Portland Harbor Sustainability Project

Executive Summary
Sustainability Evaluation of EPA Portland Harbor Superfund Site Remedial Alternatives

Prepared for the Portland Harbor Sustainability Project, including but not limited to the following companies: Atlantic Richfield Company and BP West Coast Products LLC, Crawford Street Corporation, Evraz Inc. NA, Exxon Mobil Corporation, Schnitzer Steel Industries Inc., Shaver Transportation Company, and Toyota Motor Sales, U.S.A Inc.

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List of Enclosures

Enclosure A: Environmental Sustainability Analysis Report, Evaluation of EPA Portland Harbor Superfund Site Remedial Alternatives
Enclosure B: Economic Impacts of EPA Portland Harbor Superfund Site Remedial Alternatives Report
Enclosure C: Social Analysis Report, Evaluation of EPA Portland Harbor Superfund Site Remedial Alternatives

Study Team and Acknowledgments

Lead authors of The Portland Harbor Sustainability Project team consisted of the following organizations:

AECOM Technology Services, Inc.
NERA Economic Consulting
SEA Environmental Decisions, Ltd.

The Team appreciates the contributions of all the organizations and individuals that participated in the Study.

Note that the individual reports represent the views of the authors of each report and do not necessarily represent the views of any organization.
1. Introduction & Background

The Portland Harbor Superfund Site is designated by the United States (US) Environmental Protection Agency (EPA) as one of the “mega-sediment sites” in the United States. The EPA published a Proposed Plan (PP) based upon the 2016 Feasibility Study (FS) which includes eight alternatives, labeled A through I. Alternative A is the “no further action” case and is considered the baseline alternative for this analysis. The EPA-preferred remedial option in the PP is Alternative I. EPA developed detailed expenditure, construction, and other information on the alternatives in the FS, but EPA has not provided a comprehensive sustainability analysis of the alternatives that integrates environmental, economic and social considerations. In the context of remediation, sustainability has been defined as “the practice of demonstrating, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than its impact, and that the optimum remediation solution is selected through the use of a balanced decision-making process” (Sustainable Remediation Forum – United Kingdom).

The Portland Harbor Sustainability Project (PHSP) fills this gap by evaluating the sustainability of six remedial alternatives in terms of environmental, economic and social pillars (see Figure ES-1 for a visual summary of this approach). The PHSP evaluated 2016 EPA Alternatives A (no further action), B, D, I, E, and F (in order of increasing cost); the two largest alternatives, G and H, were not included in this study. Each pillar is composed of various quantitative metrics and the results for the three pillars are integrated into a framework that aggregates metrics weighted by their relative value to local stakeholders. This aggregation method provides a great deal of flexibility in summarizing the results and determining the robustness of sustainability conclusions to differences in stakeholder priorities. The need to consider sustainability is underscored by several publications prepared for EPA by the National Research Council (NRC), including a 2011 report that calls for EPA to include environmental, economic and social considerations in Superfund decision making.

Figure ES-1. Three Pillars of Sustainability

The PHSP team includes experts in the disciplines of environmental, economic and social analysis. State-of-the-art tools are used to develop individual assessments and metrics as well as the overall aggregation framework. Detailed technical reports have been prepared for each of the individual studies. This Executive Summary summarizes the results of the individual assessments and provides the aggregated results. We rely upon these assessments to provide overall conclusions regarding the relative sustainability of the EPA remedial alternatives. The final section provides some broader implications of the sustainability framework developed in this study.
2. Environmental Sustainability

The environmental sustainability analysis consisted of three major components:

1. **Cost and Time Analysis.** Clean-up costs and construction times from the 2016 EPA FS for Alternatives B, D, I, E, and F were evaluated in a Excel-based cost tool adapted by AECOM from the Lower Duwamish Waterway (LDW) Final FS and verified by comparison with recent project experience in the Pacific Northwest (PNW).

2. **Net Environmental Benefit Analysis (NEBA).** Environmental scores were determined for each remedial alternative in the context of six of the nine remedy evaluation criteria defined in the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), each weighted according to their relative importance in the remedy selection.\(^1\)

3. **Human health risks.** Post-construction risks were estimated using EPA’s conservative deterministic assumptions regarding fish/shellfish consumption.

