb) × (1 - soxcnv) -HC(g/hp-hr)] × 0.01 × soxdsl(%) × 2 (p. 34).<br>BSFC = 0.408 (lb/hp-hr; 0-100 hp) and 0.367 (lb/hp-hr; >100 HP); 0.87 = carbon mass fraction of diesel; 44/12 = ratio of $CO_2$ mass to carbon mass; soxcnv = 0.02247, which is the fraction of fuel sulfur converted to direct PM; soxdsl = 15 ppm (0.0015%), which is the episodic weight percent of sulfur in nonroad diesel fuel; 0.01 = conversion factor from weight percent to weight fraction and 2 = g $SO_2$ /g sulfur.<br>VOC emissions are 1.053 times HC emissions.<br>Reference: EPA Technical Highlights *Emission Factors for Locomotives* (April 2009; OTAQ; EPA-420-F-09-025). |
| Volatile Organic Compounds (VOCs) | 37.2 | 9.1 | 0.601 | g/gal | |
| Carbon Monoxide (CO) | 140.2 | 68.9 | 11.112 | g/gal | |
| Nitrous Oxides ($NO_X$) | 435.1 | 212.9 | 59.867 | g/gal | |
| Particulate Matter 10 µm ($PM_{10}$) | 20.9 | 6.9 | 0.467 | g/gal | |
| Particulate Matter 2.5 µm ($PM_{2.5}$) | 20.2 | 6.6 | 0.453 | g/gal | |
| Sulfur Dioxide ($SO_2$) | 0.3 | 0.3 | 0.253 | g/gal | |
| Carbon Dioxide ($CO_2$) | 27,500 | 27,500 | 27,500 | g/gal | |
| Distance from LDW Middle Reach to Intermodal Facility (Transport of Dredged Sediment for Off-site Disposal) | | 6 | | miles | Upland transport of dredged sediment for off-site disposal, by truck, from offloading facility to a nearby intermodal facility is a conservative assumption for the distance required for truck transportation from the LDW middle reach to the intermodal facility. Used Union Pacific Railroad – Argo Yard, which is 3 miles away. |
| Distance from RAA 24B-D to the Transload Facility (Truck Transport of Subtitle D-level Identified Debris) | | 2 | | miles | Upland transport of RAA 24B-D Identified Debris by truck, from offloading facility to a transload facility which is 1 mile away (2 miles round trip) |
| Distance from Local Quarry to Onshore Staging Area (Transport of Clean Materials for Placement) | | 20 | | miles | Upland transport of clean material, by truck, is a conservative assumption for the distance required for truck transportation from the quarry to an onshore staging area in the LDW. |

Notes:
Ton-mile is a unit of freight transportation equivalent to a ton of freight moved 1 mile.
In order to use emission factors in g/gal, the steady state factors are converted using the average horsepower of the specific equipment and the fuel consumption rate (gal/hr).
Emission factors (g/gal) = Emission Factors (g/hp-hr)*Equipment horsepower (hp)/ Fuel Consumption (gal/hr).
µm: micron
BSFC: brake specific fuel consumption (lb/hp-hr)
EPA: U.S. Environmental Protection Agency
g: gram
gal: gallon
hp: horsepower
hr: hour
kg: kilogram
lb: pound
LDW: Lower Duwamish Waterway
OTAQ: Office of Transportation and Air Quality
ppm: part per million
RAA: remedial action area

**Table L4-5b**
**On-Road Truck Transportation Assumptions**

| Parameter | Tier 2 | Tier 4 | Unit | Comments/Reference |
|---|---|---|---|---|
| **Dump Truck** | | | | |
| Average Power | 600 | | hp | Assumed truck capacity and fuel consumption based on engineering best professional judgement and experience on other similar sediment projects. Source: *A Survey of Fuel Economy and Fuel Usage by Heavy-Duty Truck Fleets* [(SWT-2016-12, October 2016). |
| Capacity | 20 | | tons | |
| Fuel Consumption | 7.3 | | mile/gallon | |
| $CO_2$ Emission Factor for Trucks | 0.19 | | kg $CO_2$/ton-mile | Source: Table 8 - Scope 3 Category 4: Upstream Transportation and Distribution and Category 9: Downstream Transportation and Distribution, from *Emission Factors for Greenhouse Gas Inventories,* January 2025. Truck type - Medium- Heavy Duty Truck. |
| Diesel Fuel Economy for Trucks | 147 | | ton-mile/gallon | Calculated as 10.21 kg/gal / 0.19 kg/ton-mile ≈ 53.7 ton-mile/gal |
| **Emission Factors** | | | | |
| Hydrocarbons (HC) | 6.61 | 3.64 | g/gal | Source: *Bureau of Transportation Statistics, National Transportation Statistics for 2021*<br>Emission factors for HC, CO, $NO_x$ and $PM_{2.5}$ are from Table 4-43 (p. 282).<br>Source: *Exhaust and Crankcase Emission Factors for Nonroad Compression-Ignition Engines in MOVES3.0.2* (EPA-420-R-21-021, September 2021).<br>$PM_{2.5}$ emissions are 0.97 times $PM_{10}$ emissions (p. 35).<br>$SO_2$ (g/hp-hr) = [BSFC(lb/hp-hr) × 453.6(g/lb) × (1 -soxcnv) - HC(g/hp-hr)] × 0.01 × soxdsl(%) × 2 (p. 34).<br>BSFC = 0.408 (lb/hp-hr; 0-100 hp) and 0.367 (lb/hp-hr; >100 HP); soxcnv = 0.02247, which is the fraction of fuel sulfur converted to direct PM; soxdsl = 15 ppm (0.0015%), which is the episodic weight percent of sulfur in nonroad diesel fuel; 0.01= conversion factor from weight percent to weight fraction and 2 = g $SO_2$ /g sulfur.<br>VOC emissions are 1.053 times HC emissions.<br>Reference: EPA Technical Highlights *Emission Factors for Locomotives* (April 2009; OTAQ; EPA-420-F-09-025). |
| Volatile Organic Compounds (VOCs) | 6.96 | 3.84 | g/gal | |
| Carbon Monoxide (CO) | 31.48 | 19.77 | g/gal | |
| Nitrous Oxides ($NO_X$) | 136.36 | 55.43 | g/gal | |
| Particulate Matter 10 µm ($PM_{10}$) | 6.16 | 2.18 | g/gal | |
| Particulate Matter 2.5 µm ($PM_{2.5}$) | 5.98 | 2.12 | g/gal | |
| Sulfur Dioxide ($SO_2$) | 0.40 | 0.40 | g/gal | |
| Carbon Dioxide ($CO_2$) | 10,210.00 | 10,210.00 | g/gal | |
| Distance from AC Vendor (Ridgefield, Washington) to LDW Middle Reach | 150 | | miles | For Intermediate (60%) RD, AC is assumed to be transported from a vendor located in Ridgefield, Washington, to the LDW middle reach. |
| Distance from Cement Vendor (Seattle, Washington) to LDW Middle Reach | 4 | | miles | For Preliminary (60%) RD, Cement is assumed to be transported from Ashgrove Cement located in Seattle, Washington, 4 miles to the LDW middle reach. |

Notes:
Ton-mile is a unit of freight transportation equivalent to a ton of freight moved 1 mile.
In order to use emission factors in g/gal, the steady state factors are converted using the average horsepower of the specific equipment and the fuel consumption rate (gal/hr).
Emission factors (g/gal) = Emission Factors (g/hp-hr) × Equipment horsepower (hp) / Fuel Consumption (gal/hr).
µm: micron
AC: activated carbon
BSFC: brake specific fuel consumption (lb/hp-hr)
EPA: U.S. Environmental Protection Agency
g: gram
gal: gallon
hp: horsepower
hr: hour
kg: kilogram
lb: pound
LDW: Lower Duwamish Waterway
OTAQ: Office of Transportation and Air Quality
RD: remedial design

**Table L4-6**
**Barge Transportation Assumptions**

| Parameter | Pre-Tier | Tier 2 | Tier 4 | Unit | Comments/Reference |
|---|---|---|---|---|---|
| **Tug/Barge – Diesel Inboard/Sterndrive (3,000 hp)** | | | | | |
| Average Power | 3,000 | | | hp | Average fuel consumption of empty and fully loaded tug/barge: (15+85)/2 = 50, rounded down to 40 gal/hour in order to use NONROAD EPA emission factors.<br>Empty tug/barges typically consume 15 gal/hour.<br>Fully loaded tug/barges consume 85 gal/hour in Seattle area, derived from 1999 Puget Sound Clean Air Agency (www.pscleanair.org) document entitled *1999 Tugboat Fuel Consumption in Seattle Area* . |
| Fuel Consumption | 40 | | | gal/hr | |
| $CO_2$ Emission Factor for Diesel Fuel | 10.21 | | | kg $CO_2$/gal | Source: Table 2 - Mobile Combustion $CO_2$, from *Emission Factors for Greenhouse Gas Inventories,* January 2025). https://www.epa.gov/climateleadership/ghg-emission-factors-hub |
| $CO_2$ Emission Factor for Boats | 0.077 | | | kg $CO_2$/ton-mile | Source: Table 8 - Scope 3 Category 4: Upstream Transportation and Distribution and Category 9: Downstream Transportation and Distribution, from *Emission Factors for Greenhouse Gas Inventories,* January 2025. https://www.epa.gov/climateleadership/ghg-emission-factors-hub |
| Diesel Fuel Economy for Boats | 516 | | | ton-mile / gallon | Calculated as 39.700 kg/gal / 0.077 kg/ton-mile ≈ 516 ton-mile/gal. |
| **Emission Factors** | | | | | |
| Hydrocarbons (HC) | 51.0 | 12.5 | 2.63 | g/gal | Source: *Exhaust and Crankcase Emission Factors for Nonroad Compression-Ignition Engines in MOVES3.0.2* (EPA-420-R-21-021, September 2021).<br>$PM_{2.5}$ emissions are 0.97 times $PM_{10}$ emissions (p. 35).<br>$CO_2$ = [BSFC (lb/hp-hr) × 453.6(g/lb) - HC (g/hp-hr)] × 0.87 × (44/12) (p. 34).<br>$SO_2$ (g/hp-hr) = [BSFC(lb/hp-hr) × 453.6(g/lb) × (1 - soxcnv) - HC(g/hp-hr)] × 0.01 × soxdsl(%) × 2 (p. 34).<br>BSFC = 0.408 (lb/hp-hr; 0–100 hp) and 0.367 (lb/hp-hr; >100 HP); 0.87 = carbon mass fraction of diesel; 44/12 = ratio of $CO_2$ mass to carbon mass; soxcnv = 0.02247, which is the fraction of fuel sulfur converted to direct PM; soxcnv is equal to 0.02247 for the Base- T4B technology types and 0.3 if PM< 0.1 g/hp-hr for Tier 4F; soxdsl = 15 ppm (0.0015%), which is the episodic weight percent of sulfur in nonroad diesel fuel; 0.01= conversion factor from weight percent to weight fraction and, 2 = g $SO_2$ /g sulfur<br>VOC emissions are 1.053 times HC emissions (p. 4) (EPA Technical Highlights *Emission Factors for Locomotives* [April 2009; Office of Transportation and Air Quality (OTAQ); EPA-420-F-09-025]). |
| Volatile Organic Compounds (VOCs) | 53.7 | 13.2 | 2.76 | g/gal | |
| Carbon Monoxide (CO) | 202.5 | 57.3 | 9.83 | g/gal | |
| Nitrous Oxides ($NO_X$) | 628.5 | 307.5 | 170.85 | g/gal | |
| Particulate Matter 10 µm ($PM_{10}$) | 30.2 | 9.9 | 1.58 | g/gal | |
| Particulate Matter 2.5 µm ($PM_{2.5}$) | 29.2 | 0.4 | 0.39 | g/gal | |
| Sulfur Dioxide ($SO_2$) | 0.4 | 0.4 | 0.37 | g/gal | |
| Carbon Dioxide ($CO_2$) | 39,700 | 39,800 | 39,800 | g/gal | |
| Distance from LDW Middle Reach to the Transload Facility (Barge Transport of Subtitle D-level Sediment and Identified) | 5 | | | miles | Dredged sediment is assumed to be transported by barge to a transloading facility, which is assumed to be 5 miles from middle point of the LDW middle reach. |
| Distance from Onshore Staging Area to LDW Middle Reach (Transport of Clean Materials for Placement) | 5 | | | miles | Sand, gravelly sand, gravel, and quarry spalls are assumed to be transported by barge from onshore staging area to the LDW middle reach. |

Notes:
Ton-mile is a unit of freight transportation equivalent to a ton of freight moved 1 mile.
In order to use emission factors in g/gal, the steady state factors are converted using the average horsepower of the specific equipment and the fuel consumption rate (gal/hr).
Emission factors (g/gal) = Emission Factors (g/hp-hr) × Equipment horsepower (hp) / Fuel Consumption (gal/ hr)
µm: micron
BSFC: brake specific fuel consumption (lb/hp-hr)
EPA: U.S. Environmental Protection Agency
g: gram
gal: gallon
hp: horsepower
hr: hour
kg: kilogram
lb: pound
LDW: Lower Duwamish Waterway
OTAQ: Office of Transportation and Air Quality