The results of these environmental studies were compared to remediation costs in order to assess the cost-effectiveness of the EPA remediation alternatives. These analyses are detailed in Enclosure A, Environmental Sustainability Analysis Report.

### 2.1 Cost and Time Analysis

As described in the 2016 EPA FS, the remedial technologies potentially applied to the remedial alternatives include a combination of removal (mechanical dredging and dry excavation), partial removal and capping, isolation capping, enhanced natural recovery, monitored natural recovery, off-site dredge material disposal in Subtitle C and D landfills, and off-site thermal treatment for sediment that exceeds acceptable landfill criteria.

Clean-up costs and construction times from the 2016 EPA FS for Alternatives B, D, I, E, and F were evaluated in an Excel-based cost tool adapted by AECOM from the LDW Final FS and verified with recent project experience in the PNW (the most expensive Alternatives H and G were not evaluated). Net present value (NPV) estimates of costs were developed based on discount rates of 7%, 2.3%, and 0%. Our review of the EPA cost assumptions—one part of the detailed sustainability analyses conducted by the PHSP—is contained as an Appendix to Enclosure A, Environmental Sustainability Analysis Report.

EPA costs for the five alternatives in this study range from about $642 million to almost $2.2 billion assuming 2016 dollars and a 0% discount rate (2016 EPA FS). AECOM FS-level cost estimates were 36 to 64% higher than EPA’s cost estimates for the same alternatives. AECOM cost estimates range from $1.1 billion to over $2.9 billion using the same 2016 dollar year and 0% discount rate.

EPA’s construction periods (excluding activities such as long-term monitoring and five year reviews) ranged from 4 to 13 years. However, these construction periods are underestimated based on recent sediment remediation experience in the PNW at Boeing Plant 2, Port of Seattle Terminal-117, City of Seattle Slip 4 in the LDW, and PGE RM 13.5 in the Willamette River. AECOM construction times are estimated to be approximately 1.3 to 2 times longer than EPA estimates (5 to 26 years, with 11 years, specifically, for Alternative I).

Our analysis indicates that the EPA construction times are unrealistic based on recent PNW project experience. For example, EPA estimates Alternative I construction time will be 7 years for three dredges operating at 80 to 100% efficiency. The AECOM estimate is closer to 11 years at 64% seasonal efficiency (and up to 14 years if non-current dredged/cap construction is assumed). US Army Corps of Engineers guidance (2008) states that a seasonal efficiency of about 60% is

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\(^1\) Among the remaining three CERCLA evaluation criteria, “Cost” was evaluated but not included in the overall net benefit score because scores were compared to costs. “State Acceptance” and “Compliance with ARARs” were not included because they were difficult to quantify.
reasonable and adequately accounts for issues such as equipment downtime, clean-up passes, water quality exceedances, and best management practice (BMP) adjustments.

Separate cost analyses conducted by other firms confirm the AECOM conclusion that EPA’s costs are understated. EPA’s PP and 2016 FS estimate for the preferred clean-up alternative (Alternative I) estimates a $1.17 billion remedy (0% discount rate) compared to AECOM total cost estimate of $1.62 billion for the same alternative. We believe EPA costs are underestimated by about 40 to 50%. EPA’s preferred remedy (Alternative I) will likely cost from $1.6 billion to $1.8 billion, based on various cost assumptions. Three other independent cost estimates similarly estimated greater costs than EPA estimates, with these studies within +/- 20% of each other (see Table ES-1).

<table>
<thead>
<tr>
<th>Source</th>
<th>Total Remedy Cost ($ billions 0% NPV)</th>
<th>% Higher than EPA Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016 EPA FS</td>
<td>$1.17</td>
<td>n/a</td>
</tr>
<tr>
<td>PHSP / AECOM</td>
<td>$1.62</td>
<td>38%</td>
</tr>
<tr>
<td>de Maximis</td>
<td>$1.72</td>
<td>47%</td>
</tr>
<tr>
<td>Geosyntec</td>
<td>$1.79</td>
<td>53%</td>
</tr>
<tr>
<td>Integral</td>
<td>$1.80</td>
<td>54%</td>
</tr>
</tbody>
</table>

Note: These are FS-level cost estimates in the range of +50 to -30% accuracy (range of $1.2 to $2.6 billion among the average of the 4 estimates).

2.2 Net Environmental Benefit Analysis (NEBA)

Environmental metrics were quantified for Alternatives A, B, D, E, I and F and linked to CERCLA remedy evaluation criteria. To aggregate metric results and scores across the various criteria, AECOM developed quantitative net environmental benefit analysis (NEBA) scores for each CERCLA criteria, scaled from 0 to 10. These benefit scores are aggregations of the scores of more than 30 individual environmental metrics that reflect the various criteria and were quantified in one of three ways:

- **Feasibility Study (FS).** Data were extracted from information presented in the 2016 EPA FS, including the spatial extent technology assignments, reduction in sediment concentrations, and residual risk immediately post-construction.

- **SiteWise™.** The greenhouse gas (GHG) and air pollutant emissions and worker safety risks were estimated using SiteWise™, a series of publicly available Excel spreadsheets used to calculate the environmental footprint of remediation activities in terms of sustainability metrics, developed in a joint effort by Battelle Memorial Institute, the US Navy, and the US Army Corps of Engineers.

- **GIS mapping.** Disturbances to businesses, recreational access, and ecological habitats were estimated using geographic information system (GIS) mapping to calculate the amount of overlap between the active remediation footprint (i.e., dredging and capping) of each alternative and various shoreline uses and over-water structures.

Figure ES-2 depicts the overall CERCLA-linked environmental benefit score for each alternative with an overlay of their remediation costs. The CERCLA criteria were weighted according to their relative importance in the remedy selection process. The benefit scores for the remedial alternatives across alternatives range from 3.8 for Alternative A (no further action) to 6.4 for Alternative F.

The major result from the NEBA analysis is that the least expensive alternative, Alternative B, has the highest benefit score. Although this result may seem surprising, it reflects important negative effects of the more costly alternatives—alternatives with larger remedial footprints and longer construction...
times have much higher air emissions, construction worker risk, and upland landfill disposal than the lower footprint alternatives. Air emissions associated with construction and waste transportation include GHG and criteria air pollutant emissions.

One important aspect of the “Overall Protectiveness” criterion is exposure at the end of construction, expressed in Figure ES-3 in terms of cumulative reduction in surface-weighted average concentration (SWAC). Figure ES-3 illustrates that Alternative B provides the most SWAC reduction per dollar spent.
2.3 Post-Construction Human Health Risks

Figure ES-4 illustrates post-construction risks for human consumption of fish and shellfish for the alternatives based upon EPA assumptions regarding fish consumption and other risk parameters, along with the various standards of comparison for the risks. The following are the key results:

- Post-construction risks do not meet the upper end of target risk levels for Alternatives B, D, E, and I, nor the background risk levels for any of the remedial alternatives.

- For the subsistence angler who is assumed to consume 142 grams/day of resident fish (228 Study Area fish meals per year), risk reduction is limited by background. Background concentrations\(^3\) pose risks that exceed the long-term risk management target goals of \(10^{-5}\) and hazard index of 1 (PCBs, PCDDs/DFs).

As stated in the US Navy guidance\(^4\), when a remedial technology is not effective in meeting the remedial goals and achieving the required level of protectiveness, the technology is simply not sustainable. In terms of risk reduction, a sustainable remedy should have clean up goals that are risk-based, that are achievable in a reasonable restoration time, and that consider the ongoing contributions of background concentrations. Residual risks (the risk remaining over time once the preliminary remediation goals (PRGs) are achieved at some point in the future) were not evaluated by EPA in the 2016 FS, but all alternatives will likely reach similar residual risk levels over time.

\(^3\) For PCBs, residual risk is defined as background which EPA identifies as 9 µg/kg in sediment; the risk-based PRGs are below background and therefore not achievable.