**Table L4-7**
**Air Emission Factors for Construction Equipment and Vehicles**

| Type of Vehicle / Equipment Used | SCC Description | hp | Fuel Consumption Rate (gal/hour) | Pre-Tier Emission Factors (g/gal) | | | | | | | | Tier 2 Emission Factors (g/gal) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | HC | VOCs | CO | $NO_X$ | $PM_{10}$ | $PM_{2.5}$ | $SO_2$ | $CO_2$ | HC | VOCs | CO | NOX | $PM_{10}$ | $PM_{2.5}$ | $SO_2$ | $CO_2$ |
| Work Boat | Two-Stroke Outboard (WB) | 45 | 1.5 | 54.00 | 56.86 | 150.00 | 207.00 | 24.00 | 23.28 | 0.161 | 17,539 | 8.37 | 8.81 | 45.97 | 141.84 | 10.17 | 9.86 | 0.163 | 17,684 |
| Push Boat | Two-Stroke Outboard (PB) | 875 | 28 | 21.17 | 22.30 | 84.07 | 260.94 | 12.52 | 12.14 | 0.151 | 16,438 | 5.20 | 5.48 | 23.79 | 127.67 | 4.11 | 3.99 | 0.152 | 16,519 |
| 100-ton and 150-ton Cranes | Diesel Cranes | 675 | 16 | 28.69 | 30.21 | 113.91 | 353.53 | 16.96 | 16.45 | 0.2051 | 22,312 | 7.05 | 7.42 | 55.98 | 172.97 | 5.57 | 5.40 | 0.2057 | 22,381 |
| Hydraulic Excavator | Diesel Excavators | 450 | 20 | 15.30 | 16.11 | 60.75 | 188.55 | 9.05 | 8.77 | 0.109 | 11,900 | 3.76 | 3.96 | 18.97 | 97.54 | 2.97 | 2.88 | 0.110 | 11,936 |
| Hydraulic Excavator (Tidally Restricted Work Only) | Diesel Excavators | 450 | 20 | 15.30 | 16.11 | 60.75 | 188.55 | 9.05 | 8.77 | 0.11 | 11,900 | 3.76 | 3.96 | 18.97 | 97.54 | 2.97 | 2.88 | 0.11 | 11,936 |
| Tug Boat (800 hp) | Diesel Inboard/Sterndrive (800 hp) | 875 | 28 | 21.17 | 22.30 | 84.07 | 260.94 | 12.52 | 12.14 | 0.151 | 16,468 | 5.20 | 5.48 | 23.79 | 127.67 | 4.11 | 3.99 | 0.152 | 16,519 |
| Telebelt | Diesel Other Material Handling Equipment | -- | 4 | 76.50 | 80.55 | 303.75 | 942.75 | 45.23 | 43.87 | 0.547 | 59,498 | 18.79 | 19.78 | 94.84 | 487.69 | 14.85 | 14.40 | 0.549 | 59,682 |
| Front-end Loader | Diesel Rough Terrain Forklifts | 238 | 6 | 26.92 | 28.34 | 106.88 | 331.71 | 15.91 | 15.44 | 0.192 | 20,935 | 12.23 | 12.88 | 29.61 | 158.33 | 5.23 | 5.07 | 0.193 | 20,981 |
| Mini Excavator | Diesel Excavators | 10 | 2 | 20.40 | 21.48 | 81.00 | 251.40 | 12.06 | 11.70 | 0.146 | 15,866 | 5.01 | 5.28 | 25.29 | 130.05 | 3.96 | 3.84 | 0.146 | 15,915 |

**Table L4-7**
**Air Emission Factors for Construction Equipment and Vehicles**

| Type of Vehicle / Equipment Used | SCC Description | hp | Fuel Consumption Rate (gal/hour) | Tier 4 Emission Factors (g/gal) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | HC | VOCs | CO | $NO_X$ | $PM_{10}$ | $PM_{2.5}$ | $SO_2$ | $CO_2$ |
| Work Boat | Two-Stroke Outboard (WB) | 45 | 1.5 | 4.08 | 4.30 | 12.24 | 82.86 | 0.81 | 0.79 | 0.105 | 17,698 |
| Push Boat | Two-Stroke Outboard (PB) | 875 | 28 | 1.09 | 1.15 | 4.08 | 70.93 | 0.65 | 0.63 | 0.109 | 16,533 |
| 100-ton and 150-ton Cranes | Diesel Cranes | 675 | 16 | 0.46 | 0.49 | 9.03 | 48.64 | 0.38 | 0.37 | 0.2059 | 22,402 |
| Hydraulic Excavator | Diesel Excavators | 450 | 20 | 0.25 | 0.26 | 4.82 | 25.94 | 0.20 | 0.20 | 0.079 | 11,948 |
| Hydraulic Excavator (Tidally Restricted Work Only) | Diesel Excavators | 450 | 20 | 0.25 | 0.26 | 4.82 | 25.94 | 0.20 | 0.20 | 0.08 | 11,948 |
| Tug Boat (800 hp) | Diesel Inboard/Sterndrive (800 hp) | 875 | 28 | 1.09 | 1.15 | 4.08 | 70.93 | 0.65 | 0.63 | 0.109 | 16,533 |
| Telebelt | Diesel Other Material Handling Equipment | -- | 4 | 1.24 | 1.30 | 24.08 | 129.71 | 1.01 | 0.98 | 0.393 | 59,738 |
| Front-end Loader | Diesel Rough Terrain Forklifts | 238 | 6 | 0.44 | 0.46 | 8.47 | 45.64 | 0.36 | 0.35 | 0.138 | 21,019 |
| Mini Excavator | Diesel Excavators | 10 | 2 | 0.33 | 0.35 | 6.42 | 34.59 | 0.27 | 0.26 | 0.105 | 15,930 |

**Table L4-7**
**Air Emission Factors for Construction Equipment and Vehicles**

Notes:
Emission factors derived from *Exhaust and Crankcase Emission Factors for Nonroad Compression-Ignition Engines in MOVES3.0.2* (EPA-420-R-21-021, September 2021). Steady state factors derived from Table A-4 (Appendix A). Emissions factors are based on the equipment horsepower and Tier category.

Pre-Tier emission factors were assumed to be Tier 0. Emissions Factors for Tier 4 were the most conservative of the final emissions factors from Table A4. $PM_{2.5}$ emissions are assumed to 0.97 times $PM_{10}$ emissions (see p. 35).

$CO_2$ (g/hp-hr) = [BSFC (lb/hp-hr) × 453.6(g/lb) -HC (g/hp-hr)] × 0.87 × (44/12); $SO_2$ (g/hp-hr) = [BSFC(lb/hp-hr) × 453.6(g/lb) × (1 -soxcnv) -HC(g/hp-hr)] × 0.01 × soxdsl(%) × 2 (p. 34). BSFC = 0.408 (lb/hp-hr; 0-100 hp) and 0.367 (lb/hp-hr; >100 HP); 0.87 = carbon mass fraction of diesel; 44/12 = ratio of $CO_2$ mass to carbon mass; soxcnv = 0.02247, which is the fraction of fuel sulfur converted to direct PM; 0.01= conversion factor from weight percent to weight fraction and, 2 = g $SO_2$ /g sulfur.
VOC emissions are 1.053 times HC emissions (see p. 4).
Reference: EPA Technical Highlights *Emission Factors for Locomotives* (April 2009; OTAQ; EPA-420-F-09-025).
Emission factors (g/gal) = Emission Factors (g/hp-hr) × Equipment hp / Fuel Consumption (gal/hr)
--: not applicable
BSFC: brake-specific fuel consumption
CO: carbon monoxide
$CO_2$: carbon dioxide
EPA: U.S. Environmental Protection Agency
gal: gallon
g: gram
HC: hydrocarbon
hp: horsepower
hr: hour
lb: pound
$NO_X$: nitrogen oxides (NO and $NO_2$)
OTAQ: Office of Transportation and Air Quality
PB: push boat
$PM_{2.5}$: particulate matter less that 2.5 microns in diameter
$PM_{10}$: particulate matter less than 10 microns in diameter
SCC: Standard Classification Code
$SO_2$: sulfur dioxide
soxcnv: 0.2447 or 0.3 (fraction of fuel sulfur converted to direct PM)
soxdsl: 0.0015% (episodic weight percent of sulfur in nonroad ultra low sulfur [15 ppm] diesel fuel)
VOC: volatile organic compound
WB: work boat

**Table L4-8**
**Detailed Summary of Direct Emissions by Construction Activity of Each Tier**

| Construction Activity | Type of Vehicle/Equipment Used | SCC Description | Notes | Equipment Uptime | Equipment Quantity | Total Daily Diesel Usage (gal/day) | Shift Duration (hr) | Production Rate (quantity/day) | One-way Distance (miles) | Quantity Units | Pre-Tier – Total Emissions (Metric Tonnes) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | HCs | VOCs | CO | $NO_X$ | $PM_{10}$ | $PM_{2.5}$ | $SO_2$ | $CO_2$ |
| ***MOBILIZATION/DEMOBILIZATION/SITE PREPARATION*** | | | | | | | | | | | | | | | | | | |
| **Equipment Mobilization/Demobilization (8 hours/day)** | | | | | | | | | | | | | | | | | | |
| | Tug Boat (800 hp) | Diesel Inboard/Sterndrive (800 hp) | Assume mobilization/demobilization of 2 derrick rigs and 3 material barges. Assume 8 hrs/day for 4 days per construction season. | 0.2 | 5 | 225 | 8 | 0.75 | N/A | Construction season | 0.0571 | 0.0601 | 0.2268 | 0.7039 | 0.0338 | 0.0328 | 0.0004 | 44.4 |
| **Site Clearing and Grubbing (8 hours/day)** | | | | | | | | | | | | | | | | | | |
| | Mini Excavator | Diesel Excavators | Assume mobilization/demobilization of 1 mini-excavator. Assume 10 hrs/day for 4 days per construction season. | 0.7 | 1 | 14 | 10 | 0.60 | N/A | Construction season | 0.0032 | 0.0034 | 0.0128 | 0.0396 | 0.0019 | 0.0018 | 0.0000 | 2.5 |
| | | | ***SUBTOTAL EMISSIONS – SITE PREPARATION*** | | | | | | | | **0.060** | **0.064** | **0.240** | **0.744** | **0.036** | **0.035** | **0.00043** | **46.9** |
| ***STRUCTURAL WORK*** | | | | | | | | | | | | | | | | | | |
| **Pulling of Timber and Steel Piling and Replacement with Steel Piles – Multiple RAAs (10 hrs/day)** | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. Assume pile removal or replacement occurs at 25 piles/day. | 0.7 | 1 | 112 | 10 | 25 | N/A | # piles | 0.0090 | 0.0095 | 0.0357 | 0.1109 | 0.0053 | 0.0052 | 0.0001 | 7.0 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 25 | N/A | # piles | 0.0117 | 0.0123 | 0.0463 | 0.1437 | 0.0069 | 0.0067 | 0.0001 | 9.1 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 25 | N/A | # piles | 0.0005 | 0.0005 | 0.0013 | 0.0017 | 0.0002 | 0.0002 | 0.0000 | 0.1 |
| **Re-Routing of Outfalls OF27 and OF28 – RAAs 24B-D** | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 10-hr shift. Assume a total of 4 days. | 0.7 | 1 | 140 | 10 | 500 | N/A | cy soil | 0.0031 | 0.0033 | 0.0125 | 0.0387 | 0.0019 | 0.0018 | 0.0000 | 2.4 |
| | Front-end Loader | Diesel Rough Terrain Forklifts | | 0.8 | 1 | 48 | 10 | 500 | N/A | cy soil | 0.0019 | 0.0020 | 0.0075 | 0.0234 | 0.0011 | 0.0011 | 0.0000 | 1.5 |
| **Double-Wall Cofferdam and Shoring Wall Installation and Removal – RAAs 24B-D** | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. Assume a total of 153 Days (133 days to install and 20 days to remove sheet piles). | 0.7 | 1 | 112 | 10 | 1 | N/A | # of days | 0.49 | 0.52 | 1.95 | 6.06 | 0.29 | 0.28 | 0.00 | 382.34 |
| | Front-end Loader | Diesel Inboard/Sterndrive (800 hp) | | 0.8 | 1 | 48 | 10 | 1 | N/A | # of days | 0.20 | 0.21 | 0.78 | 2.44 | 0.12 | 0.11 | 0.00 | 153.74 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 1 | N/A | # of days | 0.0248 | 0.0261 | 0.0689 | 0.0950 | 0.0110 | 0.0107 | 0.0001 | 8.0503 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 1 | N/A | # of days | 1.4245 | 1.5000 | 5.6216 | 17.3092 | 0.8379 | 0.8128 | 0.0101 | 1,093.8629 |
| **Removal of Submerged Barge – RAA 14A** | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. Assume 20 ton removed per hour according to the structural team. | 0.7 | 1 | 112 | 10 | 200 | N/A | ton | 0.1977 | 0.2082 | 0.7849 | 2.4361 | 0.1169 | 0.1134 | 0.0014 | 153.7 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 200 | N/A | ton | 0.0248 | 0.0261 | 0.0689 | 0.0950 | 0.0110 | 0.0107 | 0.0001 | 8.1 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 200 | N/A | ton | 0.6372 | 0.6710 | 2.5302 | 7.8531 | 0.3767 | 0.3654 | 0.0045 | 494.7 |
| **Demolition of Derelict Structures (RAA 24B-D, 8F, 8H)** | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. Assume a total of 28 days. RAA 24's derelict structure will be removed in the dry; therefore, a push and work boats will not be required. Production rate from structural team. | 0.7 | 1 | 112 | 10 | 200 | N/A | # of days | 0.0161 | 0.0169 | 0.0638 | 0.1980 | 0.0095 | 0.0092 | 0.0001 | 12.5 |
| | Front-end Loader | Diesel Inboard/Sterndrive (800 hp) | | 0.8 | 1 | 48 | 10 | 200.00 | N/A | # of days | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.27 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 200 | N/A | # of days | 0.0265 | 0.0279 | 0.1051 | 0.3262 | 0.0156 | 0.0152 | 0.0002 | 20.6 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 200 | N/A | # of days | 0.0008 | 0.0009 | 0.0023 | 0.0031 | 0.0004 | 0.0003 | 0.0000 | 0.3 |
| | | | ***SUBTOTAL EMISSIONS – STRUCTURAL WORK*** | | | | | | | | **1.425** | **1.500** | **5.622** | **17.309** | **0.838** | **0.813** | **0.010** | **1093.863** |
| ***SEDIMENT REMOVAL*** | | | | | | | | | | | | | | | | | | |
| **Identified Debris Removal – Multiple RAAs (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 1 | N/A | # of days | 0.0900 | 0.0947 | 0.3572 | 1.1087 | 0.0532 | 0.0516 | 0.0006 | 69.9700 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 1 | N/A | # of days | 0.1166 | 0.1228 | 0.4631 | 1.4372 | 0.0689 | 0.0669 | 0.0008 | 90.5323 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 1 | N/A | # of days | 0.0045 | 0.0048 | 0.0126 | 0.0174 | 0.0020 | 0.0020 | 0.0000 | 1.4733 |
| **Open-Water Dredging (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 990 | N/A | cy sediment | 1.1014 | 1.1597 | 4.3730 | 13.5725 | 0.6511 | 0.6316 | 0.0079 | 856.6 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 990 | N/A | cy sediment | 1.4277 | 1.5033 | 5.6687 | 17.5940 | 0.8440 | 0.8187 | 0.0102 | 1108.3 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 990 | N/A | cy sediment | 0.0555 | 0.0585 | 0.1543 | 0.2129 | 0.0247 | 0.0239 | 0.0002 | 18.0 |
| **Nearshore/Slope/Slow Dredging (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 580 | N/A | cy sediment | 0.2901 | 0.3055 | 1.1520 | 3.5754 | 0.1715 | 0.1664 | 0.0021 | 225.6 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 580 | N/A | cy sediment | 0.3761 | 0.3960 | 1.4933 | 4.6348 | 0.2223 | 0.2157 | 0.0027 | 292.0 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 580 | N/A | cy sediment | 0.0146 | 0.0154 | 0.0406 | 0.0561 | 0.0065 | 0.0063 | 0.00004 | 4.8 |
| **Restricted Access Dredging (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 140 | 10 | 330 | N/A | cy sediment | 0.1108 | 0.1167 | 0.4399 | 1.3653 | 0.0655 | 0.0635 | 0.0008 | 86.2 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 330 | N/A | cy sediment | 0.2154 | 0.2268 | 0.8553 | 2.6547 | 0.1274 | 0.1235 | 0.0015 | 167.2 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 330 | N/A | cy sediment | 0.0084 | 0.0088 | 0.0233 | 0.0321 | 0.0037 | 0.0036 | 0.000025 | 2.7 |
| **Tidally Restricted Dredging (4 hours/day)** | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator (Tidally Restricted Work Only) | Diesel Excavators | Assume each work day contains one 4-hr shift. | 0.7 | 1 | 56 | 4 | 180 | N/A | cy sediment | 0.0855 | 0.0900 | 0.3396 | 1.0539 | 0.0506 | 0.0490 | 0.0006 | 66.5 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 4 | 180 | N/A | cy sediment | 0.1109 | 0.1167 | 0.4402 | 1.3661 | 0.0655 | 0.0636 | 0.0008 | 86.1 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 4 | 180 | N/A | cy sediment | 0.0043 | 0.0045 | 0.0120 | 0.0165 | 0.0019 | 0.0019 | 0.000013 | 1.4 |
| **Contingency Redredging (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 390 | N/A | cy sediment | 0.0855 | 0.0900 | 0.3396 | 1.0539 | 0.0506 | 0.0490 | 0.0006 | 66.5 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 390 | N/A | cy sediment | 0.1109 | 0.1167 | 0.4402 | 1.3661 | 0.0655 | 0.0636 | 0.0008 | 86.1 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 390 | N/A | cy sediment | 0.0043 | 0.0045 | 0.0120 | 0.0165 | 0.0019 | 0.0019 | 0.00001 | 1.4 |
| **Shoreline/Bank Excavation (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 140 | 10 | 500 | N/A | cy sediment | 0.0329 | 0.0346 | 0.1304 | 0.4049 | 0.0194 | 0.0188 | 0.0002 | 25.6 |
| | Front-end Loader | Diesel Rough Terrain Forklifts | | 0.8 | 1 | 48 | 10 | 500 | N/A | cy sediment | 0.0198 | 0.0209 | 0.0787 | 0.2442 | 0.0117 | 0.0114 | 0.0001 | 15.4 |
| | | | ***SUBTOTAL EMISSIONS – SEDIMENT DREDGING*** | | | | | | | | **4.35** | **4.58** | **17.17** | **52.82** | **2.56** | **2.48** | **0.03068** | **3338.2** |
| ***SEDIMENT TRANSLOADING OR CONTAINERIZED SEDIMENT TRANSFER, UPLAND TRANSPORTATION, AND DISPOSAL*** | | | | | | | | | | | | | | | | | | |
| **Mechanical Transloading (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | Tug Boat (3,000 HP) | Diesel Inboard/Sterndrive (3,000 hp) | Assume each work day contains one 10 hr-shift. Assume bulking factor of 5% for mechanical offloading. Assume tug boat transports dredge sediment to a transload facility 5 miles away (one-way). Total quantities encompass Subtitle D and Subtitle C bulk dredged sediments, TSCA, TSCA/RCRA dredge sediments, and debris from both MR and SMA 10, as well as the sunken barge. Excluding RAAs 24B-G. | 0.2 | 1 | N/A | 10 | N/A | 5 | ton | 0.3284 | 0.3458 | 1.3038 | 4.0467 | 0.1941 | 0.1883 | 0.0023 | 255.6 |
| | 100-ton Crane | Diesel Cranes | | 0.7 | 1 | 112 | 10 | 990 | N/A | cy sediment | 1.5067 | 1.5865 | 5.9824 | 18.5677 | 0.8907 | 0.8640 | 0.0108 | 1171.8 |
| | Front-end Loader | Diesel Rough Terrain Forklifts | | 0.8 | 1 | 48 | 10 | 990 | N/A | cy sediment | 0.6059 | 0.6380 | 2.4056 | 7.4664 | 0.3582 | 0.3474 | 0.0043 | 471.2 |
| **Subtitle D (Bulk Sediment and Dangerous Waste) – Upland Transportation and Disposal (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | Truck (20-ton Dump Truck) | Diesel Off-highway Trucks | Assume Identified Debris from RAA 24B-G trucked from LDW middle reach to a transload facility. Assume 1 mile each way (2 miles round trip). | N/A | 1 | N/A | 10 | N/A | 2 | ton | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Rail | N/A | Assume non-hazardous contaminated bulk sediments, dangerous waste containerized sediments, identified debris, and contaminated riprap railed from transload facility to an off-site landfill disposal facility in Arlington, OR, for 300 miles (one-way). | N/A | 1 | N/A | N/A | N/A | 300 | ton | 8.2930 | 8.7326 | 41.4652 | 66.3443 | 1.8245 | 1.7697 | 0.0355 | 4070.8 |
| **Subtitle C (TSCA and RCRA) – Upland Transportation and Disposal (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| Subtitle C | Truck (20-ton Freight Truck) | Diesel Onroad Trucks | Assume cement used for stabilization is transported 4 miles by truck from Ashgrove Cement, Seattle, WA, vendor to LDW middle reach (one-way). | N/A | 1 | N/A | 10 | N/A | 4 | ton | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Truck (20-ton Dump Truck) | Diesel Off-highway Trucks | Assume PCB remediation waste and/or RCRA hazardous waste removed trucked from LDW middle reach to a transfer (intermodal) facility in south Seattle. Assume 3 miles each way (6 miles round trip). Quantity includes TSCA and Mixed TSCA Waste/RCRA Hazardous Waste from RAAs 24B through G). | N/A | 1 | N/A | 10 | N/A | 6 | ton | 0.0052 | 0.0055 | 0.0207 | 0.0642 | 0.0031 | 0.0030 | 0.0000 | 4.0567 |
| | Rail | N/A | Assume PCB remediation waste and/or RCRA hazardous waste railed from intermodal facility to an off-site landfill disposal facility in Arlington, OR, for 300 miles (one-way). Total quantities encompass dredged sediments and debris from RAA 24B-D. | N/A | 1 | N/A | N/A | N/A | 300 | ton | 0.0454 | 0.0478 | 0.2268 | 0.3629 | 0.0100 | 0.0097 | 0.0002 | 22.2680 |
| | | | ***SUBTOTAL EMISSIONS – SEDIMENT TRANSLOADING, UPLAND TRANSPORTATION, AND DISPOSAL*** | | | | | | | | **10.78** | **11.36** | **51** | **97** | **3.28** | **3.18** | **0.05** | **5996.0** |