3. Economic Sustainability

Economic sustainability can be evaluated using three major methodologies:

1. Cost-effectiveness comparisons. Comparisons of the incremental gains in effectiveness (as measured by one or more metrics) with the incremental costs of increasingly expensive alternatives.

2. Benefit-cost comparisons. Comparisons of the net benefits (i.e., monetary benefits minus monetary costs) of alternatives, including assessments of the likely relative significance of benefits and costs that are not monetized.

3. Economic impact comparisons. Comparisons of the impacts on the regional economy of alternatives, taking into account both the positive impacts of expenditures and the negative impacts due to financing of expenditures by local governments (e.g., increased taxes) and local businesses (e.g., higher costs and thus less-competitive positions relative to similar businesses in other regions).

3.1 Cost-Effectiveness and Cost-Benefit Considerations

Results from the environmental assessments provide evidence that the more costly alternatives are less cost effective than Alternative B, with effectiveness measured by NEBA scores, SWAC values, or human health risk reduction. Indeed, NEBA scores indicate that Alternative B “dominates” the other alternatives—Alternative B has a higher NEBA score and lower costs than the other alternatives. Cost-effectiveness results for the other metrics show a marked “knee of the curve” at Alternative B, as the more extensive alternatives would lead to much greater increases in cost relative to their added SWAC or human health risk reduction.

Although a formal benefit-cost analysis was not performed—in which risks and other benefits would be put in monetary terms to the extent feasible—these environmental results suggest that the more costly alternatives also would not pass a benefit-cost test, i.e., that the monetary value of the additional environmental benefits relative to Alternative B would be less than the additional costs for all of the other alternatives.

3.2 Economic Impact Assessment

The economic study undertaken by the PHSP concentrated on assessing the impacts of EPA’s remedial alternatives on the Portland regional economy. The details of this analysis are provided in Enclosure B, Economic Impact Analysis Report. This focus was particularly important because the two prior economic impact assessments of Portland Harbor remediation—both done in 2012 before EPA had identified its remedial alternatives in the FS—came to opposite conclusions, one finding positive impacts and the other negative impacts.5 6 These seemingly contradictory results arose because one study estimated only the positive effects of expenditures and the other study estimated only the negative effects if all of the expenditures were paid for by local businesses and governments.

NERA used the Regional Economic Models, Inc. (REMI) Policy Insight Plus Model (PI+) to develop estimates of the net economic impacts of the EPA alternatives, taking into account both of these effects. REMI PI+ is a state-of-the-art regional economic model that is used by public agencies in most states as well as numerous governments abroad. Using the REMI PI+ model, the total regional impacts were estimated for both (a) increased spending associated with remediation activities and (b) local financing burdens, including the direct as well as the indirect and induced (often referred to as “multiplier”) effects. The REMI PI+ model also incorporates various important market effects, including effects on local wage rates, prices, and other economic variables. Impacts on the seven-county

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Portland Metropolitan Statistical Area (MSA) were estimated over the 31-year period from 2020, when it is assumed remediation activities would begin, through 2050.

Table ES-2 summarizes the estimated average annual impacts to the Portland regional economy as well as cumulative impacts over the 31-year period from 2020–2050. The impacts are measured in terms of changes in: (1) jobs; (2) Portland gross regional product (GRP), a regional measure equivalent to gross national product (GNP, which is calculated for the US as a whole); (3) personal income; and (4) population. Figure ES-5 summarizes the ranges of average annual job and GRP impacts for the five EPA alternatives. The ranges for a given EPA alternative reflect uncertainties in how the local government and local business costs might be financed. The results assume that local governments, local businesses, and national/international businesses share equally—i.e., one-third each—in the financing of remediation expenses.

### Table ES-2. Economic Impacts of Combined Expenditures and Financing of EPA Alternatives on Portland MSA

<table>
<thead>
<tr>
<th>Gross Regional Product (Million 2016$)</th>
<th>B</th>
<th>D</th>
<th>I</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Annual</td>
<td>-$18</td>
<td>-$49</td>
<td>-$28</td>
<td>-$74</td>
<td>-$36</td>
</tr>
<tr>
<td>Cumulative (3% DR)</td>
<td>-$381</td>
<td>-$815</td>
<td>-$575</td>
<td>-$2,133</td>
<td>-$747</td>
</tr>
<tr>
<td>Personal Income (Million 2016$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Annual</td>
<td>-$13</td>
<td>-$39</td>
<td>-$20</td>
<td>-$59</td>
<td>-$26</td>
</tr>
<tr>
<td>Cumulative (3% DR)</td>
<td>-$261</td>
<td>-$632</td>
<td>-$401</td>
<td>-$962</td>
<td>-$528</td>
</tr>
<tr>
<td>Total Employment (Jobs/Job-Years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Annual</td>
<td>-110</td>
<td>-340</td>
<td>-170</td>
<td>-510</td>
<td>-230</td>
</tr>
<tr>
<td>Cumulative</td>
<td>-3,430</td>
<td>-10,430</td>
<td>-5,290</td>
<td>-15,780</td>
<td>-7,020</td>
</tr>
<tr>
<td>Population (Persons/Person-Years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Annual</td>
<td>-290</td>
<td>-470</td>
<td>-440</td>
<td>-710</td>
<td>-570</td>
</tr>
<tr>
<td>Cumulative</td>
<td>-9,100</td>
<td>-14,540</td>
<td>-13,770</td>
<td>-22,150</td>
<td>-17,690</td>
</tr>
</tbody>
</table>

The following are the major results of the REMI analysis.

- **Net impacts are negative for each alternative, meaning that the negative economic impacts of local government/business financing outweigh the positive impacts of expenditures. These net negative impacts are reflected in net losses in jobs, GRP, personal income and population in the Portland MSA.**

- **The more expensive alternatives result in substantially larger negative impacts than the less expensive alternatives. Based on the maximum value financing assumptions, the average annual job loss ranges from about 340 jobs under Alternative B to 1,250 jobs for Alternative F. With regard to the equivalent GRP values, the range is from -$49 million (GRP loss) under Alternative B to -$178 million (GRP loss) for Alternative F.**
Potential losses to the Portland regional economy could differ substantially based upon uncertainties in how the expenditures will be financed. For example, with regard to Alternative I, the estimated range of average annual job losses over the 31-year period ranges from 230 to 640.

Most sectors of the Portland regional economy are affected. Multiplier effects lead to negative impacts on nearly every sector of the Portland regional economy.

Socioeconomic losses are concentrated in relatively high-wage sectors. Approximately forty percent of the estimated job losses due to the remedial alternatives under consideration are projected to be in relatively high-wage sectors.

### 3.3 Business Disruption and “Stigma” Effects

The EPA alternatives could have additional impacts on the regional economy through effects on riverfront activities, which were not included in the REMI modelling. NERA prepared a business questionnaire that was administered to riverfront businesses (on conditions of anonymity) to assess these potential impacts.

The questionnaire responses generally identified two impact categories as potentially significant:

1. Negative impacts related to business disruption; and
2. Positive impacts related to stigma removal.

Questionnaire respondents did not consider increased noise a concern but did indicate potential increased truck traffic is of some concern.

Virtually all respondents indicated that changes in their river operations were “very likely” if access were disrupted during the EPA’s in-water work window. Changes depended on the nature of the available options.

- Participants with nearby alternative facilities with port access (e.g., on the Columbia River in Washington) would likely consider relocating operations.
- Participants without nearby facilities—particularly those with highly specialized and stationary equipment—would consider shipping by other higher-cost means in the near term (e.g., relying more on rail or trucks); eventually, this group might eliminate local production altogether.

Most participants responded that remedial alternatives with longer durations would lead to greater disruption and more severe reactions (i.e., relocation or permanent shutdown of riverfront facilities).

Most respondents believed there was a stigma associated with the listing as a Superfund site and that this stigma affected business. A majority believes that remediation might remove this stigma; however, participants cautioned that stigma removal would require two major changes.