**Table L4-8**
**Detailed Summary of Direct Emissions by Construction Activity of Each Tier**

| Construction Activity | Type of Vehicle/Equipment Used | SCC Description | Notes | Tier 2 – Total Emissions (Metric Tonnes) | | | | | | | | Tier 4 – Total Emissions (Metric Tonnes) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | HCs | VOCs | CO | $NO_X$ | $PM_{10}$ | $PM_{2.5}$ | $SO_2$ | $CO_2$ | HCs | VOCs | CO | $NO_X$ | $PM_{10}$ | $PM_{2.5}$ | $SO_2$ | $CO_2$ |
| ***MOBILIZATION/DEMOBILIZATION/SITE PREPARATION*** | | | | | | | | | | | | | | | | | | | |
| **Equipment Mobilization/Demobilization (8 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | Tug Boat (800 hp) | Diesel Inboard/Sterndrive (800 hp) | Assume mobilization/demobilization of 2 derrick rigs and 3 material barges. Assume 8 hrs/day for 4 days per construction season. | 0.0140 | 0.0148 | 0.0642 | 0.344 | 0.01109 | 0.01076 | 0.00041 | 44.6 | 0.0029 | 0.0031 | 0.0110 | 0.191 | 0.00176 | 0.00171 | 0.00029 | 44.6 |
| **Site Clearing and Grubbing (8 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | Mini Excavator | Diesel Excavators | Assume mobilization/demobilization of 1 mini-excavator. Assume 10 hrs/day for 4 days per construction season. | 0.0008 | 0.0008 | 0.0040 | 0.020 | 0.00062 | 0.00060 | 0.00002 | 2.5 | 0.0001 | 0.0001 | 0.0010 | 0.005 | 0.00004 | 0.00004 | 0.00002 | 2.5 |
| | | | ***SUBTOTAL EMISSIONS – SITE PREPARATION*** | **0.015** | **0.016** | **0.068** | **0.365** | **0.012** | **0.011** | **0.00043** | **47.1** | **0.003** | **0.003** | **0.012** | **0.197** | **0.002** | **0.002** | **0.000** | **47** |
| ***STRUCTURAL WORK*** | | | | | | | | | | | | | | | | | | | |
| **Pulling of Timber and Steel Piling and Replacement with Steel Piles – Multiple RAAs (10 hrs/day)** | | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. Assume pile removal or replacement occurs at 25 piles/day. | 0.0022 | 0.0023 | 0.0176 | 0.0542 | 0.0017 | 0.0017 | 0.0001 | 7.0 | 0.0001 | 0.0002 | 0.0028 | 0.0153 | 0.0001 | 0.0001 | 0.0001 | 7.0252 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0029 | 0.0030 | 0.0131 | 0.0703 | 0.0023 | 0.0022 | 0.0001 | 9.1 | 0.0006 | 0.0006 | 0.0022 | 0.0391 | 0.0004 | 0.0003 | 0.0001 | 9.1055 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0001 | 0.0001 | 0.0004 | 0.0012 | 0.00009 | 0.000083 | 0.000001 | 0.1 | 0.0000 | 0.0000 | 0.0001 | 0.0007 | 0.0000 | 0.0000 | 0.0000 | 0.1487 |
| **Re-Routing of Outfalls OF27 and OF28 – RAAs 24B-D** | | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 10-hr shift. Assume a total of 4 days. | 0.0008 | 0.0008 | 0.0039 | 0.0200 | 0.0006 | 0.0006 | 0.0000 | 2.5 | 0.0001 | 0.0001 | 0.0010 | 0.0053 | 0.0000 | 0.0000 | 0.0000 | 2.4533 |
| | Front-end Loader | Diesel Rough Terrain Forklifts | | 0.0009 | 0.0009 | 0.0021 | 0.0111 | 0.0004 | 0.0004 | 0.0000 | 1.5 | 0.0000 | 0.0000 | 0.0006 | 0.0032 | 0.0000 | 0.0000 | 0.0000 | 1.4797 |
| **Double-Wall Cofferdam and Shoring Wall Installation and Removal – RAAs 24B-D** | | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. Assume a total of 153 Days (133 days to install and 20 days to remove sheet piles). | 0.12 | 0.13 | 0.96 | 2.96 | 0.10 | 0.09 | 0.00 | 383.52 | 0.01 | 0.01 | 0.15 | 0.83 | 0.01 | 0.01 | 0.00 | 383.88 |
| | Front-end Loader | Diesel Inboard/Sterndrive (800 hp) | | 0.09 | 0.09 | 0.22 | 1.16 | 0.04 | 0.04 | 0.00 | 154.09 | 0.00 | 0.00 | 0.06 | 0.34 | 0.00 | 0.00 | 0.00 | 154.36 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0038 | 0.0040 | 0.0211 | 0.0651 | 0.0047 | 0.0045 | 0.0001 | 8.1171 | 0.0019 | 0.0020 | 0.0056 | 0.0380 | 0.0004 | 0.0004 | 0.0000 | 8.1234 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.1565 | 0.1648 | 0.7160 | 3.8422 | 0.1237 | 0.1200 | 0.0046 | 497.1546 | 0.0328 | 0.0345 | 0.1228 | 2.1348 | 0.0197 | 0.0191 | 0.0033 | 497.5492 |
| **Removal of Submerged Barge – RAA 14A** | | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. Assume 20 ton removed per hour according to the structural team. | 0.0898 | 0.0946 | 0.2174 | 1.1628 | 0.0384 | 0.0372 | 0.0014 | 154.1 | 0.0032 | 0.0034 | 0.0622 | 0.3352 | 0.0026 | 0.0025 | 0.0010 | 154.3640 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0038 | 0.0040 | 0.0211 | 0.0651 | 0.0047 | 0.0045 | 0.0001 | 8.1 | 0.0019 | 0.0020 | 0.0056 | 0.0380 | 0.0004 | 0.0004 | 0.0000 | 8.1234 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.1565 | 0.1648 | 0.7160 | 3.8422 | 0.1237 | 0.1200 | 0.0046 | 497.2 | 0.0328 | 0.0345 | 0.1228 | 2.1348 | 0.0197 | 0.0191 | 0.0033 | 497.5492 |
| **Demolition of Derelict Structures (RAA 24B-D, 8F, 8H)** | | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. Assume a total of 28 days. RAA 24's derelict structure will be removed in the dry; therefore, a push and work boats will not be required. Production rate from structural team. | 0.0039 | 0.0042 | 0.0314 | 0.0969 | 0.0031 | 0.0030 | 0.0001 | 12.5 | 0.0003 | 0.0003 | 0.0051 | 0.0272 | 0.0002 | 0.0002 | 0.0001 | 12.5451 |
| | Front-end Loader | Diesel Rough Terrain Forklifts | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.27 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0120 | 0.0127 | 0.0291 | 0.1557 | 0.0051 | 0.0050 | 0.0002 | 20.6 | 0.0004 | 0.0005 | 0.0083 | 0.0449 | 0.0004 | 0.0003 | 0.0001 | 20.6723 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0001 | 0.0001 | 0.0007 | 0.0021 | 0.0002 | 0.0001 | 0.0000 | 0.3 | 0.0001 | 0.0001 | 0.0002 | 0.0012 | 0.0000 | 0.0000 | 0.0000 | 0.2655 |
| | | | ***SUBTOTAL EMISSIONS – STRUCTURAL WORK*** | **0.394** | **0.415** | **2.015** | **8.458** | **0.276** | **0.268** | **0.010** | **1098.092** | **0.048** | **0.050** | **0.367** | **3.484** | **0.030** | **0.029** | **0.008** | **1099.199** |
| ***SEDIMENT REMOVAL*** | | | | | | | | | | | | | | | | | | | |
| **Identified Debris Removal – Multiple RAAs (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.0221 | 0.0233 | 0.1756 | 0.5424 | 0.0175 | 0.0169 | 0.0006 | 70.1865 | 0.0015 | 0.0015 | 0.0283 | 0.1525 | 0.0012 | 0.0012 | 0.0006 | 70.2524 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0286 | 0.0302 | 0.1310 | 0.7032 | 0.0226 | 0.0220 | 0.0008 | 90.9825 | 0.0060 | 0.0063 | 0.0225 | 0.3907 | 0.0036 | 0.0035 | 0.0006 | 91.0547 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0007 | 0.0007 | 0.0039 | 0.0119 | 0.0009 | 0.0008 | 0.0000 | 1.4855 | 0.0003 | 0.0004 | 0.0010 | 0.0070 | 0.0001 | 0.0001 | 0.0000 | 1.4866 |
| **Open-Water Dredging (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.2705 | 0.2848 | 2.1493 | 6.6405 | 0.2138 | 0.2074 | 0.0079 | 859.2 | 0.0178 | 0.0188 | 0.3466 | 1.8674 | 0.0146 | 0.0141 | 0.0079 | 860.0390 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.3506 | 0.3692 | 1.6040 | 8.6081 | 0.2771 | 0.2688 | 0.0102 | 1113.8 | 0.0735 | 0.0774 | 0.2750 | 4.7827 | 0.0441 | 0.0428 | 0.0073 | 1114.7046 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0086 | 0.0091 | 0.0473 | 0.1459 | 0.0105 | 0.0101 | 0.0002 | 18.2 | 0.0042 | 0.0044 | 0.0126 | 0.0852 | 0.0008 | 0.0008 | 0.0001 | 18.1996 |
| **Nearshore/Slope/Slow Dredging (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.0713 | 0.0750 | 0.5662 | 1.7493 | 0.0563 | 0.0546 | 0.0021 | 226.3 | 0.0047 | 0.0049 | 0.0913 | 0.4919 | 0.0038 | 0.0037 | 0.0021 | 226.5595 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0924 | 0.0973 | 0.4226 | 2.2676 | 0.0730 | 0.0708 | 0.0027 | 293.4 | 0.0194 | 0.0204 | 0.0725 | 1.2599 | 0.0116 | 0.0113 | 0.0019 | 293.6460 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0023 | 0.0024 | 0.0125 | 0.0384 | 0.0028 | 0.0027 | 0.00004 | 4.8 | 0.0011 | 0.0012 | 0.0033 | 0.0224 | 0.0002 | 0.0002 | 0.0000 | 4.7943 |
| **Restricted Access Dredging (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 10-hr shift. | 0.0272 | 0.0286 | 0.1373 | 0.7063 | 0.0215 | 0.0209 | 0.0008 | 86.4 | 0.0018 | 0.0019 | 0.0349 | 0.1878 | 0.0015 | 0.0014 | 0.0006 | 86.5128 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0529 | 0.0557 | 0.2420 | 1.2988 | 0.0418 | 0.0406 | 0.0015 | 168.1 | 0.0111 | 0.0117 | 0.0415 | 0.7217 | 0.0067 | 0.0065 | 0.0011 | 168.1951 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0013 | 0.0014 | 0.0071 | 0.0220 | 0.0016 | 0.0015 | 0.000025 | 2.7 | 0.00063 | 0.0007 | 0.0019 | 0.0129 | 0.00013 | 0.00012 | 0.000016 | 2.7461 |
| **Tidally Restricted Dredging (4 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator (Tidally Restricted Work Only) | Diesel Excavators | Assume each work day contains one 4-hr shift. | 0.0210 | 0.0221 | 0.1669 | 0.5156 | 0.0166 | 0.0161 | 0.0006 | 66.7 | 0.0014 | 0.0015 | 0.0269 | 0.1450 | 0.0011 | 0.0011 | 0.0006 | 66.7792 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0272 | 0.0287 | 0.1245 | 0.6684 | 0.0215 | 0.0209 | 0.0008 | 86.5 | 0.0057 | 0.0060 | 0.0214 | 0.3714 | 0.0034 | 0.0033 | 0.0006 | 86.5532 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0007 | 0.0007 | 0.0037 | 0.0113 | 0.0008 | 0.0008 | 0.000013 | 1.4 | 0.00033 | 0.0003 | 0.0010 | 0.0066 | 0.00006 | 0.00006 | 0.000008 | 1.4131 |
| **Contingency Redredging (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.0210 | 0.0221 | 0.1669 | 0.5156 | 0.0166 | 0.0161 | 0.0006 | 66.7 | 0.0014 | 0.0015 | 0.0269 | 0.1450 | 0.0011 | 0.0011 | 0.0006 | 66.7792 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0272 | 0.0287 | 0.1245 | 0.6684 | 0.0215 | 0.0209 | 0.0008 | 86.5 | 0.0057 | 0.0060 | 0.0214 | 0.3714 | 0.0034 | 0.0033 | 0.0006 | 86.5532 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0007 | 0.0007 | 0.0037 | 0.0113 | 0.0008 | 0.0008 | 0.00001 | 1.4 | 0.0003 | 0.0003 | 0.0010 | 0.0066 | 0.00006 | 0.00006 | 0.000008 | 1.4131 |
| **Shoreline/Bank Excavation (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 10-hr shift. | 0.0081 | 0.0085 | 0.0407 | 0.2094 | 0.0064 | 0.0062 | 0.0002 | 25.6 | 0.0005 | 0.0006 | 0.0103 | 0.0557 | 0.0004 | 0.0004 | 0.0002 | 25.6555 |
| | Front-end Loader | Diesel Rough Terrain Forklifts | | 0.0090 | 0.0095 | 0.0218 | 0.1166 | 0.0038 | 0.0037 | 0.0001 | 15.4 | 0.0003 | 0.0003 | 0.0062 | 0.0336 | 0.0003 | 0.0003 | 0.0001 | 15.4747 |
| | | | ***SUBTOTAL EMISSIONS – SEDIMENT DREDGING*** | **1.06** | **1.12** | **6.18** | **25.98** | **0.84** | **0.82** | **0.03082** | **3352.3** | **0.16** | **0.17** | **1** | **11.47** | **0.10** | **0.10** | **0.03** | **3,355** |
| ***SEDIMENT TRANSLOADING OR CONTAINERIZED SEDIMENT TRANSFER, UPLAND TRANSPORTATION, AND DISPOSAL*** | | | | | | | | | | | | | | | | | | | |
| **Mechanical Transloading (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | Tug Boat (3,000 HP) | Diesel Inboard/Sterndrive (3,000 hp) | Assume each work day contains one 10 hr-shift. Assume bulking factor of 5% for mechanical offloading. Assume tug boat transports dredge sediment to a transload facility 5 miles away (one-way). Total quantities encompass Subtitle D and Subtitle C bulk dredged sediments, TSCA, TSCA/RCRA dredge sediments, and debris from both MR and SMA 10, as well as the sunken barge. Excluding RAAs 24B-G. | 0.0806 | 0.0849 | 0.3689 | 1.9799 | 0.0637 | 0.0025 | 0.0024 | 256.3 | 0.0177 | 0.0187 | 0.0664 | 1.1550 | 0.0106 | 0.0026 | 0.0025 | 269.0715 |
| | 100-ton Crane | Diesel Cranes | | 0.3700 | 0.3896 | 2.9403 | 9.0844 | 0.2925 | 0.2837 | 0.0108 | 1175.5 | 0.0244 | 0.0257 | 0.4742 | 2.5547 | 0.0199 | 0.0193 | 0.0108 | 1176.5648 |
| | Front-end Loader | Diesel Rough Terrain Forklifts | | 0.2753 | 0.2899 | 0.6665 | 3.5639 | 0.1176 | 0.1141 | 0.0043 | 472.3 | 0.0098 | 0.0103 | 0.1907 | 1.0273 | 0.0080 | 0.0078 | 0.0031 | 473.1160 |
| **Subtitle D (Bulk Sediment and Dangerous Waste) – Upland Transportation and Disposal (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | Truck (20-ton Dump Truck) | Diesel Off-highway Trucks | Assume Identified Debris from RAA 24B-G trucked from LDW middle reach to a transload facility. Assume 1 mile each way (2 miles round trip). | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Rail | N/A | Assume non-hazardous contaminated bulk sediments, dangerous waste containerized sediments, identified debris, and contaminated riprap railed from transload facility to an off-site landfill disposal facility in Arlington, OR, for 300 miles (one-way). | 2.4879 | 2.6198 | 12.4396 | 45.6117 | 0.8293 | 0.8044 | 0.0355 | 4070.8 | 1.1610 | 1.2226 | 12.4396 | 10.7809 | 0.2488 | 0.2413 | 0.0355 | 4070.7642 |
| **Subtitle C (TSCA and RCRA) – Upland Transportation and Disposal (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| Subtitle C | Truck (20-ton Freight Truck) | Diesel Onroad Trucks | Assume cement used for stabilization is transported 4 miles by truck from Ashgrove Cement, Seattle, WA, vendor to LDW middle reach (one-way). | 0.0001 | 0.0001 | 0.0004 | 0.0019 | 0.0001 | 0.0001 | 0.0000 | 0.1385 | 0.0000 | 0.0001 | 0.0003 | 0.0008 | 0.0000 | 0.0000 | 0.0000 | 0.1385 |
| | Truck (20-ton Dump Truck) | Diesel Off-highway Trucks | Assume PCB remediation waste and/or RCRA hazardous waste removed trucked from LDW middle reach to a transfer (intermodal) facility in south Seattle. Assume 3 miles each way (6 miles round trip). Quantity includes TSCA and Mixed TSCA Waste/RCRA Hazardous Waste from RAAs 24B through G). | 0.0013 | 0.0013 | 0.0102 | 0.0314 | 0.0010 | 0.0010 | 0.0000 | 4.0567 | 0.0001 | 0.0001 | 0.0016 | 0.0088 | 0.0001 | 0.0001 | 0.0000 | 4.0567 |
| | Rail | N/A | Assume PCB remediation waste and/or RCRA hazardous waste railed from intermodal facility to an off-site landfill disposal facility in Arlington, OR, for 300 miles (one-way). Total quantities encompass dredged sediments and debris from RAA 24B-D. | 0.0136 | 0.0143 | 0.0680 | 0.2495 | 0.0045 | 0.0044 | 0.0002 | 22.2680 | 0.0064 | 0.0067 | 0.0680 | 0.0590 | 0.0014 | 0.0013 | 0.0002 | 22.2680 |
| | | | ***SUBTOTAL EMISSIONS – SEDIMENT TRANSLOADING, UPLAND TRANSPORTATION, AND DISPOSAL*** | **3.23** | **3.40** | **16.49** | **61** | **1.31** | **1.21** | **0.05** | **6001.4** | **1.22** | **1.28** | **13** | **16** | **0.29** | **0.27** | **0.05** | **6,016** |

**Table L4-8**
**Detailed Summary of Direct Emissions by Construction Activity of Each Tier**

| Construction Activity | Type of Vehicle/Equipment Used | SCC Description | Notes | Equipment Uptime | Equipment Quantity | Total Daily Diesel Usage (gal/day) | Shift Duration (hr) | Production Rate (quantity/day) | One-way Distance (miles) | Quantity Units | Pre-Tier – Total Emissions (Metric Tonnes) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | HCs | VOCs | CO | $NO_X$ | $PM_{10}$ | $PM_{2.5}$ | $SO_2$ | $CO_2$ |
| ***CLEAN MATERIAL TRANSPORTATION AND PLACEMENT*** | | | | | | | | | | | | | | | | | | |
| **Transportation of Clean Materials to LDW Middle Reach and LDW Upper Reach SMA 10** | | | | | | | | | | | | | | | | | | |
| | Truck (20-ton Dump Truck) | Diesel Off-highway Trucks | Assume coarse sand, gravelly sand, sandy gravel, and quarry spalls are transported 20 miles from quarry to onshore staging area by truck and 20 miles to LDW middle reach by barge. | N/A | 1 | N/A | 10 | N/A | 20 | ton | 1.6257 | 1.7119 | 6.4552 | 20.0349 | 0.9611 | 0.9323 | 0.0116 | 1266.2 |
| | Tug Boat (3,000 hp) | Diesel Inboard/Sterndrive (3,000 hp) | | 0.2 | 1 | N/A | 10 | N/A | 20 | ton | 0.6734 | 0.7091 | 2.6738 | 8.2987 | 0.3981 | 0.3862 | 0.0048 | 524.2 |
| | Truck (20-ton Freight Truck) | Diesel Onroad Trucks | Assume AC is transported 150 miles by truck from Ridgefield, WA, vendor to LDW middle reach (one-way). | N/A | 1 | N/A | 10 | N/A | 150 | ton | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| **Open-Water Placement of Coarse Sand for RMC (Neatline+ Daylight+ Stability+ Perimeter) (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 960 | N/A | cy coarse sand | 0.0877 | 0.0923 | 0.3482 | 1.0808 | 0.0518 | 0.0503 | 0.0006 | 68.2 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 960 | N/A | cy coarse sand | 0.1137 | 0.1197 | 0.4514 | 1.4010 | 0.0672 | 0.0652 | 0.0008 | 88.4 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 960 | N/A | cy coarse sand | 0.0044 | 0.0047 | 0.0123 | 0.0170 | 0.0020 | 0.0019 | 0.00001 | 1.4 |
| **Nearshore Placement of Coarse Sand for ENR + Perimeter RMC (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 610 | N/A | cy coarse sand | 0.0284 | 0.0299 | 0.1127 | 0.3497 | 0.0168 | 0.0163 | 0.0002 | 22.1 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 610 | N/A | cy coarse sand | 0.0368 | 0.0387 | 0.1461 | 0.4534 | 0.0217 | 0.0211 | 0.0003 | 28.6 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 610 | N/A | cy coarse sand | 0.0014 | 0.0015 | 0.0040 | 0.0055 | 0.0006 | 0.0006 | 0.00000 | 0.5 |
| **Restricted Access Placement of Coarse Sand ENR + Perimeter RMC (4 hours/day)** | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 4-hr shift. | 0.7 | 1 | 140 | 4 | 440 | N/A | cy coarse sand | 0.0284 | 0.0299 | 0.1127 | 0.3497 | 0.0168 | 0.0163 | 0.0002 | 22.0725 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 4 | 440 | N/A | cy coarse sand | 0.0368 | 0.0387 | 0.1461 | 0.4534 | 0.0217 | 0.0211 | 0.0003 | 28.6125 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 4 | 440 | N/A | cy coarse sand | 0.00143 | 0.00151 | 0.00397 | 0.00549 | 0.00064 | 0.00062 | 0.00000 | 0.46475 |
| **Restricted Access Placement of Coarse Sand ENR + Perimeter RMC (Underpier) (4 hours/day)** | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 4-hr shift. | 0.7 | 1 | 140 | 4 | 120 | N/A | cy coarse sand | 0.0206 | 0.0217 | 0.0818 | 0.2538 | 0.0122 | 0.0118 | 0.0001 | 16.0159 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 4 | 120 | N/A | cy coarse sand | 0.0214 | 0.0225 | 0.0848 | 0.2632 | 0.0126 | 0.0122 | 0.0002 | 16.6090 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 4 | 120 | N/A | cy coarse sand | 0.00083 | 0.00087 | 0.00231 | 0.00318 | 0.00037 | 0.00036 | 0.00000 | 0.26978 |
| **Land-Based Equipment Placement of Coarse Sand ENR + Perimeter RMC (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 140 | 10 | 500 | N/A | cy coarse sand | 0.0864 | 0.0910 | 0.3430 | 1.0646 | 0.0511 | 0.0495 | 0.0006 | 67.1896 |
| | Front-end Loader | Diesel Rough Terrain Forklifts | | 0.7 | 1 | 140 | 10 | 500 | N/A | cy coarse sand | 0.0034 | 0.0035 | 0.0093 | 0.0129 | 0.0015 | 0.0014 | 0.0000 | 1.0914 |
| **Open-Water Placement of Gravelly Sand Backfill (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 790 | N/A | cy gravelly sand | 0.0262 | 0.0276 | 0.1040 | 0.3227 | 0.0155 | 0.0150 | 0.00019 | 20.4 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 790 | N/A | cy gravelly sand | 0.0339 | 0.0357 | 0.1348 | 0.4184 | 0.0201 | 0.0195 | 0.00024 | 26.4 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 790 | N/A | cy gravelly sand | 0.0013 | 0.0014 | 0.0037 | 0.0051 | 0.0006 | 0.0006 | 0.0000039 | 0.4 |
| **Nearshore/Slope/Slow Placement of Gravelly Sand for Backfill (Nearshore/Slope/Slow Backfilling) (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 610 | N/A | cy gravelly sand | 0.1829 | 0.1926 | 0.7264 | 2.2545 | 0.1082 | 0.1049 | 0.0013 | 142.3 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 610 | N/A | cy gravelly sand | 0.2372 | 0.2497 | 0.9416 | 2.9225 | 0.1402 | 0.1360 | 0.0017 | 184.4 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 610 | N/A | cy gravelly sand | 0.0092 | 0.0097 | 0.0256 | 0.0354 | 0.0041 | 0.0040 | 0.00003 | 3.0 |
| **Restricted Access Placement of Gravelly Sand Backfill (4 hours/day)** | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 4-hr shift. | 0.7 | 1 | 140 | 4 | 440 | N/A | cy gravelly sand | 0.1829 | 0.1926 | 0.7264 | 2.2545 | 0.1082 | 0.1049 | 0.0013 | 142.2860 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 4 | 440 | N/A | cy gravelly sand | 0.2372 | 0.2497 | 0.9416 | 2.9225 | 0.1402 | 0.1360 | 0.0017 | 184.4448 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 4 | 440 | N/A | cy gravelly sand | 0.00922 | 0.00971 | 0.02562 | 0.03536 | 0.00410 | 0.00398 | 0.00003 | 2.99592 |
| **Land-Based Equipment Placement of Gravelly Sand Backfill (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 140 | 10 | 500 | N/A | cy gravelly sand | 0.0582 | 0.0613 | 0.2310 | 0.7171 | 0.0344 | 0.0334 | 0.0004 | 45.2552 |
| | Front-end Loader | Diesel Rough Terrain Forklifts | | 0.7 | 1 | 197 | 10 | 500 | N/A | cy gravelly sand | 0.0023 | 0.0024 | 0.0063 | 0.0087 | 0.0010 | 0.0010 | 0.0000 | 0.7351 |
| **Open-Water Placement of Standard/Modified Engineered Cap (Gravelly Sand for Chemical Isolation Layer) (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 790 | N/A | cy gravelly sand | 0.0802 | 0.0844 | 0.3183 | 0.9878 | 0.0474 | 0.0460 | 0.0006 | 62.3397 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 790 | N/A | cy gravelly sand | 0.1039 | 0.1094 | 0.4126 | 1.2804 | 0.0614 | 0.0596 | 0.0007 | 80.8107 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 790 | N/A | cy gravelly sand | 0.0040 | 0.0043 | 0.0112 | 0.0155 | 0.0018 | 0.0017 | 0.0000 | 1.3126 |
| **Open-Water Placement of Standard/Modified Engineered Cap (Sandy Gravel for Filter Layer and Sloped RMC) (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 770 | N/A | cy gravel | 0.0868 | 0.0914 | 0.3446 | 1.0697 | 0.0513 | 0.0498 | 0.0006 | 67.5082 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 770 | N/A | cy gravel | 0.1125 | 0.1185 | 0.4468 | 1.3866 | 0.0665 | 0.0645 | 0.0008 | 87.5106 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 770 | N/A | cy gravel | 0.0044 | 0.0046 | 0.0122 | 0.0168 | 0.0019 | 0.0019 | 0.0000 | 1.4214 |
| **Open-Water Placement of Standard/Modified Engineered Cap (Quarry Spalls for Erosion Protection Layer and Sloped RMC) (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 730 | N/A | cy quarry spalls | 0.3239 | 0.3411 | 1.2861 | 3.9917 | 0.1915 | 0.1857 | 0.0023 | 251.9209 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 730 | N/A | cy quarry spalls | 0.4199 | 0.4421 | 1.6672 | 5.1744 | 0.2482 | 0.2408 | 0.0030 | 326.5641 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 730 | N/A | cy quarry spalls | 0.0163 | 0.0172 | 0.0454 | 0.0626 | 0.0073 | 0.0070 | 0.0000 | 5.3043 |
| **Nearshore Placement of Standard/Modified Engineered Cap (Gravelly Sand for Chemical Isolation Layer) (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 550 | N/A | cy gravelly sand | 0.0161 | 0.0169 | 0.0638 | 0.1981 | 0.0095 | 0.0092 | 0.0001 | 12.5002 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 550 | N/A | cy gravelly sand | 0.0208 | 0.0219 | 0.0827 | 0.2568 | 0.0123 | 0.0119 | 0.0001 | 16.2039 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 550 | N/A | cy gravelly sand | 0.0008 | 0.0009 | 0.0023 | 0.0031 | 0.0004 | 0.0003 | 0.0000 | 0.2632 |
| **Nearshore Placement of Standard/Modified Engineered Cap (Sandy Gravel for Filter Layer) (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 540 | N/A | cy gravel | 0.0219 | 0.0231 | 0.0870 | 0.2701 | 0.0130 | 0.0126 | 0.0002 | 17.0444 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 540 | N/A | cy gravel | 0.0284 | 0.0299 | 0.1128 | 0.3501 | 0.0168 | 0.0163 | 0.0002 | 22.0946 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 540 | N/A | cy gravel | 0.0011 | 0.0012 | 0.0031 | 0.0042 | 0.0005 | 0.0005 | 0.0000 | 0.3589 |
| **Nearshore Placement of Standard/Modified Engineered Cap (Quarry Spalls for Erosion Protection Layer) (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 510 | N/A | cy quarry apalls | 0.0181 | 0.0191 | 0.0720 | 0.2235 | 0.0107 | 0.0104 | 0.0001 | 14.1040 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 510 | N/A | cy quarry apalls | 0.0235 | 0.0248 | 0.0933 | 0.2897 | 0.0139 | 0.0135 | 0.0002 | 18.2829 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 510 | N/A | cy quarry apalls | 0.0009 | 0.0010 | 0.0025 | 0.0035 | 0.0004 | 0.0004 | 0.0000 | 0.2970 |
| **Restricted Access Placement of Standard/Modified Engineered Cap (Gravelly Sand for Chemical Isolation Layer) (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 140 | 10 | 410 | N/A | cy gravelly sand | 0.0092 | 0.0097 | 0.0365 | 0.1134 | 0.0054 | 0.0053 | 0.0001 | 7.1543 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 410 | N/A | cy gravelly sand | 0.0179 | 0.0188 | 0.0710 | 0.2204 | 0.0106 | 0.0103 | 0.0001 | 13.9111 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 410 | N/A | cy gravelly sand | 0.0007 | 0.0007 | 0.0019 | 0.0027 | 0.0003 | 0.0003 | 0.0000 | 0.2260 |
| **Restricted Access Placement of Standard/Modified Engineered Cap (Sandy Gravel for Filter Layer and Sloped RMC) (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 140 | 10 | 410 | N/A | cy gravel | 0.0128 | 0.0135 | 0.0509 | 0.1579 | 0.0076 | 0.0073 | 0.0001 | 9.9649 |
| | Push Boat | Diesel Inboard/Sterndrive (800 HP) | | 0.7 | 1 | 197 | 10 | 410 | N/A | cy gravel | 0.0249 | 0.0262 | 0.0989 | 0.3070 | 0.0147 | 0.0143 | 0.0002 | 19.3761 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 410 | N/A | cy gravel | 0.0010 | 0.0010 | 0.0027 | 0.0037 | 0.0004 | 0.0004 | 0.0000 | 0.3147 |
| **Restricted Access Placement of Standard/Modified Engineered Cap (Quarry Spalls for Erosion Protection Layer) (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 140 | 10 | 390 | N/A | cy quarry spalls | 0.0227 | 0.0239 | 0.0902 | 0.2799 | 0.0134 | 0.0130 | 0.0002 | 17.6667 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 390 | N/A | cy quarry spalls | 0.0442 | 0.0465 | 0.1754 | 0.5443 | 0.0261 | 0.0253 | 0.0003 | 34.3520 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 390 | N/A | cy quarry spalls | 0.0017 | 0.0018 | 0.0048 | 0.0066 | 0.0008 | 0.0007 | 0.0000 | 0.5580 |
| **Nearshore Placement of Gravelly Sand/AC for Amended ENR (RAA 5A, 8C, 9L) (10 hours/day)** | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.7 | 1 | 112 | 10 | 610 | N/A | cy gravelly sand/AC | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 10 | 610 | N/A | cy gravelly sand/AC | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 10 | 610 | N/A | cy gravelly sand/AC | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| **Restricted Access Placement of Gravelly Sand/AC for Amended ENR (RAA 5A, 8C, 9L) (Underpier) (4 hours/day)** | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Cranes | Assume each work day contains one 4-hr shift. | 0.7 | 1 | 140 | 4 | 120 | N/A | cy gravelly sand/AC | 0.0221 | 0.0233 | 0.0878 | 0.2725 | 0.0131 | 0.0127 | 0.0002 | 17.2010 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 4 | 120 | N/A | cy gravelly sand/AC | 5.4648 | 5.7545 | 21.6155 | 66.7549 | 3.2205 | 3.1238 | 0.0388 | 4221.0283 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 4 | 120 | N/A | cy gravelly sand/AC | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| **Tidally Restricted Access Placement of Coarse Sand (Perimeter RMC), Gravelly Sand (Backfill and Cap CIL), Gravelly Sand/AC (Amended ENR), Armor (Cap Erosion Layer – RAAs 5A, 9A-9D, 9F, 9I, 9L, 9M, 20A, 20C) (4 hours/day)** | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator (Tidally Restricted Work Only) | Diesel Cranes | Assume each work day contains one 4-hr shift. | 0.7 | 1 | 56 | 4 | 150 | N/A | coarse sand, gravelly sand, gravelly sand/AC, and quarry spalls | 0.1865 | 0.1963 | 0.5180 | 0.7148 | 0.0829 | 0.0804 | 0.0006 | 60.5616 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.7 | 1 | 197 | 4 | 150 | N/A | coarse sand, gravelly sand, gravelly sand/AC, and quarry spalls | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.2 | 1 | 3 | 4 | 150 | N/A | coarse sand, gravelly sand, gravelly sand/AC, and quarry spalls | 0.1132 | 0.1192 | 0.3146 | 0.4341 | 0.0503 | 0.0488 | 0.0003 | 36.7789 |
| | | | ***SUBTOTAL EMISSIONS – MATERIAL TRANSPORTATION AND PLACEMENT*** | | | | | | | | **5.46** | **5.75** | **22** | **67** | **3.22** | **3.12** | **0.04** | **4221.0** |
| ***SURVEYS*** | | | | | | | | | | | | | | | | | | |
| | Work Boat | Two-stroke Outboard (WB) | Assume one survey per day and each work day contains one 10 hr-shift. Assume a total of 1,151 survey events based on pre-construction (bathy and topo), post-dredge and post-placement surveys per RAA, post-construction (bathy and topo) for each construction seasons, contractor progress surveys for the construction duration, and as-built survey in the final construction season. | 0.2 | 1 | 3 | 10 | 1.00 | N/A | surveys | 0.19 | 0.20 | 0.52 | 0.715 | 0.0829 | 0.0804 | 0.0006 | 60.6 |
| | | | ***SUBTOTAL EMISSIONS – SURVEYS*** | | | | | | | | **0.19** | **0.20** | **0.52** | **0.715** | **0.0829** | **0.0804** | **0.0006** | **60.6** |
| ***CONFIRMATIONAL SEDIMENT SAMPLING AND ENVIRONMENTAL MONITORING*** | | | | | | | | | | | | | | | | | | |
| | Work Boat | Two-stroke Outboard (WB) | Assume one water quality monitoring event per dredge day and each work day contains one 10 hr-shift. Assume 699 water quality monitoring events. Assume 52 confirmational sediment sampling events. | 0.2 | 1 | 3 | 10 | 1.00 | N/A | monitoring events | 0.11 | 0.12 | 0.31 | 0.43 | 0.05 | 0.05 | 0.0003 | 36.8 |
| | | | ***SUBTOTAL EMISSIONS – CONFIRMATIONAL SEDIMENT SAMPLING AND ENVIRONMENTAL MONITORING*** | | | | | | | | **0.11** | **0.12** | **0.31** | **0.43** | **0.05** | **0.05** | **0.00** | **36.78** |
| | | | **TOTAL DIRECT AIR EMISSIONS (Metric tonnes, rounded)** | | | | | | | | **22.0** | **24.0** | **97.0** | **240.0** | **10.0** | **9.8** | **0.13** | **15,000** |