1. Legal certainty for new entrants fearing liability; and
2. Long-term perception of remediation success.

In summary the questionnaire results suggest that the net effect of Superfund remediation on businesses on the river is ambiguous (i.e., one positive, one negative). We suspect that the net effect is likely small relative to the direct effects quantified from the remedial expenditures and financing.
4. Social Sustainability

Social equity is one of the three pillars of sustainability and provides one platform for stakeholder trade-off evaluation and remedy decision making. This part of the sustainability assessment evaluates the social sustainability of five remedial alternatives presented in the 2016 EPA FS, relative to baseline, or Alternative A (no further action). This assessment is detailed in Enclosure C, Social Analysis Report.

4.1 Metrics and Stakeholder Values

The metrics quantified in other pillar assessments (environmental and economic) were adapted and integrated into a stakeholder values-based assessment that was supplemented to include social equity metrics. Metrics were aggregated into one of four Stakeholder Group (SG) Values (identified in a broad-based review of sustainability projects and regional stakeholder documents) for each pillar. Then, the sorted metrics were scored in the Excel-based Sustainable Value Assessment (SVA) tool, which was developed for this project.

A six month exploratory effort was conducted to identify Portland Harbor SGs and their values. Over 280 separate SGs, including many which are potentially underrepresented in the decision process, were identified and placed in a project-specific stakeholder mapping database. These include regional businesses and industries adjacent to or dependent on the river (including potentially responsible parties to the clean-up); neighborhood, community, and Tribal groups; recreational clubs and other associations; environmental, social justice, and other non-governmental organizations; and local, regional, state, and federal government entities. In parallel with the stakeholder mapping effort, a documentation review was conducted to collect information on inferred and elicited stakeholder values and priorities in terms of Portland Harbor remediation, restoration, planning and development issues. This review included publications, websites, newsletters, journals, brochures, meeting minutes, interviews, and written comments.

SG Values were linked to specific indicators or metrics that could be used to score each remedial alternative in terms of the SG Value. A total of 49 metrics were grouped into the following 12 SG Values (sorted by sustainability pillar) and scored for each of five alternatives (B, D, E, I, and F). The 12 SG Values are listed in Table ES-3.

<table>
<thead>
<tr>
<th>Table ES-3. Stakeholder Group Values</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Environmental Quality</strong></td>
</tr>
<tr>
<td>Fish &amp; Wildlife</td>
</tr>
<tr>
<td>Habitat</td>
</tr>
<tr>
<td>Resilience</td>
</tr>
<tr>
<td>Low Impact Remedy</td>
</tr>
</tbody>
</table>

Impact (negative) and/or benefit (positive) scores were determined for each metric and each remedial alternative on a scale of -10 to +10. The metric scores were then aggregated according to their respective SG Values to generate SG Value scores (See Enclosure C, Social Analysis Report, for detailed discussion).

4.2 Social Tool Developed to Evaluate Trade-Offs

The SVA tool was developed as a sediment remediation-specific multi-criteria assessment tool and used to evaluate trade-offs between environmental, economic, and social costs and benefits in terms of SG Values for remedial alternatives and to compare the overall SG Values-based sustainability of each remedial alternative. Comparing each remedial alternative in terms of disparate SG Values provides a platform for dialogue and communication on trade-offs, and supplements more established evaluation of incremental environmental benefits versus costs, such as those evaluated in
the CERCLA-linked NEBA. When the diverse impacts of remedial options are considered, stakeholders can better understand the full range of potential consequences of such a substantial undertaking, supporting better-informed decisions, and ideally, avoiding single-issue decision making.

4.3 Values-Based Sustainability Results

Figure ES-6 shows the aggregated scores for each SG Value, weighted equally and summed for each of the remedial alternatives. The following are the major results of the comparative social assessment.

- The net sustainability scores (i.e., the sum of the negative and positive scores) show a clear pattern, with progressively lower net scores for the larger alternatives.
- A closer look shows that the difference between remedial alternatives is driven not by increased benefits for the higher-scoring alternatives, but by increasing negative impacts for the more extensive alternatives.
- The positive benefit scores (the bars above the zero line) decrease slightly from Alternative B to the larger and more extensive alternatives. Most of the SG Values with positive scores (Fish & Wildlife, Acceptable Remedy, Cost Effectiveness, and Community Values) are among those that are frequently reflected in SG priority differences, and result in trade-offs that produce slightly decreasing net benefits scores across most alternatives (they are scored with both positive and negative values). The higher Resilience score for Alternative F reflects the more extensive removal-based remediation for that alternative.
- In contrast, for the SG Values that have net negative scores, the environmental, economic, and social impacts of a large remediation increase as the remedial alternatives become more extensive.
- For the EPA remedial alternatives under consideration, the small incremental decrease in risk for more aggressive alternatives is outweighed by the increased environmental, economic, and social costs and impacts.
4.4 Sensitivity Analysis