**Table L4-8**
**Detailed Summary of Direct Emissions by Construction Activity of Each Tier**

| Construction Activity | Type of Vehicle/Equipment Used | SCC Description | Notes | Tier 2 – Total Emissions (Metric Tonnes) | | | | | | | | Tier 4 – Total Emissions (Metric Tonnes) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | HCs | VOCs | CO | $NO_X$ | $PM_{10}$ | $PM_{2.5}$ | $SO_2$ | $CO_2$ | HCs | VOCs | CO | $NO_X$ | $PM_{10}$ | $PM_{2.5}$ | $SO_2$ | $CO_2$ |
| ***CLEAN MATERIAL TRANSPORTATION AND PLACEMENT*** | | | | | | | | | | | | | | | | | | | |
| **Transportation of Clean Materials to LDW Middle Reach and LDW Upper Reach SMA 10** | | | | | | | | | | | | | | | | | | | |
| | Truck (20-ton Dump Truck) | Diesel Off-highway Trucks | Assume coarse sand, gravelly sand, sandy gravel, and quarry spalls are transported 20 miles from quarry to onshore staging area by truck and 20 miles to LDW middle reach by barge. | 0.3993 | 0.4204 | 3.1726 | 9.8023 | 0.3156 | 0.3061 | 0.0117 | 1266.2 | 0.0263 | 0.0277 | 0.5116 | 2.7566 | 0.0215 | 0.0209 | 0.0117 | 1266.2387 |
| | Tug Boat (3,000 hp) | Diesel Inboard/Sterndrive (3,000 hp) | | 0.1654 | 0.1741 | 0.7566 | 4.0602 | 0.1307 | 0.0051 | 0.0048 | 525.5 | 0.0347 | 0.0365 | 0.1297 | 2.2559 | 0.0208 | 0.0051 | 0.0048 | 525.5160 |
| | Truck (20-ton Freight Truck) | Diesel Onroad Trucks | Assume AC is transported 150 miles by truck from Ridgefield, WA, vendor to LDW middle reach (one-way). | 0.00117 | 0.00123 | 0.0056 | 0.0241 | 0.00109 | 0.00106 | 0.000071 | 1.8056 | 0.00064 | 0.00068 | 0.0035 | 0.0098 | 0.00039 | 0.00037 | 0.000071 | 1.8056 |
| **Open-Water Placement of Coarse Sand for RMC (Neatline+ Daylight+ Stability+ Perimeter) (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.0215 | 0.0227 | 0.1711 | 0.5288 | 0.0170 | 0.0165 | 0.0006 | 68.4 | 0.0014 | 0.0015 | 0.0276 | 0.1487 | 0.0012 | 0.0011 | 0.0006 | 68.4830 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0279 | 0.0294 | 0.1277 | 0.6854 | 0.0221 | 0.0214 | 0.0008 | 88.7 | 0.0059 | 0.0062 | 0.0219 | 0.3808 | 0.0035 | 0.0034 | 0.0006 | 88.7614 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0007 | 0.0007 | 0.0038 | 0.0116 | 0.0008 | 0.0008 | 0.00001 | 1.4 | 0.0003 | 0.0004 | 0.0010 | 0.0068 | 0.0001 | 0.0001 | 0.0000 | 1.4492 |
| **Nearshore Placement of Coarse Sand for ENR + Perimeter RMC (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.0070 | 0.0073 | 0.0554 | 0.1711 | 0.0055 | 0.0053 | 0.0002 | 22.1 | 0.0005 | 0.0005 | 0.0089 | 0.0481 | 0.0004 | 0.0004 | 0.0002 | 22.1616 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0090 | 0.0095 | 0.0413 | 0.2218 | 0.0071 | 0.0069 | 0.0003 | 28.7 | 0.0019 | 0.0020 | 0.0071 | 0.1232 | 0.0011 | 0.0011 | 0.0002 | 28.7238 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0002 | 0.0002 | 0.0012 | 0.0038 | 0.0003 | 0.0003 | 0.000004 | 0.5 | 0.0001 | 0.0001 | 0.0003 | 0.0022 | 0.0000 | 0.0000 | 0.0000 | 0.4690 |
| **Restricted Access Placement of Coarse Sand ENR + Perimeter RMC (4 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 4-hr shift. | 0.0070 | 0.0073 | 0.0554 | 0.1711 | 0.0055 | 0.0053 | 0.0002 | 22.1408 | 0.0005 | 0.0005 | 0.0089 | 0.0481 | 0.0004 | 0.0004 | 0.0002 | 22.1616 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0090 | 0.0095 | 0.0413 | 0.2218 | 0.0071 | 0.0069 | 0.0003 | 28.7010 | 0.0019 | 0.0020 | 0.0071 | 0.1232 | 0.0011 | 0.0011 | 0.0002 | 28.7238 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.00022 | 0.00023 | 0.00122 | 0.00376 | 0.00027 | 0.00026 | 0.00000 | 0.46861 | 0.00011 | 0.00011 | 0.00032 | 0.00220 | 0.00002 | 0.00002 | 0.00000 | 0.46897 |
| **Restricted Access Placement of Coarse Sand ENR + Perimeter RMC (Underpier) (4 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 4-hr shift. | 0.0051 | 0.0053 | 0.0402 | 0.1242 | 0.0040 | 0.0039 | 0.0001 | 16.0654 | 0.0003 | 0.0004 | 0.0065 | 0.0349 | 0.0003 | 0.0003 | 0.0001 | 16.0805 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0052 | 0.0055 | 0.0240 | 0.1288 | 0.0041 | 0.0040 | 0.0002 | 16.6604 | 0.0011 | 0.0012 | 0.0041 | 0.0715 | 0.0007 | 0.0006 | 0.0001 | 16.6737 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.00013 | 0.00014 | 0.00071 | 0.00218 | 0.00016 | 0.00015 | 0.00000 | 0.27202 | 0.00006 | 0.00007 | 0.00019 | 0.00127 | 0.00001 | 0.00001 | 0.00000 | 0.27223 |
| **Land-Based Equipment Placement of Coarse Sand ENR + Perimeter RMC (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 10-hr shift. | 0.0212 | 0.0223 | 0.0971 | 0.5209 | 0.0168 | 0.0163 | 0.0006 | 67.3975 | 0.0044 | 0.0047 | 0.0166 | 0.2894 | 0.0027 | 0.0026 | 0.0004 | 67.4510 |
| | Front-end Loader | Diesel Rough Terrain Forklifts | | 0.0005 | 0.0005 | 0.0029 | 0.0088 | 0.0006 | 0.0006 | 0.0000 | 1.1004 | 0.0003 | 0.0003 | 0.0008 | 0.0052 | 0.0001 | 0.0000 | 0.0000 | 1.1013 |
| **Open-Water Placement of Gravelly Sand Backfill (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.0064 | 0.0068 | 0.0511 | 0.1579 | 0.0051 | 0.0049 | 0.000188 | 20.4 | 0.0004 | 0.0004 | 0.0082 | 0.0444 | 0.0003 | 0.0003 | 0.0002 | 20.4503 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0083 | 0.0088 | 0.0381 | 0.2047 | 0.0066 | 0.0064 | 0.000243 | 26.5 | 0.0017 | 0.0018 | 0.0065 | 0.1137 | 0.0010 | 0.0010 | 0.0002 | 26.5059 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.00020 | 0.00022 | 0.0011 | 0.0035 | 0.0002 | 0.000241 | 0.0000040 | 0.4 | 0.0001 | 0.0001 | 0.0003 | 0.0020 | 0.0000 | 0.0000 | 0.0000 | 0.4328 |
| **Nearshore/Slope/Slow Placement of Gravelly Sand for Backfill (Nearshore/Slope/Slow Backfilling) (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.0449 | 0.0473 | 0.3570 | 1.1030 | 0.0355 | 0.0344 | 0.0013 | 142.7 | 0.0030 | 0.0031 | 0.0576 | 0.3102 | 0.0024 | 0.0023 | 0.0013 | 142.8602 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0582 | 0.0613 | 0.2664 | 1.4299 | 0.0460 | 0.0447 | 0.0017 | 185.0 | 0.0122 | 0.0129 | 0.0457 | 0.7945 | 0.0073 | 0.0071 | 0.0012 | 185.1624 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0014 | 0.0015 | 0.0079 | 0.0242 | 0.0017 | 0.0017 | 0.00003 | 3.0 | 0.0007 | 0.0007 | 0.0021 | 0.0142 | 0.0001 | 0.0001 | 0.0000 | 3.0231 |
| **Restricted Access Placement of Gravelly Sand Backfill (4 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 4-hr shift. | 0.0449 | 0.0473 | 0.3570 | 1.1030 | 0.0355 | 0.0344 | 0.0013 | 142.7263 | 0.0030 | 0.0031 | 0.0576 | 0.3102 | 0.0024 | 0.0023 | 0.0013 | 142.8602 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0582 | 0.0613 | 0.2664 | 1.4299 | 0.0460 | 0.0447 | 0.0017 | 185.0155 | 0.0122 | 0.0129 | 0.0457 | 0.7945 | 0.0073 | 0.0071 | 0.0012 | 185.1624 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.00143 | 0.00150 | 0.00785 | 0.02423 | 0.00174 | 0.00168 | 0.00003 | 3.02078 | 0.00070 | 0.00073 | 0.00209 | 0.01415 | 0.00014 | 0.00013 | 0.00002 | 3.02312 |
| **Land-Based Equipment Placement of Gravelly Sand Backfill (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 10-hr shift. | 0.0143 | 0.0150 | 0.0654 | 0.3508 | 0.0113 | 0.0110 | 0.0004 | 45.3953 | 0.0030 | 0.0032 | 0.0112 | 0.1949 | 0.0018 | 0.0017 | 0.0003 | 45.4313 |
| | Front-end Loader | Diesel Rough Terrain Forklifts | | 0.0004 | 0.0004 | 0.0019 | 0.0059 | 0.0004 | 0.0004 | 0.0000 | 0.7412 | 0.0002 | 0.0002 | 0.0005 | 0.0035 | 0.0000 | 0.0000 | 0.0000 | 0.7418 |
| **Open-Water Placement of Standard/Modified Engineered Cap (Gravelly Sand for Chemical Isolation Layer) (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.0197 | 0.0207 | 0.1564 | 0.4833 | 0.0156 | 0.0151 | 0.0006 | 62.5326 | 0.0013 | 0.0014 | 0.0252 | 0.1359 | 0.0011 | 0.0010 | 0.0006 | 62.5912 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0255 | 0.0269 | 0.1167 | 0.6265 | 0.0202 | 0.0196 | 0.0007 | 81.0607 | 0.0053 | 0.0056 | 0.0200 | 0.3481 | 0.0032 | 0.0031 | 0.0005 | 81.1251 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0006 | 0.0007 | 0.0034 | 0.0106 | 0.0008 | 0.0007 | 0.0000 | 1.3235 | 0.0001 | 0.0001 | 0.0003 | 0.0053 | 0.0000 | 0.0000 | 0.0000 | 1.2373 |
| **Open-Water Placement of Standard/Modified Engineered Cap (Sandy Gravel for Filter Layer and Sloped RMC) (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.0213 | 0.0224 | 0.1694 | 0.5233 | 0.0168 | 0.0163 | 0.0006 | 67.7171 | 0.0014 | 0.0015 | 0.0273 | 0.1472 | 0.0011 | 0.0011 | 0.0006 | 67.7806 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0276 | 0.0291 | 0.1264 | 0.6784 | 0.0218 | 0.0212 | 0.0008 | 87.7814 | 0.0058 | 0.0061 | 0.0217 | 0.3769 | 0.0035 | 0.0034 | 0.0006 | 87.8511 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0007 | 0.0007 | 0.0037 | 0.0115 | 0.0008 | 0.0008 | 0.0000 | 1.4332 | 0.0001 | 0.0001 | 0.0003 | 0.0057 | 0.0001 | 0.0001 | 0.0000 | 1.3399 |
| **Open-Water Placement of Standard/Modified Engineered Cap (Quarry Spalls for Erosion Protection Layer and Sloped RMC) (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.0795 | 0.0838 | 0.6321 | 1.9530 | 0.0629 | 0.0610 | 0.0023 | 252.7004 | 0.0052 | 0.0055 | 0.1019 | 0.5492 | 0.0043 | 0.0042 | 0.0023 | 252.9374 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.1031 | 0.1086 | 0.4717 | 2.5316 | 0.0815 | 0.0791 | 0.0030 | 327.5746 | 0.0216 | 0.0228 | 0.0809 | 1.4066 | 0.0130 | 0.0126 | 0.0022 | 327.8346 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0025 | 0.0027 | 0.0139 | 0.0429 | 0.0031 | 0.0030 | 0.0000 | 5.3484 | 0.0003 | 0.0003 | 0.0012 | 0.0215 | 0.0002 | 0.0002 | 0.0000 | 5.0000 |
| **Nearshore Placement of Standard/Modified Engineered Cap (Gravelly Sand for Chemical Isolation Layer) (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.0039 | 0.0042 | 0.0314 | 0.0969 | 0.0031 | 0.0030 | 0.0001 | 12.5388 | 0.0003 | 0.0003 | 0.0051 | 0.0273 | 0.0002 | 0.0002 | 0.0001 | 12.5506 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0051 | 0.0054 | 0.0234 | 0.1256 | 0.0040 | 0.0039 | 0.0001 | 16.2540 | 0.0011 | 0.0011 | 0.0040 | 0.0698 | 0.0006 | 0.0006 | 0.0001 | 16.2669 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0001 | 0.0001 | 0.0007 | 0.0021 | 0.0002 | 0.0001 | 0.0000 | 0.2654 | 0.0000 | 0.0000 | 0.0001 | 0.0011 | 0.0000 | 0.0000 | 0.0000 | 0.2481 |
| **Nearshore Placement of Standard/Modified Engineered Cap (Sandy Gravel for Filter Layer) (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.0054 | 0.0057 | 0.0428 | 0.1321 | 0.0043 | 0.0041 | 0.0002 | 17.0972 | 0.0004 | 0.0004 | 0.0069 | 0.0372 | 0.0003 | 0.0003 | 0.0002 | 17.1132 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0070 | 0.0073 | 0.0319 | 0.1713 | 0.0055 | 0.0053 | 0.0002 | 22.1630 | 0.0015 | 0.0015 | 0.0055 | 0.0952 | 0.0009 | 0.0009 | 0.0001 | 22.1806 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0002 | 0.0002 | 0.0009 | 0.0029 | 0.0002 | 0.0002 | 0.0000 | 0.3619 | 0.0000 | 0.0000 | 0.0001 | 0.0015 | 0.0000 | 0.0000 | 0.0000 | 0.3383 |
| **Nearshore Placement of Standard/Modified Engineered Cap (Quarry Spalls for Erosion Protection Layer) (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.0045 | 0.0047 | 0.0354 | 0.1093 | 0.0035 | 0.0034 | 0.0001 | 14.1476 | 0.0003 | 0.0003 | 0.0057 | 0.0307 | 0.0002 | 0.0002 | 0.0001 | 14.1609 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0058 | 0.0061 | 0.0264 | 0.1417 | 0.0046 | 0.0044 | 0.0002 | 18.3395 | 0.0012 | 0.0013 | 0.0045 | 0.0787 | 0.0007 | 0.0007 | 0.0001 | 18.3541 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0001 | 0.0001 | 0.0008 | 0.0024 | 0.0002 | 0.0002 | 0.0000 | 0.2994 | 0.0000 | 0.0000 | 0.0001 | 0.0012 | 0.0000 | 0.0000 | 0.0000 | 0.2799 |
| **Restricted Access Placement of Standard/Modified Engineered Cap (Gravelly Sand for Chemical Isolation Layer) (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Excavators | Assume each work day contains one 10-hr shift. | 0.0023 | 0.0024 | 0.0114 | 0.0586 | 0.0018 | 0.0017 | 0.0001 | 7.1764 | 0.0003 | 0.0003 | 0.0054 | 0.0292 | 0.0002 | 0.0002 | 0.0001 | 13.4684 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0044 | 0.0046 | 0.0201 | 0.1078 | 0.0035 | 0.0034 | 0.0001 | 13.9542 | 0.0009 | 0.0010 | 0.0034 | 0.0599 | 0.0006 | 0.0005 | 0.0001 | 13.9653 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0001 | 0.0001 | 0.0006 | 0.0018 | 0.0001 | 0.0001 | 0.0000 | 0.2278 | 0.0001 | 0.0001 | 0.0002 | 0.0011 | 0.0000 | 0.0000 | 0.0000 | 0.2280 |
| **Restricted Access Placement of Standard/Modified Engineered Cap (Sandy Gravel for Filter Layer and Sloped RMC) (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.0031 | 0.0033 | 0.0159 | 0.0817 | 0.0025 | 0.0024 | 0.0001 | 9.9957 | 0.0004 | 0.0004 | 0.0076 | 0.0407 | 0.0003 | 0.0003 | 0.0002 | 18.7595 |
| | Push Boat | Diesel Inboard/Sterndrive (800 HP) | | 0.0061 | 0.0064 | 0.0280 | 0.1502 | 0.0048 | 0.0047 | 0.0002 | 19.4361 | 0.0013 | 0.0014 | 0.0048 | 0.0835 | 0.0008 | 0.0007 | 0.0001 | 19.4515 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0002 | 0.0002 | 0.0008 | 0.0025 | 0.0002 | 0.0002 | 0.0000 | 0.3173 | 0.0001 | 0.0001 | 0.0002 | 0.0015 | 0.0000 | 0.0000 | 0.0000 | 0.3176 |
| **Restricted Access Placement of Standard/Modified Engineered Cap (Quarry Spalls for Erosion Protection Layer) (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.0056 | 0.0059 | 0.0282 | 0.1448 | 0.0044 | 0.0043 | 0.0002 | 17.7214 | 0.0007 | 0.0007 | 0.0134 | 0.0722 | 0.0006 | 0.0005 | 0.0003 | 33.2588 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0108 | 0.0114 | 0.0496 | 0.2663 | 0.0086 | 0.0083 | 0.0003 | 34.4583 | 0.0023 | 0.0024 | 0.0085 | 0.1480 | 0.0014 | 0.0013 | 0.0002 | 34.4856 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0003 | 0.0003 | 0.0015 | 0.0045 | 0.0003 | 0.0003 | 0.0000 | 0.5626 | 0.0001 | 0.0001 | 0.0004 | 0.0026 | 0.0000 | 0.0000 | 0.0000 | 0.5630 |
| **Nearshore Placement of Gravelly Sand/AC for Amended ENR (RAA 5A, 8C, 9L) (10 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | 150-ton Crane | Diesel Cranes | Assume each work day contains one 10-hr shift. | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| **Restricted Access Placement of Gravelly Sand/AC for Amended ENR (RAA 5A, 8C, 9L) (Underpier) (4 hours/day)** | | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator | Diesel Cranes | Assume each work day contains one 4-hr shift. | 0.0054 | 0.0057 | 0.0274 | 0.1410 | 0.0043 | 0.0042 | 0.0002 | 17.2542 | 0.0007 | 0.0007 | 0.0131 | 0.0703 | 0.0005 | 0.0005 | 0.0003 | 32.3819 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 1.3370 | 1.4078 | 8.3976 | 32.7858 | 1.0615 | 0.9080 | 0.0390 | 4231.7928 | 0.1830 | 0.1927 | 1.4431 | 13.6551 | 0.1191 | 0.1005 | 0.0360 | 4329.9628 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| **Tidally Restricted Access Placement of Coarse Sand (Perimeter RMC), Gravelly Sand (Backfill and Cap CIL), Gravelly Sand/AC (Amended ENR), Armor** | | | | | | | | | | | | | | | | | | | |
| | Hydraulic Excavator (Tidally Restricted Work Only) | Diesel Cranes | Assume each work day contains one 4-hr shift. | 0.0289 | 0.0304 | 0.1587 | 0.4898 | 0.0351 | 0.0341 | 0.0006 | 61.0642 | 0.0141 | 0.0148 | 0.0423 | 0.2861 | 0.0028 | 0.0027 | 0.0004 | 61.1114 |
| | Push Boat | Diesel Inboard/Sterndrive (800 hp) | | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | Work Boat | Two-stroke Outboard (WB) | | 0.0175 | 0.0185 | 0.0964 | 0.2974 | 0.0213 | 0.0207 | 0.0003 | 37.0842 | 0.0086 | 0.0090 | 0.0257 | 0.1738 | 0.0017 | 0.0016 | 0.0002 | 37.1129 |
| | | | ***SUBTOTAL EMISSIONS – MATERIAL TRANSPORTATION AND PLACEMENT*** | **1.34** | **1.41** | **8** | **33** | **1.06** | **0.91** | **0.04** | **4231.8** | **0.18** | **0.19** | **1** | **14** | **0.12** | **0.10** | **0.04** | **4,330** |
| ***SURVEYS*** | | | | | | | | | | | | | | | | | | | |
| | Work Boat | Two-stroke Outboard (WB) | Assume one survey per day and each work day contains one 10 hr-shift. Assume a total of 1,151 survey events based on pre-construction (bathy and topo), post-dredge and post-placement surveys per RAA, post-construction (bathy and topo) for each construction seasons, contractor progress surveys for the construction duration, and as-built survey in the final construction season. | 0.029 | 0.03 | 0.16 | 0.490 | 0.0351 | 0.0341 | 0.0006 | 61.1 | 0.014 | 0.015 | 0.04 | 0.286 | 0.0028 | 0.0027 | 0.0004 | 61.1 |
| | | | ***SUBTOTAL EMISSIONS – SURVEYS*** | **0.029** | **0.03** | **0.16** | **0.490** | **0.0351** | **0.0341** | **0.0006** | **61.1** | **0.014** | **0.015** | **0.04** | **0.286** | **0.0028** | **0.0027** | **0.0004** | **61.1** |
| ***CONFIRMATIONAL SEDIMENT SAMPLING AND ENVIRONMENTAL MONITORING*** | | | | | | | | | | | | | | | | | | | |
| | Work Boat | Two-stroke Outboard (WB) | Assume one water quality monitoring event per dredge day and each work day contains one 10 hr-shift. Assume 699 water quality monitoring events. Assume 52 confirmational sediment sampling events. | 0.018 | 0.018 | 0.10 | 0.30 | 0.021 | 0.021 | 0.0003 | 37.1 | 0.009 | 0.009 | 0.03 | 0.17 | 0.00 | 0.00 | 0.00 | 37.11 |
| | | | ***SUBTOTAL EMISSIONS – CONFIRMATIONAL SEDIMENT SAMPLING AND ENVIRONMENTAL MONITORING*** | **0.02** | **0.02** | **0.10** | **0.30** | **0.02** | **0.02** | **0.00** | **37.08** | **0.01** | **0.01** | **0.03** | **0.17** | **0.00** | **0.00** | **0.00** | **37.11** |
| | | | **TOTAL DIRECT AIR EMISSIONS (Metric tonnes, rounded)** | **6.1** | **6.4** | **33.0** | **130.0** | **3.6** | **3.3** | **0.13** | **15,000** | **2** | **2** | **16** | **45** | **0.6** | **0.5** | **0.12** | **15,000** |