A sensitivity analysis was completed using different weightings to represent differing priorities among stakeholder groups, and comparing SG Value scores using AECOM vs EPA cost and time estimates. The following are results from this analysis.

- The SVA tool is sensitive to various stakeholder inputs—the relative value and pillar scores change in response to different SG priorities, identifying trade-offs, opportunities for optimization, and sources of potential disagreement.
- There were also some differences observed in time-sensitive metrics when EPA versus AECOM costs and construction times were used.
- However, the conclusions are robust—when a broad range of positive and negative impacts of large-scale remediation is considered, regardless of the weighting approach used, the overall relative sustainability rankings of the remedial alternatives remained the same.

4.5 Summary of Relative Sustainability Scores

In summary, the overall values-based sustainability scores of the Portland Harbor remedial alternatives can be ranked as: Alternative B ≥ Alternative D > Alternative I > Alternative E >> Alternative F.
5. Conclusions

This section provides conclusions regarding EPA’s cost and timing information and on the relative sustainability of the EPA’s Portland Harbor remediation alternatives in terms of the three major pillars of environmental, economic and social sustainability.

5.1 Conclusions for the Three Sustainability Pillars

5.1.1 Environmental Sustainability

AECOM’s analysis indicates that Alternative B provides greater environmental benefits as determined by the NEBA. The negative impacts of the more aggressive alternatives far outweigh the small incremental improvements in risk reduction for the more aggressive remedies. Furthermore, alternatives with longer construction times have higher GHG and air pollutant emissions than alternatives with shorter construction times. Construction activities associated with the larger alternatives will disturb up to 45% (for Alternative F) of shoreline businesses and recreational access to the river. As with air emissions, shoreline disturbance increases with construction times for larger alternatives.

While BMPs may be implemented to reduce some of the short-term impacts of the more costly alternatives, the relatively small improvements in environmental metrics do not affect NEBA ranking of the alternatives. More benefits can be achieved through selection of a lower-impact remedy.

The human health risk analysis indicates some gains for the more extensive alternatives, but these gains have a relatively low impact on human health. All of the alternatives are limited by background concentrations of contaminants that pose risks in excess of the long-term risk management targets set by EPA for the Site of $10^{-5}$ (cancer) and a hazard index of 1 (non-cancer). Even the most extensive remediation options considered by EPA (Alternatives F, G, and H) do not achieve fish consumption goals for subsistence anglers or remove fish consumption advisories. Furthermore, Alternatives B and D may achieve similar background levels over time because of ongoing natural recovery processes and source control.

5.1.2 Economic Sustainability

The environmental analysis suggests that the more extensive alternatives are inferior to Alternative B based on economic cost-effectiveness and benefit-cost metrics. Indeed, using NEBA as a metric, Alternative B dominates the other alternatives, resulting in the highest NEBA score and the lowest cost. Using SWAC and human health risk as effectiveness metrics, Alternative B is much more cost-effective, with the more expensive alternatives providing small additional gains for large additional costs. These various metrics all suggest that Alternative B would be superior based on economic benefit-cost comparisons.

The regional economic modeling indicates that all remedial alternatives would result in net job losses and other negative impacts to the Portland regional economy, a result that reconciles the two prior apparently contradictory economic impact studies done for Portland Harbor. The regional modeling results also indicate that Alternative B is superior to the other alternatives, since it results in the smallest negative impacts, as measured in terms of declines in employment, GRP, regional income and population in the Portland region.

5.1.3 Social Sustainability

The social sustainability analysis suggests that all remedial options have environmental, economic and social impacts, and that these impacts increase in proportion to the magnitude of the remedial alternative. The relatively small incremental increase in permanence and risk reduction for the more extensive options is more than offset by the increased impacts. The net SG Values-based sustainability scores (i.e., the sum of the negative and positive scores) show a clear pattern, with progressively lower net scores for the larger and more expensive alternatives. These conclusions are
robust—when a broad range of positive and negative impacts of large-scale remediation is considered, regardless of the weighting approach used, the overall relative sustainability rankings of the remedial alternatives remained the same.

5.1.4 Sensitivity Analyses

Various sensitivity analyses were developed for all three pillars—environmental (CERCLA criteria weighting factors, dredge production rates, and waste transportation and disposal scenarios), economic (financing and by whom), and social (weighting factors for diverse stakeholder groups, comparison to EPA vs AECOM cost and time estimates). Each of these analyses concluded that while the results are sensitive (notable differences between the results) the sustainability rankings of the EPA remediation alternatives are robust with respect to these parameters. The overall rankings did not change.

5.2 Overall Conclusion

We conclude that Alternative B is the most sustainable Portland Harbor Superfund Site remedy among those evaluated by EPA—with Alternative D close behind—when environmental, economic, and social benefits and impacts are considered. With regard to EPA’s preferred alternative (Alternative I), we conclude that actual costs and construction times will likely be 40 to 50% higher than EPA estimates and that the net negative environmental, economic, and social impacts of Alternative I relative to both Alternative B and Alternative D substantially outweigh the small incremental improvements in post-construction health risk.
6. Broader Implications

The PHSP is a significant step forward in developing a sustainability framework that can be used as an aid to environmental decision making for complex sediment remedies. A comprehensive analysis of the environmental, economic and social impacts (all three pillars of sustainability) associated with remedial alternatives provides a broader basis for decision-making rather than focusing on a narrow set of criteria. Moreover, integrating all of these factors into a common framework allows one to develop robust conclusions of potential trade-offs among the remediation alternatives.

Our quantitative assessment of stakeholder values is extensive, new, and robust. It advances the incorporation of sustainability considerations, and we strongly believe it is a worthwhile effort that should be considered by EPA as it decides on a final remediation plan for the Portland Harbor Superfund Site. Indeed, the framework should be used for decision-making at other environmental sites, within the existing CERCLA evaluation process. Further, the application of a sustainability framework to complex environmental decisions is consistent with recommendations from the NRC and recent US executive directives, requiring that federal decision making should consider community needs and how they are affected.

For Portland Harbor, as with other contaminated sites, risks, benefits and costs are not borne equally, in terms of time, space, stakeholders, or demographics. These issues should be kept in mind when the trade-offs described in this report are considered – it is important to consider the needs of a diverse population. It is primarily for this reason that the equal SG Value weighting scheme was developed – although some SGs are very active and vocal, there is evidence of diverse values and priorities throughout the region, and these disparate priorities should be considered, even if not all stakeholders are fully engaged in the decision making. Adverse spatial and demographic equity issues can, to some extent, be minimized using best management practices, considering community needs in design, and minimizing footprints.

For this tool to be most useful in optimizing sustainable options, a wide range of remedial options with a broad range of potential risk reductions should be evaluated, to identify the point where additional impacts overwhelm the additional gains. Identification of the risks and benefits of most interest to stakeholders can allow for negotiation and optimization of alternatives under consideration, and for collaborative design of more sustainable options.

The application of sustainability tools for complex environmental issues should, ideally, be considered earlier in the remedial process with a high level of stakeholder engagement, in order to develop more realistic and effective options. Because this study was conducted after completion of the Portland Harbor FS, the broad range of sustainability considerations were not incorporated into the development of remedial alternatives. The goal for large, complex projects should be to envision a sustainable approach from the beginning of a project with collaborative input from a large group of stakeholders. In addition, the use of a dynamic multi-year regional economic impact model that considers both the positive impacts of expenditures and the negative impacts of their financing is important to clarify potential economic impacts to stakeholders, especially for remedies like Portland Harbor that may cost close to $1 billion. An informed, transparent, and balanced decision making process will enable selection of a remedy that more stakeholders can support earlier in the process.