**Table L4-8**
**Detailed Summary of Direct Emissions by Construction Activity of Each Tier**

Notes:
Total emissions for construction equipment/vehicle are calculated as total daily diesel usage (gal/day) / production rate (units/day) × units × emission factor (g/gal) × (1E-6 metric tonne/g).
Total emissions for rail transportation are calculated as total diesel usage (gal) × emission factor (g/gal) × (1E-6 metric tonne/g).
a. Total diesel usage for train (gal) is calculated as total tonnage-distance covered (ton-mile) / train fuel economy (ton-mile/gal).
b. Total tonnage-distance covered (ton-mile) is calculated as tonnage transported (metric tonne) × one-way distance.
Total emissions for truck transportation are calculated as total diesel usage (gal) × emission factor (g/gal) × (1E-6 metric tonne/g).
a. Total diesel usage for trucks (gal) is calculated as total tonnage-distance covered (ton-mile) / truck fuel economy (ton-mile/gal).
b. Total tonnage-distance covered (ton-mile) is calculated as tonnage transported (metric tonne) × one-way distance.
Total emissions for barge transportation are calculated as total diesel usage (gal) × emission factor (g/gal) × (1E-6 metric tonne/g).
a. Total diesel usage for boats (gal) is calculated as total tonnage-distance covered (ton-mile) / barge fuel economy (ton-mile/gal).
b. Total tonnage-distance covered (ton-mile) is calculated as tonnage transported (metric tonne) × one-way distance.
µm: micron
AC: activated carbon
CO: carbon monoxide
$CO_2$: carbon dioxide
cy: cubic yard
g: gram
gal: gallon
HC: hydrocarbon
hp: horsepower
hr: hour
N/A: not applicable
$NO_X$: nitrogen oxides (NO and $NO_2$)
PB: push boat
$PM_{2.5}$: particulate matter less that 2.5 microns in diameter
$PM_{10}$: particulate matter less than 10 microns in diameter
SCC: Standard Classification Code
$SO_2$: sulfur dioxide
VOC: volatile organic compound
WB: work boat

**Table L4-9**
**High-Level Summary of Direct Emissions by Construction Activity for Local Average Market Conditions**

| Construction Activity | Total Emissions (Metric Tonnes) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Local Average Market Condition | | | | | | | |
| | HCs | VOCs | CO | $NO_X$ | $PM_{10}$ | $PM_{2.5}$ | $SO_2$ | $CO_2$ |
| Demobilization/Mobilization/Site Preparation | 0.057 | 0.060 | 0.228 | 0.712 | 0.034 | 0.033 | 0.000 | 46.934 |
| Structural Work | 2.38 | 2.51 | 9.28 | 29.17 | 1.38 | 1.34 | 0.02 | 2118.42 |
| Sediment Removal | 3.10 | 3.26 | 12.90 | 40.39 | 1.85 | 1.79 | 0.03 | 3276.01 |
| Sediment Transloading, Containerized Sediment Transfer, Upland Transportation, and Disposal | 1.91 | 2.01 | 16.51 | 24.38 | 0.72 | 0.70 | 0.05 | 6023.60 |
| Clean Material Transportation and Placement | 8.18 | 8.62 | 33.36 | 104.92 | 4.87 | 4.72 | 0.08 | 8307.09 |
| Surveys | 0.186 | 0.196 | 0.52 | 0.71 | 0.083 | 0.080 | 0.00056 | 61 |
| Confirmational Sediment Sampling and Environmental Monitoring | 0.113 | 0.119 | 0.315 | 0.43 | 0.050 | 0.049 | 0.000338 | 37 |

Notes:
See Table L4-1 for equipment assumptions and Tier engine distribution under the local average market condition.
CO: carbon monoxide
$CO_2$: carbon dioxide
HC: hydrocarbon
$NO_X$: nitrogen oxides (NO and $NO_2$)
$PM_{2.5}$: particulate matter less that 2.5 microns in diameter
$PM_{10}$: particulate matter less than 10 microns in diameter
$SO_2$: sulfur dioxide;
VOC: volatile organic compound

**Table L4-10**
**High-Level Summary of Direct Emissions by Equipment Type for Local Average Market Conditions**

| Vehicle or Equipment Type | Total Emissions (Metric Tonnes) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Local Average Market Conditions | | | | | | | |
| | HC | VOCs | CO | $NO_X$ | $PM_{10}$ | $PM_{2.5}$ | $SO_2$ | $CO_2$ |
| Dredging/Material Placement Crane | 1.211 | 1.275 | 5.949 | 19.493 | 0.760 | 0.737 | 0.022 | 2458.832 |
| Transload/Disposal Crane | 0.266 | 0.603 | 2.866 | 9.318 | 0.363 | 0.352 | 0.011 | 1174.815 |
| Excavator (Hydraulic and Mini) | 0.263 | 0.277 | 2.063 | 8.243 | 0.217 | 0.210 | 0.017 | 1867.703 |
| Front-end Loader | 0.195 | 0.205 | 0.587 | 3.140 | 0.086 | 0.084 | 0.005 | 645.972 |
| Vessels (Tugboat, Push Boat, and Work Boat) | 13.11 | 13.80 | 51.20 | 155.49 | 7.64 | 7.42 | 0.09 | 9869.78 |
| Rail Transportation | 1.167 | 1.229 | 12.508 | 10.840 | 0.250 | 0.243 | 0.036 | 4093.032 |
| Truck Transportation | 0.03 | 0.03 | 0.52 | 2.78 | 0.02 | 0.02 | 0.01 | 1272.24 |
| Mini Excavator | 0.10 | 0.11 | 1.05 | 4.18 | 0.08 | 0.08 | 0.01 | 1270.30 |
| Hydraulic Excavator (Tidally Restricted Work Only) | 0.04 | 0.05 | 0.27 | 0.89 | 0.04 | 0.04 | 0.00 | 127.80 |

Notes:
See Table L4-1 for baseline and local average market conditions and equipment assumptions for direct air emissions inventory.
CO: carbon monoxide
$CO_2$: carbon dioxide
HC: hydrocarbon
$NO_X$: nitrogen oxides (NO and $NO_2$)
$PM_{2.5}$: particulate matter less that 2.5 microns in diameter
$PM_{10}$: particulate matter less than 10 microns in diameter
$SO_2$: sulfur dioxide
VOC: volatile organic compound

# Table L6-1
# Material Use and Waste Generation Summary

| Material Use and Waste Generation | Activity Type | Activity | Quantity |
|---|---|---|---|
| Raw Materials | Material Placement | Use of Clean Raw Materials (coarse sand, gravelly sand, sandy gravel and quarry spalls) (ton) | 340,400 |
| | | Use of Cement (ton) | 500 |
| | | Use of AC (ton) | 180 |
| | Structural Work | Installation of Steel Piles (number) | 35 |
| | | Installation of Double-Wall Cofferdam and Shoring Wall (sq ft of steel sheets) | 27,500 |
| | | Re-routing of 18-inch HDPE Outfall Pipe (lf) | 350 |
| Waste Generated | From Sediment Removal | Subtitle C Disposal of TSCA Waste (ton) | 2,221 |
| | | Subtitle C Disposal of TSCA Waste and RCRA Hazardous Waste (ton) | 5,478 |
| | | Subtitle D Disposal of Dredged Bulk Sediment (ton) | 613,049 |
| | | Subtitle D Disposal of Washington State Dangerous Waste (ton) | 13,192 |
| | From Structural Work | Disposal of Double-Wall Cofferdam and Shoring Wall (sq ft of steel sheets) | 27,500 |
| | | Disposal of Timber Piles (number) | 27 |
| | | Disposal of Steel Piles (number) | 8 |
| | | Subtitle C Disposal of Timber Derelict Structures RAA 24B-D (ton) | 240 |
| | | Subtitle D Disposal of Timber Derelict Structures RAAs 8F, H (ton) | 46 |
| | | Disposal Submerged Barge (ton)[1] | 1,000 |
| | From Other Removal | Subtitle D Disposal of Identified Debris (ton)[2] | 1,350 |
| | | Subtitle C Disposal of Identified Debris (ton)[2] | 300 |

Notes:

1. Assumed a typical 1,000-ton barge.
2. Identified debris includes visible and potentially buried debris associated with concrete blocks, timber piling, steel I-beams, rubble, cables, and other items.

AC: activated carbon
HDPE: high-density polyethylene
lf: linear foot
RAA: remedial action area
RCRA: Resource Conservation and Recovery Act
sq ft: square foot
TSCA: Toxic Substances Control Act

**Table L7-1**
**Diesel Energy Consumption Summary**

| Activity | Task | Quantity of Material (cy) | Number of Work Days | Total Daily Diesel Usage (gal/day) | Volume of Diesel Consumed (gal) |
|---|---|---|---|---|---|
| Site Preparation | Site Clearing and Grubbing | N/A | 36 | 14 | 504 |
| Structural Work | Pulling of Timber Piling and Replacement with Steel Piles | N/A | 3 | 312 | 935 |
| | Re-Routing of Outfalls OF27 and OF28 (RAAs 24B through D) | N/A | 4 | 188 | 752 |
| | Double-Wall Cofferdam and Shoring Wall Installation and Removal (RAAs 24B-24D) | N/A | 153 | 360 | 55,034 |
| | Removal of Submerged Barge (RAA 14A) | N/A | 5 | 312 | 1,559 |
| | Demolition of Derelict Structures (RAAs 24B-D) | N/A | 0 | 160 | 10,784 |
| | Demolition of Derelict Structures (RAAs 8F, 8H) | N/A | 54 | 360 | 13,376 |
| Sediment Removal | Identified Debris Removal | N/A | 28 | 312 | 8,728 |
| | Open-Water Dredging | 339,352 | 343 | 312 | 106,913 |
| | Nearshore Dredging | 52,373 | 90 | 312 | 28,053 |
| | Restricted Access Dredging | 17,068 | 52 | 340 | 17,664 |
| | Tidally Restricted Dredging | 10,015 | 56 | 256 | 14,319 |
| | Contingency Re-Dredging | 10,380 | 27 | 312 | 8,416 |
| | Shoreline/Bank Excavation | 7,669 | 15 | 188 | 2,820 |
| Sediment Transloading, Upland Transportation, and Subtitle D Disposal | Mechanical Transloading | 464,246 | 469 | 560 | 262,640 |
| | Upland Transportation and Subtitle D Disposal | 464,246 | N/A | N/A | 398,800 |
| Containerized Sediment Transfer, Upland Transportation, and Subtitle C Disposal | Upland Transportation and Subtitle C Disposal | 2,507 | N/A | N/A | 4,725 |
| Material Transportation and Placement | Transportation of Clean Raw Materials (sand, gravelly sand, gravel, and quarry spalls) to LDW Middle Reach and LDW Upper Reach SMA 10 | 237,650 | N/A | N/A | 59,249 |
| | Transportation of Cement to LDW Middle Reach | 332 | N/A | N/A | 38 |
| | Transportation of AC to LDW Middle Reach | 200 | N/A | N/A | 20 |
| | Open-Water Placement | 32,642 | 36 | 312 | 11,221 |
| | Nearshore Material Placement | 40,121 | 66 | 312 | 20,572 |
| | Standard and Modified Engineered Caps | 131,763 | 192 | 452 | 86,726 |
| | Land-Based Material Placement | 8,121 | 17 | 280 | 4,760 |
| | Tidally Restricted Access Placement | 13,072 | 88 | 256 | 22,502 |
| | Restricted Access Placement | 12,131 | 51 | 340 | 17,325 |
| Other Construction Activities | Surveys | N/A | 1,151 | 3 | 3,453 |
| | Confirmational Sediment Sampling and Environmental Monitoring | N/A | 699 | 3 | 2,097 |
| | | | **Total Diesel Consumed (gal)** | | **1,164,000** |

Note:
The volume of diesel consumed for upland transportation and disposal and transportation of clean raw materials is based on the quantity of material, distance traveled, and the fuel economy by the equipment used.
AC: activated carbon
cy: cubic yard
gal: gallon
LDW: Lower Duwamish Waterway
N/A: not applicable
RAA: remedial action area
SMA: sediment management area

# Figures

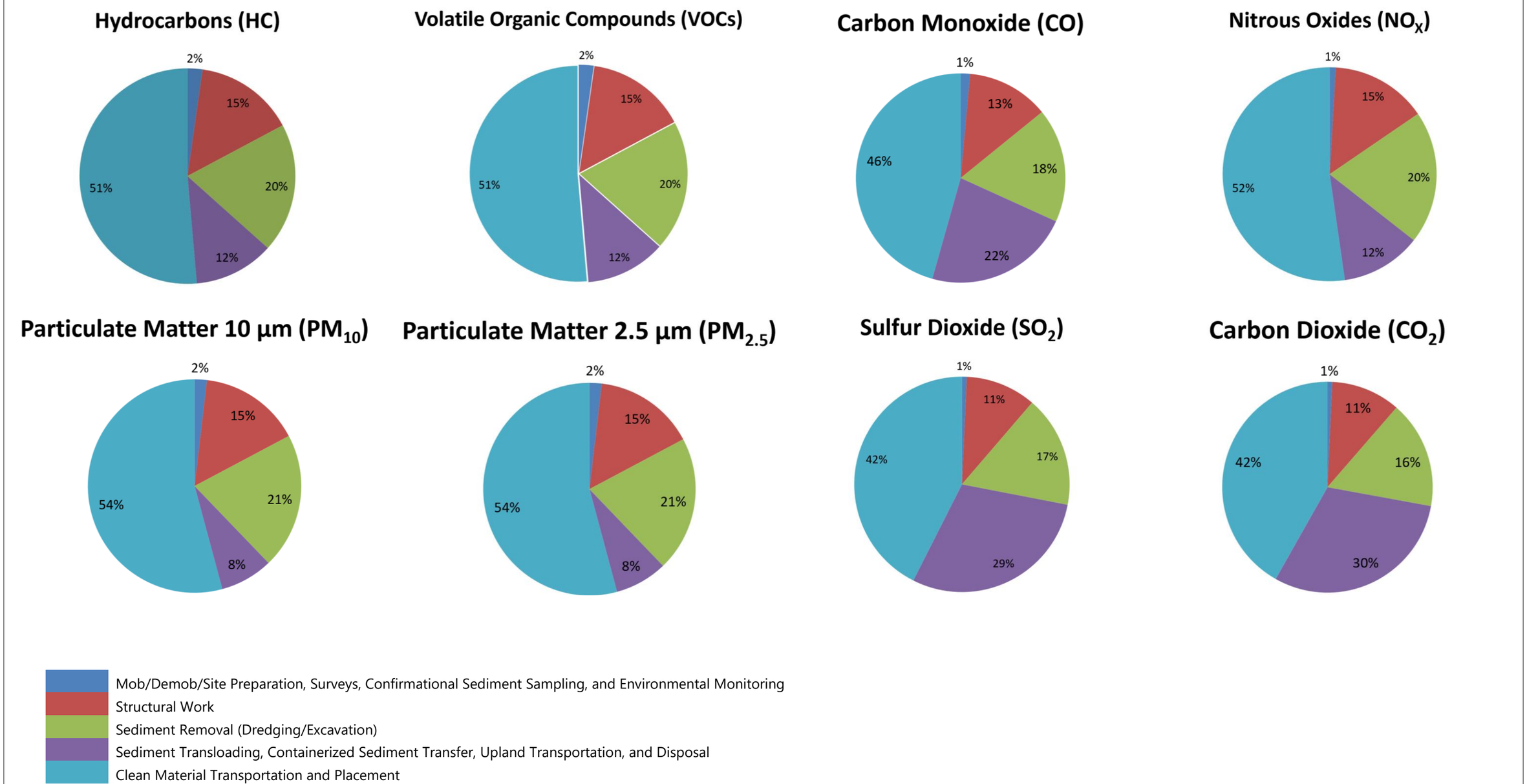


**Figure L4-1**
**High-Level Summary of Direct Emissions by Construction Activity – Local Average Market Condition**
60% Remedial Design Basis of Design Report
LDW Middle Reach

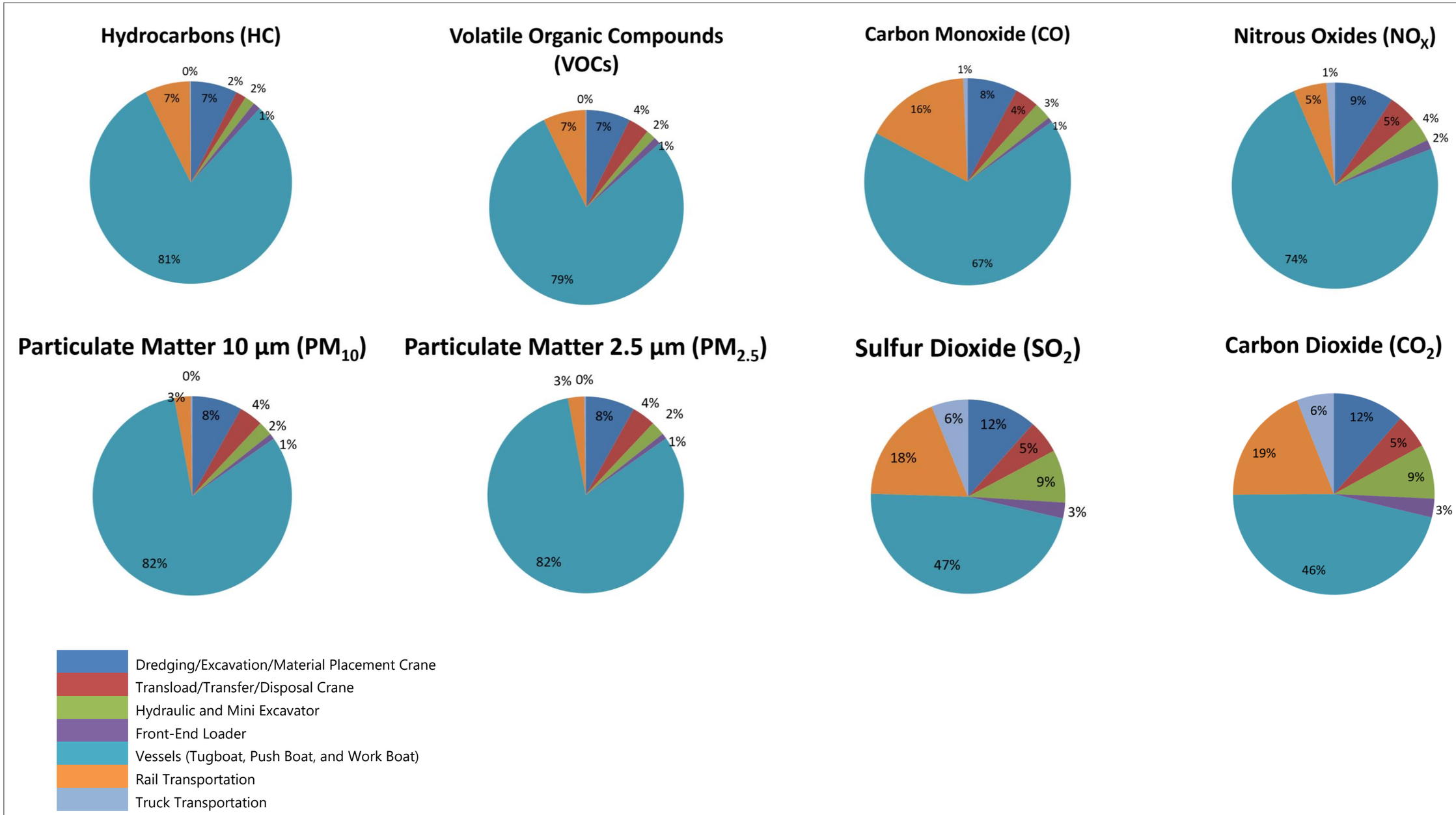




**Figure L4-2**
**High-Level Summary of Direct Emissions by Equipment Type – Local Average Market Condition**
60% Remedial Design Basis of Design Report
LDW Middle Reach